PROCEEDINGS

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PREFACE

Creating a sustainable and a healthy environment is one of the most important global issues facing mankind today. Therefore, serious consideration should be given to environmental problems and concerted efforts should be made worldwide in order to respond and prevent present and future environmental risks and challenges.

The International Conference on Environment: Survival and Sustainability (ESS 2007) organized by the Near East University between the dates 19 and 24 February 2007 was held in Lefkosa, Turkish Republic of Northern Cyprus. The main objective of this multidisciplinary conference was to gather scientists from all over the world to discuss the overall issue of the environment, to find out sustainable solutions for environmental problems and to identify areas for future collaboration in this matter. The conference brought together 2,052 participants from 108 different countries. During the conference a total of 1,463 papers were presented under 21 different subtopics, representing various scientific disciplines. The topics included environmental law and ethics, environmental knowledge, technology and information systems, media, environmental awareness, education and lifelong learning, the use of literature for environmental awareness and the effects of the green factor in politics and in international relations.

The Scientific Committee of International Conference ESS2007 evaluated all of the 1,463 papers and selected among them 610 papers to be included in The Proceedings of Environment: Survival and Sustainability. The readers will notice the wide range of topics represented by the papers included in the Conference Proceedings.

It is hoped that this book will serve to contribute to increase in awareness towards various environmental issues as well as drawing more attention to the urgency of international cooperation and collaboration in pursuing sustainable environmental management.

Prof. Dr. Hüseyin Gökçekuş
President of the Conference and the Organizing Committee
Vice Rector of the Near East University
Lefkoşa-TRNC
18 February 2009

ACKNOWLEDGMENTS

The Organizing Committee of the ESS2007 Conference would like to extend its sincere appreciation to Dr. Suat Günsel, the Founding Rector of the Near East University, to Prof. Dr. Ekmeleddin İhsanoğlu, General Secretary of the Organization of Islamic Conference and to Prof. Dr. Walter W. Kofler, President of ICSD/IAS for their significant support and encouragement in the conference.

Appreciation is also extended to the chairpersons, the keynote speakers and the presenters of papers in the conference.

We are deeply grateful for the members of the editorial board who have carefully read and recommended the papers for publishing.

We also wish to express our gratitude to numerous individuals for their valuable contribution to the editing process.

Prof. Dr. Hüseyin Gökçekuş
President of the Conference and the Organizing Committee
Vice Rector of the Near East University
Lefkoşa-TRNC

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Message from the Honorary President of the Conference

The interaction between humans and their environment has entered a critical stage as the delicate balance between them has become more fragile making it difficult for the nature in many areas to renew itself. All this poses a variety of serious challenges for us all. The main challenge before us is no less than redefining our entire relationship with our environment. At this critical juncture, I feel excited and take pride in once again hosting such a distinguished group of scientists, researchers, journalists, and students from all over the world at our university addressing such a critical global concern. I look forward to welcoming you all in Turkish Republic of Northern Cyprus.

Yours truly,
Dr. Suat İ. Günsel
Founding Rector of the Near East University

Message from President of the Conference

It gives me the utmost pleasure in welcoming you all to the International Conference " Environment: Survival and Sustainability" here at the Near East University in Turkish Republic of Northern Cyprus to be held at 19-24 February 2007.
The conference aimed at bringing together more than 2,000 scholars and researchers from over 90 countries around the world to discuss environmental issues from a variety of perspectives; underline the importance of the need for urgency in taking steps by the international organizations, states, local authorities and non-governmental organizations to move to a sustainable environment/development model; and thereby makes its contribution to worldwide debate effort on strengthening the bridge between theory and practice in meeting environmental threats/challenges.
Since our last international conference on environment, "Environmental Problems of the Mediterranean Regions", worldwide environmental disasters as well as local ones have multiplied and environmental degradation and pollution has continued. While major strides have been made in the world in analyzing, understanding and informing the public about the environmental challenges we are facing, we still have a long way to go. Our way of life is still far from a sustainable model and our environment continues to degrade and deteriorate due to human activities. The consequences can be seen in worldwide environmental disasters as well as locally in our daily lives.
This is going to be our third international conference on Environment organized by our young university since it was established in 1988.

Yours sincerely,
Prof. Dr. Hüseyin Gökçekuş
Vice Rector of the Near East University

OPENING SPEECHES

Prof. Dr. Ümit HASSAN
Rector of Near East University, TRNC

His Excellency, the Prime Minister of the Turkish Republic of Northern Cyprus,

His Excellency Secretary General Organization of the Islamic Conference,

Distinguished guests, colleagues, ladies and gentlemen,

On behalf of the Founding Rector and the Near East University, I take this opportunity to wish you all a warm welcome for a fruitful conference. It is a great pleasure for me to be a participant at this international conference.

The International Conference on Environment, Survival and Sustainability is a new and most important sequel to a chain of international conferences organized by the Near East University. I trust the conference will provide participants with an opportunity to discuss, to show and to express the related problems and share their experiences. I believe that we will have a most beneficial scientific medium taking the battles into consideration between theoretical analysis and experimental observations and studies.

It is evident that this balance of methods and techniques will have to create a high level of scientific contribution. In other words, the conference will strengthen the bridge between theory and practice in meeting environmental threats, and emphasize the urgent need for coordination and integration among all bodies towards a more sustainable environment. I would like to take this opportunity to proudly emphasize and announce the accomplishments of the Near East University in fulfilling the requirements in founding the School of Medicine as a subsequent step following the School of Pharmacology and the School of Dentistry which will start to function properly in this coming academic year. Within this context, I would like to inform you that the technological means and the academic staff needed by such schools are at the highest level at the Near East University. Our conception of the Technopark being different from the practices of other universities is solely aimed at using our efforts and resources in developing the necessary infrastructure for establishing a Medical School which will be in the service of the island. From a social-psychological perspective, I believe this will enhance the perception of people regarding the dimensions on the management of health issues of the islanders, and for us this would be a moral boost. Considering the significant intellectual and moral capacity of the participants, I simply think that we all want to declare that each and every soul on this planet has the right for survival and to be included amongst the fittest.

Thank you, thank you all.

Prof. Dr. Hüseyin GÖKÇEKUŞ
President of the Conference & Organizing Committee
Vice Rector of Near East University

Your Excellency, President of the Turkish Republic of Northern Cyprus,
Your Excellencies, Distinguished Scientists and Participants,
Ladies and Gentlemen, Members of the World Press

On behalf of the NEU, I would like to welcome you all to the "Environment: Survival and Sustainability" Conference organized by Near East University in LEFKOŞA.

Today, it has been understood that environmental problems with their cumulative characteristics are closely interrelated with many economic, social, cultural, political and administrative parameters, which are naturally interrelated with academic insight.

Near East University was established in 1988 and has since then grown to become one of the fastest developing universities in the region setting itself the strategic goal of joining the "top 500 universities in the world."

Near East University is a member of the European University Association, the International Association of Universities and the Federation of the Universities of the Islamic World.
The University has over 3,000 staff, of which 900 are academic personnel. 17,000 students from 44 different countries are attending 12 faculties and 50 departments at the university. There are 14 dormitories with a capacity of 4,000; and several new dormitories are under construction. Nearly 50% of the students receive scholarships. This figure includes full scholarships, partial support given to students who are in need of financial help, and to those students with sportive accomplishments.

The University has to date organized 12 international conferences and congresses and many local and regional conferences, seminars and panel discussions on a variety of subjects.

The Near East University is honored to host this world conference which has surpassed in scope and content the conferences it has organized before.

Around 2,000 participants from more than 100 countries in the world are present here to discuss environmental issues from a variety of perspectives.

Turning back to the cumulative characteristic of the environmental problems, it is clear that ecological deterioration is the most important problem resulting from regional conflicts, demographic outburst, consumption of natural resources, starvation, degradation of the environment, dwindling fresh water supplies, natural mega-disasters like typhoons, earthquakes, and landslides. Hunger and malnutrition are a direct result of a lack of access to/or exclusion from productive resources, such as land, the forests, the seas, water and technology. As such, this problem is gradually gaining weight in international and national environmental politics, because all these are threatening the common future of humanity. This has refocused the world's attention on the urgency of researches and practical steps on environmental issues. These issues require global solutions in accordance with their global characteristics.

In the EU programme called "*Environment 2000: Our Future, Our Choice"* 4 major topics have been selected as priority targets.
Climate Change
Biological Diversity
Environment and Health
Management of Natural Resources and Waste
Sustainable development is the solution that leads towards a strategy that will consider the environmental problems for future generations.

Most important guidelines for Sustainable Development are:
-Demographic control.
-Reforestation.
-Protection of agricultural areas.
-Energy saving.
-Development of renewable energy sources.
-Improvement in the implementation of existing legislation.
-Integrating environmental concerns into other policies.
-Working in cooperation with the business.
-Educating people to change their unfriendly behaviors towards the environment.
-Environmental accounting in land-use planning and management decisions.

Global Environmental strategy is a must.

ENVIRONMENT DOES NOT UNDERSTAND POLITICS.
IT HAS NO BOUNDARIES OR BORDERS.

The main message of our Conference will contribute to the worldwide debate and create a multi-disciplinary discussion forum where experts from various disciplines will be able to discuss environmental issues in 21 fields such as culture, biodiversity, health, education, business and economy, environmental technology, climate change and energy among others.

Dear Guests,
Environment: Survival and Sustainability Conference is going to give you all an opportunity to get to know Near East University. The Grand Library collection has reached to more than 500,000 while 52 million articles are accessible through electronic databases. The Grand Library is fully computerized and linked to many major world libraries and research institutions throughout the world. It is open 24 hours a day, serving not only the university but the whole community. In other words the Grand Library functions as a national library.

It is my pleasure to extend our gratitude to the members of the Scientific Committee and the International Advisory Board whose active role raised the scientific level of this conference and also increased the number of participants. Unfortunately, some of the Scientific Committee members withdrew due to non scientific letters they received.

In my opinion, as pointed above

**SCIENCE HAS NO BORDERS and NO BOUNDARIES.
IT IS OF THE HUMANS and FOR THE HUMANS.**

Coming to our SLOGAN:
RIO 1992
Johannesburg 2002
Nicosia 2007
We do not have much time to lose.

On behalf of the Organizing Committee, I would like to extend our special and sincere thanks to our Founding Rector Dr. Suat Günsel, whose basic aim is to provide generous support for the improvement of continental lifestyle capabilities of the island.

We extend our gratitude to Islamic Development Bank and to the Secretary General of Islamic Conference Organization, Prof. Ekmeleddin İhsanoğlu for their invaluable contributions.

I would like to convey our thanks to the government of Turkish Republic of Northern Cyprus for their support.

Our special thanks go to the Organizing Committee Members and the students who worked day and night for the success of this conference.

Last but not least, we would also like to extend our gratitude to H.E. Mr. Ban KI-MOON Secretary General of the United Nations, for his kind moral support.

I believe this conference will scientifically contribute to the solutions of environmental problems, and hope you will enjoy your stay in our beautiful country.

Thank you.

Rahmi KOÇ
Honorary Chairman & Founding Member of TURMEPA, TURKEY

Mr. President, Mr. Prime Minister, Your Excellencies, distinguished guests, Ladies and Gentlemen

I would like to express my gratitude to Mrs. Sıdıka Atalay for inviting us here for this very important international conference today. As founder of TURMEPA, The Turkish Marine Environmental Protection Association, I would like to share my views with you regarding our activities and accomplishments in Turkey. Why and how did I found TURMEPA? You can call it luck, you can call it coincidence. I was the Chairman of the Turkish-Greek Business Council for six years. During this period, every effort that I made to get the two countries' businessmen to cooperate failed. The Greeks never said no, but they never got their act together either. Again on one occasion in Athens, though I had great enthusiasm to continue to join forces for an interesting project, unfortunately I was very disappointed by their lack of response. At the end of the meeting just before we had lunch, the late shipping Tycoon, George Livanos, who was sitting at the very back of the conference room, called me and said, "Look here, I've been following you and your efforts for sometime and see that you are not getting anywhere and are becoming frustrated. If you really want the Greeks and Turks to cooperate in one area, that will be the environment." He also said, "I founded HELMEPA, Hellenic Marine Environmental Turkish Association, called TURMEPA and let them two cooperate to keep our seas clean. So in 1994, 24 friends believed in the cause and we founded TURMEPA, the first NGO specifically dedicated to keeping the seas clean. At that time, HELMEPA was already eleven years ahead of us and the World Bank had been gathering data on Turkish seas and marine life from HELMEPA. Soon, I found out that this was a long term project and would at least need one generation's commitment. During our efforts, we learned that there are four very important points. Point number one: It's more economical to keep our waters clean than to clean them after polluting them, this was very important. The second important point: the subject is a major undertaking and cannot be done by one association alone and requires a nationwide awareness of the problem. Our third finding was that it needed education; education is most important in achieving our goal. The last important point was international collaboration that is a must as the environment does not have borders, does not have barriers, religion, race or different languages and no politics are involved. With these four points in mind, we first trained teachers in primary schools in coastal areas and then distributed hundreds and thousands of books to these students and pupils. We also held a drawing competition with the subjects of clean seas, we made films for television and cinemas, we used newspaper advertising to get our messages across, and we worked with several universities to test water quality. In the 30 years, from 1960 to 1990 the number of species in the Marmara Sea, believe it or not, came down from 148 to only 14. Now they are coming back. We have started to see dolphins in the Bosphorus and this is good news because when dolphins come, other marine life generates itself. We set up a data room to collect and store information about marine life, our seas, inland waters and currents.

We learned to our surprise again that only 10% of sea pollution comes actually from shipping. The risk comes from domestic and industrial waste; therefore, we set up a system to monitor waste being dumped in our seas. Clean seas are of most importance to tourism which is a major source of revenue for our economy. Therefore to this end, we collaborated with sea side hotels, holiday villages, restaurants and cafes to ensure their compliments with environmental regulations. We then hoisted our TURMEPA flag on their premises. When they did so in the summer months, we put together a team of students to collect garbage from boats and yachts free of charge, we set up garbage containers in coastal areas where garbage can be deposited by banks, businesses, industries and then collected by municipal authorities. Our financing is usually organized on a project basis. With all this said and done, Ladies and Gentlemen, our efforts are still only a drop in the ocean if awareness is not felt by our citizens. Therefore, we are constantly telling the public at large that we have ignited a spark, which we must still help to spread throughout the country.

I am happy to say that the Turkish government and its Ministers, especially the Ministry of Transportation, our Governors, Mayors, academicians and businessmen have realized that clean seas are one of the most important issues we are facing. Clean seas mean life and oxygen. Polluted seas not only kill marine life but also tourism and give third world nation appearance.

I am delighted that I am joined today by our Chairman Eşref Cerrahoğlu, who is himself a ship owner and our Board Member Mr. İbrahim Yazıcı who is himself a sailor, and our General Secretary Levent Ballar who never stops coming up with a new project.

Before I finish, I would like to ask our Chairman, who made contacts yesterday, to give good news to our Cypriot friends.

Thank you for bearing with me.

Eşref CERRAHOĞLU
Chairman of Executive Board of TURMEPA, TURKEY

Mr. President, Mr. Prime Minister, Ladies and Gentlemen,

My Honorary Chairman addressed TURMEPA's activities. I am very pleased and honored to announce our work carried out in North Cyprus. Today, we will be opening a branch of TURMEPA in Girne, and more importantly, we will open a sea and shore observation center in Girne in partnership with the Municipality of Girne and the Near East University, and before the summer of 2009, our training and education program will start.

I would like to thank Mrs. Sıdıka Atalay for accepting the coordination of TURMEPA activities in North Cyprus, and I am confident that we will have all the backing of our President and our Prime Minister, and the people of Northern Cyprus.

Thank you.

Cemal BULUTOĞLULARI
Mayor, Turkish Municipality of Lefkoşa, TRNC

Honorable President, Prime Minister, Secretary General of the Islamic Conference and distinguished guests,

Welcome to Lefkoşa.

The habitat mentioned and diversity of living creatures are shrinking everywhere due to an increase in the fragmentation of landscape. The situation in Cyprus is heading towards a formidable shortcoming in terms of environmental resources. In Cyprus, we have already started to see the danger. There is a great need to improve the diversity and human health on the island. Despite the efforts put forward on these specific issues and existing threats, we still need to stress the fact that deeper collaboration is needed amongst the developing nations.

The conclusion that will be reached at the end of ESS 2007 conference will be a torch light for our municipality and we shall consider balanced use of sources in the future services and activities for Lefkoşa. I wish you all a fruitful conference during your stay in Lefkoşa and North Cyprus.

Thank you.

Asım VEHBI
Minister of Environment and Natural Resources, TRNC

His Excellency, the President of the Turkish Republic of Northern Cyprus,
His Excellency, the Secretary General of the Islamic Conference Organization,
Honored guests,

I would like to welcome you all to our conference on Environment, Survival and Sustainability here in the Near East University in the Turkish Republic of Northern Cyprus. Northern Cyprus is honored to host you with this international conference. I believe that the conference will be an important recognition of the issue of this week's environmental topics which concern not only Cyprus but also the whole world. This conference is bringing together almost 1,500 academicians from more than 100 different countries and there are 21 major topics that reflect all areas of environment such as business and environment, environment and health, global warming and a lot of others.

With the industrial revolution in the late 18th century, human beings started to change the global environment. Prior to industrialization the only unsustainable loses from human economic activities were forest cover topsoil. Most societies were relatively based on small and simple technologies using limited amounts of energy with limited territorial area, but the industrial revolution in Europe has changed this. After the revolution, large scale exploitation of fossil fuels enabled the human societies to consume natural resources, the potential of which seemed limitless. Most of our environmental problems today have a global dimension precisely because of the process of development initiated by the industrial revolution. After the 2nd World War, the world population increased rapidly. With this increase, the world started to use more fossil fuels, but these human activities effected the world adversely and we started to loose biodiversity in the environment. It is stated that every year we are losing at least 50 different species of live hood and every year a vast coverage of agricultural land has been lost due to unplanned development and soil erosion. The forests of the world are declining every year. Waste management of all kinds of waste is another problem including domestic waste and hazardous waste. Societies are producing more waste and waste amounts are increasing every year. The uncontrolled dumping of waste is still continuing specially in developing countries and polluting the soil, air and water resources.

Water shortage is another important problem. The amount of drinkable and usable water is decreasing while we are polluting these resources. Almost two weeks ago, IPCC released the draft project from its fourth assessment report where it puts forward that our climate is changing mainly because of inter human induced efforts. Global atmospheric concentrations of carbon-dioxide, methane and nitrous-oxide have increased as a result of human activities and now far exceed pre industrial values determined from many thousands of years. The global increases in carbon-dioxide concentration are due to primarily fossil use and land use change while those of methane and nitrous-oxide are primarily due to agriculture. The net result of these effects is a global average temperature rise of $6^{o}C$ in the last century. When we compare its greenhouse gas emissions within those other developed countries, Cyprus as an island may not have significant effects on the global warming but on the other hand, we may be one of the most effected countries from this problem. According to different United Nations scenarios, the temperature of the island may increase 2 to 4 degrees Celsius in the following century. It is also foreseen that we may have serious water problems and shortages in the near future due to increasing water demand and up to 40% decreases in the precipitation values according to the climate model predictions. Another effect of the climate change expected for Cyprus is an increasing loss of productive land leading to the desertification of the island. We have also been facing serious environmental issues like other developing countries such as problems in waste, waste water management, copper mining related problems such as the CMC and a lot of others. To solve these problems and harmonize with the European Union, the present government of the Turkish Republic of Northern Cyprus has agreed to form a separate ministry for environment: The Ministry of Environment and Natural Resources. The main mission of the ministry is to protect the environment in Northern Cyprus and ensure the sustainable use of its natural resources as well as to preserve its cultural heritage. The role of the ministry is to develop and implement the government's environmental policies in order to achieve its mission in environmental protection, sustainable use of natural resources and preservation of cultural heritage. In particular, our responsibilities include establishing coordination between different ministerial departments internally and with other ministries externally, mainly with Turkey, the European Union and others on issues of sustainability and environmental protection. We have also started to develop necessary policies and legislation. We are reviewing and endorsing different policies and legislation, submitting draft legislations to our Parliament for discussion and approval. We communicate with the media and the public on environmental issues. We provide support for environmental education in all levels of the education system. The environmental policy concerns of the Turkish Republic of Northern Cyprus should be based on economic prosperity and social coherence, taking into consideration the following three key elements.

The first one is sustainable development. Social and economical development will take place in a way that preserves our natural and cultural heritage and resources. The second one is to follow the European Union rules and standards on environmental protection. Our laws will be harmonized with the European Union environmental legislation and policies to protect and preserve our environment and the health and life of our people. The third element will be the establishment of the environmental governments' partnership model among the administration, all sectors of the economy and our people through processes which will both inform about environmental issues and standards and involve people in the associated decision making processes.

Before I finish my words, I would like to express the importance of sustainable development. All of the problems I have mentioned show us that we have to develop in an environmentally sustainable way. We have to protect the environment and preserve our natural and cultural heritage while we are developing.

I would like to thank all of the participants who came from other countries and also I would like to thank the Near East University for this wonderful organization and their great team for their outstanding efforts. I hope that this conference will shed light on most of our regional and global environmental problems.
Thank you.

Tahsin ERTUĞRULOĞLU
Leader of the National Unity Party(UBP), TRNC

Distinguished contributors, participants and honorable guests,

It is indeed an honor for all of us here in the Turkish Republic of Northern Cyprus to welcome you in a country that supposedly does not exist. Your presence here in the name of knowledge and academic freedom, and above all, in the name of service to humanity will hopefully give a valuable lesson to those who tried so desperately to prevent your participation and contributions to this conference.

Dear friends, you shall be subject to further propaganda and will be delivered misinformation about the circumstances here upon your return to your respective countries. The challenging spirit that you have, the spirit of not bothering about those that stand in the way of knowledge, friendship and partnership and service merit will guarantee the success of this most valuable conference.

In closing, I wish to thank the Near East University for working so hard and for so long in making today a reality.

I wish to thank you all for being with us here today. I wish the conference every success.

Thank you.

Assoc. Prof. Dr. Turgay AVCI
Deputy Prime Minister & Minister of Foreign Affairs of TRNC

Your Excellency, Mr President,

Your Excellency, Prime Minister,

Honorable Secretary General of the Organization of the Islamic Conference Prof. Dr. Ekmeleddin İhsanoğlu,

Your Excellencies, distinguished participants, Ladies and Gentlemen,

Today is the day. It is the day of pride and success, the day of international victory. It gives me great pleasure and honor to address a conference of which timing is very important, and welcome you all to the Turkish Republic of Northern Cyprus.

I also would like to thank the Near East University, particularly to its Founder Rector and Honorary President, Dr. Suat İ. Günsel, and the Rector, Prof. Dr. Hüseyin Gökçekuş, and many others who have patiently and continuously carried out efforts to bring this very important conference into life. A thousand papers from over 100 countries are going to be presented today. I, myself being an academician for 15 years before being a politician, know the importance of presenting a paper in such a conference. I know the excitement, the feeling, the success of presenting, asking questions and the feeling of success at the end of such a conference. I have participated in many conferences internationally. I have presented many papers in many countries. It is a great feeling; it is a great pleasure. I know your feelings and I know the success and pleasure that you will get at the end of the conference. Even under normal circumstances, conferences and organizing conferences would have been a drowning task, but in a country like this which is under an inhuman political, economical and cultural isolation and embargoes due to Greek Cypriot's political blackmail and pressure, it is much more difficult to organize such events. It is very much appreciated that you have stood up against these immoral efforts by putting science and survival of global environment first in the line rather than politics. The future of our world and of our children needs courageous scientists, thinkers and writers like you who are able to transit between politics and political pressures wherever they are fighting for the survival of humanity and the global environment. The bounties and rich resources of our planet have given their best to civilizations throughout the past, but we have reached a point in time and technology that our activities have exceeded the life saving abilities of the earth. The global challenges and the level of distraction we have caused are too great now.

The issue of globalization of environment and conservation is the most crucial and urgent issue that the whole of mankind face today. The survival and sustenance of our environment and biodiversity has importance for our future, and just opened our commitment to fight and fight hard for our world. Businessmen, scientists, intellectuals, artists, politicians, indeed the whole of humanity, must stand and strengthen our struggle in this issue. The results of this conference must provide us with the strategies of sustainable environmental management through the development of environment friendly technologies and legislation. We must also show the way for social survival to all global citizens, local governments and non-governmental organizations, and because of this, we have a very challenging but at the same time a noble task. In this context, we also strongly believe that institutions from primary schools to universities throughout the world should make in learning the most important attempts to teach about the environment and to train about the protection of environment. I am pleased to inform you that we have a coalition government in the Turkish Republic of Northern Cyprus and we have a Ministry called the Ministry of Environment and Natural Resources. My friend who spoke a few minutes ago is in charge of this ministry. With these thoughts in mind, I would once more like to take this opportunity to thank Near East University and its Honorary President Dr. Suat İ. Günsel for organizing and hosting the Environment, Survival and Sustainability Conference and wish you success in your deliberations.

I thank you for being here in the Turkish Republic of Northern Cyprus and I am sure you will enjoy your stay here and you will remember us and tell the rest of the world the Turkish Republic of Northern Cyprus is a place to be, a place to visit and a place to enjoy.

Thank you.

Türkekul KURTTEKIN
Turkish Ambassador to Lefkoşa, TRNC

Mr. President, Mr. General Secretary of the Organization of the Islamic Conference, Ministers, Members of the Parliament, Distinguished Party Members, Members of the Organizing Committee, Members of the Media,

Let me first comment on the Near East University for organizing this conference and express my pleasure that I have the opportunity to say a few words about the conference.

From my perspective, the conference is significant for a variety of reasons. Firstly, a very important topic will be addressed throughout the conference. It reminds me the 1972 United Nations Conference on the Human Environment held in Stockholm, the 1992 Earth Summit or the United Nations Conference on Environment and Development held in Rio, and the 2002 World Summit on Sustainable Development held in Johannesburg.

The world constituted combined efforts by the international Community to face a common challenge, that is, the protection and preservation of the environment while achieving developmental objectives in the rapidly changing world. In spite of these efforts, the challenge stays pretty much alive. We, the human beings, have disturbed the balances of nature and the environment. However, we have no luxury for skepticism. A few minutes ago, we heard about the cooperation between TURMEPA and HELMEPA from Mr. Rahmi Koç which proved to us that if there is a will this challenge will be gradually met. You, experts from various disciplines, from academy, various policy makers and executives responsible for the implementation in many countries will be discussing ways to overcome this challenge. Major topics of discussion in the conference show the multi dimensional character and the magnitude of that, and the outcome of your discussions and your deliberations will contribute to the efforts to increase world awareness on this important challenge, and I hope it provides useful material for the decision makers by strengthening the bridge between theory and science.

Secondly, the meaning of this conference in my opinion reflects the severity faced by the Turkish Republic of Northern Cyprus with its people and its institutions. Environment, the problems, economic and industrial development are interrelated issues. The importance of minimizing the environmental damage while achieving sustainable development is widely realized in the Turkish Republic of Northern Cyprus, which is a country going through a remarkable development in the recent year with a growth rate approaching 14% in 2005 and with an increase of 7% in 2006. The increasing public awareness in the Turkish Republic of Northern Cyprus about institutional measures such as the establishment of the Ministry of Environment and Natural Resources constitutes a good, encouraging example. Thirdly, this international conference, which we were told is the 12th of its type organized by Near East University, demonstrates the important role of universities in the Turkish Republic of Northern Cyprus. As many of you have mentioned, education was amongst the fields falling within the problems of the community in the 1960's. The progress achieved by the Turkish Cypriots in this field is commendable and demonstrates the unacceptability of the isolation the Turkish Cypriot people have been subjected to for many years. Even in such circumstances, the Turkish Cypriots have been demonstrating their will and determination to move ahead and to combine forces with the international community to face the common challenges to humanity.

Let me conclude by hoping that this conference will create more awareness around the world and in this respect, the recognition of the Turkish Cypriot People will no more remain unattended. Let me also wish all the distinguished participants of this conference every success and express my sincere hope that your deliberations will contribute to the combined efforts to give a better world to the next generations.

Thank you.

Ferdi Sabit SOYER
Prime Minister of TRNC

His Excellency, Mr. President,
His Excellency, General Secretary of the Organization of the Islamic Conference,
His Excellency, Minister and Members of Parliament and the very important scholars who have came to our country for this conference,

I would like to greet and welcome you all.

Today is the beginning of a meaningful conference where very important environmental issues will be discussed in this conference hall. As you can see, all the flags in this hall symbolize a different color and a different history of all the nations, and as we also know, the colors of nature are reflected by these flags in this beautiful atmosphere. If nature had been just one color, just yellow or just green, the richness and beauty of living would not be seen and people would not have even been able to fall in love. This colorful atmosphere reflects also the dynamism of human beings. Also, this dynamism provides the humans with the ability to find and change everything in nature which they need. It is because of this developing dynamism that human beings take what already exists in nature and turn it to their benefit. Although there are many differences among all nations we should still cooperate together to protect nature. I strongly believe that this conference will bring very important conclusions. I also believe that although the Turkish Republic of Northern Cyprus and Turkish Cypriot society have been isolated both politically and economically, this conference will have very important outcomes. We want to be recognized in the world with our nation, with our national identity. This conference also gives out this message to the world.

I would like to thank the Near East University, the valuable Rectors, and Scholars for participating in such a conference. I would also like to thank and welcome once again the valuable scientists for coming to our country.

Thank you.

Prof. Dr. Ekmeleddin İHSANOĞLU
OIC Secretary General

Your Excellency Mr. President, Mr. Prime Minister, distinguished scholars, Ladies and Gentlemen,

I sincerely greet you all. It gives me great pleasure to be with you here. It is a great pleasure to be at the opening ceremony of this important event: The International Conference on Environment, Survival and Sustainability organized by the Near East University. I am grateful to Near East University for their kind invitation which has enabled me to address such a distinguished gathering. I would also like to thank you all who have worked hard, took part in preparation and realization of this project.

Let me share with you my honest feelings. I am not a newcomer to this island and I have heard a lot about Near East University and I have also heard of its good reputation. Some of my friends' sons and daughters were here as students. I have heard all the facts and data about the universities. I am really impressed.

His Excellencies, Ladies and Gentlemen,
I am not an expert on environment issues but the convening of this important conference is very timely as the subject matter has become a very serious global matter. We read all the reports on a daily basis about the dangers of climate change. Climate change and environmental degradation affect the whole world. Meanwhile we hear the frequent comments of the world leaders about the lack understanding and cooperation on environmental issues which might lead us towards the destruction of our planet and humanity. Global pandemics, deforestation and natural disasters are only a few of the issues that presently affect the globe. All these problems are at the heart of sustainable development that we all need to achieve. We find ourselves helpless today when we see rich nations of the world continuing to load the atmosphere with carbon-dioxide; compromising the well being of human race and pushing our planet to an unknown future. It is obvious that these acts have contributed to a rapid change of climate which has caused global warming, rising sea levels, extreme droughts, erosion of soil, loss of the forests and extinction of the species. Sadly, most of the environment degradation is severely affecting the developing world. Its population is facing severe droughts and dry rivers, while some other areas are facing excess floods, rainfalls, mud slides and loss of properties. I am just back from a long trip to Indonesia and I have seen the negative side of the phenomena there. Ladies and Gentlemen, the catastrophes have also negatively affected ecological imbalance. Hence, they have been posing a serious threat to the genetic pool with ramped out breaks of disasters and leading to more poverty in the undeveloped parts of the world. Recognizing the important role played by the environment in the development and in the progress of its member states, the OIC ten year plan of action, a joined action development for the Muslim world to face the challenges of the 21st century, was developed by the 3rd Extraordinary Summit convened in Mecca in 2005 and attended by all heads of state from 57 OIC countries.

In this context, I would like to bring to your attention the fact that the heads of state present in this Summit in December 2005 made a very strong appeal to all OIC member states and their institutions on the issue and were able to coordinate their environmental policies and positions in the international environmental issues so as to prevent any adverse effects of such policies on their economical development.

Following the adoption of the OIC ten year plan of action, I have organized several meetings with the OIC institutions and stakeholders in the framework of the implementation of the OIC ten year plan of action. The OIC General Secretariat itself is committed to the world capacity and policies to contribute to the global efforts to counter the environmental challenges. The OIC also notes with pleasure that the majority of its many initiatives and activities reflect the facts of important organizations such as UNEP and our parties to various international conventions on environment in particular to the protocol. Joining such conventions reflect the fact that the OIC member states are giving their attention to the international laws and requirements. Such devotion shall certainly provide us with a solid basis for our future efforts suggested by the OIC ten year activity program.

I would like to praise the Near East University for providing the opportunity for the conference participants to address a wide range of crucial issues such as redefining the business of conservation and management of biodiversity, culture heritage and environmental factors, economics, development and sustainability, energy and development, environment and health, the threat of global warming, ecological balance and sustainable environment and social and psychological dimensions of the environmental issues.

Mr. President, Your excellencies, Ladies and Gentlemen,

I am of the view that the environment issue can be viewed from at least two major perspectives: The perspective of science and technology and the perspective of effects and impacts of environment on economic development. The important contributions and inputs from science and technology to ensure sustainable development cannot be denied. However, environmental challenges that we are talking about are mostly trans-boundary ones and cannot be faced with individual efforts of the nations. The very nature of these challenges require that these states should combine their efforts and facilities together. In this context, the OIC member states are called upon by the conclusions of various OIC gatherings and decisions to join hands to collaborate and to synergize their efforts in performing and undertaking research and development to reduce some of the environmental effects and challenges faced by them. Assessing the effects of environmental challenges on economical development also requires regional and global cooperation and coordination. In the domain of sustainable development perspective, one should address the quality and sustainability of our natural resources, the threat of global environmental changes on ecosystems, quality of life in our cities, impact of the use of energy which is essential to our economies and to the way of life. We should be making use of the technologies available with the view of reconciling economical development with environmental sustainability. The achievements of all mentioned goals require coordination, harmonization and synergizing of our entire actions. In other words, we need to follow up very closely all our activities to monitor their progress, to evaluate and assess the impacts and to take recognition of all possible shortcomings.

Naturally, addressing you today in one of the heavenly parts of the world, I cannot emphasize as much as I would like to the importance of environmental studies and undertakings aimed at the protection of the Mediterranean Sea and its ecological diversity.

Ladies and Gentlemen, as I value the timely initiative of organizing this conference on an issue of great relevance for my organization and for our member states considering the excellent academics and research qualities and standards of the Turkish Cypriot Universities, I would also like to mark an appeal from this platform to the universities and scientific institutions around the world particularly those based in the OIC.
Thank you.

Mehmet Ali TALAT
President of TRNC

Distinguished guests, dear participants,

As you may have expected, I will not make many remarks about environment or raise much concern about the environment. My remarks will be mainly political but in the concerns of the environment. Possibly you can claim that environmental concerns should cause an impact to unify humanity because the solutions to environmental problems can only be found by cooperation. So, this unifying factor must be a point of consideration, and we, the Turkish Cypriots know the importance of this fact. We know the importance of being unified with the international community because we are under severe isolation on all aspects of life including environmental issues. My Prime Minister mentioned about the lack of cooperation between the two sides. We are under continuous pressure from our neighbors. Everywhere in the world, we are in a struggle against this isolation issue and try to be unified with the world, and I wish that this conference will give fruitful results to the scientific life and to humanity.

Thank you for your participation and I wish you all success.

FINAL REPORT OF THE INTERNATIONAL CONFERENCE ON ENVIRONMENT: SURVIVAL AND SUSTAINABILITY

Environment is a subject that must be brought to the top of international agendas if the threats to sustainability and survival are to be countered. It cannot continue to be seen as something to be added on to the plans of commercial enterprises or as a minor component of poverty-alleviation programs. Economic development cannot eliminate poverty without conserving natural resources and maintaining ecosystem services. Nor can productive activity ignore the significant effects of resource extraction and waste generation. Environment must be the central focus of national and international programs at all levels.

The International Conference on Environment: Survival and Sustainability, held at the Near East University, Nicosia, Northern Cyprus 19-24 February 2007, dealt with environmental threats and proposed solutions at all scales. The 21 themes addressed by the conference fell into four broad categories:

1.Threats to Survival and Sustainability

Global warming and other climate changes pose a major threat to natural and human systems throughout the world. Major impacts addressed ranged from dieback of tropical forests to altered ecosystem functions in temperate and boreal systems, changes in sea level and in polar and alpine systems, as well as impact on water supply, agriculture and extreme weather events. Pesticides threaten natural ecosystems and human health. Health is also threatened by diseases, pollution and many forms of environmental degradation. Natural and human-made disasters interact to threaten societies in many ways.

2.Technological Advances towards Survival and Sustainability

Environmental science and technology are advancing rapidly, but are not in themselves sufficient to counter the growing threats to environment. Important areas include integrated water management, new and renewable energy sources, and conservation and management of biodiversity.

3.Activities and Tools for Social Change

Activities and tools that can be applied to move society towards greater sustainability were emphasized at the conference. These included environmental law and ethics, environmental knowledge and information systems, media, environmental awareness, education and lifelong learning, the use of literature for environmental awareness, the green factor in politics, international relations and environmental organizations.

4.Defining Goals for Sustainable Societies

The new directions that societies must take include considerations of economics, development and sustainability, redefinition of the interests of business, incorporating cultural heritage, the seas, ecological balance and sustainable environment, and the social and psychological dimensions of environmental issues.

The breadth of the issues addressed at the conference made clear the need for greatly increased interdisciplinary and international collaboration if survival and sustainability are to be achieved. The exchanges at the conference represent a step in this direction.

Cyprus is getting an equal share from these developments and 51 species are under a threat of extinction. Out of 10 regional mini-hotspots within the principal foci in the Mediterranean, and also considering that Cyprus is island number two with a rich plant diversity and narrow endemism, there is a need for protection of its biodiversity.

The matter of global sustainable development actually has a connotation for change of life styles. This calls for

- interactions and understanding of people the world over,
- fair and equitable distribution of benefits derived from resources,
- conservation of biodiversity and protection of our resources,
- the water use efficiency is very important as the availability of water is becoming scarce,
- we need more international collaboration and research for wider and reliable speculation,
- management of plans and their implementation to save the critical aspects of our heritage and environment,
- cooperation of scientific disciplines is necessary to address the situation,
- countries must work together and minimize the impact of borders on science and maximize the benefit for all mankind,
- in order to obtain global sustainability, the curses of over-consumerism should be overcome by an appeal to social and spiritual values,
- for making the world a happy home for everyone, transfer of knowledge has to take place across nations,
- environment and sustainability have to be treated globally, not just locally, before time runs out.

About 2,052 participants from 108 countries from all around the world joined us to make 1,413 presentations and discuss environmental issues from a variety of perspectives.

Global Environmental Strategy is a Must.
As I mentioned on the first day of the conference,
"ENVIRONMENT DOES NOT UNDERSTAND POLITICS".
"IT HAS NO BOUNDARIES OR BORDERS".

This Conference has contributed to the worldwide debate and tried to create a multi-disciplinary discussion forum where experts from various disciplines were able to discuss environmental issues in 21 different fields.

Thanks to the 2,052 participants from all over the world for making this interdisciplinary conference a success. Their active role raised the scientific level of this conference.

I believe this conference has scientifically contributed to the solutions of environmental problems, and hope you have enjoyed your stay in our beautiful country.

Thank you

Prof. Dr. Hüseyin Gökçekuş

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ANOTHER FALSE DAWN? TOWARDS A NON-LEGALLY BINDING INSTRUMENT ON FORESTS - CONTEMPORARY ISSUES AND POLITICAL UNCERTAINTIES

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In February 2006 the United Nations Forum on Forests (UNFF) agreed to negotiate a non-legally binding instrument (NLBI) on forests. This paper situates this decision within the context of various international negotiations for a global forests convention. This question was first considered at the United Nations Conference on Environment and Development in 1992 where the developed states argued that a forests convention would enhance the effectiveness of the Framework Convention on Climate Change and the Convention on Biological Diversity. This vision of a triumvirate of mutually reinforcing environmental regimes was shattered when tropical forest governments refused to agree to a forests convention. Since then the convention question has been revisited three times, at the Intergovernmental Panel on Forests (1997), the Intergovernmental Forum on Forests (2000), and the United Nations Forum on Forests (2005-6). The decision to negotiate a NLBI can be seen as a compromise between pro-and anti-convention states. The paper appraises the prospects for a NLBI and the political issues that will inform the negotiations.

Introduction

This paper first introduces the various arguments for and against a forests convention. It then briefly surveys the four rounds of UN negotiations that have considered the question of a forests convention since 1990, noting the positions taken by the main protagonists. The paper then surveys the likely political issues that will inform the negotiation of a non-legally binding instrument on forests and the role that such an instrument can play.[1]

[1] Much of the material that appears in this paper has been gathered from primary source documents and interviews at intergovernmental meetings on forests, namely one meeting of the Intergovernmental Forum on Forests (February 2000), three meetings of the United Nation Forum on Forests (May 2004, May 2005 and February 2006) and one ad hoc expert group meeting (September 2004). Parts of this paper draw from David Humphreys (1996) *Forest Politics: The Evolution of International Cooperation*, London: Earthscan; and David Humphreys (2006) *Logjam: Deforestation and the Crisis of Global Governance*, London: Earthscan.

Arguments for and against a forests convention

There are various arguments in favour of and against a forests convention. One argument in favour is that a forest convention would strengthen existing multilateral environmental agreements. As forests play a role in climate regulation, a forest convention would strengthen the objectives of the Framework Convention on Climate Change. Similarly, as most of the world's biodiversity is found in tropical forests, a forests convention would support the Convention on Biological Diversity. It would thus provide the third component of a triumvirate of mutually reinforcing environmental regimes. Second, with the international legal provisions on forests scattered among several international instruments, the result is fragmented and opaque coverage of forests in international law, resulting in an *ad hoc* international regulatory environment and political uncertainties. These problems would be eliminated, so it is claimed, if all forest-related provisions were rationalised under a single legal cover. Third, a convention would demonstrate high level political commitment to tackling deforestation and provide strategic and focused leadership.

However, there are some persuasive arguments against a convention. It can be argued that a convention would lead to political complications and "turf wars" with other legal instruments. It could be unclear, for example, whether the Convention on Biological Diversity or a forest convention would be the lead organisation for forest biodiversity. Far from providing a more rationalised and harmonised treatment of forests in international law a convention could, by adding another layer of international regulation, lead to further legal and political uncertainties.[2]

In addition to these generalised arguments there are arguments that individual government delegations may make based on their national interests. We can posit five propositions on why some governments may favour a forest convention, and five propositions on why they may be opposed. These propositions are grouped under forest management standards, finance and technology transfer, sovereignty, forest industry and intergenerational equity (Table 1).

[2] David Humphreys (2005) "The Elusive Quest for a Forests Convention", *Review of European Community and International Environmental Law (RECIEL)*, Vol.14, No.1, pp.1-10.

Table 1 Some arguments for and against a forest convention

	Arguments for	**Arguments against**
Forest management standards	Some states with high forest management standards may favour a convention as an instrument that will bring other countries' management standards up to their own.	Some states with weak forest management standards may oppose a convention that aims to raise standards, as such an instrument may impose additional costs on forest industries.
Finance and technology transfer	Some tropical states may favour a convention as it may provide a route for increased flows of finance and technology, including possibly opening an additional window on the Global Environment Facility.	Some developed states may oppose a convention because they do not wish to commit themselves to additional transfers of finance and technology.
Sovereignty	Some states may support a convention in order to gain some measure of control over the forest policies of other states.	Some tropical states may oppose a convention, which could infringe their sovereign rights to exploit their natural resources in line with national development policies.
Forest industry	Some states with a large forest industry sector may favour a convention as a mechanism that will promote the international trade in forest products.	Some states may oppose a convention as a form of international regulation that would impose additional costs on forest industry.
Intergenerational equity	Some states may favour a convention to promote long-term forests conservation for future generations	Some states may oppose a convention with a strong conservationist ethos since such an instrument may threaten key economic and political constituents

A brief history of forest convention negotiations

During the United Nations Conference on Environment and Development (UNCED) forest negotiations the developing countries, represented by the Group of Seventy-Seven caucus (G77), strongly opposed a convention. Malaysia, which led for the G77 during the forest negotiations, argued that developing countries have full sovereignty over their forest resources. Developed countries – the G7 and European Community – argued for a convention. The G77 argued that if the tropical forest governments were to be expected to conserve rather than develop their countries than the developed countries would have to pay for the opportunity cost foregone. With the negotiation lines firmly drawn between the developed North and the developing South states were unable to agree upon the need for a global forests convention. However they did agree a non-legally binding statement of Forest Principles, although these principles avoided hard commitments.

After three years during which there was no international dialogue on forests the Intergovernmental Panel on Forests (IPF) was created in 1995. The IPF agreed about 120 non-legally binding proposals for action for states and other actors to take into consideration when formulating forest policy. It reported to the Commission on Sustainable Development and was discontinued in 1997. The European Union continued to support a convention at the IPF.[3] IPF co-chair Manuel Rodríguez (Colombia) was lobbied to support a convention by European Union delegations, especially Germany and the Netherlands. Some EU delegates intimated to Rodríguez that new financial resources would be available if a convention was agreed, but that developing countries should not expect this without a convention.[4]

The United States, which had supported a convention during the UNCED negotiations, changed position at the IPF to oppose such an instrument. The influence of the corporate sector in the United States explains this change. Whereas the first term of the Clinton administration saw a policy shift in favour of environmental protection, with the administration signing the Convention on Biological Diversity, Clinton's second term witnessed business reassert its opposition to international environmental regulation. At the same time the US energy sector was failing to make progress on stabilising carbon dioxide emissions as called for under the Framework Convention on Climate Change. Overall US domestic politics had moved against making additional international environmental commitments.

The Canadian forest industry, unlike its US counterparts, supported a convention. The Canadian Pulp and Paper Association intervened at the Panel to say that an element of a convention could be "the promotion of worldwide trade in forest products."[5] It appeared that Canada, which has been the strongest forest convention proponent over the last 15 years, supported a convention for trade, rather than conservation, purposes. During the IPF negotiations the debate shifted within the G77, with many African countries now supporting a convention. Malaysia had been the strongest G77 voice against a convention at Rio. But at the IPF Malaysia advocated a convention.

3 EU document COM(96) 569 final, para.17, p.6; and EU document number 12713/96, para.8, p.6.
4 Manuel Rodríguez, interview, New York, 10 September 2004.
5 *Earth Negotiations Bulletin*, Vol.13, No.20, p.2.

As with the US, the shift in the Malaysian position can be explained by domestic politics. After the UNCED the lead government agency on forests was switched from the Ministry of Foreign Affairs to the Ministry of Primary Resources. This enabled the views of Malaysian industry, in particular the Malaysian Timber Council, which now supported a forest convention, to come to the fore. By the mid-1990s many Malaysian timber corporations had established logging operations outside southeast Asia, and it seems that the Malaysian forest industry was looking for a convention to establish rights for forest businesses. Malaysia's neighbour Indonesia also changed position to support a convention. Other developing countries that supported a convention included Costa Rica and Papua New Guinea. However, most Latin American countries, especially Brazil, Columbia and Peru, remained strongly opposed to a convention. From these positions the G77 synthesised the common line that it was too early to commence negotiations for a convention, although the desirability of a convention should be reassessed later.

With Brazil, the country with the world's largest expanse of tropical forests, and the US, the country with the world's largest timber industry, firmly opposed to a convention the idea was, inevitably, defeated. However after the IPF's final session the United Nations General Assembly 19th Special Session to review the implementation of Agenda 21 (UNGASS) agreed to establish an Intergovernmental Forum on Forests (IFF) for three years. The IFF was, to all intents and purposes, the same as the IPF, with a revised agenda. Like the IPF the IFF reported to the Commission on Sustainable Development, and like the IPF it agreed a number of proposals for action.

The fourth and final session of the IFF was dominated by negotiations on the future institutional arrangement on forests. The position of the European Union (EU) was dominated by internal coordination problems; some EU states no longer supported a convention, principally the UK and Sweden. The countries that pushed most strongly for a convention within the EU were Spain and Finland, with some support from Germany and the Netherlands.[6] The result was that the EU, led by Portugal which held the EU presidency, could offer no negotiating position on this issue. Despite spending much of the IFF's final session in caucus, the EU neither supported nor opposed a forest convention when the plenary reconvened on the final day of negotiations. Once again the G77 was divided between pro and anti convention states, and as at the IPF the G77 agreed the synthesised position that it was premature to launch negotiations for a convention, although the question should be reconsidered later.

Canada initially tried to entice the G77 countries to support a convention by appealing to their concerns on finance. Canada suggested that it was unlikely that new provisions for finance would be made outside a convention, whereas a convention could include a global forests fund. Other countries that supported a convention were Chile, Costa Rica, Guatemala, Malaysia, Panama, Poland, Russia and Switzerland. However Brazil and the US remained resolutely opposed to a convention, supported by Ghana, India, New Zealand and most South American countries.

[6] Interview with EU delegate, fourth session of the Intergovernmental Forum on Forests, New York, 9 February 2000.

Early on during this round of negotiations there was agreement to create a United Nations Forum on Forests that would have a higher profile in the UN system than the IPF and IFF. However Canada then hardened its position and argued that if there was no consensus for a convention, then Canada could not support the creation of a United Nations Forum on Forests. This act of brinkmanship led to an all night negotiating session on the final day. At 2.20 a.m. the chair suspended the plenary and asked delegates to sort out their differences in private session. There followed three and a half hours of informal discussions, principally between Brazil, Canada, the EU, the G77 and the US, in between which impromptu EU and G77 coordination meetings took place on the floor. Finally, at 5.55 a.m. agreement was reached after the exchange of several hand-written drafts. It was agreed to create the United Nations Forum on Forests (UNFF) for an initial five sessions. In fact Canada had little real option but to agree to the creation of the UNFF. What had appeared a high risk tactic that could push the negotiations towards collapse was merely a carefully controlled negotiating tactic. Had the UNFF not been created, global forest politics would have regressed to the wilderness years of 1992-95 when there was no international forests dialogue, clearly not a desirable situation for the Canadian government which has striven for the heightened level of international cooperation that would ensue from a forests convention.

The UNFF, which reports to the UN Economic and Social Council (ECOSOC), held its first session in 2001. Most of its second, third and fourth sessions were spent negotiating resolutions. Like the IPF and IFF proposals for action, the UNFF resolutions are non-legally binding. Indeed in many cases the contents of the UNFF resolutions are substantially weaker than the IPF/IFF proposals, and on some issues, such as traditional forest-related knowledge, negotiations broke down with no agreed resolution.

It was clear from the outset that the UNFF's fifth session (May 2005) would, like the final sessions of the IPF and IFF, be preoccupied with the question of whether a convention should be agreed. Two preparatory meetings were held on this question in advance of the fifth session (New York, September 2004; Guadalajara, January 2005). During these meetings the options crystallised into two main categories. The first was a legally-binding instrument, either a forests convention or a forests protocol to another convention.[7] The second category of options centred on strengthening the UNFF. Two proposals featured prominently in the UNFF negotiations. The first was for quantifiable and time-bound targets; for example, the rate of deforestation should be reduced by *x* per cent by, say, 2015.[8] The second was for the negotiation of a non-legally binding instrument.

By the time the UNFF's fifth session convened the proposal for a non-legally binding instrument had been informally developed, with various non-papers being circulated advocating a voluntary code for sustainable forest management, a *Codex Sylvus*. (A non-paper is a document that is circulated amongst delegates to float informal proposals and suggestions. Non-papers are not formal proposals and are non-attributable.) The name *Codex Sylvus* owes its inspiration to the *Codex Alimentarius*, a body of non-legally binding but widely implemented food standards administered by the Food and Agriculture Organisation (FAO) and World Health Organisation. The idea of a code illustrates that there is no simple distinction between soft law and hard law, and that the two can be seen as poles to a continuum.

[7] UN document E/CN.18/2005/2, para.55-65, pp.16-18; UN document E/CN.18/2005/11, pp.15-17.
[8] UN document E/CN.18/2005/2, p.11; UN document E/CN.18/2005/11, para.20, p.9.

A non-legally binding instrument could provide a bridge between pro-convention and anti-convention states. For the pro-convention states a non-legally binding instrument offers the possibility of a stronger regulatory framework than the IPF/IFF proposals and UNFF resolutions, but without foreclosing the possibility of a convention at a later date. For states opposed to a convention – including the most powerful opponents, Brazil and the US – a non-legally binding instrument has the advantage of strengthening the UNFF politically while avoiding legally binding commitments. Against this it can be argued that anti-convention states might oppose a non-legally binding instrument in case it were eventually to lead to legal codification. A precedent for this is the non-legally-binding International Undertaking on Plant Genetic Resources of 1983, which was later renegotiated as the International Treaty on Plant Genetic Resources of 2001.
The formal position of the forest industry, voiced by the International Council of Forest and Paper Associations, was that business neither supported nor opposed any particular international arrangement on forests.[9] However the idea of a code was endorsed by some North American forest industry leaders, which explains its support by the US and Canada. There was a feeling amongst business that with many industrial sectors adopting codes, the forest industry should move towards this now rather than risk being pushed towards it later.

At all forest negotiations prior to the UNFF's fifth session the G77 had managed to prevent a united front, despite containing within its membership pro-convention and anti-convention states. But G77 unity on this subject had always been paper-thin. At the second week of the UNFF's fifth session divisions between the developing countries proved so deep that the G77 fractured as a negotiating caucus. Developing countries subsequently negotiated individually. The main axis of conflict was between the Latin American countries, with the Central American countries, supported by Argentina and to a lesser degree by Chile and Mexico, arguing in favour of a convention, opposed by the Amazonian Pact countries, led by Brazil.[10] The two main timber-producing states of Southeast Asia were also divided, with Indonesia now inclining against a convention while Malaysia inclined in favour. Other developing countries that indicated support for a convention were Cuba, China, Cambodia and Iran. Outside the G77 a convention was supported by Canada, Switzerland, South Korea and the EU, which managed to avoid the divisions on this subject that had been so clearly apparent at the IFF.

The UNFF negotiations witnessed the return of a principle that has a chequered history in international forest politics, namely *common but differentiated responsibilities*. In 1992 this concept was written into the Framework Convention on Climate Change to signify that while all states share responsibilities for tackling global warming, those states that historically have emitted the most greenhouse gasses are the most responsible and should thus carry the burden of adjustment.[11] The concept was proposed by the G77 during the UNCED forest negotiations where it was opposed by developed states; it does not appear in the UNCED forest outputs. Three years later developed states agreed to its mention in the IPF proposals for action.[12]

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[9] UN document E/CN.18/2005/3/Add.1, "Discussion paper contributed by the business and industry major group", 24 February 2005, p.1.
[10] Interview with G77 delegate, fifth session of the UNFF, New York, 26 May 2005.
[11] Framework Convention on Climate Change, Article 3.1.
[12] UN document E/CN.17/1997/12, para.143.

Thereafter the concept waned; it does not feature in the IFF proposals or the resolutions agreed by the UNFF up to and including 2004. At the UNFF's fifth session it was proposed by Ecuador, India, Iran and Syria.[13] The practical application of common but differentiated responsibilities for forest policy is unclear. It is used by some developing countries to claim financial aid on the basis that developed countries bear most historical responsibility for deforestation through high demand for timber and other forest products. However this line of argument tends to negate the repeated assertions of developing countries that they have sovereignty over their forests. It also downplays the contributions that political and economic elites in developing countries have made to tropical deforestation.

A key area of disagreement during these negotiations was the issue of global targets.[14] Quantifiable and time-bound targets were favoured by Canada, Costa Rica, the EU, Mexico, Norway, South Korea and Switzerland, but opposed by Brazil, India, Indonesia, Iran, Peru and the US. Brazil and the US in particular negotiated hard on this issue. Late in the negotiations the EU and Canada dropped their insistence on quantifiable targets, asking for a *quid pro quo* commitment to strong time-bound commitments from other countries. When this concession was not reciprocated the negotiations collapsed.[15] A contributory factors to the failure of the UNFF's fifth session to reach agreement was that the developed countries had different visions of a code, with the US advocating a statement of general political commitments, while the EU and Canada favoured a more detailed code of practice.[16]

After the negotiations ended it was agreed to hold two further UNFF sessions. The draft text was forwarded to the sixth session of the UNFF that convened in February 2006. Negotiations were complicated by the continuing fragmentation of the G77, which had failed to agree a common forests strategy since its fracture during the fifth session. The main developing country caucuses were the Amazonian Pact, Central American countries, the African Group and the Association of South East Asian Nations (ASEAN). States eventually agreed to negotiate a non-legally binding instrument (NLBI) on forests. It was agreed that the negotiations for the NLBI should be initiated in April 2007. The NLBI should pursue four global objectives, also agreed at the UNFF's sixth session:

- Reverse the loss of forest cover worldwide through sustainable forest management, including protection, restoration, afforestation and reforestation, and increase efforts to prevent forest degradation
- Enhance forest-based economic, social and environmental benefits including by improving the livelihoods of forest dependent people
- Increase significantly the area of protected forests worldwide and other areas of sustainably managed forests, and increase the proportion of forest products from sustainably managed forests
- Reverse the decline in official development assistance for sustainable forest management and mobilize significantly increased new and additional financial resources from all sources for the implementation of sustainable forest management.

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13 Ecuador, Syria, India, Iran, verbal interventions, fifth session of the UNFF, New York, 24 May 2005.

14 Quantifiable and time bound targets were proposed in two non-papers: "Informal Non-paper, Potential Elements of a Codex Sylvus" (undated); "Informal Non-paper – Towards the Future International Arrangement (IAF) on Forests: A Way Forward", 26 April 2005.

15 *Earth Negotiations Bulletin*, Vol.13, No.133, p.14.

16 *Earth Negotiations Bulletin*, Vol.13, No.133, p.14.

However the time bound dimension to these objectives was evaded through compromise language, with states agreeing only "to make progress towards their achievement by 2015."[17] 2015 was also agreed as the year when states would review the effectiveness of the international arrangement on forests. In agreeing this the UNFF has, in effect, extended its life for an additional nine years, although it will now meet only every second year.

Argentina, the EU, Canada and the Central American states pressed successfully for inclusion in the text of language that a "legally-binding instrument" (in other words a forests convention) should be a future option.[18] However Canada also expressed disillusionment with the UNFF and said that it wished to consider options outside the UN. Canada then arranged an invitation-only event during the second week of the sixth session, inviting only states that have previously expressed interest in a convention. Countries that attended included Argentina, Canada, Chile, China, Costa Rica, Finland, Germany, Guatemala, Ghana, Japan, Kenya, Mexico, Netherlands, South Africa and Spain.[19] Only Argentina, Costa Rica and Mexico had publicly intimated that they might be interested in pursuing options outside the UN. At the time of writing (September 2006) Canada has yet to garner a sufficient "critical mass" of countries to negotiate a forests convention outside the UN. The agreement to negotiate a non-legally binding instrument is likely to marginalise the Canadian initiative for the time being.

It is likely that the UNFF will shift towards a two-tiered approach, meeting every two years with regional meetings concentrating on implementation being held every other year. Regional processes may be structured around either the ECOSOC regional commissions or the FAO regional forestry commissions. The view that regional processes are necessary can be seen as part of an historical cycle in which the political locus of global forest policy moves over time between the international and regional levels. In the mid-1980s the FAO created an international mechanism, the Tropical Forestry Action Plan (TFAP). By 1990 the TFAP was seen as overly-centralised and removed from the political realities on the ground. The solution was a restructured TFAP with responsibility devolved from FAO headquarters in Rome to the FAO regional offices. By the mid-1990s there was consensus that an international forest policy was necessary, hence the creation of the IPF. There is now a widespread recognition that the UNFF as a purely international process has proved ineffective and that a shift back to the regional level is needed.

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17 UN document E/2006/42-E/CN.18/2006/18.

18 UN document E/2006/42-E/CN.18/2006/18, para.27.

19 I have compiled this list from discussions at the sixth session of the UNFF with three delegates who attended this invitation only event.

Towards a non-legally binding instrument on forests?

The negotiations for a NLBI to promote the four global objectives will open at the UNFF in April 2007. From the proposals submitted by member states so far it is clear that certain issues will dominate the negotiations.[20] There is some indication in a proposal from South Africa on how the principle of *common but differentiated responsibilities* might be operationalised for forests. South Africa has proposed that

There is a need to spell out clearly defined obligations or commitments for all parties …obligations could creatively be divided between different categories of actors …and the obligation levels for the various categories can be differentiated within the categories.[21]

A framework of differentiated responsibilities could, in principle, allow for developed states to acknowledge an obligation to assist tropical countries through financial and technology transfers, in exchange for a commitment from tropical forest countries to acknowledge an obligation to conserve an agreed area of forests. Such a deal is, however, extremely unlikely for two reasons.

First, a number of influential tropical countries wish the principle of *sovereignty* to be a central feature of a NLBI on forests, including Brazil, Indonesia, Pakistan, South Africa and the US. The principle also appears in a joint proposal issued by the ASEAN countries. The sovereignty principle is often used by tropical forest countries to assert that no state should interfere in the natural resource use policies of other states. Its appearance at this early pre-negotiation stage in the NLBI process is a strong indication that any instrument agreed will not contain meaningful conservation commitments. Brazil has explicitly stated in its proposal that "Each country is responsible for the conservation of its forests and for the enforcement of its forest laws…"[22] Second, although developing countries will use the negotiations to reiterate their calls for developed countries to establish a Global Forests Fund for sustainable forest management,[23] previous calls have been resisted or ignored by major donors, principally Canada, the EU and the US. All the indications are that the NLBI will see no global bargain whereby states cooperate to protect the world's remaining forests.

[20] These proposals can be found in United Nations Forum on Forests Secretariat (2006) "Compilation of proposals submitted by member States and other groups for a Non-legally Binding Instrument on All Types of Forests", 31 July 2006. Available online at: http://www.un.org/esa/forests/adhoc-nlbi.html (accessed 30 August 2006).
[21] "Possible elements of a non-legally binding instruments (NLBI), South Africa, in *Ibid*.
[22] "Proposal by Brazil", p.3, in *Ibid*.
[23] The proposals for Brazil, Indonesia and South Africa call for this.

It is possible, however, that the negotiations might see movement towards an agreement to create an international clearing house for the transfer of environmentally sound technologies (EST). (ESTs include, for example, technologies that enable the felling of trees and their removal from forests without damaging surrounding stands.) Proposals for such a clearing house have been made by Brazil, ASEAN, the EU and the US. Previous forest negotiations have seen developing countries arguing that if the developed states want to see a stemming of deforestation rates in the tropics they must agree to the transfer of ESTs on “concessional and preferential terms”. The standard response of the EU and the US has been that technology transfer must take place through normal market mechanisms. It is possible that the NLBI negotiations could lead to a bargain whereby developing countries acknowledge the principle of technology transfer through the market, in exchange for which developed countries agree to create a fund made up of voluntary contributions so that technology can be transferred at prices that are discounted below market prices. (The EU and US will certainly not countenance a technology clearing house that requires mandatory contributions.)

It is clear that some countries will use the negotiations to press not for measures to conserve forests, but for increased access to forests for forest industries. The IPF and IFF proposals contain several references to the need to provide an enabling climate for investment. Historically two groups of countries have pressed for such language: developing countries with a shortage of investible funds that wish to attract foreign capital for the forests sector; and countries with a surplus of investible funds and/or a major forest business sector that wish to pry open new forest spaces for private sector investment. The US, in particular, has negotiated aggressively on this issue at previous negotiations; other delegations that have pressed for this include Canada and the EU. Forest businesses from Asian countries, in particular Indonesia and Malaysia, are increasingly active in other countries and are looking for new market opportunities. Of the proposals so far submitted for a NLBI four advocate clauses for an enabling environment for investment, or equivalent language; Australia (which uses the term “attract capital for the forest sector”), ASEAN, South Africa, and the US.

Following on from this point: two countries – Canada and Switzerland – have proposed that a NLBI should encourage forest industries to develop voluntary codes of conduct “going beyond national legislation”, while a third, the US, has proposed that the NLBI should “Encourage the private sector …to develop, promote and implement voluntary instruments with a view to adopting good business practices that support sustainable forest management.”[24] What this clearly suggests is that the governments of these three countries do not envisage that a NLBI will impose additional duties or obligations on forest businesses, which should be free to develop their own standards consistent with national law. These countries, all of which have significant forest industries, are looking for a NLBI that will promote the rights of business, rather than forest conservation and sustainable forest management. A NLBI would thus be consistent with the norms of the neoliberal global economy, which prioritises trade and investment over all other considerations. All the indications so far are that a NLBI will not impose additional obligations on states and forest businesses, although it will promote market-based policies, enhanced investment opportunities for forest businesses, and voluntary codes of conduct.

[24] See the proposals from Canada, Switzerland and the US in United Nations Forum on Forests Secretariat (2006)

Conclusion

If and when it is concluded a NLBI on forests will add to the body of soft law on forests that has emerged over the last fifteen years. This comprises the 1992 Forest Principles; Chapter 11 "Combating Deforestation" of Agenda 21; the IPF proposals for action of 1997; the IFF proposals for action of 2000; and the UNFF resolutions negotiated since 2002. Given that this body of soft law on forests already exists, what precisely will a NLBI achieve?

One view is that such an instrument will prove significant. The UNFF, it can be argued, is now confronting its own weaknesses with the result that a revitalised international arrangement on forests is being created. The proposed NLBI can build upon and strengthen the commitments made in existing soft law and will usher in a new era of international cooperation on forests built around the four global objectives and a vibrant regional structure. However the evidence assembled in this paper – namely the historical record of previous forest negotiations and the proposals for a NLBI that have so far been circulated - does not support such a view. Instead it appears that the UNFF, despite its high profile in the UN system, has reached the law of diminishing marginal returns, and there is little to be gained from trying to agree further political commitments. While the IPF and IFF agreed the proposals for action and catalysed work on national forest programmes, these sorts of benefits cannot be continually reaped. Most of the UNFF resolutions that have been agreed so far are weaker than the IPF/IFF proposals. The UNFF has completely failed as a guiding body that provides leadership to other forest-related institutions. There is nothing intrinsic to a NLBI on forests that will make it necessarily stronger than the soft law on forests that currently exists. From a conservation perspective an NLBI is likely at best to yield only incremental gains. If it merely reiterates existing commitments then it will prove an irrelevancy. And if it contains stronger commitments on the rights of business than it does on forest conservation it is likely to prove harmful to the long-term future of forests.

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GREEN POLITICS AND SOCIAL SUPPORT FOR ENVIRONMENTALISM IN TURKEY

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Today we know that keeping an eye on environmental values isn't just an ecological or a political matter. It's also an ethical attitude, way of thinking and responding the problems taking place in nature. At the right wing of the political block environmental values had never been major criteria of making politics since 1990's. The left wing was not totally innocent as well because before 1980's most of the socialist youth leaders regarding the importance of green politics by comparing it with the revolution theories they had indulged in.

In this paper the concept of green politics for Turkey will be discussed. The paper will begin with a short history of green politics in Turkey under the terms of the International Conventions Turkey has signed. The political steps taken at forming a frame for green politics and why green parties could not get enough support for their activities from the public is an another important issue that readers can find answers for. At the end the paper will glance through the leading parties programs for environmental issues, as well.

Introduction:

Today it is weel known the protection of the environmental values is not only an ecologic or economical issue, but it is aslo "a matter of ethics". According to this approach, every choice made about the future of humanity also brings forth giving up something else, and abandoning some activities in certain fields/sectors. As a matter of fact, the lack of reconciliation of differences, knotted between the representatives of the environmentalist movement and the industry lobby in the well-developed world, originates from the unwillingness of the capitalist technocrats in changing the current technology, which provides an easy profit, with the quite costly new ecological technology, rather than the *"anti-environmental"* attitude of the industry lobby. Jardins summarizes this dilemma in his work about the *"environmental ethics"* as follows:

"Baxter reminds us that most of our decisions have both a positive and a negative side. If I prefer to do something, this means that I have to give up another thing. Every possibility chosen, replaces some other lost possibilities. This is the meaning of the cost in classical economy. The cost of something is equal to the value abandoned for acquiring it. If we use the example that Baxter gives, if we choose to construct a dam, we can no longer use the sources which we used in the construction of the dam for making hospitals, fishing poles, schools or electricity." (JARDINS,2006: 125)

According to this view, we inevitably face the classical cost theories, for the possible steps taken towards the protection of the environment. Therefore, first of all the public's support for the carrying out of the programs is required if the construction of a dam will be abandoned, the turning over of a forested area to the private sector will be prevented or the building of factories which would pollute the environment will be objected, as it is the public whom will be effected by these new developments. Otherwise, the environmentalist movement would have to start their action plan without a public support, which they are in an absolute need of; and this is the main reason behind the perceiving of the environmentalists generally as *"Anti-progressive groups with eccentric views"* in the public opinion.

Classical cost solutions and environmental problems:

Moreover, the main approach developed by the classical economists, whom form the theoretical fundamentals of the capitalist way of thinking, and their follower schools concerning the natural resources, widens the gap between the two sides. The classical economists have developed an approach, which either excludes or at least does not give much importance to the environmental problems, as they evaluate the natural resources theoretically as values which have the potential of renewing themselves continuously and have an eternal and limitless accessibility. (DULUPÇU-OKÇU,2000: 1-3) The mentioned tendency has resulted with giving a secondary importance to the environmentalist tendencies both in the well-developed and developing countries. The problem could not be solved when the environmental values were included in the *"classical cost analysis"* either. The obvious profit of the environmental values is calculated at a very low ratio when compared to the high profit of technology and industry. (JARDINS: 143)

Therefore, at the point reached today, it is a must to advance beyond the classical economical policies and market values, in the struggle against the macro environmental problems. Economic policies can't solve the philosophical and ethical problems regarding the environmental problems. (SAGOFF,1990: 22-23) The general increase in the population which is rightfully remarked by the environmentalist movement, and the realization that the natural resources balance forms a threat for the future generations, proves that the issue must be examined from different point of views. According to statistical datum, the population of the world reached the critical level of 6 billions at 12 October 1999, while it was around 1 billion at 1804. Even though the population growth ratio of the world has relatively decreased, the 7^{th} billion citizen of the world will join us at 2015, while the 9^{th} billion citizen will join at 2050.

The facts that the USA whom has less than 5 percent of the world population uses up 30 percent of the yearly resource usage, and the most wealthy 1 billion people owns 80 percent of all resources, while about a rate of 20 percent is left to the majority of 5 billions, displays how ambitious and involved with social pressure the developing countries are on their way to advance to the upper level, as well as the imbalance of the technological development. The USA-China comparison made by Becker, whom was researching the pace of the developing countries in the industrialization race, can be summarized as follows:

"China produced 1.8 million automobiles in 2003. At this speed, if the automobile ownership in China catches up with the American values, China would have more automobiles then the rest of the whole world. If China uses up petroleum equal to the American values, they would need more than 80 million barrels of petroleum daily. Whereas, we know that the petroleum production in the whole world is 75 million barrels daily. ….Moreover, China has begun increasing her meat and fish consumption. If, China increases her meat consumption to the American values and fulfills this; they would need 343 million tons of meat every year. This quantity is a number equal to the whole meat production of the USA. If China consumes fish as much as Japan, this would mean 100 million tons of fish a year, which is a number equal to the fish production of the whole world." (BECKER,2004: 68-95)

The environmental right in EU and the international agreements:

EU whom has placed some environmentalist policies, which the superpower of the world USA has a negative approach against in order to sustain her current status, among the foundation stones of her envisioned future project, is one of the organizations where the environmentalist politics can voice their arguments at the highest level today. Moreover, Turkey, whom has engaged in heavy rearrangements in her laws and domestic policies for being able to join the union, is closely effected by the environmental policies of EU both in the scopes of political integration and commercial relations.

The different environmental policy in charge in the EU countries, and the development of different environmental criteria causes changes in the costs of some products which are at circulation in the union market. Likewise, the usage of the technologies harmonious with the ecological balance by the union members give a first-degree importance to the environmental factors raises the product costs, and interrupts the free circulation of the products and free competition conditions which EU gives outmost importance. The rise in the environmentalist sensitivity in the public opinions of the EU member countries, and the variation in the living conditions and quality in the states which are parts of the same economical system, because of the differences in the practiced environmental policies, had made it a must to make a standardization in the environmental mentality of the union in the political sense. (www.ikv.org.tr: 3)

The United Nations Conference on the Human Environment, carried out at Stockholm in 1972, made EU take action and the Environmental Action plan was confirmed by the Council and member country representatives at 22 November 1973. The Action Plan was continued with, 2. in 1977, 3. in 1983, 4. in 1987 and 5. Action Plans in 1993 and the last Action Plan which covered a 10 year process was declared in 2002. The inclusion of the clauses about giving authority to the union institutions for taking initiatives regarding the environmental problems to the founding agreements could take place with The Single European Act which came into force in 1987. EU has planned reaching a global-comprehensive program for the protection of the natural resources especially in the 3. and 4. Actions Plans, and the dominant topic of the plan was slid towards the prevention of pollution, rather than the controlling of it. The Environmental Effects Assessment practice was agreed to be prepared in 1985, and the environmental policy was strengthened in the union texts with the Maastricht Agreement, which came into force at 1993.

The principle of the protection of the environment was clearly included in the Union goals with the mentioned agreement, and sustainable development and the sharing of responsibilities in the protection of the natural balance policies were concentrated on at the 5.th Action Plan which was prepared in the same year. In the last action plan which was declared at January 2001, in the program titled as *"Environment 2010: Our Future, Our Choice"*; the subjects of climate change, nature and biological variation, environment and health, and natural resources and wastes were listed as the major goals. (ikv.org.tr: 4-6)

Sevim, whom evaluates the Environmental Policy of EU, lists the basic principles of the program as; comprehensiveness, protection at a high level principle, caution, prevention, prevention at the source principles and the *"who pollutes pays"* principles says the following especially about the third, fourth and sixth principles: *"The 'who pollutes pays' principle is the foundation stone of the Union's environment policy as it is stated so in the First Environment Action Plan. Making the people who pollute, pay for the costs of the struggle against the pollution which they had caused, encourages them for lessening the pollution and finding less polluting products and technologies."* (SEVİM,2000: 38)

Although, the mentioned environmental action programs are not binding for the union institutions on the legal basis, but; the effect of the plans especially for the expansion policies is also known. (KABOĞLU,1996: 141-143) Therefore, Turkey has to take the action plans into consideration and follow the environmental policies which are expected to form a legal foundation for the mid-long term actions carefully; as Turkey has undertook arranging her domestic policy also in the field of environment to be harmonious with the EU acquits communitarian.

The steps taken towards the protection of the environment is undoubtedly not limited with only EU. In this context, the report published by the Roman Club, titled as *"The Limits of Growth"*, which was the first report which included a remark on the mutual dependency relation of the economical and natural environment, and the principles of *"human centrism"* and *"the protection of the resources of the future generations"* which were mentioned in the *"eco-development policy"*, proposed in the following UN conference, should not be forgotten. However, sustainable development could achieve the status of being the valid policy in the international field only after the 1992 Rio Summit, and this date alone displays the power of the technocratic capitalist industrialization lobby. (UNEP,1981: 43) The common Environmental Pact which was legally binding could not be signed, in the huge summit held in Rio de Janeiro with the attendance of 117 states and over 30 thousand attendants. A total of five important documents were signed and presented for confirmation in the meeting. The pact about the *"Protection of the Animal and Plant Species"* which was signed by 153 countries including Turkey, was rejected by the USA as it would put the biotechnology industry in danger. It was remarkable that the same pact was criticized by both the well-developed North because of the reason that it would block their access to the resources, and by the developing south because of the concern that it would limit their rights of sovereignty. The Climate Change Convention, which was concerning the warming of atmosphere and climate, was also met with objections by some developing countries including Turkey, even though it was signed by 153 countries. (GÜLER-DURAL,2005: 4-7)

The situation in Turkey:

Turkey, which is a developing country, has also conditioned itself for protecting the natural resources and maintaining environment-sustainable development relation by both the international agreements that she signed, and as being a country which had taken the environment issue in her Constitution at a date earlier than many countries. (SOMERSAN, 1992: 29-30) Turkey began taking steps towards the determination of the environment policies at 1973-1977 with the Third Five Year Development Plan. The Prime Ministry Environment Counsellorship was established at 1978. The institution first evolved into The General Principality of Environment at 1984 and it was again transformed to Environment Counsellorship at 1989. The "*state's environment institution*", whose authorities were altered almost at every government period at the cost of creating many authority confusions, was organized as a ministry in 1991, and finally in 1993, it was made a joint-ministry during the reconstruction of the public units program, and was united with the Ministry of Forests. It seems like, the state first founded the Ministry of Environment, which comprises organizations like the High Environmental Committee, Special Environmental Protection Institution, Provincial Environment Principality and Local Environment Institutions, and then started to undergo a confusion like *"What will we do with this institution now?"* (TORUNOĞLU, www.sendika.org, 2005)

The Constitution accepted in 1982 had clauses which indirectly contain ecological sensitivity, as well as the 56. clause which directly mentions the environmental right and protect the natural riches. However, specialists point out that clauses which protect the natural resources in the TC Constitutions can also be seen, in the texts of 1930s and even 1920s, as well as the 1961 Constitution. (EKİNCİ,1991: 40-42) (KABOĞLU: 42) According to the 56. clause of the current Constitution, which examines the environmental right under the titles of *"Health services and the protection of the environment"*, it is stated that: *"Everyone has the right of living in a healthy and balanced environment. Developing the environment, protecting the health of the environment and preventing the pollution of the environment are the duties of the state and citizens."* (ANAYASA, 1997: 67-68)

On the other hand, it is seen that Turkey, whom took a progressive step by adding a special clause for the protection of the environment to its Constitution, does not show the same resolution at the point of carrying out the law and her obligations stated in the international agreements. Because while the 2872 Numbered Environment Law was being discussed in 1983, the law was based on the thesis which was condemned at Stockholm. The *"first development and then the environment if there is time for that"* mentality was added to the law with an extra sentence added to the objective clause. In other words, the environment was transformed into a side element of development. (EKİNCİ: 48) The law was thus stating that the protection of the environment activities should not be done in a way which would obstruct development or make it harder to achieve. The environmental right was overshadowed with the industrialization right, especially by the technocrat personnel, whom started working in the right wing governments' periods and were supporting the *"fast industrialization at all costs"* policy.

According to the authorities of the state, the greatest problem behind the pollution of the environment is *"The unconsciousness of the people"* and *"ignorance"*. The authorities generally try to educate the people with the films which are prepared by TRT, and they do not go any further than advising the citizens to *"Brush their teeth, and keep their surroundings clean"*. However, in fact, the accumulation that pollutes the environment and damages the ecologic balance quite a lot, originates from the public sector and the industrial establishments which carry on their production without taking sufficient protective measures, together with the multi-star tourism facilities which turn the coastline into a pile of concrete, rather than the citizens. For instance, it is known that most cement factories and iron-steel facilities either carry on their production without a protective filter, or stop operating their filters a short time after their opening dates; and thus the mentioned facilities harm their surroundings with a rate which cannot be easily overcome in medium and long terms. Furthermore, the state does not only pollute the environment with its own factories, but also almost steps forward for the role of being the *"locomotive"* element of unconsciousness by giving incentives to the insensitive industrialists and giving the permission of plundering the coasts, which it should spare for the public benefit, to the tourism investors.

Meanwhile, it becomes the general tendency of the state and especially the fast development supporter right wing governments, to ignore the warnings directed at them which especially come from the environmentalist movement. For instance, one of the Ministers of Energy in the ANAP period, Fahrettin Kurt, could say *"They should go to the forests then"* about the people whom objected Aliağa Thermic Power Plant with the reason of their love for the trees, or Mükerrem Taşçıoğlu, whom was a Minister of Tourism and Culture from the same party, could say *"Environment is a luxury for Turkey. These deeds are the same as putting a necktie on a beggar in our country."* Moreover, the astonishing attitude developed by the governments in Turkey against the environmental problem is not limited to these. Likewise, it is known that, Turgut Özal, the leader of ANAP, which is the most serious representative of the technocrat lobby in favor of industrialization *"at all costs"*, in Turkey, had responded the objections about the ruining of the ancient city of Phaselis at Sarıgerme, which is bound to Muğla, as *"We cannot prefer Byzantine, Roman works against touristy facilities"*. (EKİNCİ: 52)

The attitude of DYP, which formed a coalition with SHP after the 12 September coup, was not any different than ANAP's. Demirel, the leader of DYP at that period, made a comparison between industrialization and environment before the 1991 elections; defined the primary problem of the country as development, mentioned the high cost of development, and noted that the environmental "expenses" should be regarded as a part of this cost. In the mentioned period, DYP Environment Commission President Baki Durmaz, spoke at the Environment Council which was held at the Ankara Hilton Hotel, stated that Turkey would become a country with a high income through their party's government, and underlined that Turkey could not be as environmentalist as the well-developed countries in the near future. (SOMERSAN: 52-53)

However, the state, which does not show the proper interest and pursuance regarding the environmental problems in the domestic politics, acts more carefully when the international agreements and obligations are the case. While the Environment and Forests, Health, and Domestic Affairs Ministries which are operating in the domestic politics frequently withhold the measurement results which they have from each other, especially the coordination formed by the Ministry of Foreign Affairs with the Ministry of Environment and Forestry is remarkable. The Ministry of Foreign Affairs, which executed a serious tracking operation about the prevention of the poisonous wastes which were trying to be carried to Turkey from abroad and carried the reaction of Ankara to the international platform without wasting time, displays that Turkey is the guardian of the promises it had given to its allies. As it can be recalled, Turkey has undertaken some binding obligations by signing the Mediterranean Action Plan with the 1976 Barcelona Agreement and the Black Sea Region Environmental Action Plan with the 1993 Bucharest Agreement alongside with the European general environment policies. (CHP, www.chp.org.tr) (EKİNCİ, 1997: 54-67)

The new Environment Law:

Meanwhile, even though being quite late, some steps are being taken in the domestic law for the protection of the environmental riches. For instance the 2872 Numbered Environment Law has been almost totally altered with the 26.4.2006 day and 5492 Numbered law. It was frequently stated that the old law, which was re-examined and altered in favor of the *"industrialization right"* for countless times between 1983-1993, did not have a serious sanction force because of the *"neighborhood rights"* and the *"penal sanctions which were kept at a low rates".* The new law, which came into force after being published in the 26167-numbered Official Gazette on 13.5.2006, had been sent to TBMM by Tansu Çiller in 1995, but it could only be made a law by the Erdoğan government after 11 years. Even this situation alone, clearly displays how *"urgently"* the decisions can be made regarding the protection of the environmental values.

However, the environmentalist institutions, whom learned that the proposal would be discussed in TBMM after 11 years and wondered the changes, could only read the proposal with its 11 year old form from the website of TBMM, as the state did not gave any information. In the mentioned change, which was done in an anti-democratic atmosphere, and by almost hiding the information from the citizens, this time, the state clearly violated the principle of the free circulation of information while it was trying to take a positive step. (ÖZKAN,2006, www.rightsagenda.org) Özkan, whom approached the subject from a legal point of view, emphasizes that the concepts of *"sustainable development"* and *"sustainable environment"* were used side by side in the new law, in 2 clauses both concepts were explained in detail, and thus the harmony with the UN environment and development criteria were established. Özkan remarks the 3.rd clause, notes that the right of protecting the environment was given to everyone and especially the civil society institutions and profession associations, and states that the *"environment right"* concept, which had been present only in theory and was even obstructed until today, has been given a strong legal basis by the advice in the law for the ministries and local administrations to carry out associated activities with the related institutions.

The coordination with the international decrees which were signed until today has been established with the decrees which state the basic values of protecting the environment in the 9.clause. However, the government did not avoid placing some clauses in the law as a whole, from which it can be sensed that they prefer the industrialization and development goals over the environmental values. In the whole of the law, it can be clearly sensed that the AKP government's approach towards the natural riches was affected by a desire for *"unearned income"*. (ÖZKAN, www.rightsagenda.org) The mineral searching activities were decided to be left out of ÇED's scope with a sentence which was added to the Mining Law in 2004. The lawsuit sued by the main opposition party for the annulment of the clauses like this, which can not be seen in the other European Council countries and are *"gifts"* to the Turkish laws, has not been decided yet, even tough it has been 2 years now.

The most remarkable features of the law are, the hardened conditions of the *"who pollutes pays"* principle and the considerable increase in the monetary penalties given against crimes committed against the environment. Moreover, alongside with the increase in the monetary penalties which take place in the 20.th clause, it is interesting that the decrees about the occurrence of the crime are hidden in Turkish Criminal Law and the other laws. Thus, with the new law, suits can be brought against those who deliberately pollute the environment and make noises to the extent of harming someone's health, as both administrative money suits and penal suits because of the violation of the 181-182 and 183. clauses of TCL.. However, lawyer Güney Dinç complains that the *"deliberately polluting"* action could not be placed in an easily definable frame, and says that: *"The incongruities against the technical rules, which are determined by administrative procedures as statutes, regulations and circulars, are not enough for the occurrence of a crime. If the 'technical ways' which should be applied during the disposal of the waste or wastes into the nature are not determined by the law, an incongruity against the law cannot be talked about, and thus the crime of 'deliberately polluting the environment' can not occur."* (DİNÇ, www.rightsagenda.org, 2005)

In addition to all of these, the postponing of the application against the new crimes defined by the law for 2 years right at the start of it, by an alteration proposal given by the governing party's deputies; caused an irreconcilable conflict for the law doctrine, by both protecting those who pollute the environment from the clutch of the law even if for a short period, and creating serious doubts concerning the political authority's sincerity. (DİNÇ, www.rightsagenda.org)

On the other hand, when the environmental programs of the political parties are examined, we can tell that the general approach is dualistic. An important part of the Turkish right wing, and especially the center-right parties, perceive the environment as a side value of development, and adopt an approach that exalts development; while it can be sensed that some radical leftist movements, whom do not hide their competing tendencies against capitalism, are no better than the right wing parties in the field of environmental sensitivity. For instance, AKP's program, which mentions that Turkey will not be made a cemetery for harmful wastes, and it is underlined that the development models which pollute the environment will not be adopted. The program also emphasizes that the environmental problems will be solved by *"locally administrating"* and it is mentioned that the planned *"Environment Administration System"* will be a program mostly based on the local administrations. (AKP, www.akparti.org.tr)

On the contrary to the positive statements in its program, the report card of the government party does not seem to be very bright. Because in the single party government period, the people whom occupied sit areas were pardoned and owning lands in the villages and coasts were eased, by the changes made in a total of 21 laws. The government, whom wanted to transform the alder and chestnut tree groves, which were deemed as forests before, into unearned income areas by removing their forest status, was blocked by the lawsuit sued by the President of the Republic Sezer at the Constitution Court. Likewise, even though the government's related arrangement, prepared according to the proposal known as 2-B by the public, which was planning to open the forest areas to the occupiers, was returned to TBMM twice by Sezer, it is known that the government is working on another proposal on this issue. (ÇEKÜL, www.cekulvakfi.org.tr, 2004) The government, mentioning that Turkey should be prepared for being introduced to nuclear energy in almost every opportunity, also harms the trust of the environmentalist institutions with this attitude.

"Environment"al filling material for the party programs:

The main opposition party CHP is one of the parties which have given the environment issue a detailed part in their programs. In the CHP program, where it is remarked that the environmental right is counted among the third degree solidarity rights in the international agreements, it is noted that the party perceives living in a clean, healthy and green environment as a basic right of the individuals. The program plans carrying out the growth and industrialization efforts in harmony with the environment, rather than the *"at all costs"* mentality, while it also reminds the state to follow the international documents that it had signed. The CHP program gives an assurance for preparing a National Action Plan against the erosion danger which threatens the soil cover of Turkey, and declares that effective measures will be taken in order to protect the animal and plant species and the country will sign the *"Universal Declaration of Animal Rights"*. (CHP, www.chp.org.tr)

The CHP administration, whom had also prepared an environment report consisting of six chapters, points out that sustainable development is a target which closely concerns the Countries on the Way of Development, and claims that the well-developed countries have a double standard attitude especially in the field of technology transfer, where they are selling the technological equipment and facilities which are hostile to the environment and they are trying to get rid of to the developing countries. The idea that Turkey cannot be transformed into a garbage dump of harmful technologies is underlined in the report, while the following are also stated: *"In fact, it is impossible to provide freedom, democracy, equality and prosperity for neither of today's and tomorrow's people in an atmosphere where the environment is rashly destructed. The public benefit and social solidarity concepts, which are the core of social democracy, make it necessary to use the environment by also considering the prosperity of the future generations."* (CHP, www.chp.org.tr)

In the report, which makes an attribution to the *"Think universally, act locally"* mentality, which is generally used by the environmentalist organization, it is stated that the environmental problems can be solved in the axis of localization, based on the basing model, by giving the initiative to the local administrations and gaining the active support of the people for the environmentalist practices. The report mentions that the Reference Laboratory of the Ministry of Environment will be adjusted to the international standards, laboratories and tracking centers will be founded in the provinces for being able to make healthy measurements, and underlines that the human resources and equipment problems that the state needs in the field of environment will be solved. (CHP, www.chp.org.tr)

Another example of the mass parties with an ideological spine which have given a detailed place for the environment topic is MHP. The MHP program, which views the issue from the frame of sustainable development, claims that the *"sensitive balance"* between industrialization and the protection of the environmental values will be established, and it underlines that a developed Turkey, of whose environmental sources are protected, will be inherited to the future generations. The program claims that the media will be encouraged in the subject of environmental sensitivity, and the people will be made conscious about and educated in the environment subject starting from the very early ages. It is told that the technologies which are friendly to the environment will be encouraged to be used in all investments. The MHP program emphasizes that the state does not keep track of and guard the rules that it had set. It is especially noted in the report that an *"Environment Guard Organization"* and *"Special Environment Courts"* will be founded in order to establish efficiency; and thus MHP has exceeded the general environment policies of other right wing parties by one step. (MHP, www.mhp.org.tr)

DSP's updated program which is published in the internet, emphasizes that the *"Geographical Information System"*, which is a part of the e-Turkey project, will be used for the tracking and protection of the country's natural riches. The program says the following: *"The protection of our water sources and their usage in the most productive way, and recycling the waste waters for using them again are among the indispensable opinions of DSP. ... The environment policy of DSP aims to protect and spread all of our natural riches, without obstructing the development of tourism and industrialization."* (DSP, www.dsp.org.tr)

The right wing parties speak the same language:

As it can be recalled, Mesut Yılmaz, whom had carried out the General Presidency of ANAP, which gives the impression of being one of the parties *"with the worst record"* in the protection of the environmental values, for a period as well as being its Prime Minister, had been the spokesman about his party's general views in the field of environment by making the statement of *"Quit talking about environment or whatever else like that"* about the Çanakkale Çan Thermic Power Plant and the Fırtına (Storm) Valley projects, which were among the energy investments of the year 1999. The environmental sensitivities, which can only find place with a single sentence in the ANAP program today, just like the past, are clearly regarded as a secondary, or even a third degree element of the fast development and industrialization at all costs program which is cherished by the party. The environmental sensitivities are mentioned under the topic of *"Natural resources"* in the DYP program, which is the other strong party of the center-right, while it is told that the mining sector will be developed and thus a new field for intensive employment will be created. Other than DYP, which evaluates the natural resources as potential *"virgin areas"* which can be used in the efforts of development, Genç Parti, which had drew the attentions on itself by succeeding in rising its votes to around 6 percent in a period, also does not hide that it will be a fervent follower of the traditional right wing policies developed about the environment problem. It is emphasized that naval transportation will replace the expensive land transportation in the Genç Parti program, which is remarkable as a text, in which the greatest support is shown towards nuclear energy on the basis of program.(GP, www.gp.org.tr,)

SHP, which is one of the social-democratic parties, begins their words by emphasizing that their party has a *"high sensitivity"* in the issue of environment. The program mentions that it is a must for the state and civilian society institutions to carry out projects in cooperation for being able to protect the ecological balance. The program briefly states the following: *"SHP does not approach the environmental problems from just a technical point of view, but also evaluates this problem in a much larger scale, as a problem of civilization; SHP thinks that our planet is owned not only by the humans, but all living beings. SHP undertakes the responsibility of fighting against any activity that threatens the human life, harms the nature and ruins the ecologic structure; and protecting, not only our country's, but the whole world's physical, biological, sociological and cultural values with the same sense of responsibility. SHP shows the same sensitivity, that it has about the erosion that our lands are suffering and the pollution of our seas, to the destruction of the rain forests too."* (SHP, www.shp.org.tr)

It is known that the other parties which give an extensive place for the environmental sensitivities in their programs are generally small parties. Likewise, BBP from these parties, start their words by stating that the environment problem is a global issue and thus its solution should be examined in a global basis. The BBP program, which emphasizes that the state itself is the main actor in polluting the environment in Turkey, can be distinguished from the other parties regarding its frankness. The program underlines that an unlimited growth cannot be possible in a limited environment, and it remarks that first of all, the consumption culture, which spreads from the well-developed countries towards the developing ones, should be questioned and it is important to give an end to the current consumption culture, which does not have any other function than wasting the natural resources further. (BBP, www.bbp.org.tr)

The Green Movement in Turkey: The Green Manifest

When studied under the light of all this information, in fact; it is seen that there are many present conditions in Turkey for the presence of a relatively strong Greens Party in the political sense. However, this only carries importance as a first impression, as it is impossible for the current time to talk about the presence of a Green movement in Turkey which can be heard with a loud voice. The Green Movement made its first attempt for becoming a party in the year of 1988, but it was closed by the Constitution Court in 1994, as even though they had survived for 6 years, they could not meet the minimum general organization and activity limits which were stated at the Constitution. In this process, the Greens Party attracted the attentions, especially with their opposition against sexual discrimination, but it could not be more than a radical thinking club, which could only carry out partial activities in the big cities like İstanbul, Ankara and İzmir.

The Greens Party could only participate in the 1994 elections by forming an alliance with the socialist parties, and mostly preferred the method of showing candidates from the lists of the socialist parties. Even though they found the opportunity of participating in the local elections in İstanbul, Ankara, İzmir and Bursa, they could not show any success other than the relatively high votes received from two important districts of İstanbul. The Green candidates participated in the 1999 General and Local Elections together with ÖDP, and they chose the method of supporting the politicians whom were known for their sensitivity about the environment, but had been successful by competing for other parties, and carried out their activities in the provinces and districts where these people had been elected, and thus created an area of presence for themselves, probably because of not being able to show any success on their own. For instance, in the past, the candidates whom had won the elections had been the people whom had received the active support of the Greens both before and after the elections. (YEŞİLLER, www.yeşiller.org, 2004)

In the manifest of the Greens Movement, which carries on its efforts for founding a party, which was released on 5 November 1999, it is pointed out that the huge technologies created by the industrialist movements, had reached to a scale of threatening the future of the humankind as well as the other species; and the recognition of *"The right of deciding their own fate"* for those affected by the ecological and economical crisis is proposed. The Green Manifest advises for stopping the expenses made in the fields of armament, nuclear energy and genetic engineering, while it demands the encouragement of energy conservation, recyclable energy and mass transit systems. Briefly, the proposals the manifest includes are as follows:

"A minimum of 20 percent of Turkey's budget should be appropriated for the protection of the environment and nature. The necessary activities will be done for the prevention of the entering of the nuclear power plants and nuclear waste areas, which are abandoned by the well-developed countries, to our country. The energy budget of Turkey should be appropriated for energy conservation and alternative energy sources such as wind, solar, water, geothermal, and wave energies. … The highway investments should be abandoned, and railways should be preferred." (YEŞİLLER, www.yeşiller.org)

On the other hand, the Turkish Green Movement, which is being observed to sometimes engage in a *"leftist argument race"* with the radical left parties in their political texts, cannot exceed the yearly activity capacity of a simple thinking club, in spite of their efforts for forming a party, which they carry out very slowly. For instance, the facts that, the Greens were able to make only 11 public declarations during the dates of January-October 2004, and they have formed a Greens Initiative in Ankara, İzmir and Kadıköy and started closed-session meeting activities alongside with their regular Wednesday-Saturday meetings in İstanbul, displays that the activity area of this movement is at least *"unproductive"*.

Conclusion:

Constituting the Green Movement and gaining a permanent social support in a developing country presents a problem on its own. The Turkish public, whom has a tendency of evaluating even EU, prefer a murderer of the nature type of factory or facility, which they hope that will provide a job for themselves in short and medium terms, over the mission of claiming a suitable environment, which is the symbol of a high quality life. Moreover, the masses whom have gathered at the shacks which constitute more than half of the big cities like İstanbul, Ankara and İzmir, and whom have pessimistic views about their future, do not give a priority to the protection of the natural life, probably because of the reason that they have built their shacks at the cost of a serious harm for the environment.

When the *"absolutely development and at all costs"* ideology, which is carried out by the right wing governments that rise to the power one after another in the country, is added to all of these factors, a permanent base support for the Green Movement in the country can not exceed the potential of *"being a dream"* at least for the near future. However, the higher interest shown by the university youth towards the concept of environment when compared to the past generations, and even though its scale is only local, the social opposition that rose from the resistance centers such as Bergama, Gökova and Aliağa against the rash development, also displays that the efforts of the Green Movement and the people whom advocate the environmental consciousness are not completely useless.

It seems like, if the representatives of the environmentalist movement abandon their slogans which are perceived as radical by the majority of the public and scares the large masses, and soften their arguments which influences all Green movements in the developing countries and *"Scares the masses, and repeatedly voices disaster scenarios regarding the future"*, this could make a quite positive contribution to the social support which would be given to the Greens at the first stage. Again, if the environmentalist leaders give up giving the impression of being an industrialization enemy, and abandon their attitudes of completely excluding development, this would create the elements that would benefit the national environmentalists more than anyone else.

Perhaps the greatest duty that falls to the local environmentalists is, leading the public, whom have difficulties in insisting on their rights when they encounter a difficulty either against the state or in the general sense, directing the individuals and masses for insisting on their rights about the environment right, supporting the civilian society institutions which are the reconcilers between the state and the public and carrying out an extensive and conscious *"exposing"* campaign against the sections that violate the environmental health. Moreover, even if it is being done for the necessity of adjusting to the EU acquis communautaire, the state, whom is in the process of carrying out reforms in many fields and especially the field of environment, currently needs a serious, strong and sensible Green movement which would show the right path to itself and give ideas with its suggestions, more than it had ever needed before.

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THE GREENS IN TURKISH POLITICS TRANSFORMATION FROM AN NGO TO A POLITICAL PARTY

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The Greens of Turkey (Yeşiller) consider themselves as a political movement and group that works for the creation of an ecological, just, and pluralistic society. Green political movement in Turkey has a history of nearly two decades. Public actions against the thermal power plant in Gökova was one of the first examples of unorganized environmental movements. As a result of increasing public awareness about environmental issues, the Green Party was established in 1988. It was a short-lived experience because the Party was closed in 1994 by the Constitutional Court. However, this did not stop Turkish Greens to organize various actions and campaigns under different structures. Anti-nuclear campaigns, resistance against gold mining with cyanide in Bergama, actions against the thermal power plant in Yatağan, anti-war and armament demonstrations are some examples of such activities in the past decade. In April 2002, political platform for Green Party Initiative is decided on multidimensional and detailed program embracing all fields of society. The basic principles are direct democracy, anti-violence, struggle against the patriarchy, recognition of cultural, religious, ethnic, sexual, and philosophical differences and diversity.

1. The Green Parties

Green political parties have been formed as a response to the experience of social movements of early 1970s and the lobbying practices of environmental NGOs **(Doyle and McEachern, 2001:112)**. Development of these parties took place in the early 1980s when environmental issues associated with the peace movements and in particular the placement of cruise missiles on European soil **(Radcliffe, 2000:149)**. Even though these parties were based on similar principles, in each country, environmental movements have used different strategies to deal with electoral politics. Therefore, they have achieved different levels of electoral success. For instance, the most successful green party was formed in West Germany in 1980 and won seats in the Bundestag in 1983 **(Doyle and McEachern, 2001:112, 120)**.

However, the formation of green parties was controversial and led to splits and conflicts within most national environmental movements. Many activists contended that movements could not operate as formal political parties, and that the establishment of green parties would be counter-productive. In countries like Sweden, Denmark, and the Netherlands the formation of green parties was opposed by many of the leading activists from the antinuclear movement, many of whom continued to work within the traditional parties and movement organizations **(Jamison, 2002:92)**. There are also internal factional disputes between those members who wish to remain ideologically independent and pure, and those who are willing to engage in coalitions and pragmatic compromises **(Connely and Smith, 1999:71)**.

Eventually, when these parties have taken part in parliamentary systems, they experienced major changes in their politics for the worse, by comparison with the grassroots-oriented, revolutionary outlook of the earlier movements. Especially the Green parties in Germany, France, Italy, and Britain have adapted themselves to conventional power politics and the nation-state, abandoning movement ties, accountability structures, and programmatic principles in policy-making process **(Biehl, http://www.social-ecology.org/article.php?story=20031028141607676, 09.03.2006)**.

2. The Greens of Turkey - Yeşiller

Yeşiller (The Greens of Turkey) is a political movement and group that works for the creation of an ecological, just, and pluralistic society. Yeşiller believes that industrial consumerism is the cause of natural and social destruction. Poverty, inequality, discrimination and violence are affecting every strata of society. The ecosystems are being threatened for the sake of profit. Therefore, Yeşiller is defending green politics against this system that increase poverty, ecological destruction and inequalities. They advocate global struggle against capitalism and neoliberalism and support resistance against autharitarian and domineering structures. These aims can be achieved through decentralized organizational structure based on local groups and networks along with social and collectivist perspectives that improve individual autonomy. Direct democracy, anti-violence, struggle against the patriarchy, recognizing the differences and diversity in the society are among the basic principles the green politics based on **(http://www.yesiller.org/index_eng.htm, 09.10.2006)**.

The greens in Turkey had been getting together around many groups, associations, publications, citizen initiatives, including the Green Party between 1988 and 1994. The group decided to strengthen their political activities in the beginning of 2002 and set the target of establishing a new Green Party. Since 2002, crucial organizational and political steps have been taken, including the works on the basic principles and the political program, and other practical works such as publishing a journal, web site, e-mail network, and press releases. The political organizational structure is being formed, with the main national body, namely Coordination, the basic functional and representative bodies, such as Coordination Committee, working groups, and local groups. At present, there are four local groups in Ankara, İstanbul, İzmir, and Kadıköy, three local group initiatives in Bursa, Alanya, and Bodrum. Coordination Committee consists of the coordinators from the working groups (program, organization, international relations, press-publication, energy, climate change), the local groups and general coordinator. **(http://www.yesiller.org/index_eng.htm, 09.10.2006)**.

2.1. Basic Principles of Yeşiller

Ten basic principles of Yeşiller are discussed and adopted in April 2002. These principles are recognized as the baseline for creating green policies and organizations. Yeşiller also considers Global Green Charter and the Guiding Principles of the European Greens as the major international documents for its political works.

1- Harmony with nature and ecological wisdom.
2- Ecological, just and pluralistic society against the industrialist consumer society.
3- Global struggle against capitalism and neoliberalism.
4- Resistance to patriarchy.
5- Antimilitarism and peace against militarism and war.
6- Direct democracy.
7- Decentralized organizational structure based on local groups and networks.
8- Social justice and improved individual liberation and autonomy.
9- Resistance against authoritarian and domineering structures.
10- Recognizing cultural, religious, ethnic, sexual, and philosophical differences and diverse societies **(http://www.yesiller.org/index_eng.htm, 09.10.2006)**.

2.2. Organizational Structure of Yeşiller

The network of Yeşiller is a non-central and horizontal communication structure formed by the local groups, initiatives and individuals who come together to make politics based on green principles. The smallest basic unit of the organization is the individual. *The Coordination Group* (briefly Coordination) is the nation-wide organizational structure which consists of active members, the Coordination Committee and the working groups. The Coordination is responsible for working on the political strategies of Yeşiller, setting the agenda, creating the working groups, approving new local groups and initiatives. *The Coordination Committee* is a sub-committee elected by the Coordination in order to manage and harmonize the policies. The general coordinator is responsible for the functioning of the Coordination, short and long term planning, work and organization principles, coordination of the cooperation fund, planning, directing and monitoring secretarial work. In the election of coordination committee and for all other duties and posts, electing the equal number of women and men is the main principle. *The Press Bureau* is a working unit set up by the Coordination to organize the internal and the external communication, to make publications, to carry out contact with press and to prepare printed and audio-visual documents. *Working groups* are units set up by the Coordination or the local groups to carry out the practical works of the managerial and/or political themes. Yeşiller uses the ‘sunflower’ as their sign which is a symbol of the green movement in most of the world and which also has a special meaning in Turkey’s culture and geography **(http://www.yesiller.org/index_eng.htm, 09.10.2006)**.

The national and international works as well as local issues are discussed in the Coordination meetings. Along with the Coordination members, supporters, people who want to know more about Yeşiller and some other invited people may attend these meetings. The practical activities of Yeşiller are carried out by the working groups. Active members and supporters come together in working groups, plan and implement activities about their field of action. Specific working groups set up to coordinate activities according to the division and delegation of tasks are listed below:

1. *Program and Campaign Working Group*: This group develops the political program and organizes the campaigns on different issues. Methods like petitions, establishing or taking part in other platforms are also used.
2. *Organisation Working Group*: The form of organization and the implementation of the work principles is developed and monitored by this group.
3. *International Relations Working Group*: Following international green policies and meetings, developing international relations are tasks of this group. Yeşiller supports alternative global movements such as Social Forum. They also send representatives or delegates to the meetings of European Federation of Green Parties (EFGP), Mediterannean Greens Network, Balkan Greens Network, Greens/EFA Group of European Parliament, Black Sea Greens Network, and Global Greens. For instance, Yeşiller is an observer member of European Federation of Green Parties which is an organization that includes 33 Green parties in 30 European countries, facilitates communication between member parties, green parliamentarians and ministers, coordinates green European policy, supports small green parties in order to strengthen the green political movement in Europe as a whole.
4. *Social Activities Working Group*: This group is responsible for setting up information and campaign stands in meetings or conventions, organizing social activities like dinners, trips, concerts, festivals, and participation and coordination of group members in such organizations **(http://www.yesiller.org/index_eng.htm, 09.10.2006)**.

The preferred mode of communication among Yeşiller is face to face communication, forums, meetings and talks. Communication, decision making process and information about activities are transparent to all members. It is a basic principle that decisions are taken via compromise after open discussions. In order to inform the public on the activities of Yeşiller, publications like bulletins, newspapers, magazines, books, e-bulletins, website or e-mails are used **(http://www.yesiller.org/index_eng.htm, 09.10.2006)**.

2.3. Transformation to Green Party

In 1999 greens, environmentalists, conservationists and ecologists set the basic principles of green movement in Turkey, adopted the Green Manifesto announcing their existence both locally and worldwide. According to this manifesto, "our planet is under the threat of mankind's interference in the natural balance. The giant technology created and used by industrial systems in the fields of transport and communication, mass production and consumption, industrialized agriculture and military are putting the future of human race, of all the other species and of the planet as a whole at risk."

Yeşiller's guiding principles and policies about international, national and local issues were also declared in this manifesto. Some of the important points recommended regarding Turkey's environmental policies are summarized here:

- Armament and nuclear energy projects must be stopped along with any expenditure on these sectors.
- Energy saving policies, renewable energy sources, clean and healthy public transportation should be encouraged.
- All biological species and their habitats must be protected. The size and number of cultural, archeological, natural and urban sites should be increased. At least 20% of Turkey's budget must be spent for the protection of the natural environment.
- Sacrificing agricultural land to housing and industrial policies must be prevented. Excessive use of agrichemicals and other causes of soil pollution must be stopped.
- Active contribution of scientists, NGOs and chambers for any planning concerning the country, a region or a town must be provided. There must be an environmental impact assessment for each plan, program and project and final decisions must be taken by an autonomous committee **(http://www.yesiller.org/index_eng.htm, 09.10.2006)**.

In April 2002 Bodrum meeting, political platform for Green Party is decided to be a multidimensional and detailed program embracing all fields of society. Works on political platform will be made under four titles:
1- Macropolitics: World, Turkey, foreign politics, human rights, women liberation, Kurdish question;
2- Economy politics: Economic system, industry, agriculture, energy, mining, tourism, trade, technology, transport, communication;
3- Ecology politics: Global ecological destruction, natural life, protection of historical environment, rural and urban places, energy production, industries, mass tourism, transport, industrial agriculture, mining;
4- Social politics: Science and education, health, labour and social security, justice, residences, life styles, social support, art, sport **(http://www.yesiller.org/index_eng.htm, 09.10.2006)**.

It is also proposed that anti-war activities, human rights, Balkans, European Union, energy policies, agriculture policies, global warming, struggle against polluting industries, animal rights, green Mesopotamia, protection of historical environment, tourism, transport, clean water, mining, genetics will be the priority topics of the political program and of the further activities of Green Party **(http://www.yesiller.org/index_eng.htm, 09.10.2006)**.

CONCLUSION

Even though Yeşiller is a well-organized group with globally accepted ecological and political principles and democratic structure, it is rather a small and ineffective initiative in terms of political decision-making process. There have been many activities and demostrations concerning environmental problems such as thermal power plant constructions or protection of endangered species in Turkey, yet the movement could not be regarded as grassroots that can reach most of social strata. One of the reasons is that Turkish politics is dominated by mainstream parties for whom the economics has always had priority over environmental concerns. Unfortunately, environmental activities are mostly considered as hobby or free-time engagements of a minority group rather than real political issues. Hopefully, the hard work of local and national green initiative will create social consciousness, leading Yeşiller to be more effective and powerful in politics.

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USING THE SLEUTH URBAN GROWTH MODEL TO SIMULATE THE IMPACTS OF FUTURE POLICY SCENARIOS ON URBAN LAND USE IN THE HOUSTON-GALVESTON-BRAZORIA CMSA

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We used the SLEUTH urban growth model, closely coupled with a land transition model, to simulate future urban growth in the Houston metropolitan area, one of the fastest growing metropolises in the United States during the past three decades. The model was calibrated with historical data extracted from a time series of satellite images. Three specific scenarios are designed to simulate the spatial pattern of urban growth under different environmental conditions. Then first scenario depicts an unmanaged growth with no restriction on environmental areas, such as forest, agriculture, and wetland. The second scenario assumes a managed growth with moderate protection. The last scenario simulates a managed growth with maximum protection on forest, agricultural areas, and wetland. The third scenario demonstrates the most conserved natural land with the least urban development. This scenario should be the most desirable for the future urban growth of Houston.

Keywords: *Land Use / Land Cover (LULC) change, Urban Growth, SLEUTH Model, Houston CMSA, Prediction.*

1. Introduction

In industrialized countries, the current pattern of urban development is increasingly taking the form of low-density, decentralized residential and commercial development. This form of development, the environmental and quality-of-life impacts of which are becoming central to debates over land use and land cover in urban and suburban areas is now commonly known as “sprawl.” Many classic symptoms are loss and fragmentation of the natural resource, declining water quality, and traffic congestion (Burchell et al, 1998). “Smart growth,” a land use policy orientation embodied by a suite of policies aimed at natural resource and agricultural preservation, transit-oriented development, and “brownfield” redevelopment, is becoming a reality for some areas within the Houston CMSA.

Land cover is an important element of ecological function (Wickham et al, 2002). While urbanization has occurred, natural resource lands, such as forest, wetlands and agriculture, have been replaced by land uses with more impervious surfaces. Predicting future environmental consequences requires being able to predict the spatial pattern of land use change.

In recent years, spatially explicit simulation models of urban growth patterns have emerged. The economic versions of these models estimate land use transition probabilities using discrete choice methods based on the behavior of agents making land use decisions (Bockstael, 1996). The spatially explicit model of Landis (1995) for the San Francisco Bay and Sacramento areas is an example of a micro-level model that makes use of data from a geographic information system (GIS) to generate spatially disaggregated predictions of land use change. These modeling efforts require detailed parcel-level and GIS data that are often not widely available. This limits the ability to expand the models to a broader region or transfer them to other areas together.

A relatively simple class of models, cellular automata (CA), has gained attention from researchers attempting to simulate and predict spatial patterns of urban development. CA models require that space should be represented as a grid of cells that can change state as the model iterates. These changes are regulated by rules that specify a set of neighborhood conditions to be met before a change in state can occur (O'Sullivan, 2001). CA models are not only conceptually elegant but also they have the potential to simulate the complex behavior of systems, such as cities (Torrens et al, 2001). CA models have been used to simulate different types of urban forms (Yeh & Li, 2001) and development densities (Yeh & Li, 2002), and to investigate the evolution of urban spatial structure over time (White & Engelen, 2000). Although pure CA models have been quite successful at recreating patterns of urban development, they have been criticized for their seeming inability to account for processes driving urban change. Recently, advances have been made in developing hybrid CA that can incorporate process-based factors.

Webster & Wu (2001), for example, incorporate microeconomic urban theory into a spatially explicit CA to investigate the effects of alternative planning regimes on land use patterns. As planning tools, CA urban models have several benefits: they are interactive, potential outcomes can be visualized and quantified, they can be closely linked with CIS, and raster based spatial data derived from remote sensing platforms are easily incorporated into the CA modeling environment (Couclelis, 1997).

The amount of urbanized land in the USA increased by 47% to 307,500 km^2, while the population grew by 17% between 1982 and 1997 (Fulton et al., 2001). The conversion of land for development was estimated to have increased from about 5,000 km^2 per year between 1982 and 1992 to 13,000 km^2 per year between 1992 and 1997 (NRCS, 1999). In general, urban sprawl in the south has been aggravated by a decline in population density in urban centers (Fulton et al., 2001).

Population growth has been especially rapid in the states along the USA-Mexico border (USCB, 1993). In Texas, population is projected to increase from 19 to 33 million by 2030, with over 70% of the growth expected to occur along the central and southern portions of the I-35 highway corridor and in the Lower Rio Grande Valley (Conner & James, 1996). Houston was the fastest growing city in the United States in the 20th century. Houston has also become one of the fastest growing metropolitan areas in the USA, experiencing a 20% increase in population from 1990 to 2000, reaching approximately 2 million in 2000 and now being the fourth largest city in the country (Demographia, 2000). This growth can be attributed to a steady growth in employment in the Houston area, and less expensive housing among 20 metropolitan areas with populations of more than 2 million (ACCRA, 2000), and low cost of living (ACCRA, 2001).

This population growth is increasingly impacting rural areas, especially those close to major urban centers in the southern part of Texas, by accelerating land subdivision and reducing the average size of land parcels (Conner & James, 1996). In addition, increase in urban sprawl generally leads to greater traffic volumes, increased pressure on local resources, less open space (Holtzclaw, 1999), and such land use changes often have a significant negative impact on the affected ecosystems and the goods and services that they provide. Ecosystem services represent the benefits that living organisms derive from ecosystem functions that maintain the earth's life support system, and include nutrient cycling, carbon sequestration, air and water filtration, and flood amelioration, to name a few (Costanza et al., 1997).

Changes in land use may significantly affect ecosystem processes and services. Monitoring and processing the impacts of such land use changes are difficult for several reasons. Impact of land use changes on ecosystems often become noticeable at the regional scale however monitoring changes is difficult because of the large volume of data and interpretation required. In addition, accurately quantifying the impacts of urban sprawl on changes in ecosystem services is difficult because of the lack of information about the contribution of alternate landscapes to these services.

The objectives of this study were: (1) to quantify land use change in Houston CMSA from 1992 to 2002; and (2) to predict land use change in study area from 2002 to 2030.

2. Materials and Methods

Houston, the seat of Harris County, Texas, is located on the upper Gulf coastal plain at 80 km from the Gulf of Mexico. The Houston-Galveston-Brazoria Consolidated Metropolitan Statistical Area (Houston CMSA) consists of three Primary Metropolitan Statistical Areas (PMSAs): Houston (Chambers, Fort Bend, Harris, Liberty, Montgomery, and Waller Counties), Galveston-Texas City (Galveston County), and Brazoria (Brazoria County) (see Fig. 1). The Houston CMSA's population of 4.8 million is 10th largest among U.S. metropolitan statistical areas. The population is concentrated mainly around the city of Houston. The city of Houston has a population of 1.9 million and is the fourth most populous city in the nation (trailing only New York, Los Angeles, and Chicago), and the largest in the southern U.S. and Texas. Houston is the only metropolitan U.S. city that functions without a zoning plan (Vojnovic, 2003). Houston CMSA encompasses an area of 22,735.80 km^2.

The City of Houston lies in three counties: Harris (1,511.13 km^2), Fort Bend (20.92 km^2), and Montgomery (6.73 km^2). Harris County contains part or all of 35 individual incorporated areas. Under Texas' Municipal Annexation Act of 1963, cities have certain powers over surrounding unincorporated areas, termed the Extraterritorial Jurisdiction (ETJ). The ETJ is a function of population, for cities over 100,000, it can cover all unincorporated area within 8 kilometers of any point on the city limits. Houston's ETJ encompasses 3,397.93 km^2, excluding the area of cities lying within it.

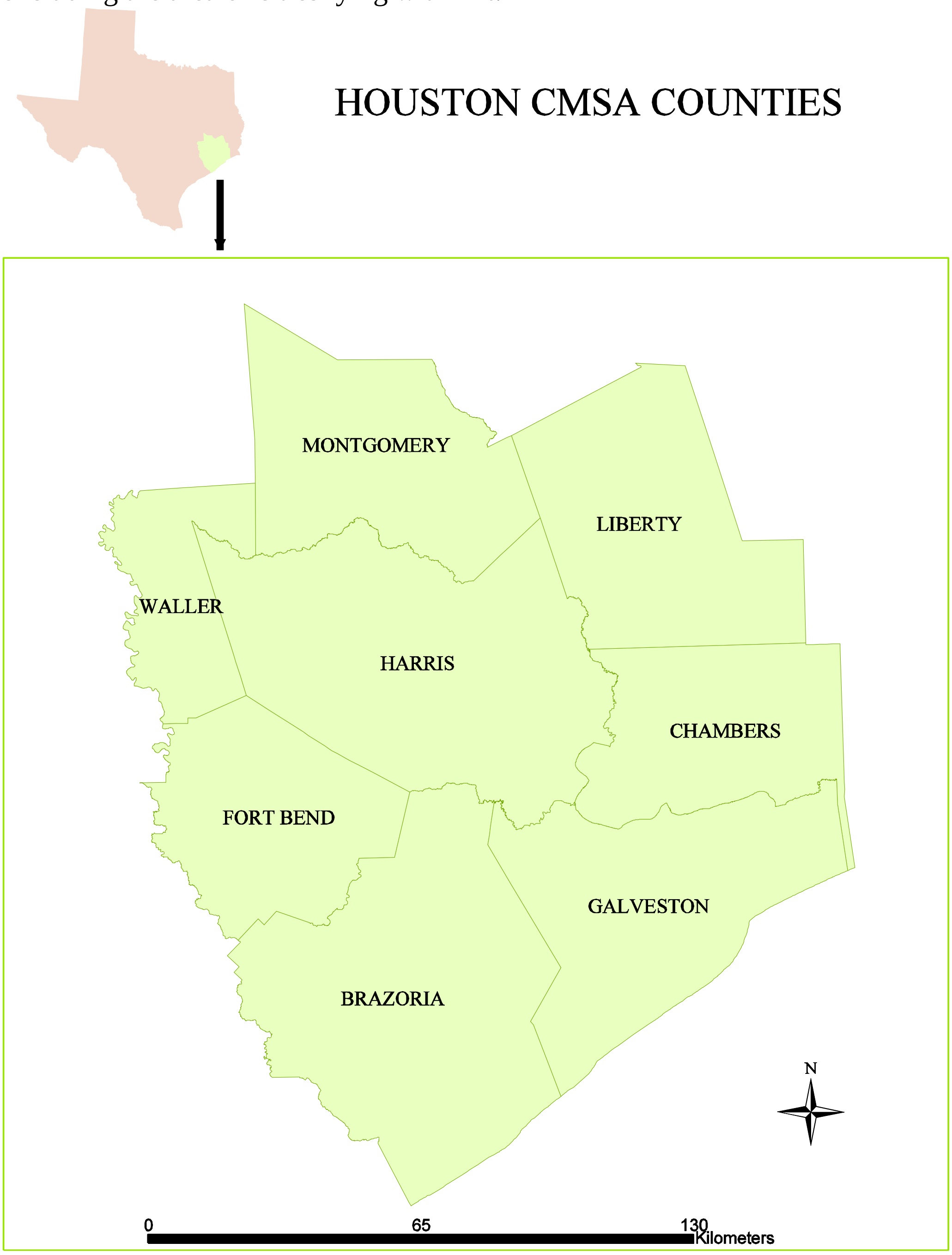

Fig. 2. 1 The Houston CMSA counties

Houston lies largely in the northern portion of the Gulf coastal plain, a 64- to 80-kilometer-wide swath along the Texas Gulf Coast. Typically, elevation rises approximately 0.19m per kilometer inland. The northern and eastern portions of the area are largely forested, while the southern and western portions are predominantly prairie grassland. Surface water in the Houston region consists of lakes, rivers, and an extensive system of bayous and manmade canals that are part of the rainwater runoff management system. Approximately 25%-30% of Harris County lies within the 100-year flood plain. Elevation ranges for each county as follows: Brazoria 0-45m, Chambers 0-30m, Fort Bend 4-48m, Galveston 0-13m, Harris 0-94m, Liberty 0-82m, Montgomery 13-133m, and Waller 24-109m.

Houston's land surfaces are unconsolidated clays, clay shales, and poorly-cemented sands extending to depths of several kilometers. The region's geology developed from stream deposits from the erosion of the Rocky Mountains. These sediments consist of a series of sands and clays deposited on decaying organic matter that, over time, was transformed into oil and natural gas.

The City of Houston was founded in 1836 and incorporated in 1837. The city grew slowly, increasing in population to only about 45,000 by 1900. Galveston, located on the Gulf of Mexico, 80 km south of Houston, was the economic center of Texas throughout the nineteenth century. Galveston was a key commercial port for cotton in the U.S.

Two events early in 1900s stimulated Houston's first phase of significant growth. First, the Galveston Hurricane of 1900 that killed about 6,000 people destroyed much of Galveston, contributing to its decline as the commercial center of the State. Second, the discovery of large oil reserves at Spindletop in 1901, 145 km east of Houston, led to Houston's rapid growth. In the 19th century, new investment on transportation infrastructure began with the railroad and port projects. In the 20th century, federal and state intervention in the Houston economy expanded to include the funding of petrochemical plants, gas pipelines, refineries, and research and development in the petrochemical industry. The decision to locate the National Aeronautics and Space Administration (NASA) complex was another boost to the Houston area in the 1960s. Houston ship channel and its port were the two areas that received considerable attention in the 19th and 20th centuries. Major improvements were needed along Buffalo Bayou, the San Jacinto River and Galveston Bay if Houston would like to have central role as a shipping port in Texas. With the improvements of the waterway, large ships were pulling into Houston and taking its principal product directly to Europe. In addition to that, combustion engine production demanded petroleum and oil began to play an increasing important role in the Houston economy (Vojnovic, 2003).

2.1. SLEUTH Model

The Urban Growth Model (UGM) is a C program running under UNIX that uses the standard gnu C compiler (gcc) and may be executed in parallel. The land cover transition model is included within the code and will be called and driven by the UGM. The land cover transition model is tightly coupled with the urban code, but the UGM can run independently of it. Together, these coupled models are referred to as SLEUTH. The name SLEUTH is an acronym for the input image requirements of the model (Slope, Land use, Exclusion, Urban extent, Transportation, Hillshade) (Gigalopolis, 2003).

SLEUTH is adopted because of its success with regional scale modeling, its ability to incorporate different levels of protection for different areas, and the relative ease of computation and implementation (Gigalopolis, 2003). Each cell in the study area for urban extent layer had only two possible states: urbanized or non-urbanized. The land use layer had seven different possible states: unclassified, urban, agriculture, forest, water, wetland, other. The transportation layer had four possible states: non-road, 2-lane roads, 3 or 4-lane roads, more than 4-lane roads. Whether or not a cell becomes urbanized is determined by four growth rules, discussed below, each of which attempts to simulate a particular aspect of the development process. In their original application of the Clarke urban growth model, a predecessor to SLEUTH, in the San Francisco Bay area, Clarke et al (1997) stressed the utility of the model in simulating historic change, the description of which can help in the explanation of growth processes at a regional scale, and in predicting future urban growth trends. The model was successful in simulating urban change between 1900 and 1990 for the San Francisco area, and was later applied to the Baltimore/Washington corridor (Clarke & Gaydos, 1998), where calibrations and long term predictions for both San Francisco and Baltimore/Washington were presented, allowing for an effective comparison to be made between the growth patterns and processes of the two urban systems.

SLEUTH simulates four types of urban land use change: spontaneous growth, new spreading center growth, edge growth, and road-influenced growth. These four growth types are applied sequentially during each growth cycle, or year, and are controlled through the interactions of five growth coefficients: dispersion, breed, spread, road gravity, and slope (Table 1). Each coefficient has a value that ranges from 0 to 100. In conjunction with the excluded layer probabilities, the five growth coefficients determine the probability of any given location becoming urbanized. The user-defined excluded layer specifies areas that are completely or partially unavailable for development. Water and unclassified areas, for example, would have an exclusion value of 100, indicating that it is 100% excluded from development. If a cell that is chosen for potential urbanization has an exclusion-value of 50, it has a 50% probability of being urbanized in any given simulation.

Table 1.
Summary of growth types simulated by the SLEUTH model

Growth Cycle Order	Growth Type	Controlling Coefficients	Summary Descriptions
1	Spontaneous	Dispersion	Randomly selects potential new growth cells
2	New Spreading Center	Breed	Growing urban centers from spontaneous growth
3	Edge	Spread	Old or new urban centers spawn additional growth
4	Road-Influenced	Road-Gravity, Dispersion, Breed	Newly urbanized cell spawns growth along transportation network
Throughout	Slope Resistance	Slope	Effect of slope on reducing probability of urbanization
Throughout	Excluded Layer	User-Defined	User specifies areas resistant or excluded to development

Spontaneous growth simulates the random urbanization of single pixels, which has the potential to capture low density development patterns and is not dependent on closeness to existing urban areas or the transportation infrastructure. The overall probability that a single non-urbanized cell in the study area will become urbanized is determined by the dispersion coefficient.

New spreading center growth models the emergence of new urbanizing centers by generating up to two neighboring urban cells around areas that have been urbanized through spontaneous growth. The breed coefficient determines the overall probability that a pixel produced through spontaneous growth will also experience new spreading center growth.

A newly urbanized cluster can then experience edge growth, which simulates outward growth from the edge of new and existing urban centers. Edge growth is controlled by the spread coefficient, which influences the probability that a non-urban cell with at least three urban neighbors will also become urbanized.

The final growth step, road influenced growth, simulates the influence of the transportation network on growth patterns by generating spreading centers adjacent to roads. When road influenced growth occurs, newly urbanized cells are randomly selected at a probability level determined by the breed coefficient. For each selected cell, the existence of a road is sought within a search radius defined by the road-gravity coefficient. If roads are found near the selected cell, a temporary urban cell is placed at the closest location adjacent to a road. This temporary urban cell then searches along the road for a permanent location. The direction of the search along the road is random and the search is determined by the dispersion coefficient. The permanent location becomes a new spreading center, so up to three cells along a road can be urbanized at this point.

The slope coefficient accounts for the influence of topography on development patterns and is applied as a suitability test before any location is urbanized. A high slope coefficient value will decrease the likelihood that development will occur on steep slopes.

SLEUTH also has a functionality termed "self-modification" (Clarke et al, 1997), which allows the growth coefficients to change throughout the course of a model run and which is intended to more realistically simulate the different rates of growth that occur in an urban system over time. When the rate of growth exceeds a specified critical threshold, the growth coefficients are multiplied by a factor greater than one, simulating a development "boom" cycle. Likewise, when the rate of development falls below a specified critical threshold, the growth coefficients are multiplied by a factor less than one, simulating a development "bust" cycle. Without self-modification, SLEUTH will simulate a linear growth rate.

Implementation of the model occurs in two general phases: (1) calibration, where historic growth patterns are simulated, (2) prediction, where historic patterns of growth are projected into the future. For calibration, the model requires inputs of historic urban extent for at least four time periods, at least two historic land use layers, a historic transportation network for at least two time periods, slope, and an excluded layer.

2.2. Input Data

Unsupervised classification (ISODATA) is applied to Landsat Thematic Mapper (TM) and Multispectral Scanner (MSS) imagery. This allowed us to map urban extent for 1974, 1984, and land use for 2002. 1992 land use map is acquired from EPA MRLC National Land Cover Data (NLCD) website (EPA, 2002). The original data were at 30m resolution in TM and 60m in MSS imagery. Because high resolution TM images produced an array that exceeded the available computational resources of our Linux PC and SUN UNIX machine, the data were therefore resampled to a lower resolution of 100 meters to reduce the size of the array while maintaining the spatial extent of the study area.

Five time steps for transportation were also prepared (Table 2). Roads layers for 1974, 1984, 1990, and 2002 were developed using the primary road network and TXDOT road maps. 2025 road map is developed by using TxDOT Texas Corridor Plan. Slope and hillshaded are created from National Elevation Dataset (NED) which was downloaded from Texas Natural Resources Information System (TNRIS) website. For the calibration phase, the excluded layer consisted of water, which was 100% excluded from development, as well as federal, state, and local parks, which were 90% excluded from development. All input files were rasterized at a 100-meter resolution to the spatial extent of the study area.

Table 2.
Input dataset for SLEUTH

SLEUTH Inputs	Input Data Types	Input Data Years
Urban	Landsat MSS, Landsat TM	1974, 1984, 1992, 2002
Lulc	Landsat TM	1992, 2002
Road	Shapefiles	1974, 1984, 1990, 2002, 2025
Excluded	Landsat TM	
Slope	NED	
Hillshade	NED	

2.3. Model Calibration

The goal of calibration is to derive a set of values for the growth parameters that can effectively model growth during the historic time period, in this case from 1974 to 2002. This was achieved in the SLEUTH modeling environment through a brute force Monte Carlo method, where the user indicates a range of values and the model iterates using every possible combination of parameters. For each set of parameters, simulated growth is compared to actual growth using several least squares regression measures, such as the number of urban pixels, urban cluster edge pixels, the number and size of urban clusters, and other fit statistics, such as Leesallee metric. The model calculates these statistics internally and writes the results to a log file that can be manipulated by the user to evaluate the performance of different parameter sets. For each set of parameter values in a Monte Carlo iteration, the model calculates measurements of simulated urban patterns for each control year in the time series. These measurements are then averaged over the set of Monte Carlo iterations and compared to measurements calculated from the actual historic data to produce least squared regression measures (U.S. Geological Survey, 2003). The Leesallee metric (Lee et al, 1970) is the only metric that specifically measures spatial fit. SLEUTH model calculates a modified Lee and Sallee index by taking a ratio of the intersection and the union of the simulated and actual urban areas (Clarke & Gaydos, 1998). A perfect spatial match would result in a value of 1. As Clarke & Gaydos (1998) point out, achieving high values for this index is challenging. With an earlier version of the model, they did not report values of the Lee and Sallee statistics that exceeded 0.3, although recent applications of SLEUTH have achieved values that approach 0.6 (Silva & Clarke, 2002). We achieved a value of 0.51 for leesallee for this particular research.

Calibration was performed in three phases: coarse, fine, and final. Coarse and fine calibration phases are done on our Linux machine, however, final calibration was done at USGS Rocky Mountain Mapping Center in Denver, CO by Mark Feller. It was done on a Beowulf PC Cluster with a 16-node system. All calibration (coarse, fine, final) process took approximately 2 months.

Leesallee metric was used as primary metric to evaluate the performance of the model. After each calibration phase, the top set of leesallee scores determined the range of values used in the subsequent phase of calibration.

To perform a spatial accuracy assessment, the model was initialized with 1974 urban extent and growth was predicted out to the year 1992. One hundred Monte Carlo iterations were performed, and an urban extent of 2002 was produced (Fig. 2). This is compared with 2002 observed urban extent (Fig. 3).

The confusion matrix is calculated for the observed versus predicted urban areas in 2002. As you can see in the Table 3, we have found high overall classification accuracy, 98%, and a high kappa coefficient, 0.89, between observed urban area and predicted urban area.

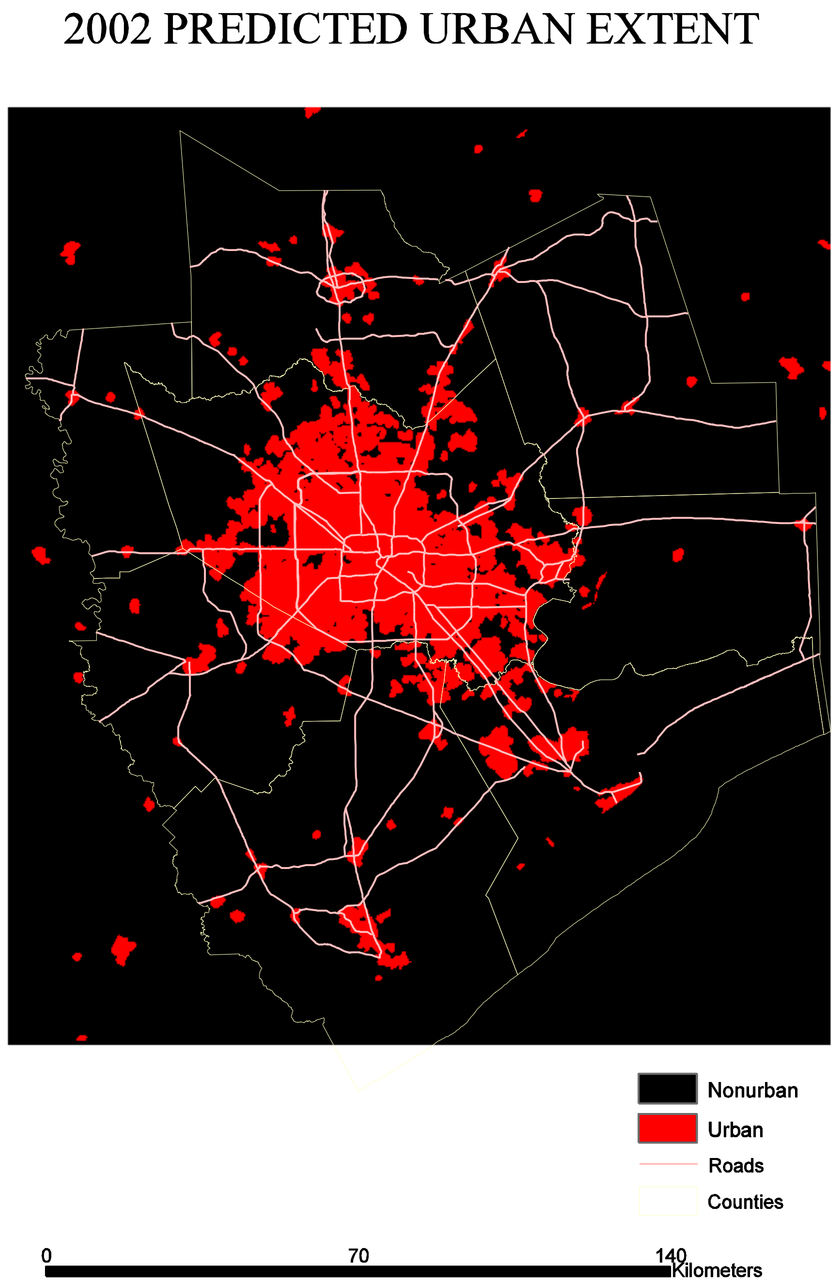

Fig. 2 The Houston CMSA 2002 predicted urban extent

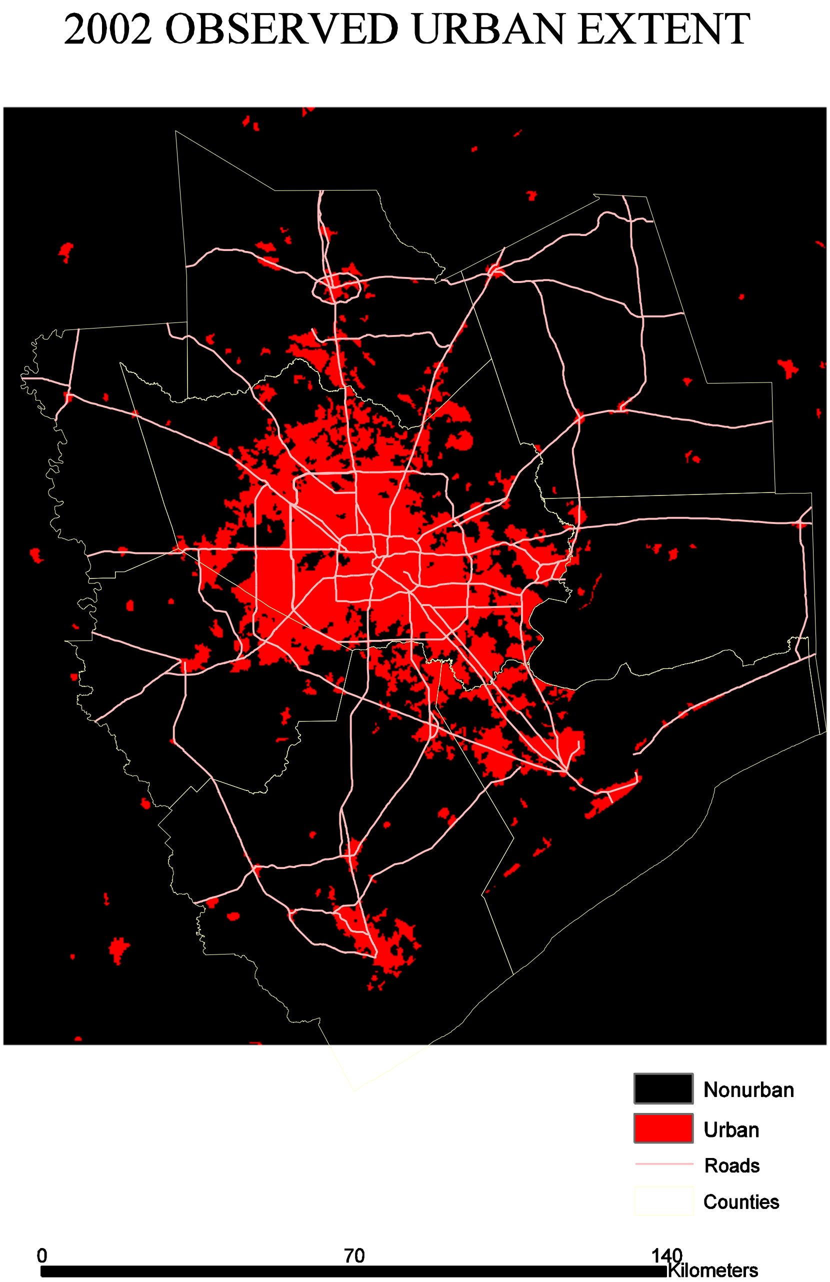

Fig. 3 The Houston CMSA 2002 observed urban extent

2002 OBSERVED URBAN EXTENT

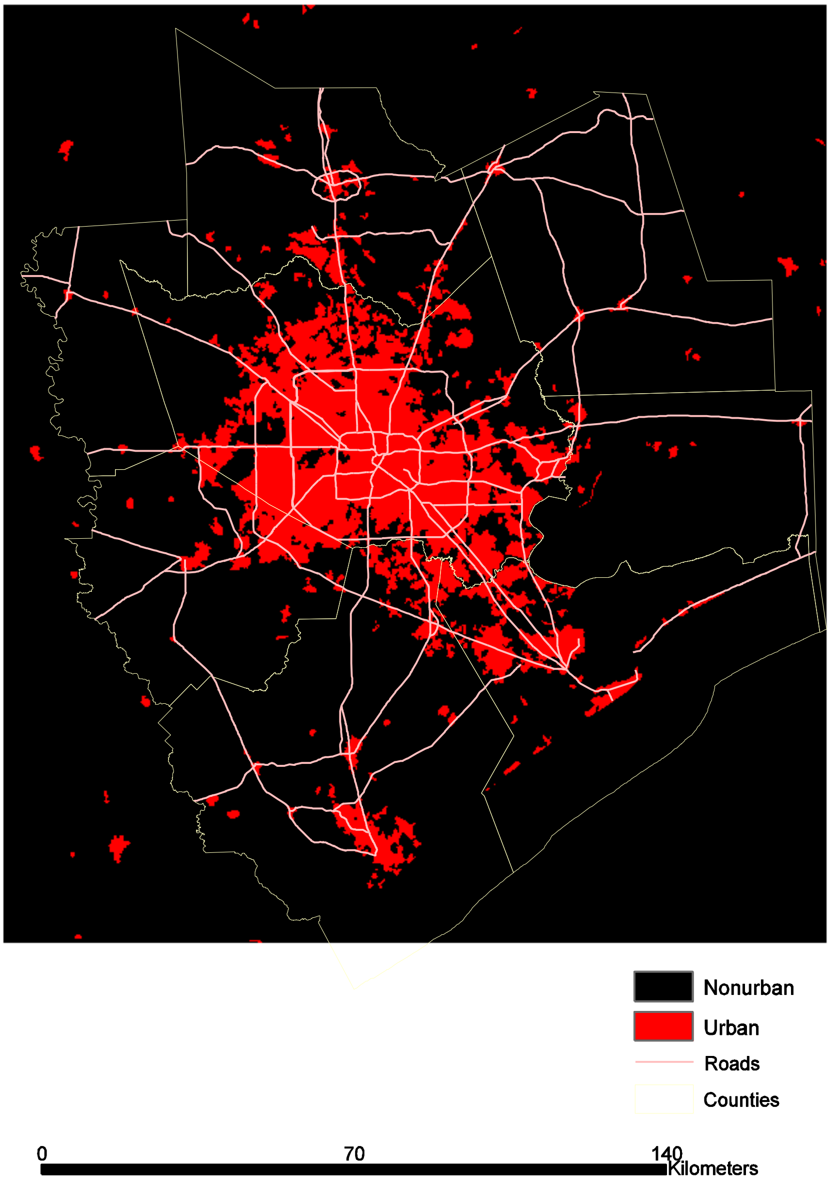

Fig. 2. 2 The Houston CMSA 2002 observed urban extent

Table 3.
Confusion matrix and kappa coefficient for the 2002 predicted urban extent

		Reference Data Points (OBSERVED URBAN 2002)				
		Nonurban	Urban	Row Total	Producers Accuracy	Users Accuracy
Classified Data Points	Nonurban	227	3	230	99.13%	98.70%
	Urban	2	24	26	88.89%	92.31%
	Column Total	229	27	256		

Overall Classification Accuracy = 98.05%
Kappa (Khat) Coefficient = 0.89

2.4. Prediction

SLEUTH requires the following inputs for prediction phase: urban extent, land use/land cover (LULC), roads, excluded layer, slope, and a hillshade. Three future growth scenarios were simulated: Unmanaged growth, managed with moderate protection, and managed with maximum protection. The excluded layer served as the primary instrument to differentiate between three policy scenarios. The future transportation network, Texas Corridor, which is planned to be completed in 2025, was also created and incorporated into the model for the year 2025.

3. Results

The unmanaged trend scenario reflects that there is no protection against development. Natural resource land was not protected except city and county parks. Unclassified pixels, water and parks are fully excluded from development. However, wetland, agricultural land, forest, and floodplain were not protected. The managed growth with moderate protection scenario, however, reflects a stronger commitment to spatially focused growth and resource protection. In the excluded layer higher levels of protection were assigned to wetlands, agricultural land, forest land, and floodplain. The third and last scenario, managed growth with maximum protection, implies a more extreme set of protection on resource land. The data elements for the excluded layer are similar to those in the managed growth with moderate protection case, but protection levels are higher.

Data layers and probabilities of exclusion or levels of protection, for each scenario are summarized in Table 4 below.

Table 4.
The growth scenarios and levels of protection

Growth Scenarios	Excluded From Development (in percent)						
	Agriculture	Forest	Floodplain	Wetland	Parks	Water	Unclassified
Unmanaged	0	0	0	0	100	100	100
Managed with Moderate Protection	40	40	40	60	100	100	100
Managed with Maximum Protection	60	60	60	80	100	100	100

The results of the scenario predictions (Figs. 4 - 6) show higher dispersed development patterns for the unmanaged than the managed growth scenario with moderate protection, while the managed growth with maximum protection scenario shows highly constrained growth over the whole region, with most occurring in and around existing urban centers. Unmanaged growth trend shows similar to low-density development patterns. This is predicted to lead to substantial land consumption throughout the study area with a simultaneous loss of resource lands. Due to the higher levels of protection, the growth rates for the managed growth scenarios are reduced, producing a much lower predicted loss of resource lands as illustrated in Figs. 4 - 6.

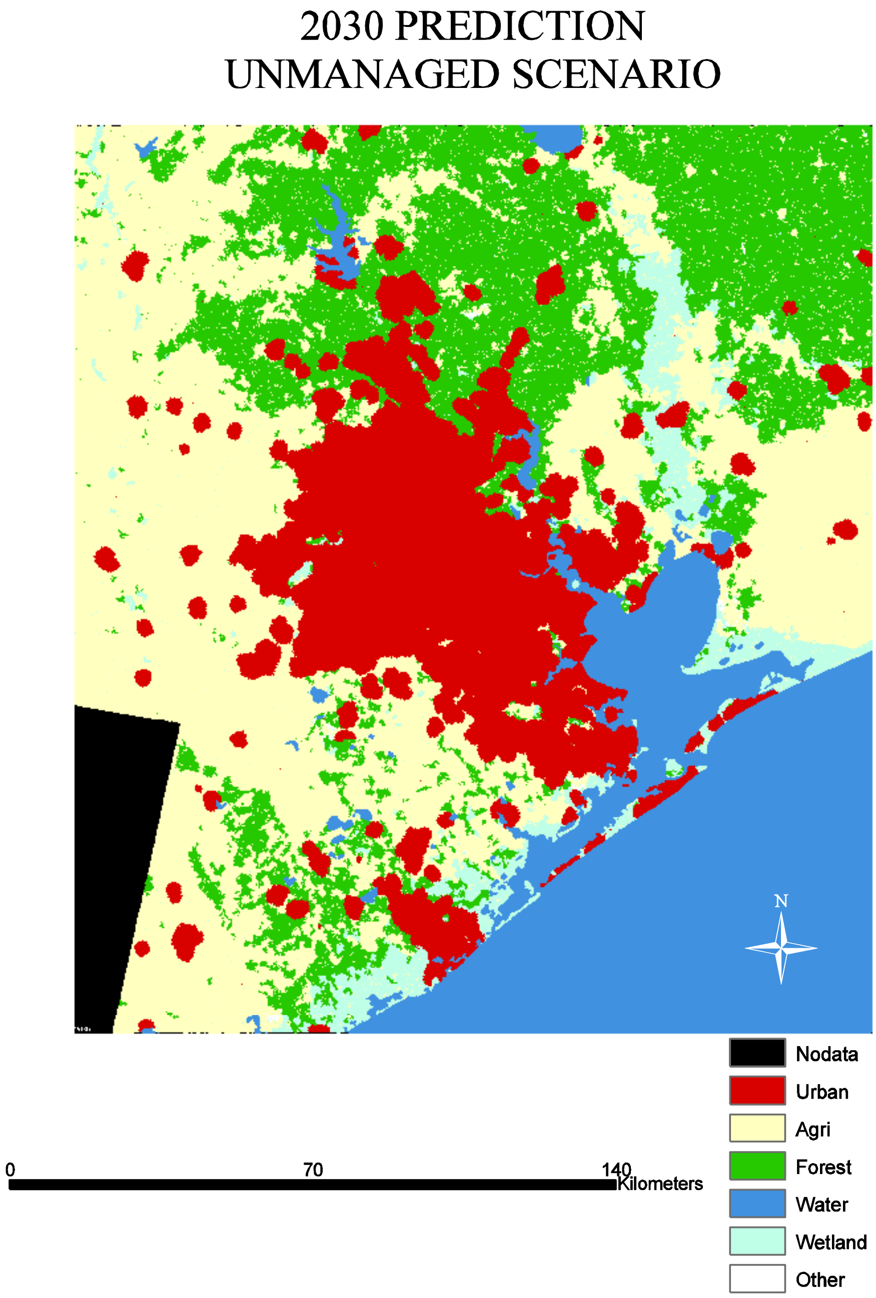

Fig. 4 Unmanaged growth scenario prediction

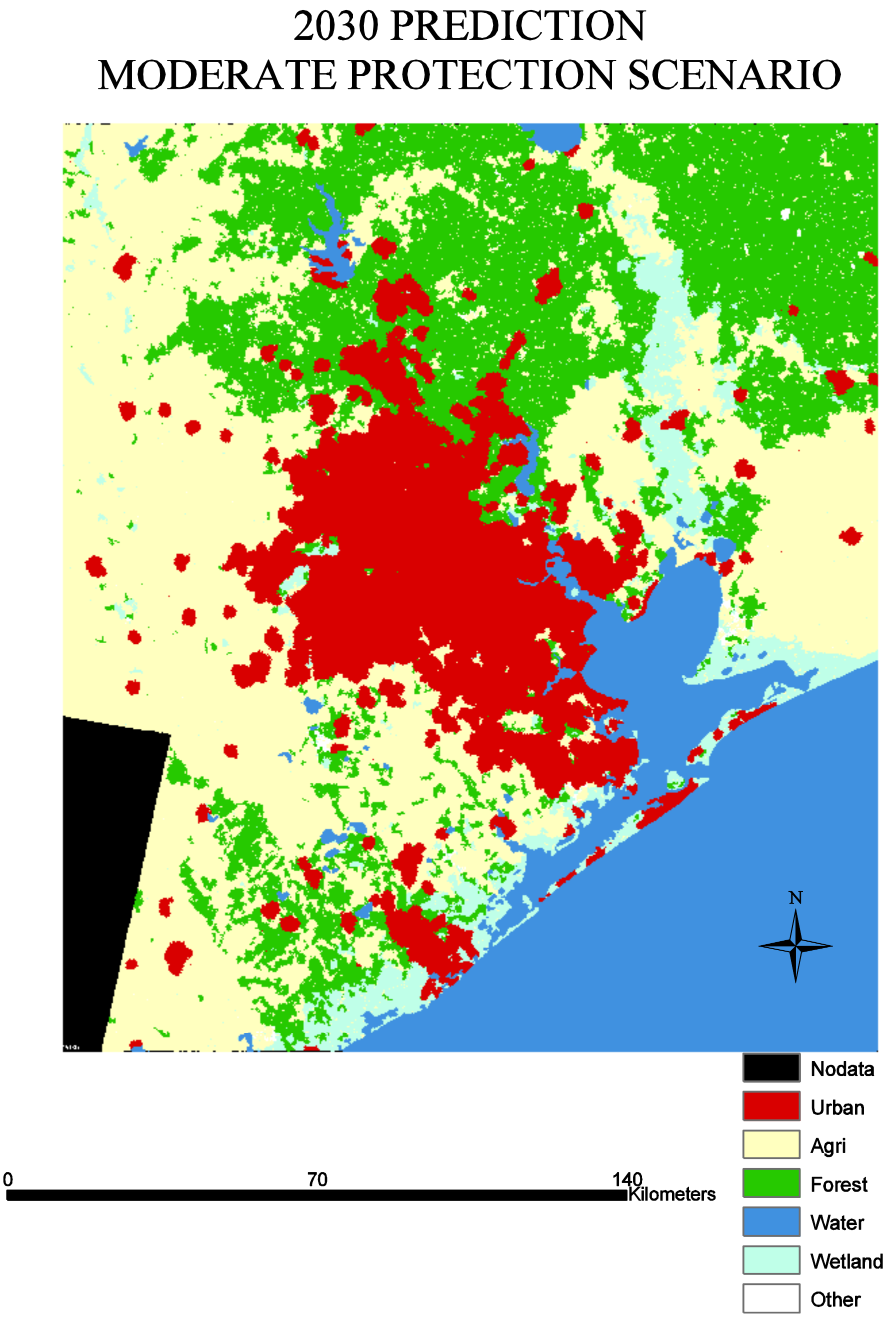

Fig. 5 Managed with moderate protection scenario prediction

2030 PREDICTION
MAXIMUM PROTECTION SCENARIO

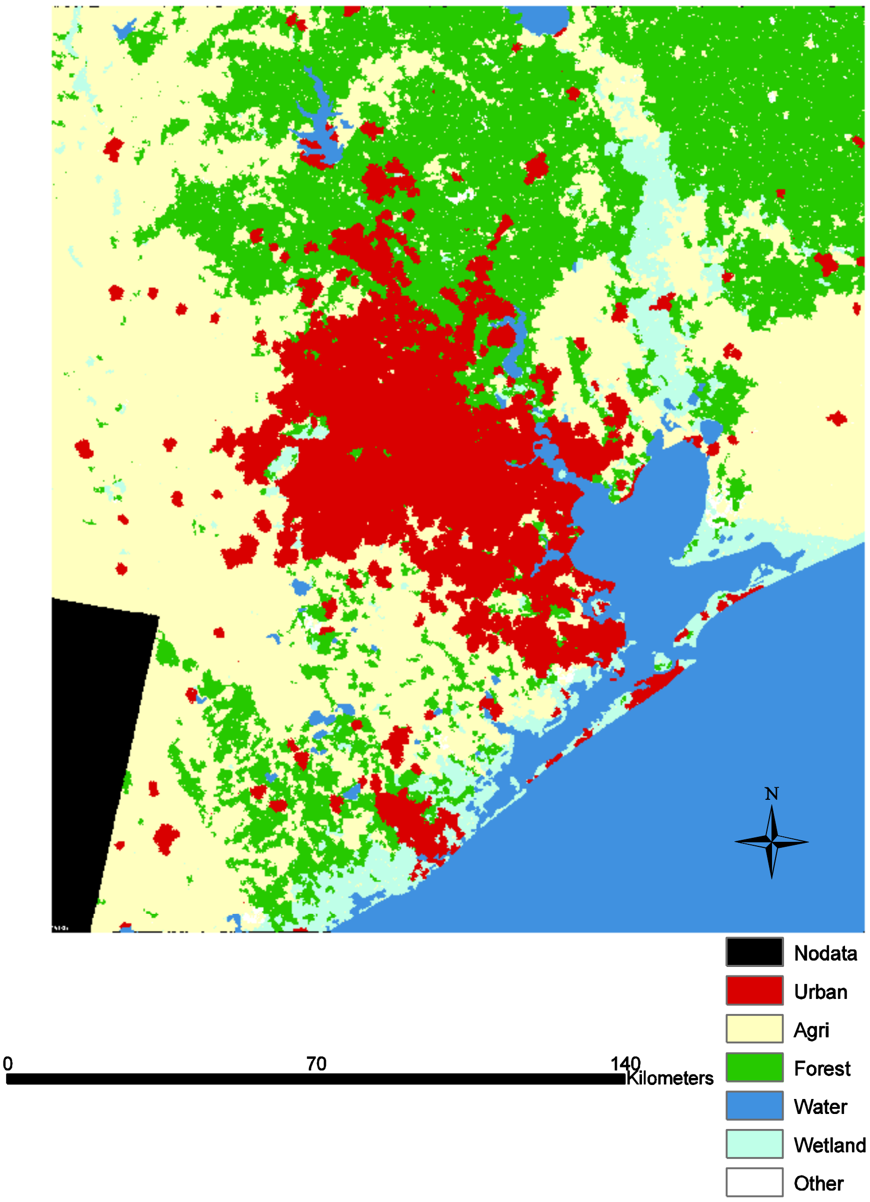

Fig. 6 Managed with maximum protection scenario prediction

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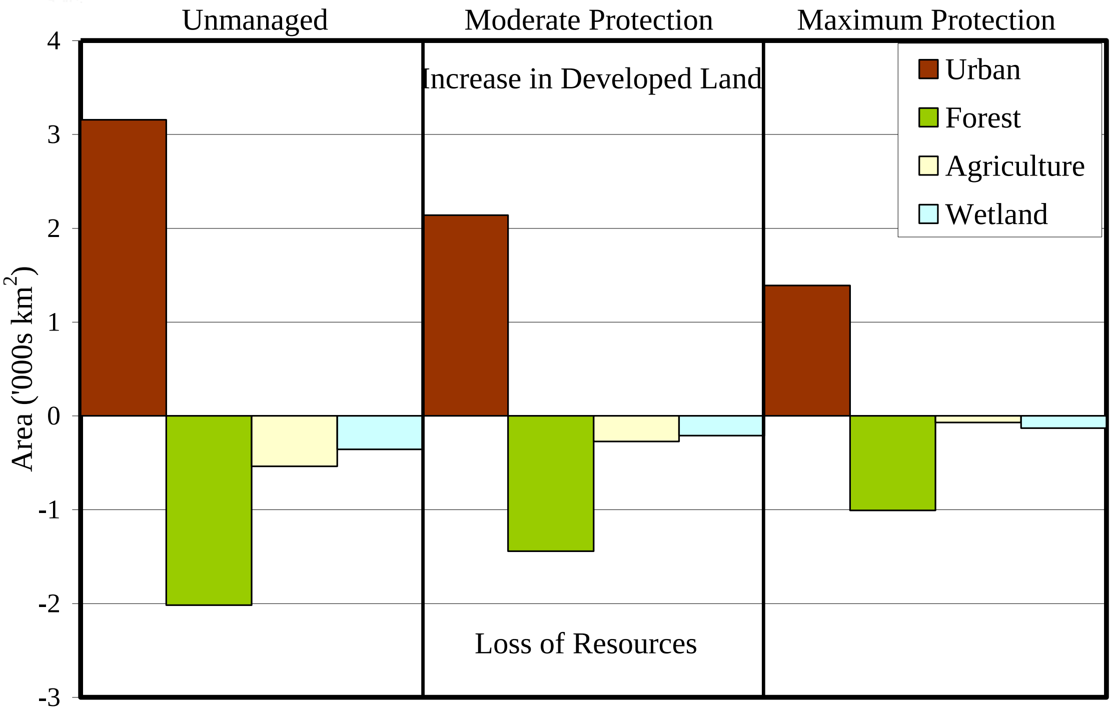

Fig. 7 Comparison of three scenarios for future predictions in Houston CMSA

As seen from Fig. 7, third scenario would save 1000 km^2 forest land compare to unmanaged scenario, and about 500 km^2 compare to moderate scenario. Urban sprawl seems to affect forested land more than other resource lands. Spatial distribution of the predicted forest loss is illustrated in Figs. 8, 9, 10 for unmanaged growth scenario, managed growth with moderate protection scenario, and managed growth with maximum protection scenario respectively.

PREDICTED FOREST LOSS
UNMANAGED GROWTH SCENARIO

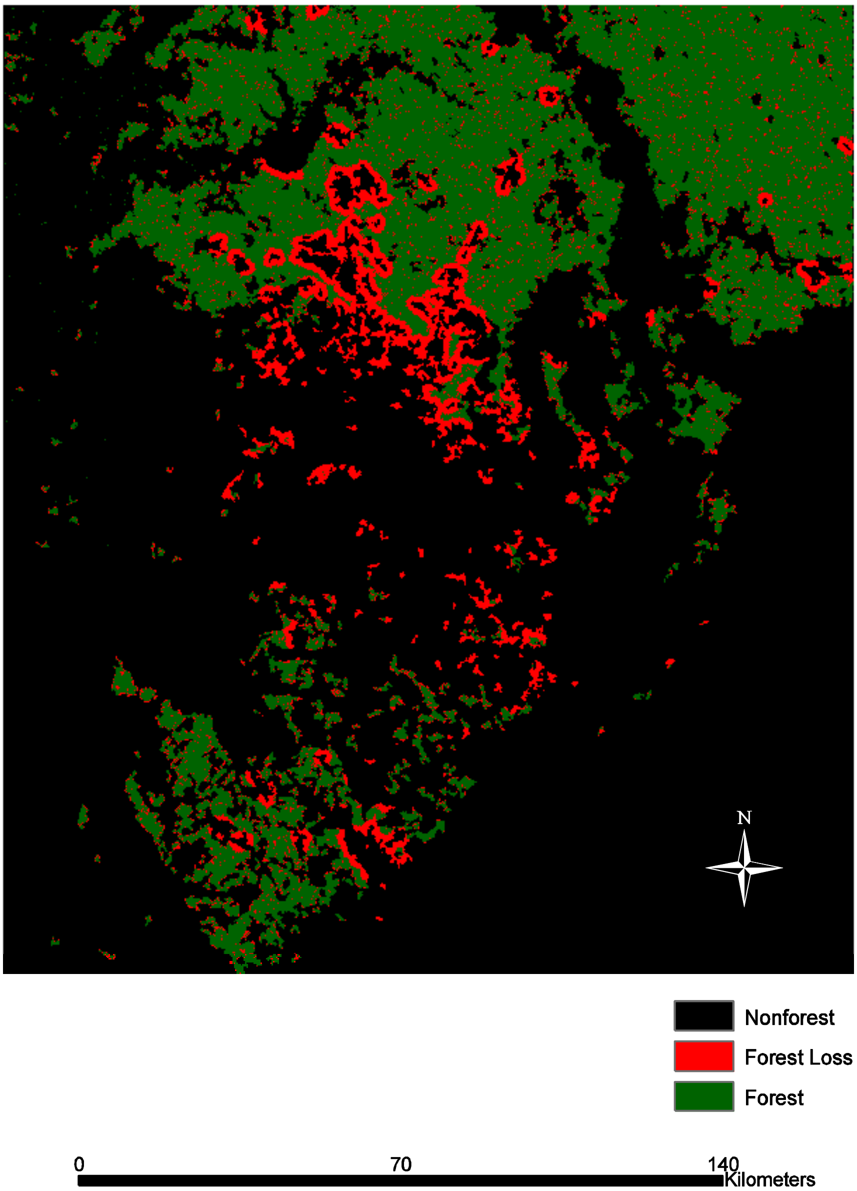

Fig. 8 Predicted forest loss in unmanaged growth scenario by 2030

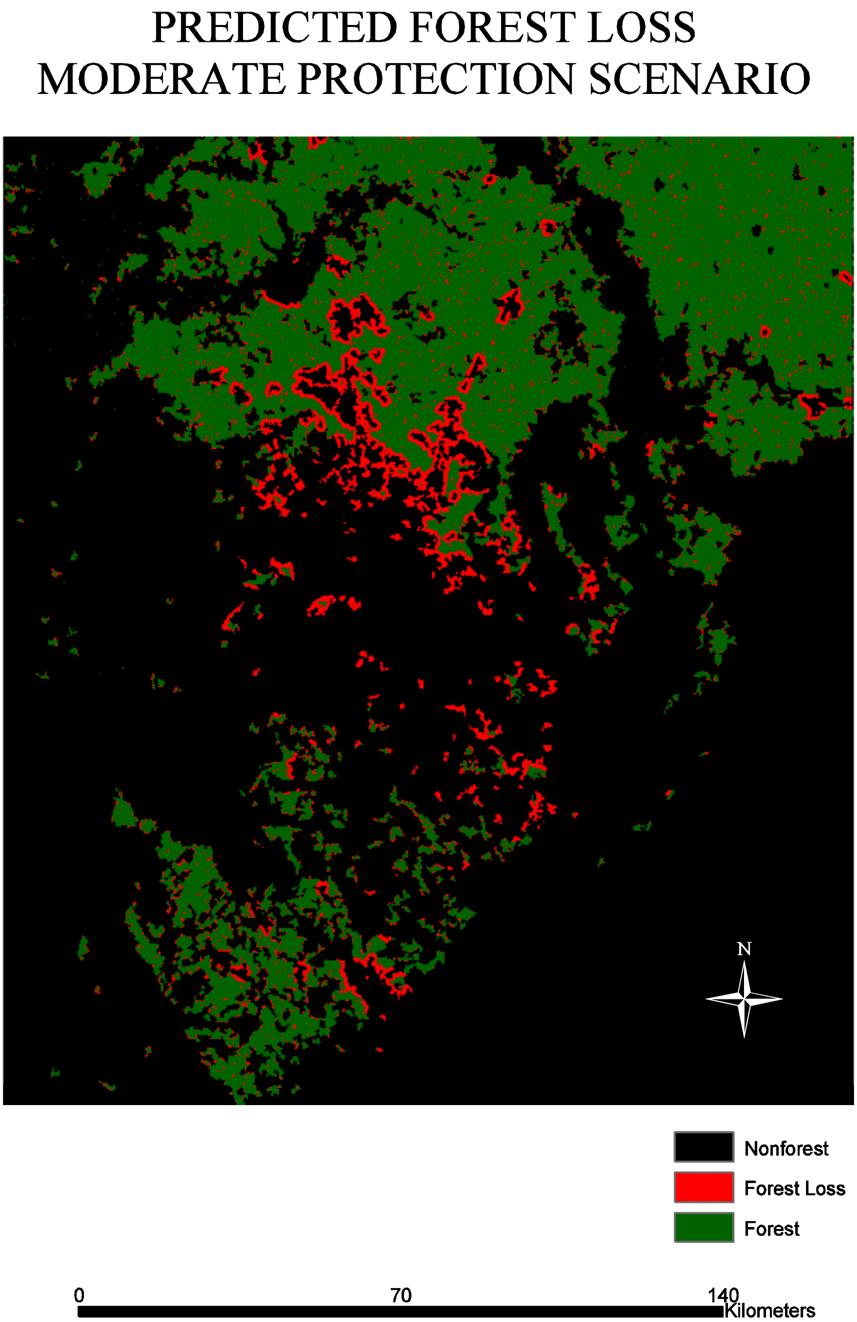

Fig. 9 Predicted forest loss in moderate protection scenario by 2030

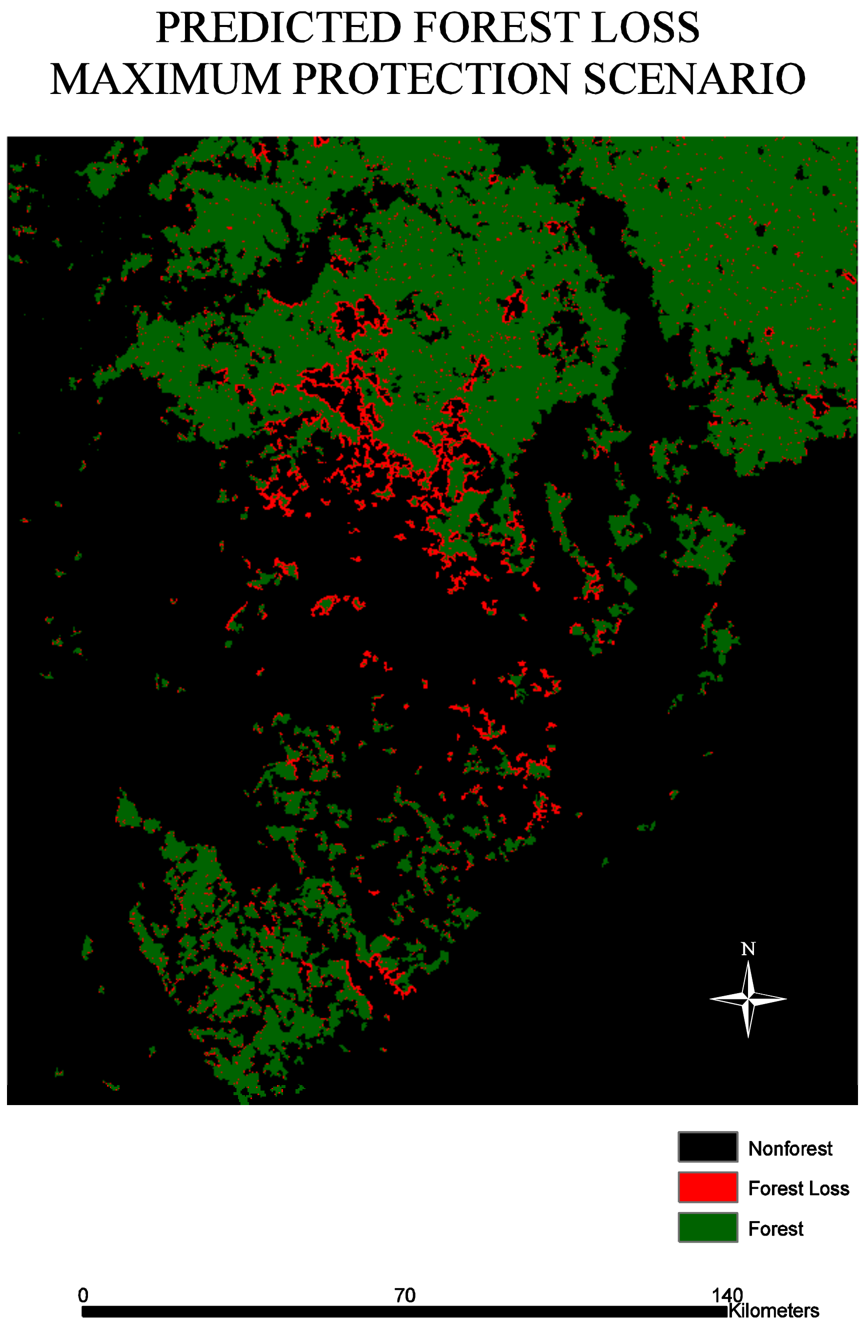

Fig. 10 Predicted forest loss in maximum protection scenario by 2030

The predicted forest loss area by each Houston CMSA county is illustrated in Fig. 11.

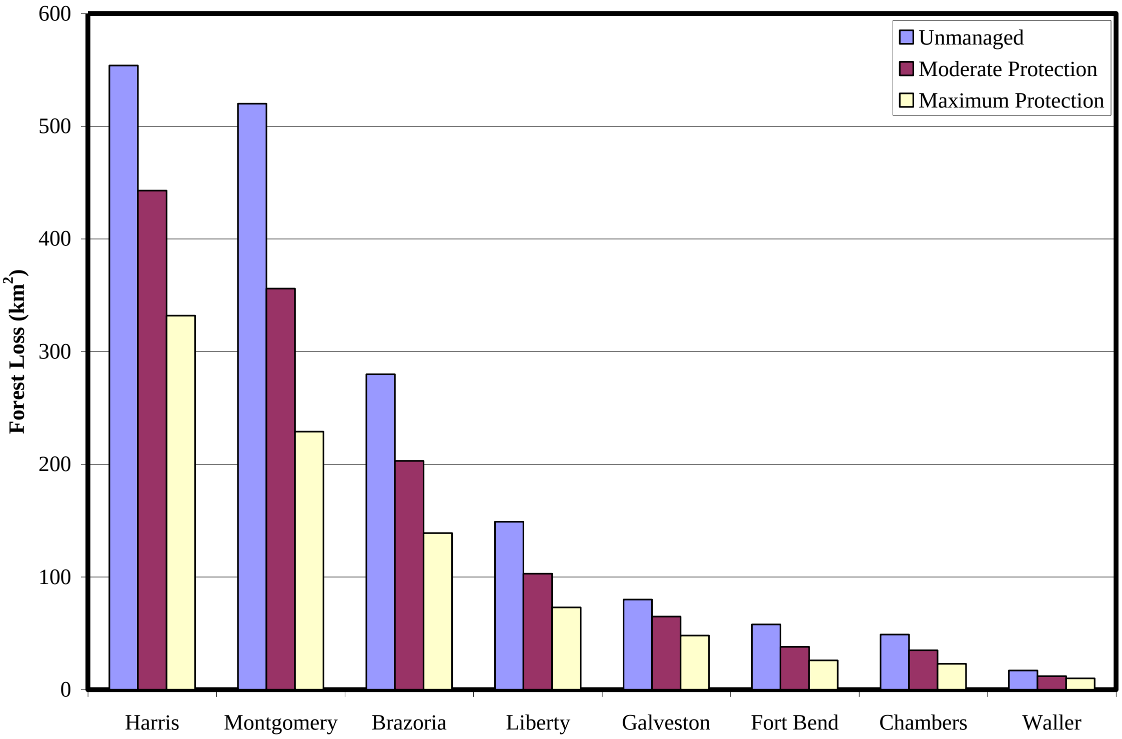

Fig. 11 Predicted forest loss by 2030 for Houston CMSA counties for the three growth scenarios

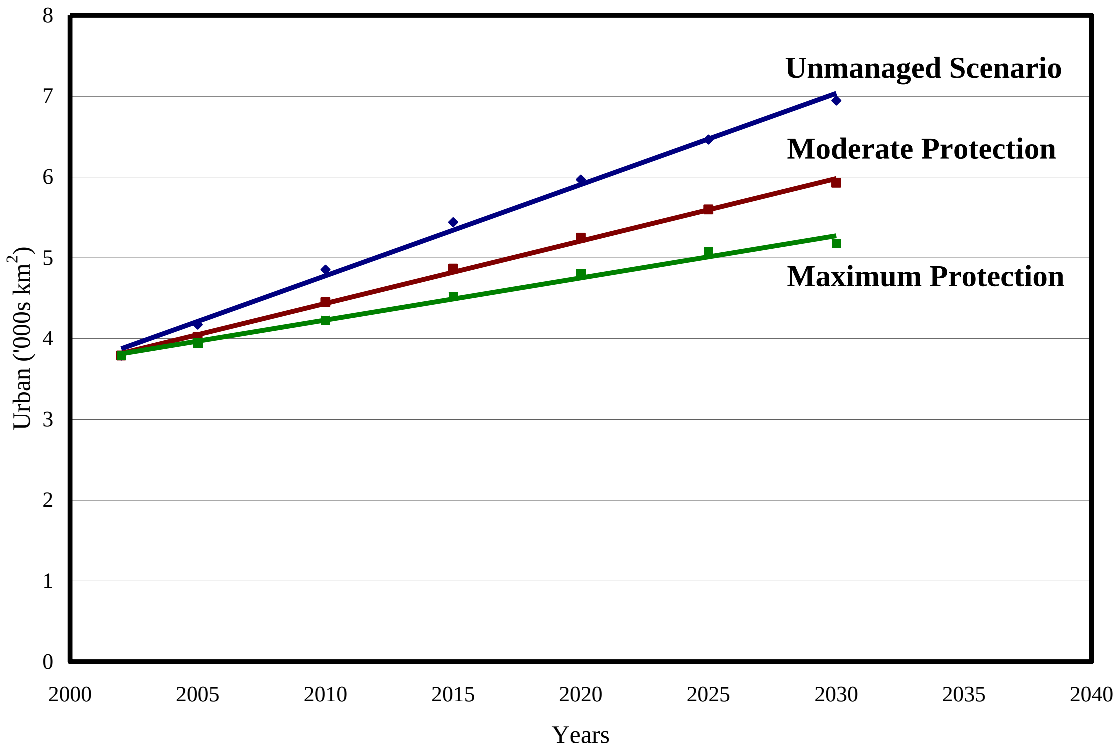

Fig. 12 Comparison of urban areas in the Houston CMSA for the three growth scenarios

It's predicted that urban area will cover approximately 7,000 km^2 by 2030 in unmanaged scenario in the Houston CMSA. With the maximum protection scenario, around 2,000 km^2 of land could be saved from development (Fig 12).

4. Discussion

The results from this regional scale assessment have provided interesting insights into the future of the region. Given these findings, SLEUTH could be an appropriate model for regional assessments of urban land use change, the results of which could be used to guide more localized modeling efforts. The visualization of potential land use change has proven to be a powerful tool for raising public awareness and facilitating discussion. Reports about this research were published in several well-known media sources, such as the Washington Post newspaper (Huslin, 2002), and appeared on the website for the Chesapeake Bay Foundation, a prominent regional environmental group. The results for the unmanaged trends scenario are especially important to public discussion since they demonstrate the potential losses in resource lands that could occur if the observed rates of land use change were to continue into the future. Moreover, as efforts to improve the health of the Houston CMSA progress, the need for the regional-scale land use change assessments is becoming critical. SLEUTH may be a tool that can meet these needs and this has been recognized by state and regional agencies to explore the use of SLEUTH as a potential tool for modeling environmental vulnerability.

The excluded layer proved to be an effective tool for exploring different policy scenarios, and illustrates the advantages of linking the modeling process to a GIS. All data integration and manipulation was performed within GIS, allowing for the precise designation of target conservation areas, such as wetlands. For each scenario, all land within the study area was ranked in terms of conservation using a grid-based model. The resulting excluded layer was easily integrated into the model. Translating various policies into exclusion probabilities was done by Mid. Atlantic RESAC (2003), and was not an intuitive process. It consisted of an informed qualitative ranking of each conservation policy. These rankings of low, medium, or high were then translated into generalized exclusion probabilities. In our scenarios, we have used Mid Atlantic RESAC's policy exclusion probabilities.

Although the excluded layer is ideal for simulating the effects of conservation or regulatory policies, SLEUTH does not have an adequate mechanism to simulate the potential impacts of incentive policies. By encouraging denser and more compact development in areas that have existing urban infrastructure, it is hoped to decrease the amount of new development occurring in outlying areas (Northrup & Duket, 1997).

We also obtained significantly higher values for the Leesallee measure than Clarke & Gaydos (1998), but this is likely due to the fact that we were working with a shorter time series, 28 years compared to 200 years. We also worked with land cover data that were obtained from a single source, satellite imagery, while Clarke & Gaydos (1998) had obtained data from variety of cartographic sources. The satellite data is more advantageous to the SLEUTH modeling environment, and probably contributed to the higher values we obtained for the Leesallee metric.

5. Conclusions

Increasing urban growth through the world has aroused concerns over the degradation of our environment. Therefore, understanding the dynamics of urban systems and evaluating the impacts of urban growth on the environment are needed and they involve modeling. In regions where regional approaches to land use management are being developed, a realistic modeling system that can be used to explore different regional futures is critically needed. Because of an ability to simulate the complex behavior of urban systems, CA models represent a possible approach for regional scale modeling. Furthermore, consistent, regional data sets derived from satellite imagery and other sources can be readily integrated into the CA modeling environment. Our research explored the suitability of utilizing one CA, the SLEUTH model, for regional planning applications.

The Houston metropolitan area was used as our study area. The study indicated the usefulness of cellular modeling and geographical information systems for urban scenario planning. Three scenarios have been designed and simulated in this research. The first scenario simulated the continued growth (unmanaged) trend if the urban sprawl is allowed to continue. The second scenario projected the growth trend with moderate environmental protection. The last scenario simulated the development trend with maximum environmental protection. The three scenarios of future urban growth simulation predict the general trends under different conditions nicely. Results from first scenario indicate that Houston metropolitan area would lose considerable amount of open space and natural land, such as forest. The second scenario results are not encouraging as much as the last scenario. The growth rate is controlled and natural land is conserved most with the last scenario. The results are encouraging, although more accurate simulations could be achieved if more growth constraints were considered. The role of remote sensing and GIS in cellular automata-based urban modeling is necessary, especially for input data preparation, model calibration and verification, urban pattern analysis, and also growth impact assessment.

SLEUTH provides key functionalities like interactive scenario development and the ability to visualize and quantify outcomes spatially. The availability and consistency of historic data sets, especially those that are earlier than satellite availability, is a potential issue for some applications. Empirical calibration of the model using Landsat TM image maps of past change aided the model predictions of future change. Calibration at high level of spatial detail remains a computationally intensive process, requiring sufficient use of a parallel computing environment, and may prevent the use of the model by local or nongovernmental agencies where computing resources may be a limiting factor. Despite these considerations, we found SLEUTH to be a useful tool for assessing the impacts of alternative policy scenarios.

Concerns over the degradation of the environment we live in are raised because of an increasing urban growth throughout the world. Modeling and simulation are required to understand the dynamics of complex urban systems and to evaluate the impacts of urban growth on environment.

Houston was selected as the study site because Houston is the only major metropolitan area in the U.S. that functions without a zoning. This research focuses on modeling urban growth and land use/land cover change in Houston metropolitan area using SLEUTH urban growth model. For the past 3 decades, Houston has been one of the fastest growing metropolises in the U.S. and has emerged as commercial, industrial, and transportation urban center of the south.

Calibration of the SLEUTH model for Houston indicates a very high spread coefficient, which means that the predicted mode of growth in Houston is "organic" or edge growth. Houston has been experiencing "organic" or edge growth. Among Houston PMSAs, Houston PMSA was the major metropolitan area that drove the population and urban growth in Houston CMSA. The Galveston and Brazoria PMSAs did not show increase in both and they reflect very small part of Houston CMSA. According to our county level analysis, Harris and Galveston counties contain the highest percentage of urban land in proportioned their area. Urban growth rates for Harris and Galveston are higher than other six counties in Houston CMSA. We also developed three environmental scenarios in our study area. The third scenario provides the best protection for Houston CMSA, and protects most of the resource land. Without any protection on resource lands, Houston CMSA is estimated to lose 2,000 km^2 of forest land by 2030, about 600 km^2 of agricultural land, and approximately 400 km^2 of wetland. Approximately half of all resource land could be saved by the third scenario, managed growth with maximum protect.

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ANALYSIS OF RESEARCH AND DEVELOPMENT OF SOIL FERTILITY AND WATER MANAGEMENT TECHNOLOGIES IN MALAWI- A REVIEW

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Various agricultural technologies have been developed in Malawi with respect to soil fertility amelioration and water management. Technologies on soil fertility focused particularly on organic and inorganic fertilizers. A number of recommendations have been passed on to extension and farmers in various forms. The most important ones include the maize blanket fertilizer recommendations, the area-specific fertilizer recommendations, grain legume rotations, farm yard manure, compost manures and liming recommendations particularly in maize-based cropping systems. There have also been recommendations on water management practices, especially in the areas of rainwater harvesting and tillage systems. Other recommendations are on fertilizer use in other crops, such as soybeans, the common bean, cotton and sunflower. The paper presents a detailed review of research and extension activities in relation to soil fertility enhancing technologies and improved water management practices. The technology adoption levels and/or constraints to adoption by smallholder farmers in Malawi and the suggested way forward are also presented.

Key Words*: Malawi, soil fertility, technologies, water management*

OVERVIEW OF SMALLHOLDER AGRICULTURE IN MALAWI

Malawi is a small South East African Country with a total land area of 118,484 km^2. Maize (*Zea mays L.*) is a commonly grown crop. It is grown on approximately 1.235 million hectares (CIMMYT, 1999) with an average production of 1.65 to 1.09 t ha^{-1} between 1998 and 2002. The area planted to maize and maize mixtures by smallholder farmers was about 65 % in the early 1960s, and increased to 70-85 % of the land under cultivation (Smale *et al.*, 1991). Several other crops are also grown for cash and food. Major food crops being grown by farmers include maize, cassava, potatoes, soybean, groundnuts, common bean, sorghum and rice. Cash crops include tobacco, tea sugar, coffee, cotton, sunflower and spice crops, and maize, among others. The production levels and area grown for selected crops over 1998-2002 seasons is shown in Table 1. In terms of area committed to a crop, the importance of various crops is in the following order: maize, tobacco, cassava, beans, sweet potato, beans groundnuts and pigeon peas.

Production over the years has been low compared to potential production. Potential production is 6-7 t/ha for maize, 3t/ha for sorghum, 1-2 t/ha for groundnuts, 2.5 t/ha for beans, 4.5 t/ha for soybean, 2.0 t/ha for cowpeas, 18-30 t/ha for cassava, and 30 t/ha, sweet potatoes, 15-20 t/ha for potatoes. Yields of maize leave the widest gap, since potential yields are up to four fold of actual yields. There are many reasons for this yield gap. Zambezi *et al* (1993) attributed the yield gap in maize mainly to low soil fertility. This arises from the high cost on inputs such as inorganic fertilizers and seed for maize, which results in low yield, and farmers are rendered food insecure. The consequences of poor maize yields are that farmers commit more land to maize, at the expense of other crops, such as legumes, which could help restore fertility, spread the food range, and increase the yield options in times of drought. Farmers also resolve to growing maize in marginal land. In the last decade, Malawi has changed from being a food secure to food insecure country. For example, in the early 1970's average per capita maize production was 204 kg, declining to 161 kg during the 1985 period (Conroy, 1993). Assuming that all the required calorie intake of 22,000 come from maize, then the required per capita production would be 230 kg. However, other food crops are also important sources of calories.

Table 1. Yields and area planted to various crops in the past 4 seasons (After Ministry of Agriculture and Irrigation, 2002).

Crop	Yield and area planted	Seasons			
		1998/1999	1999/2000	2000/2001	2001/2002
Maize	Yield, kg ha^{-1}	1,650	1,137	1,093	1,093
	Area, ha	1,446,773	1,507,088	1,506,528	1,487,831
Sorghum	Yield, kg ha^{-1}	699	669	680	720
	Area, ha	59,310	55,030	54,098	54,404
Groundnuts	Yield, kg ha^{-1}	731	694	820	-
	Area, ha	170,517	176,100	189,245	-
Beans	Yield, kg ha^{-1}	364	436	496	437
	Area, ha	135,489	171,775	219,809	233,547
Soyabean	Yield, kg ha^{-1}	617	639	685	649
	Area, ha	64,284	76,166	54,605	48,309
Cowpeas	Yield, kg ha^{-1}	401	363	393	394
	Area, ha	66,994	61,088	66,129	66,361
Pigeon pea	Yield, kg ha^{-1}	652	679	778	753
	Area, ha	140,686	137,332	136,019	139,899
Cassava	Yield, kg ha^{-1}	16,170	16,230	15,870	-
	Area, ha	166,125	172,186	201,703	-
Sweet	Yield, kg ha^{-1}	11,180	12,210	13,441	12,665
Potatoes	Area, ha	152,271	157,118	192,457	219,766
Potatoes	Yield, kg ha^{-1}	11,870	11,198	14,184	13,352
	Area, ha	13,472	14,312	22,794	25,814
Cotton	Yield, kg ha^{-1}	951	888	776	873
	Area, ha	53,191	41,135	48,481	47,469
Tobacco	Total sales, kg	134,386,237	159,705,835	440,098,524	-
	Area, ha	162,200	193,314	382,948	
Sunflower	Yield, kg ha^{-1}	533	611	630	651
	Area, ha	4580	4903	5704	6311

Interface between cropping systems, and soil fertility and water management. Due the predominance of Maize in the cropping systems in Malawi, recommendations and actual practice of soil fertility and water management have always been influenced by maize recommendations. To give examples, rotation systems are maize based. Ridge spacing of other crops are automatically the same as for maize, even though narrower spacings (other than the most common 90 cm between rows) are required for crops such as groundnuts and beans.

Highlights of soil fertility and water management research in Malawi, 1950's to 2004. Between 1950 and 1980 agricultural research was in its infancy during this time. However, a lot of achievements were made. The country was challenged to meet the food requirements of its growing population of about 4 million people. Between 1960 and 1975 the area planted to maize by small holder farmers rose from 65 % to about 75 %. Therefore, most of the work was on determining fertilizer packages for maize for the various hybrids and varieties, including the identification of the types of fertilizer. There were also recommendations for dollop (point placement) of fertilizer. This work led to the development of the blanket fertilizer recommendation of 90 kg N and 40 kg P_2O_5 ha^{-1}. Some of the highlights of the work are reported by Brown (1958). Some studies on use of farmyard manure were also conducted and recommendations drawn. The main linkage to extension was through demonstration and on-farm or "district" trials. Tables 2 and 3 are matrices summarizing water and soil fertility technologies available in Malawi, their adoption levels, and suggested way forward for maize based cropping systems, and groundnuts and legume systems.

Green manure studies. Studies were initiated by the maize agronomy team at Chitedze Research Station originally to screen for dry matter production and dry season survival (Kumwenda, 1990). However, few species survived the 7 month dry season in Malawi except pigeon peas. Further, damage by free ranging goats was a problem even for work on the station. Some species such as mucuna and crotalaria spp yielded high amount of dry matter (above 5 t ha^{-1}). Further work evaluated the performance of these species in row intercrops with maize. This work showed that the high biomass yielding species green manure are not suitable for intercropping. Some of this work was conducted on farm, but little farmer feedback was obtained. Work on grain legumes and green manures for soil fertility improvement was picked up by ICRISAT. They worked on pigeon peas, crotalaria and *Tephrosia vogelli* in Dowa, Dedza and Zomba. Their approach was participatory and they developed and documented what is now popularly called the "Mother and Baby trial" approach.

Table 2. A matrix summarizing water management and soil fertility technologies available in Malawi, their adoption levels, and suggested way forward for maize based cropping systems.

Activity	Research recommendation	Source	Farmers practice	Adoption levels and why	What can be done, experiments required
Tillage	Ridges at 90 cm	Department of Agricultural Research 1960's	Flats, mounds	Very high, was mandatory, believed to be effective	Reduce or increase row spacing according to environment
	Flat planting	Ngwira *et al.*, 1987; Saka and Kumwenda, 1998	Ridge	Very low, no promotion	Promote with conservation tillage (CT)
Planting	3 seeds x 90 or 75 cm, 2 seeds x 50 or 45 cm and 1 seed x 30 or 25	Department of Agricultural Research 1960-1970; 1985-1990	Variable	Quite high	Improve precision and make environment specific
Soil conservation	Contour ridges, bunds	Department of Land Resources, 1970's	None then	Low, accelerated by project activities only	Farmer to farmer promotion
Water conservation	Tied ridges	Department of Land Resources, 1970's , Kumwenda and Saka, 1998	Ridges only	Very low adoption-low promotion, labor issues, don't work when improperly done	Show importance in drought seasons, and no harm in wet seasons
	Pot holes	Kumwenda and Saka, 1998	Ridges only	None, no official support	Link with conservation tillage
Fertility management	92:40:0	Department of Agricultural Research, 1970's	Slash and burn, shifting cultivation	30% plus. Adoption linked to use of improved maize seed. High price main depressor, plus low produce prices	A need for area-specific, promote organic inorganic combinations
	Animal manure	Department of Agricultural Research, 1950-1970's	Mainly in southern Malawi, burying of maize and weeds during ridging as substitute	Low application. Transport bottlenecks cited	Promote as reclamation for abandoned land, or with more serious livestock farmers
	Green manures	Kumwenda 1995-1999	Continuous cropping, some stover incorporation	Negligible. Farmers cannot give up season	Link manure to animal feed, determine value of below ground and free falling litter
	Area-specific fertilizers	Maize Productivity Task Force (MPTF), 1999	Blanket rate, and variable types and rates	Very low adoption,- not promoted, trusted, complex to understand and manage generally	Develop and promote locally
Weeding	Weeding 3 times in the first 6 weeks	Department of Agricultural Research, 1960's	Haphazard	All sorts of combinations	Link with conservation tillage, farmer field school type demonstrations
	Herbicides	Department of Agricultural Research, 1960's	Haphazard	All sorts of combinations	Link with conservation tillage, farmer field school type demonstrations

Table 3. A matrix summarizing water management and soil fertility technologies available in Malawi, their adoption levels, and suggested way forward for groundnuts and legume systems.

Activity	Research recommendation	Source	Farmers practice	Adoption levels and why	What can be done, experiments required
Tillage	Ridges at 90 cm, 75 or 60 cm.	Department of Agricultural Research 1960's, Department of Agricultural Research , 1980'	Ridge planting, Flats, mounds in wetlands	Very high, was mandatory, believed effective	Reduce or increase row spacing according to environment
Planting	3 seeds x 90 or 75 cm, 2 seeds x 50 or 45 cm and 1 seed x 30 or 25	Department of Agricultural Research 1960-1970; 1985-1990	Variable	Quite high. Limitations is seed	Experiments have shown variation with variety and environment.
Soil and water conservation	Same as maize	Same as maize	Same as maize	Same as maize	Same as maize
Fertility management	None fertilizer application	Department of Agricultural Research, 1970's, 1980's	No amendments, sometimes residue incorporation	Widely adopted, farmers like no input crops	Fertility has declined. Need to examine again, especially where yields are low. Develop area specific recommendations

Development of organic manure recommendations. Most of this work on organic manure was conducted between 1950's and 1970's, and focused on determining optimum application rates for farm yard manure (compost) and khola manure (cattle) of varying qualities. The test crop was predominantly maize. The trials were large statistically designed, replicated trials. They were usually factorial experiments that sought to find out best combinations of organic and inorganic interactions.

SOIL FERTILITY RECOMMENDATIONS FOR MAIZE

Inorganic fertilizer types, rates and management. The guiding principle in fertilizer use is to supply the right type of fertilizer to the crop such that uptake by the crop is maximized, while minimizing losses and costs. This entails minding the soil's fertilizer requirements, and capacity of the soil to hold nutrients without being subject to leaching or volatilization. Fertilizer management is critical for the attainment of maximum yields in maize (Table 2).

Fertilizer types and rates. To obtain high yields and maximum returns from investment in fertilizers, farmers are advised to base their fertilizer application on soil tests. However, the major nutrients known to be deficient in Malawi are nitrogen and phosphorus. Responses to sulfur and other trace elements such as zinc and boron have also been detected in some areas such as Dedza Hills and Mulanje high rainfall areas. It is now recommended that basal dressing fertilizer should contain sulfur. This was demonstrated in the nation-wide verification trials coordinated by the Maize Productivity Task Force Action Group 1. The recommendations will change depending on whether the objective of the producer is to consume the maize or to sell. It is important to indicate that these area-specific recommendations were developed at a particular price for maize and fertilizer. At the time of development, the ratio of the urea to maize price was 2.3, using the price that a consumer would pay for maize. The general guide is that if the fertilizer- price shifts by about 15 %, an adjustment should be made in the fertilizer rates. Recommended nitrogen fertilizer sources are urea, calcium ammonium nitrate and to some extent sulfate of ammonia. Urea is the cheapest source of nitrogen based on unit values in Malawi. Urea is best applied when soils are wet, and it is best to cover or bury applied fertilizer to avoid volatilization loss as gaseous ammonia. Nitrogen in form of nitrates (as in Calcium ammonium nitrate) is prone to leaching losses, which may be controlled by only applying small amounts which the crop may use.

SOIL FERTILITY RECOMMENDATIONS FOR LEGUMES

There are far fewer recommendations for legumes compared to maize (Table 3). In the draft Guide to Agricultural production, there is no mention of soil fertility recommendations for groundnuts (*Arachis hypogaea*, pigeon peas, ground beans or bambara groundnuts (*Vigna sub terranean*), chickpeas (*Cicer arietinum*), cowpeas, field peas (*Pisum sativum*), green or black grams and guarbean (*Cyamopsis tetragoloba*). Only soybeans and common beans (*Phaseolus vulgaris*) have a recommendation on fertilizer. For both, a basal dressing of 23:21:0+4S at a rate of 80 to 100 kg ha^{-1} is recommended, to be applied at planting. It is generally recommended that a crop of legumes, particularly those grown in pure stands, should follow a crop of maize, or any crop which received fertilizer, so that it can take advantage of the residual fertilizer in the crop, inparticular, phosphorus. Many of the recommended soil fertility amendments for maize are meant to benefit subsequent legume crops.

SOIL FERTILITY RECOMMENDATIONS FOR NON-LEGUMES

The fertilizer recommendation for cotton is 34 kg ha^{-1} N, 45 kg ha^{-1} P_2O_5 and 22 kg ha^{-1} S. There are special emphases for manure use and rotations. However, the common assumption is that the rotations and manure recommendations for maize will benefit the cotton crop. To avoid build up of insect pest problems, a cotton crop should not be repeated on the same piece of land. For sunflower, the recommended nutrients are 40 kg ha^{-1} P_2O_5 and N 40 kg ha^{-1} P_2O_5 and N. There are no fertilizer recommendations for cassava and sweet potato. There are no particular recommendations for improving fertility even with manures and green manures specifically for these crops.

CURRENT WATER MANAGEMENT RECOMMENDATIONS

Water management of crops through crop management options. Agronomic practices have been used by smallholder farmers in semi-arid areas of Malawi to harness the use of water and soil moisture. Planting of early maturing varieties, early planting and tied ridging are some of the agronomic practices recommended to overcome drought effects and consequently improve crop yields (Thornton *et al.*, 1995; Panje, 1986; Johnson, 1973). The recommended time of planting maize is with the first effective rains. As a guide, planting should be after a rainfall of at least 24 mm has occurred. This is most likely to occur within a rainy pentad. This enables the plant to take full advantage of the season. In addition, the crop takes advantage of ‘nitrogen flush’. This is the release of nitrogen from dead microbial organisms and organic matter from the soil following the first rains. This nitrogen is normally accumulated at the end of the rainy season and remains so through the dry season. Delaying planting causes considerable yield losses. There are many reasons for reduced yield due to late planting. One such reason is a drop in temperatures. The optimum temperature for germination and emergence is the range 20-22 ^{o}C. After prolonged rains soil temperatures tend to drop, and this could slow down germination and render crop prone fungal and pest attack. As the season progresses rainfall pests such as grass hoppers, rodents and weeds build up and these may retard attainment of good crop establishment. Cool temperatures during the seedling stages normally restrict nutrient absorption and cause slow growth. In the V3 stage the tassel initiation and total number of leaves formed are delayed.

For both maize and legumes, we highlight the fact that a lot of options have been evaluated for increased production. However, over the years, conclusions that were drawn in one season differed from another, and responses of fertility amendments depended on sites and type of variety. At the present time, fertility has declined further in Malawi. Hence, we recommend that responses of crops to nutrients should be correlated to soil test results, soil type, and stratified by agro-ecological zone. At the local level, simple demonstrations should be conducted, and farmers should be trained to evaluate these, using simple cost-benefit analysis.

Plant density and spatial arrangement: Another means of managing water and soil fertility is through regulating plant density. Plant densities are regulated to match with the rainfall amount, distribution and duration. As an example, recommended plant populations of maize which show variations with soil fertility and climatic conditions are presented below.

Recommendations of plant populations for different ecologies and production environments

In the mid-altitude areas which receive more than 800 mm annual rainfall, maize population can be increased to 44,444 plants ha^{-1} for medium to late maturing hybrids. For early hybrids, the population may go up to 55,000 plants ha^{-1}.

In the Lake Shore areas and marginal areas which receive less than 800 mm annual rainfall, population density of maize is in the range of 27,000 to 37,000 plants ha^{-1}.

When maize is grown without fertilizer, plant densities should be much lower than 37,000 plants ha^{-1}, preferably in the range 20,000 to 24,000 plants ha^{-1}.

Ridge spacing: spacing of ridges at 75 cm is comparable or better to 90 cm in terms of yields. Further, planting on 75 cm ridges is advantageous in that other crops such as beans, groundnuts or soybeans can easily be grown at densities, which are desirable for high yields. It is easier to attain low or high maize population density, when desired, by adjusting the distance between stations within the ridge.

Single plant or hill spacing: In theory, plants planted singly grow better as they have minimum interplant competition, as access of leaves to light is optimal. In practice, this concept has not been consistently demonstrated. One must also consider the labor involved in the system. Seeds planted in hills help each other to overcome crusted surface or soil clods during emergence. Also, single plant spacing may not be compatible with in-row maize-legume intercropping systems. The rule is that the number of plants per hill should not exceed 3. Lower plant populations are generally associated with greater weed problems.

WATER MANAGEMENT OF CROPS THROUGH SOIL MANAGEMENT OPTIONS

Tied ridging. Tied ridging, a water conservation technique, has been shown to increase crop yields in Malawi (Wiyo, 1999), Zimbabwe (Vogel, 1994; Vogel, Nyagumbo and Olsen, 1994), and in Tanzania (Hatibu *et al.*, 1994). Despite its merits, tied ridging is not popular among smallholders in Malawi. This is because this system is associated with forced labor soil conservation practices in colonial era (Materechera and Mloza-Banda, 1994). According to Kumwenda and Saka (1998), planting on the flat with pot holes is more attractive than ridging with cross-ties because it is less labor demanding. The only operations required for flat planting and pot holing are land clearing (if necessary), planting and pot holing in first weeding. Pot holes serve to harvest and store water for use by the crop during dry spells. Flat planting is also known to give higher crop yields than planting on ridges (Ngwira, Kumwenda and Minjale, 1987). Kumwenda and Saka (1998) reported that flat planting with or without pot holes resulted in highest yields with or without fertilizer application when compared to ridging suggesting that higher soil-water storage characteristics and perhaps infiltration resulted in efficient fertilizer and/or nutrient utilization. This indicates that pot holing has potential as a soil-water conservation practice which should result in increased yields especially in drought years.

Surface mulching. Some of the functions of mulching, which is the deliberate placement of plant residue on the soil surface, is to conserve moisture and control weeds through smothering. Mloza-Banda and Materechera (1999) compared the effects of maize residue removal; incorporation and burning on maize yield and weed response. They reported that highest yields were recorded where residues were incorporated or mulched. Cover crops can also be used as mulches to smother weeds and conserve moisture. Suitable cover crops are short and creeping plant types and should preferably fix nitrogen. In Malawi, velvet beans, sweet potatoes are potential cover crops. Yenish *et al*., (1996) reported that although cover crops had significant control of weeds, they should always be used in combination with other control measures due to their inconsistency. In Malawi conservation agriculture as a system is being widely promoted in a partnership between the Ministry of Agriculture, Sasakawa Global 2000 and Monsanto. Apparently many farmers are taking up the system voluntarily. It is well established that the benefits of mulching in conservation agriculture comes at least in the second year of practice.

Surface mulch, ridge-tillage system. There are various forms of tillage and mulching in between conventional tillage and conservation agriculture (reduced or zero tillage) in Malawi. There are some surface mulch-ridge tillage systems that were adopted for demonstration to smallholder farmers as a variation of conservation tillage systems which are systems for managing crop residues on the soil surface with reduced or no tillage (Unger and McCalla, 1980; Lal, 1995). The goals of these management systems are to maintain adequate plant residues on the soil surface at all times to control wind and water erosion effectively, to conserve water, and to maintain or improve crop yields. Thus conservation tillage is aimed at alleviating specific constraints, e.g., accelerated erosion, drought stress, surface sealing and crusting, subsoil compaction, unfavorable soil temperature regimes, anaerobic conditions in the root zone, and other factors responsible for low soil fertility. Reductions in energy, labor, amount of equipment, and its frequency of use are often additional benefits (Mloza-Banda, 1995).

Crops differ in their requirements relative to tillage-induced conditions, such as soil water content, weed control, aeration, root zone depth, and fertility (Lal, 1995). For instance, soybean is more sensitive to fluctuations in soil temperature and moisture than maize or cowpea. High temperatures and drought stress commonly experienced during the growing season adversely affect soybean germination and seedling establishment. Groundnuts are sensitive to soil compaction associated with old ridges or in no-till situations. Brown (1958) reported that there was a slight yield advantage obtained from splitting the ridge (other than using old ridges and digging furrows) purportedly arising from better rainwater percolation. Nyirenda (1977) compared crop growth and yield of maize planted on new ridges, old ridges, furrows and on flat. Highest and lowest percent seedling emergence were obtained from planting on flat and on old ridges, respectively. Although grain yield did not vary significantly, there was an appreciable yield difference between old ridges, which yielded lowest, and the other three treatments whose yields were similar. Kumwenda (1990) evaluated the efficacy of a permanent ridge system (use of old ridges) in the reduction of labor required for remaking ridges and facilitating early planting. He reported that there were no significant differences in plant height, number of leaves, and grain yield of maize in the first season between permanent ridges and ridges that were remade. Mloza-Banda and Materechera (1995) and Materechera and Mloza-Banda (1995) reported that bulk density and penetration resistance of soil on the ridges were less under conventional tillage than minimum tillage and this was reflected in lower root length and density, roots being concentrated on the surface under minimum tillage than conventional tillage.

Various modifications of surface land configuration have been attempted for rainwater management in different rainfall regions of the country although without employing surface mulch (Mloza-Banda, 1995). The aim has been to increase storage of water in the soil profile and to increase runoff collection, storage, and use in areas or seasons with rainfall deficits (Unger, 1984). Singa (1986) at Chitedze found that planting on flat on “well ploughed land” was superior to ridge cultivation in yield and labor saving in groundnuts and maize production. He noted, how ever, that crop performance for flat planting deteriorated over the three-year period of the trial and associated this with poor plant root extension. The water-conserving benefits of a mulch tillage system have been ascribed to reduced run-off and lower evaporation (Unger, 1984). Maintenance of crop residues on the soil surface during non-crop period is also seen as a way of increasing soil water storage. In arid or semi-arid locations, additional water can improve crop growth and yield while in shimmed locations it is less beneficial except during short-term droughts or at planting when precipitation is limited or erratic. Evaporation accounts for the major loss of water from many cultivated soils especially in semi-arid regions. The effect of a surface mulch to reduce evaporation of soil water has long been recognized. However, the effect of mulches on evaporation is difficult to establish because of the interacting influence on water infiltration, distribution, and subsequent evaporation (Unger, 1984; Unger and McCalla, 1980). Weed management as a water management measure. Weeds are the single most important factor capable of causing the greatest negative impact of on yield. The effects of weeds are mainly through competition for water and nutrients. Therefore, weed management is an integral component f both soil and water management. The general recommendation in maize is that weeds must be controlled within the first 6 weeks of crop growth. Weeds are controlled by primary tillage practices such as plowing, harrowing and discing, followed by secondary tillage operations.

Tillage operations, however, have a setback in that they render the soil prone to erosion through loosening of the soil. In the mid-altitude areas of Malawi, at least two weeding operations are recommended. The first should be within first two weeks, and the second within 6 weeks. In the warmer Lake Shore areas, plant growth is much faster and weed growth is equally vigorous. At least three weeding operations are recommended. Weeding should begin earlier.

Integrated crop and nutrient management approach. As there are many reasons for decline in soil fertility in Malawi, such as soil erosion, non-use of fertilizers and lack of crop rotation, farmers are advised to practice an integrated crop and nutrient management approach. In this approach all aspects of crop and nutrient management within the farmers' reach are encouraged. For example, farmers must follow practices that control erosion such as contour ridging and planting of soil binding plants such as vertiver, and constructing box ridges. In addition farmers must utilize available organic nutrient sources such as animal manures and legume crop residues for soil fertility enhancement. Leaf loppings from existing shrubs such as Tithonia (wild sunflower) Glilicidia, Casia etc must be used. The animal manure should be well cured for effective results. Non-nitrogen rich crop residues should be used in compost making. All these fertilizers should be combined with proper crop management already described in this paper, such as early planting and timely weeding.

ADOPTION LEVELS, CONSTRAINTS TO TECHNOLOGY ADOPTION AND SUGGESTED PRIORITIES FOR CHANGE

Summary of present status and related research and development issues. There have been numerous research efforts and notable levels of adoption of soil fertility and water management technologies. Maize and groundnuts ideally represent the maize based system and the legume crop system. The reason is that all crops follow maize in the crude rotation system practiced by Malawian small holder farmers. However, as discussed earlier on, the ideal situation on ridge spacing of many legume crops is compromised this way. For the legumes, one of the constraints is that farmers do not incorporate residues. The reasons vary with various crops. For groundnuts, the harvesting practice is that farmers uproot and heap the stover in several parts of the field for plucking. It then becomes laborious for farmers to redistribute the stover and bury. For soybean, the situation is similar, since plants are usually carried to the homestead. In many cases these residues are burned by wild fires or by children roasting potatoes or groundnuts. Advantage could be taken of the residues taken to the homestead to make compost manure.

Comparison of yield gap for maize and legumes. The yield gap described already shows that crop productivity is low particularly for maize. Potential production is 6-7 t ha^{-1} for maize, 3 t ha^{-1} for sorghum, 1-2 t ha^{-1} for groundnuts, 2.5-3 t ha^{-1} for beans, 4.5 t ha^{-1} for soy bean, 2.0 t ha^{-1} for cowpeas. Yields of maize leave the widest gap, since potential yields are up to four fold of actual yields. There are several major constraints frequently mentioned. Several studies carried out in Malawi listed the major constraints for maize as: declining sol fertility, high cost of inputs, predominant use of unimproved varieties, and labor bottlenecks. For maize, the high cost of inputs, particularly fertilizer is a major problem. Being open pollinated, maize seed cannot be recycled, unless it is an OPV. Even with an OPV, seed can not be multiplied in tiny fields, as the more likely it will be contaminated. For other crops such as groundnuts, the main problem is access to original good quality seed which the farmer can multiply. Although for some crops there are no fertilizer application recommendations, this is only so because these crops are meant to follow maize.

Non-adoption of area specific fertilizer recommendations (maize) to make an impact. A key research and development issue was the development of area specific fertilizer recommendations, and related soil fertility technologies by the Maize Productivity Task Force (MPTF). Chirembo *et al.* (1999) noted that the small plots of 0.01 ha used would be one possible reason of poor effectiveness of the MPTF demonstrations. They argue that extrapolation of results from such small plots to larger units such as a hectare tends to be obscure to farmers. They recommended the use of larger plots, such 0.1 ha or above to enable farmers to visualize treatment differences and also the associated practices. In addition, farmer field days should highlight the totality of such demonstrations. For example, fertilizer or manure field days should also emphasize on timely planting, fertilizer application and use of improved varieties and good weed management. Farmers should be told that crop response to inputs may vary. The different factors responsible, such as crop rotations, use of manures and type of tillage should be emphasized. Adoption of these technologies has been very low. It is, therefore, important to move with caution on issues of research and development. However, by following trends in past research results, particularly with groundnuts, it is seen that few conclusions were drawn due to inconsistency in results. In some areas the crops responded to application of manures or fertilizers, and in some cases not. For future area specific technology development, it is recommended that only technologies that are much more intimate to farmer participatory approach should be encouraged. Farmers should be in agreement with the problem of low yields and its possible causes, followed by farmer-designed farmer-managed trials in liaison with researchers and extension workers.

Constraints to adoption of technologies. In a report on the findings of a snap survey, Kabambe *et al*. (2005) reported that some stakeholders cited laziness as a constraint, lack of access to credit, high cost of inputs as major constraints. Other constraints are listed below.

1. Shortage of seed such as pigeon peas and groundnuts and planting materials in some areas.
2. Lack of appropriate technical messages knowledge, and skills and their technical back-up.
3. Limited land holding sizes particularly for technologies requiring pure stand or improved fallow.
4. Technologies such as organic manure are said to be labour demanding as most farmers have no farm carts or wheelbarrows
5. Limited access to inputs such as fertilisers and wheelbarrows for transporting manure to the field.
6. Lack of market for grain legumes such as mucuna and pigeon peas in areas where they are not consumed.
7. Farmers are unwilling to adopt technologies such as agroforestry that have long-term benefits. Farmers who experience regular ‘hunger periods’ cannot wait for benefits that take a number of years to be realised.
8. Farmers are unwilling to adopt technologies that have no significant impact on yields.

Suggested way forward

Attractive technologies. It is important therefore that technologies must be quite attractive to farmers even in the first year. Non yield or food crop benefits (such fire wood, animal feed) should be well evaluated and ranked with farmers so that they satisfy an important need for the farmer. Some technologies do not meet farmers' objectives; soil fertility is not the sole objective. Farmers have multiple objectives for adopting a particular technology.
The holistic approach in recommendations where several options are given is commendable. Minimum quantity and quality requirements for technology to work must be given. A good example exists with compost manure where when there is no emphasis on minimum quality standards and amounts it can frustrate farmers and kill enthusiasm.

Improved learning process. In Malawi many credit schemes have been implemented and concluded and gone. Many of these have recorded high levels of success during the life of projects or schemes. For example there was the Lilongwe land development project which was operational in the 1970's and 1980's. Farmers had access to seed and, and fertilizer loans and assisted with produce marketing. The result was high levels of productivity of maize, which made a surplus food for the country. Now it is the same farmers that are food insecure, for more than 3 years in a row. To date, Sasakawa SG 2000 is promoting high input, high management of maize, and generally, collaborating farmers are recording high yields. These points seem to suggest that farmers in Malawi do not only need credit, but require close supervision in early stages, to enable them obtain conviction about the superiority of a technology. Therefore approaches such as the farmer field schools, farmer to farmer extension, and other farmer extension involving farmer participatory management of demonstrations would probably be useful.

Participatory technology development. For market oriented farmers, as markets become lucrative and demand increases, farmers would be more willing to increase inputs in order to increase yield and income from the same piece of land. For such farmers, farming practices such as seed dressings to control insect pests and diseases, spraying for control of foliar diseases, liming and other yield increasing practices should be evaluated basing on recommended and improved practices.

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IMPACTS OF LAND-USE CHANGE ON THE WATER QUALITY OF THE MAIN SOURCE OF PIPE BORNE WATER FOR KUMASI, GHANA (A CASE STUDY OF THE BAREKESE RESERVOIR CATCHMENT AREA)

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The barekese reservoir provides 80 percent of the total public pipe borne water to the kumasi metropolis and its environs. However over the past two decades there has been persistent degradation of the watershed through anthropogenic activities along its catchment area which also raises concern on the deteriorating water quality. The aim of this study was to identify the main land-use changes along the catchment area and asses its impacts on the reservoir's water quality. Data was extracted from three cloud-free landsat thematic mapper images obtained in 1973, 1986 and 2003. Questionnaires were administered in seven communities along the catchment area. From 1973 to 1986 the closed forest decreased by 43.54% whereas the open forest increased by 52.91%. From 1986 to 2003 open forest decreased extensively by 55.25% resulting in more grassland and open area/towns. Despite wide recognition of the need for catchment-scale management to ensure the integrity of the reservoir. The study reveals unsustainable agricultural practices, bushfires, uncontrolled deforestation, enormous encroachment of the reserve as a result of poverty and weak institutional mechanisms were the factors responsible for the degraded water quality and quantity of the reservoir. It is paradoxical that humans, who are the worse affected by water shortage are the architect of their own misfortune.

Keywords*:* barekese reservoir, land use change, water quality and catchment area.

1.0. INTRODUCTION

The impacts of Global Change induced by a changing climate or by various land-use changes on the regional water cycle are some of the most urgent issues of today's hydrological research. Since the most important sources and drivers of Global Change are located at regional and local scales, a stronger emphasis is needed at these scales, where political and technical measures can be taken, in order to avoid critical developments for the environment and society. Though the direction and magnitude of climate changes are not yet fully clear, studies indicate considerable regional vulnerabilities against changes of both temperature and precipitation patterns. Land use or land cover changes, on the other hand, represent another anthropogenic 'system disturbance' which directly or indirectly influences many hydrological processes (Lahmer et al,2000).Besides the given physical characteristics of a region, socioeconomic aspects play a crucial role in these kinds of changes.

Land use or land cover is the second of the main boundary conditions which directly or indirectly influence many hydrological processes. Under certain circumstances land-use changes as another important component of Global Change may induce comparable effects on water quantity and quality. Like climatic changes, changes of the actual land-use have far-reaching impacts on the regional water cycle. Besides the given physical characteristics of a region, socio-economic constraints strongly influence measures of land use changes (Lahmer et al, 2000). The concept of land use is often considered a relatively stable subject related mainly to the use to which the land, in a certain region at a certain time, is put. A series of operations on land, carried out by man, with the intention to obtain products and/or benefits through using land resources is called land use (Huizing, 1993). Land use is carried out in many different ways; the broadest categories include rural land use and urban /industrial land use (Suraj, 2005). In this study emphasis is put on the rural and use.

In Ghana, only about 30% of the population of Ghanaians can be said to have readily access to portable water. The progress in improving water supply in Ghana has been much slower than in health and agriculture. Yet, a dollar spent on clean water produces a greater improvement in the quality of life than a dollar spent on doctors or hospitals. Although Ghana has abundant water resources, the country experiences chronic water shortages due to poor distribution of rainfall, prolonged drought and poor management of water resources. In many areas, particularly in the urban centres, many people lack access to potable water supply. Throughout the country, problems of urban water supply are severe because the Ghana Water Company Limited (GWCL) has not been able to supply water to meet urban water demand for household and industrial consumption. The principal objective of the study is to identify the main land use and assess the implications of the of land-use change along the Barekese catchment area on the water quality.

2.0 MATERIALS AND METHODS

Study Area

The Barekese Basin is located approximately 26km north of Kumasi. It lies on latitude 060 52'N and longitude 010 49'W. The overall crest length of the width is 6.096 meters above sea level and has a maximum width of 91.74m 5. It was formed by building an earth and concrete dam of 548.78m long transversely across the river Offin that takes it source from the Mampong Ridge. The reservoir has a surface area of approximately 16.000 acres with average depth of 33m and a catchment area of 351sq miles (10800 acres). The Barekese Head works which solely draws water from the Barekese Reservoir supplies 80% of the daily water requirement of the Kumasi metropolis. The remaining 20% is augmented by the Owabi Reservoir. The reservoir and water works is therefore of immense importance to the people of Kumasi and its environs in terms of water, sanitation and health needs.

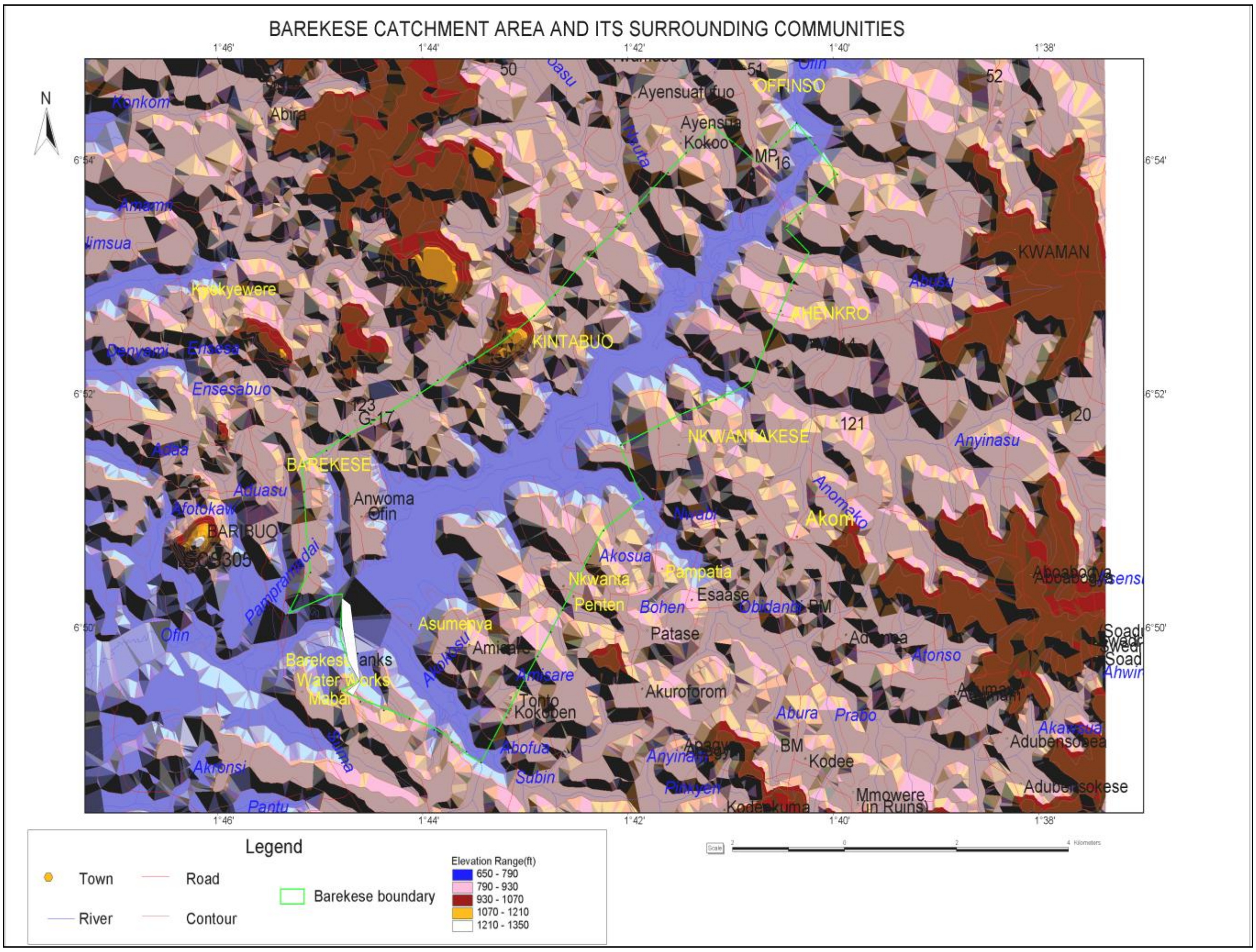


Fig. 1 Barekese catchment area and its surrounding communities.

Questionnaire Administration

The following towns and villages along the Barekese catchment area were selected for questionnaire administration: Ayensua Fufuo, Ayensua Kokoo, Penten, Denasi, Esaase, Pampatia, Nkwanta and Nkwantakese. Formal questions were framed and written down for the inhabitants to provide answers. The questionnaire will contain both closed and open-ended questions framed to satisfy the objectives of the study.

Change Detection

Geographic Information System (GIS) technique was employed to establish land-use change within and along the Barekese catchment area.The data used to estimate land use changes were extracted from three cloud-free LANDSAT Thematic Mapper (TM) images obtained in 1973, 1986 and 2003. All the three images were registered to the Universal Transverse Mercator (UTM), Zone 31 geographic projection. The ERDAS Imagine and Arcview GIS softwares were employed in the change detection. Satellite scene used was 194055 on Satellite path 194 and row 055. The Landsat Thermatic Mapper satellite imagery was preprocessed to convert the image to reflectance to correct for sun angle and seasonal differences. The Satellite image was first geometrically corrected to orient the pixels to the real world coordinates. TM Ghanafeet projection was used because the base vector data is in TM Ghanafeet projection and also to ease the computation of the area.

Erdas Imagine was used to classify the image into five classes. Using ERDAS IMAGINE, the data was stacked by date within the same path and principal components, a process that prepares the data for classification by reducing noise and redundancy. An unsupervised classification method was ran on the imagery the field data used to identify spectral categories and finally verified on the field. A 3x3 filter was passed to remove noise to define real boundaries for area calculation. The three different images were analysed and compared using a simple bar chart in ArcView to determine the change over the thirty-three (33) year period.

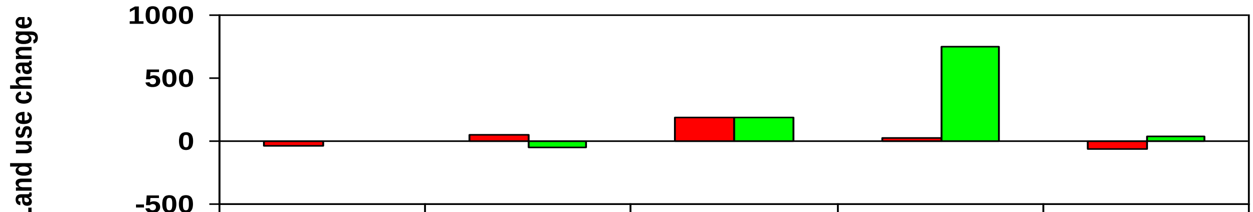
DATA ANALYSIS

The statistical package for social sciences (SPSS) was employed for testing the various statistical relationships between variables (Anon, 1988).

3.0 RESULTS

Change detection from 1973-1986-2003

From 1973 to 1986 the forest (closed) decreased by 43.54% whereas the open forest increased by 52.91%. Grassland and open area/town increased appreciably from 1973 to 1986 by 186.52% and 25.96% respectively. The size of the reservoir decreased in size by 60.91%. From 1986 to 2003 the closed forest increased by a very small margin of 1.06%. Grassland increased by 181.32%, though this increase was not as much as that of 1973 to 1986 (186.52%). From 1986 to 2003 the catchment area experienced momentous increase in open areas/towns by 755.40%.



	FOREST	OPEN FOREST	GRASSLAND	OPEN AREA/TOWN	WATER BODY
%change86	-43.54084056	52.91485731	186.5236343	25.96759401	-60.91197219
%change2003	1.065489584	-55.25241272	181.3245303	755.3975342	38.27160494

Land use

Figure 2 Percentage land use change along the Barekese catchment area from 1973 - 1986 - 2003

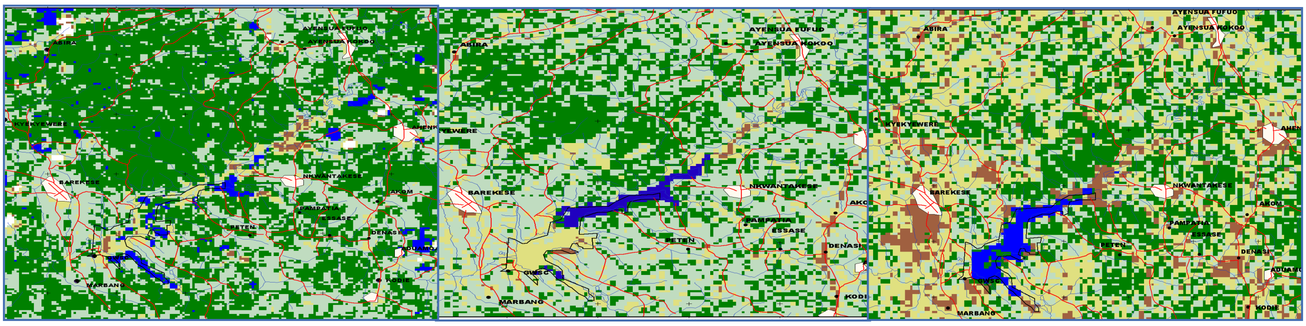


Fig. 3 CHANGE DETECTION OF THE BAREKESE CATCHMENT AREA FROM 1973 -1986-2003

IMPACTS OF LAND USE CHANGE

Farming was the dominant land use with 80 percent of the communities lacking kumasi ventilated latrine pits and coupled with the deplorable sanitary conditions which, has the potential to contaminate the water resources.

Table 1 Respondent's accessibility to KVIP

% within Community of Respondent

		Community of Respondent							
		Ayensua Fofuo	Ayensua Kokoo	Denase	Esaase	Nkwantakese	Pampatia	Penten	Total
Respondent's accessibilit to KVIP	Yes	7.4%	15.8%	100.0%	40.0%	33.9%	100.0%	8.8%	47.6%
	No	92.6%	84.2%		60.0%	66.1%		91.2%	52.4%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

In general 70% of all the communities did not have access to pipe-borne water and depended solely on the feeder streams of the reservoir (Table 2), with more than half (51.6%) of the communities not having access to KVIP facilities (Table 1).

Table 2 Respondent Source of Drinking Water

% within Community of Respondent

		Community of Respondent							
		Ayensua Fofuo	Ayensua Kokoo	Denase	Esaase	Nkwantakese	Pampatia	Penten	Total
Respondent Source of Drinking Water	Pipe-borne	7.4%		3.6%		1.6%			2.0%
	Well/ Dugout					3.2%		2.9%	1.2%
	Stream			5.4%	20.0%	24.2%		64.7%	18.4%
	Bore-hole			14.3%					3.2%
	Pipe-borne and Strean	92.6%	100.0%	76.8%		66.1%		8.8%	52.4%
	Well/Dugout and Strea				80.0%	4.8%		23.5%	14.0%
	Stream and Bore-hole						100.0%		8.8%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The use of the reserve was very alarming in all the communities 88.6% (Table 3)

Table 3 Farming or Hunting in the Reserve

% within Community of Respondent

		Community of Respondent							
		Ayensua Fofuo	Ayensua Kokoo	Denase	Esaase	Nkwantakese	Pampatia	Penten	Total
Farming or Hunting in the Reserve	Yes	88.9%	100.0%	5.4%	53.3%	54.8%	45.5%	79.4%	53.2%
	No	11.1%		92.9%	46.7%	41.9%	54.5%	20.6%	45.6%
	Not Applicable			1.8%		3.2%			1.2%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

In Ayensua Fufuo and Ayensua Kokoo as much as 96.3% and 89.5% respectively were farming on water courses (Table 4). Several reasons were given for this activity which includes scarcity of land, non payment of compensation and as a form of protest.

Table 4 Farming on watercourses

% within Community of Respondent

		Community of Respondent							
		Ayensua Fofuo	Ayensua Kokoo	Denase	Esaase	Nkwantakese	Pampatia	Penten	Total
Farming on watercourses	Yes	96.3%	89.5%	23.2%	53.3%	48.4%	40.9%	35.3%	49.2%
	No	3.7%	10.5%	76.8%	46.7%	48.4%	59.1%	64.7%	50.0%
	Not Applicable					3.2%			.8%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The use of fertilizer and other agro-chemicals for the cultivation of vegetables and cocoa was 75% in the communities (Table 5).

Table 5 Respondent's use of fertilizer and chemicals on the farm

% within Community of Respondent

		Community of Respondent							
		Ayensua Fofuo	Ayensua Kokoo	Denase	Esaase	Nkwantakese	Pampatia	Penten	Total
Respondent use of fertilizer and chemical on the farm	Yes	55.6%	73.7%	8.9%	53.3%	27.4%	27.3%	41.2%	34.8%
	No	44.4%	26.3%	91.1%	46.7%	71.0%	72.7%	58.8%	64.8%
	Not Applicable					1.6%			.4%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

4.0 DISCUSSION

IMPLICATIONS OF CHANGE DETECTION OF THE BAREKESE CATCHMENT AREA FROM 1973-1986-2003

The Barekese reservoir catchment area has undergone tremendous change from 1973-1986-2003 as a result of anthropogenic activities. It is obvious that the decrease in the closed forest from 1973 -1986 led to an increase in open forest, grassland and open area/town. The decrease in closed forest and an increase open forest, grassland and open area/town could be attributed to the 1983 countrywide bushfires and also as a result of human activities. The decrease in the size of the water body could be as a result of uncontrolled water weeds which covered the surface of the water from 1973 to 1886. The evasive water weeds were confirmed by the Ghana water company which at that time resorted to the use of chemicals to control the weeds. However the chemicals did not help since it rather escalated the water weeds. Presently the weeds are removed manually with the aid of a boat.

From 1986 to 2003 the closed forest increased by a very small margin of 1.06%.This increase could be attributed to increased plantations undertaken by the Ghana water company to salvage the deforested area. The campaign of planting trees to protect the integrity of the reserve could have resulted in the 1.06% increase though this increase was not encouraging because the project was abolished before the objectives were met as a result of lack of funds to sustain the entire project. The open forest decreased extensively by 55.25% resulting in more grasslands and open area/towns. Increased grassland can be attributed to increased agricultural activities, logging and chain saw activities by a rather increasing population which results in the clearing of more open forests and closed forests. This earth-shattering increase may possibly be credited to increased population of the communities along the catchment area and ensuing encroachment of the reserve.

Implications of Land use change along the Barekese catchment area

Ideally, there should not be farming in the reserve and on water courses. Forests protect watersheds and ensure perennial supplies of freshwater. The reasons for the increased anthropogenic activities in the reserve are multifaceted. Firstly, the populaces along the catchment area are bitter they feel they have not been given a fair share of the national cake. To them they lost their lands as far as 1969 and have since not been compensated and all the promises of free access to pipe-borne water and electricity never materialized. Agriculture is the basis for human food security and sustainable development. It is also a major contributor to habitat change and, in the worst cases, environmental degradation. Throughout the country destruction of watersheds, contamination, and overexploitation of underground water resources pose a serious challenge to agriculture, industrial development and the health of people in the urban and peri-urban areas.

According to Harris (1997) the chemical fertilizers most commonly used in and around Kumasi include compound 15(N): 15(P): 15(K) and ammonium sulphate, mainly applied to vegetables. Application of these fertilizers and their subsequent leaching into surrounding water bodies by runoffs and other hydrological processes could raise the nutrient status of the water resources, even though the current nutrient status of the waters in the Ashanti Region is found to be generally low (CEDAR, 1999). In these vegetable-producing areas, riverbanks are cultivated and large amount of water is pumped to water crops. The use of water to increase biomass production in agriculture and forestry affect both the quantity and quality of water sent to the downstream communities. The increased effects of deteriorated water quality on the health of living beings in general and on the humans in particular could be potentially devastating, given the significant role of water in human activities.

The annual burning of vegetation at watersheds has devastating effects on water resources. According to Nsiah-Gyabaah (2000) when watersheds are cleared of vegetation, several environmental changes may occur to include: increasing stream run-off, floods and travelling more quickly after storms. Sediments may be deposited on previously 'clean' streambeds and the migration and spawning of fish may be affected. Soil erosion spreads, the sediment in rivers increase, and river channels become silted alter significantly the flow of rivers during floods. Sedimentation in resources may alter their ecological characteristics and reduce their useful lifetime. A catchment approach to the study of the Midwestern U.S.A. river system indicates that water quality, habitat and biotic integrity of the river are strongly influenced by land use. It can be suggested that human alteration of the landscape affects the riverine ecosystem via multiple processes operating database. The present results suggest that management of local and riparian conditions will provide some benefits, but regional landscape conditions may be of greater importance (Doppelt et al., 1993).

Water can be considered not only as a public good, but has also to be regarded as a natural resource that is traded regionally and nationally and thus has its price. The political guidelines and standards are crucial. Land use on the other hand plays an important role in water resources management, which means that the farmers have to be involved in the process at a local level. The European WFD includes the polluter-pays principle. Under this aspect the compensation payments to farmers who are allowed to farm in water protection areas only under certain conditions can be seen in another light. The added value of water that is exported out of a region has to return to the region in order to guarantee the use of the resource in the long term. The socio-economic, physical-geographical and ecological interactions have to be recognised and recorded.

In some of the communities bilharzia was a major problem among children who bathed in the water bodies. The unsanitary conditions of these communities coupled with the contaminated water quality could account for this. Water pollution can render the water unfit for various usages, from nutrition to agriculture and industry (Marcoux, 1994). Marcoux (1994) asserted that the quantitative supply of water certainly can be a local issue, but in many regions, the most serious problems hindering the utilization of water resources is the deterioration of water caused by pollution. The utilization of degraded and contaminated waters for activities as bathing and drinking is one of the principal pathways for infections by diseases that kill millions and sickens more than a billion people each year. The inadequate safe drinking water or rather the lack of it renders its consumer vulnerable to water-related diseases, such as cholera, bacillary dysentery, *E. coli* infections, viral hepatitis A, typhoid, etc. In the case of the communities in the catchment area, the situation may be precarious considering the sanitary situation prevailing.

In a survey made by McGregor et al (2000) in some representative selected peri-urban areas around Kumasi reveal that there had been reported cases of Dysentery, cholera and bilharzias among other diseases to which children were being reported susceptible – as they tended to be more careless with hygiene, and as they swam in the surrounding rivers and streams. These effects are reported as being more prevalent downstream of Kumasi. The impact of contaminated water on food quality has also been reported by Ogoe (1996) and Owusu (1998) in Kumasi peri-urban irrigation agriculture, where nematode eggs have been detected in sampled water bodies including shallow and hand-dug wells, indicating the presence of helminthes.

5.0 CONCLUSION

The present price of water is often a political price that does not include all the costs incurred, but that can nevertheless be sometimes too high. The quantity and quality of the water available for a certain use have to be ensured subject to the physical-geographical conditions of a catchment area, i.e. not everywhere can every commodity be produced, if the water is to be used cost-effectively. Closer cooperation with water polluters has to be sought. Long-term effects of harmful input decades ago and short-term impact loads as a result of accidents, both at localised points and from diffuse sources in a body of water, require, because of the differing residence times, different standards. Ghana has a long history of attempting to safeguard the environment from being abused by enacting and including environmental protection in appropriate legislation. The cost at which treated water is made available is very critical especially in developing countries likely to be battling with abject poverty. If water rates are high people may consume lesser quantity. They will therefore resort to the use of raw surface water that is usually not safe for many purposes. The end result will be the epidemics of water.

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MULTIPLE PURPOSE FOREST RESOURCES MANAGEMENT: THE WATER PERSPECTIVE

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The idea of multiple purpose management of forest resources emerged in the United States in the first part of the 20th century, and has been emphasized worldwide since 1960s, by consecutive IUFRO (International Union of Forest Research Organizations) meetings as the basis of modern forestry. There wasn't however, much effort to diversify the forest products and uses in Turkey until recently, as forest management plans have mostly been established on an objective of optimum timber production. We recognize the lack of knowledge related to the other uses of forests, particularly on water production as one of the factors behind this ignorance. However, it is now clear that transformation towards meeting the growing demands of the public, or adapting the future vague stresses (e.g. water scarcity, energy crisis, climate change) is inevitable for all agencies in charge.

In this paper we discuss two major points related to this situation. The first one is; why Forestry service in Turkey, and the neighboring countries should focus on the water production functions of the forests, and give priority to this issue. This question also gives way to a discussion on the sustainability of water resources. The second one is to identify the challenges to achieve multiple purpose forestry, particularly related to water production.
The water resources management is rising as a crucial issue worldwide. It should be handled in harmony with the forest resources management, considering the production area of clean water. This statement is the basis of our approach to discuss the water production role of forests. We see the poorness of the region for long-term ecological and hydrological research as the main challenge towards this technical issue.

In this paper, we also mention a hierarchical planning, suggested for a conversion from traditional forestry management approach to a more flexible and beneficial modern one that promises the sustainability of forest resources in the long run, supporting a broader range of services. The points we discuss, and the solutions we propose should not be considered applicable solely in the context of Turkish forestry, but rather be perceived as a local reflection of emerging regional issues.

Keywords: *Sustainable forest resources management, multiple uses, water production.*

INTRODUCTION

Forests serve people by a mixture of various goods and services. In addition to many types of tangible goods, many services including recreational activities, soil, water and air conservation, avalanche, torrent and flood control are delivered by forest ecosystems (Ok, 2001). Managing forest resources towards more than one objective is simply referred as “multiple purpose management of forest resources”. One objective that should be prioritized in the regions of low precipitation is water production.

The 2006 human development report published for UNDP (United Nations Development Programme) emphasized the importance of water for humanity and mentioned water scarcity as a factor to hold back human development. The belief that suggest the shortage of physical resources as the reason of upcoming water crisis is rejected in the report, and the “roots of the crisis” were identified as poverty, inequality, and unequal power relationships as well as flawed water management policies (UNDP, 2006).

Signals of upcoming water problems are becoming more apparent in Turkey, too. Recently, ADASU (Adapazarı Water and Sewerage Administration) of Sakarya province sued ISU (Izmit Water and Sewerage Administration) of Kocaeli province because of a water conflict. Due to low precipitation in the Eastern Marmara region, a water scarcity problem emerged in one of the most industrialized cities of Turkey, Izmit. Water level of surrounding dams decreased below critical levels and therefore Izmit Great City Municipality started seeking further available water resources around. One option was carrying water from Sapanca lake to Izmit. However, municipality of Adapazarı claimed that ADASU has the only right to utilize the water of Sapanca located on the border of provinces (Cumhuriyet, 15/12/2006). Currently, the case is on trial. This was a typical sample of water conflict between two neighbouring organizations in local scale. In the next decades, the issue has a potential to rise to a regional level.

The problem of water scarcity can arguably be solved with the implementation of efficient and integrated management methods according to Stikker (1998). Even though not applicable to all situations according to us, this statement should be valid for most of the cases, in Turkey. Turkey is not a country rich in freshwater. With about 1500 cubic meters per capita, freshwater availability is far less than North America and Europe, somewhere around regional average. Considering semi-arid regions of Central Anatolia, SAP (Southeastern Anatolia Project), water quality issues, and transboundary rivers (Rowley, 1993; De Villiers, 2000), water is a major concern for Turkey. Another point is the cancer-like sprawls to consume all water resources around them. For example, more than 15 potable water reservoirs are in operation to supply more than 11 million people (census bureau estimation for 2005) of Istanbul (Serengil et al., 2006). Huge water resources development projects are underway to carry water to similar 3-4 cities. On the other hand, the rainiest geographic region, Blacksea, is not populated as much as Marmara, the industrial heartland of the country. In other words, available freshwater is not parallel with the population density throughout the country and due to summer water deficit for the most part, an effective water resources management policy is quite challenging. Population growth, water pollution, and increased water consumption due to economic development makes the situation even worse.

The efficient consumption of water by the people, sustainable use of water resources, and regulation of water regime arise as the main water issues around big cities. Watershed management discipline of forestry provides proven methods for the latter two. These methods involve vegetation management towards water production objective.

Forest management towards water production objective

Water is an essential output of forests and is critical to other processes, functions, and values of forest ecosystems. The studies related to the water production function of forests goes back to the first quarter of the 20th century. Long-term experiments, based on paired watershed methodology, constitute most of our knowledge on forest-water relationship. Some major points that have been put forward with these experiments are;

- Cutting timber increases water yield, while regrowth decreases. The amplitude of response is highly variable (Hibbert, 1967),
- Flow regime can alter with forestry treatments. Infiltration and ET (Evapotranspiration) determines the degree of reaction to perturbation (Bruinjeel, 1988),
- Forest vegetation properties including tree species, stand closure, leaf area, and stand age affect the flow pattern, water yield, and sediment discharge (Bosch and Hewlett, 1982; Vertessy, 1999; Vertessy, 2000, Brown et al, 2005),
- Different harvesting methods sometimes cause contradicting results in different ecological conditions (Vertessy, 1999; Vertessy, 2000; Brown et al., 2005),
- The duration of the increase in water yield is strongly related to the amount of cutting with the highest increase in the first year (Hornbeck et al., 1993; Stednick, 1996; Şahin and Hall, 1996),
- Forest-extreme flow interaction has not been studied extensively. However, Serengil et al. (2005) showed that forests can affect low flows much more than high flows.

According to these statements, forestry treatments can be implemented in a way to enable and sustain the water yield, regime and quality. In other words, forests can be managed towards water production objective if there is enough knowledge on the hydrological consequences of forestry treatments and planning decisions.

Other than general principles as explained above, regional studies are needed to identify, characterize, and propose site-specific forestry treatments. The only way to do that is long term hydro-ecological research (Serengil, 2005).

Department of Watershed Management in Faculty of Forestry of Istanbul University conducts Turkey's only long-term hydro-ecological research project on the hydrological effects of forestry treatments. Many long-term results, including a thinning treatment have been put forward and documented with that study (i.e. Özyuvacı et al., 2004; Serengil et al., 2006). However, the following points still remain intact;

- Species conversion (from deciduous to coniferous or vice versa),
- Different harvesting methods (clearcutting and strip cutting, various selective cutting intensities etc.),
- Forest type effects (coppice, old-growth etc.),
- Forest road construction,
- Wildfires,
- Fertilization and pesticides,
- Insect outbreaks,
- Cumulative effects of forestry treatments,
- Trade offs between various forestry functions (i.e. timber-water, recreation-water, recreation-timber),
- Optimum stand structures of the forests allocated for water production concerning age, species, density,
- Relation between time of the forestry treatments and annual precipitation periods,
- Valuation of outputs produced by water function of forest planning,

All these points, mentioned above, should be identified with long term experimental studies from both quality and quantity aspects in order to embody the water management in an effective multiple purpose forest management plan. Only forestry research administrations of the Ministry of Environment and Forestry have the capacity to carry out such extensive studies, but unfortunately the issue has not been prioritized in the current or master plans yet. The lack of researchers in this field is another constraint to be considered.

Challenges to establish an effective multiple purpose forestry approach

As mentioned above, the gateway to an advanced multipurpose forestry system is scientific research on the functions of forests. Planning studies on conflicting and consistent functions is the only way to provide applicative information that is required for forest management plans.
This is a key point for the implementation of a multiple purpose forestry because more than one objective need to be prioritized in most of the situations. In a study realized at Belgrad forest in Istanbul (Serengil and Özhan, 2006); water production and recreational use objectives were analyzed for their agreement and surprisingly recreational activities found to be harmless with respect to water quality. In controlled and suitable conditions (soil, slope etc.), recreational activities that cause compaction at the topsoil horizons were not causing a detectable level of deterioration on the quality of stream and reservoir water.

Belgrad State Forest Enterprise is an exceptional model for multiple purpose forestry concept. Because of the reservoirs it includes, water production function has been prioritized even in the earliest forest management plan (Eker and Ok, 2001). In the earliest forest management plan (1937) around 29 % of the forest was allocated water production. The share of timber production was still high (56 %) despite the unhealthy situation of the forest degraded by mass deforestations during the long war years. The areas allocated for non-timber functions increased in time. Finally, in 1990-1999 forest management plan, the portion of forestland allocated for water production decreased to 26 % percent, while the area remained almost the same (around 1 400 ha). The timber production objective was cancelled to give the emphasis on erosion control, scientific, recreational, and wildlife functions together with water collection. However, public pressure on the forest is still increasing but changed direction. The main problem now is uncontrolled intensive recreation.

On the other hand a problem still remain even if there is enough data to manage a forestland. That is decision making. One of the primary tools of multiple purpose forestry and a phase of planning process is decision support systems (DSS). A decision support mechanism follows the following logical path (Ok, 1999);

- Determination of decision alternatives,
- Selection of decision support criteria,
- Decision process by comparing the decision alternatives and criteria.

DSS are interactive information systems that provide support for decision-making in complicated conditions. The fundamental intend of DSS for forest managers is to provide efficient, explicit, and explainable means of choosing among alternative courses of action based on available information and outcome preferences (Rauscher, 1999). A multiple purpose forestry system requires readily available DSS in addition to data mentioned above.

Planning of forest resources

Forest resources of Turkey is planned by forest management commissions of Forest Management and Planning Administration with the authority given by a management regulation dates back to 1991 (Ok, 1999). Forest management commissions have to prepare management plans generally called as traditional plans regarding the articles written generally towards timber production in the regulation. In addition, forest management regulation is structured to explain the decisions needed by forestry administrations in only one step. As a result of this understanding, traditional forest management plans generally focus on timber production and the objective naturally is to maximize timber production.

However, traditional forest management plans have been discussed and criticized in Turkey for the last couple of decades. In this period, a new approach, called as functional planning, was offered by some foresters and scientists as a solution of the problems arise in traditional planning process. Many forest management plans were prepared concerning functional planning.

Functional forest management plans are basically a bunch of maps painted with different colors to sign different forest functions such as water, timber, wildlife. Decision criteria and methods used in allocation of the forest parts to any forestry function are still discussed by forestry society in Turkey. In addition, as functional forest management plans assign a function for any part of forest, further problems related to manage a function can still emerge in this planning process For example, functional plans cannot clarify the best management regimes for any functions in different time scales. For this reason, new approaches must be taken into consideration. Multilevel planning or hierarchical planning in forestry is one of them that must be investigated concerning its advantages and disadvantages for multi purpose forestry, especially for water production.

The hierarchical approaches are proposed due to excessive number of objectives, products, and criteria (Ok, 1999). In Table 1, a hypothetical hierarchy was established to demonstrate relations among forest functions and planning phases. Of course, cells related with each characteristic and phases in Table 1 may change with respect to problem specifications. The first step in this approach is strategic planning phase.

Strategic planning phase

Determination of the objectives (i.e. timber, soil-water conservation, or wilderness) is the main issue, while land allocation is the main decision in this uppermost level (Weintraub and Cholaky, 1991). Forestry functions, and their level to meet the demands of public and depending industrial sectors are the primary concerns (Table 1). Also, the amount of forestlands that will be allocated for each objective must be determined in this phase.

Table 1. Some characteristics of water production planning related forest resources concerning different planning phases.

Characteristics	Planning Steps		
	Strategic planning	**Tactical planning**	**Operational planning**
Objective	To determine the public demand towards various forestry functions and decide the level of supply for each demanded function.	The general management guidelines for water should be proclaimed.	Treatments to reach the specific objectives should be determined.
Horizon	Long range planning	Mid-term planning	Short term planning
Points to be considered	The percentages of forestlands that should be allocated for timber production, soil-water conservation and production, recreation, wildlife, and protected areas.	The trade off point between water production and other functions such as timber production or recreational use.	The methods and timing of the treatments will be arranged. The forest structures that need to be achieved for each different level of water production.
Alternates	Different areas allocated for different forest functions	Different forest types allocated for water production	Different forestry treatments needed for maintenance of forest allocated for water production
Outcome	Y ha for timber, X ha for soil-water, Z ha for recreation, t ha for wildlife, and P ha for protected areas will be allocated in the planning unit (The areas mentioned overlaps).	X_1 ha for soil conservation (very steep slopes, riparian zones, erodible or instable hillsides), X_2 ha for high-level water production, X_3 ha for low-level water production.	The yield and regime of streamflow calculated taking reservoir evaporation into account (this is a detailed assessment to put forward the amount of water that is planned to be produced).
Criteria	Total value of all forest functions or number of beneficiaries for all forest functions	Total water level produced by forests allocated for water production	Annual water yield produced by forests regulated for water production
Planning approach to be used	An interdisciplinary evaluation of land, forest, and socio-economic parameters.	A hydrologic based field and bureau evaluation performed by forest management, forest economics and watershed management specialists.	Watershed management, forest economics, silviculture, transportation specialists determine the methods and seasonal pattern of the treatments.

A point to be underlined is that strategic decisions are not constant as the decision structure and environment are dynamic and sometimes quite variable in time (Hinssen, 1994). Therefore, strategic decisions and plans must be revised as often as main variables and targets change. Results of the strategic plans provide inputs to tactical plans.

Tactical planning phase

The tactical planning deals with the site specific location and timing of activities for implementing a long term strategic plan (Jones et al., 1991). In tactical planning stage, each forest function or set of functions are modelled separately and in more detail than strategic stage. Tactical planning stage produces many plans such as timber management plan, water management plan or wildlife management plan.
Management regimes are decided for each forest function in this second stage. The term, management regime, refers to another partition further ahead. For example, the forest lands assigned for recreational function are partitioned once again and assigned for camping, fishing, picnic, and trekking sub-groups. If applied to water production objective, the procedure progresses ahead to put forward necessary technical adjustments like;

- Methods to arrange ET (evapotranspiration) component of forests via manipulating the relevant structure parameters, i.e. biomass, leaf area or interception,
- Measures to minimize soil compaction, erosion, landslides, and torrents,
- Maintenance of conservation (i.e. terraces) and hydraulic structures (i.e. ditches),

to optimize water yield, quality, and regime to meet public demands.

In a planning unit even if water production is the main concern, some areas can be left to soil conservation or assigned as low-level water producing areas. The term low level refers to the priority here, not the quality of water. It means that the water production is the marginal objective but the primary objective have to be reached in a hydrological–safe way.

Operational planning phase

The treatments or practice schedules are decided in the operational planning phase. Operational planning is based on guidelines from tactical planning and concerns the implementation of forestry treatments. Annual conservation activities, annual harvest treatments, arrangement of bids, personnel management subjects are clarified in detail by operational plans. Operational plans must support the tactical plans. For timber production function; rotation periods, harvest methods and divisions, storage, stock, and sale amounts and seasonal arrangements need to be in consideration. The activities for each month should be scheduled. For water production function, many solid decisions including;

- The timing and methods of treatments to achieve desired species mixture, crown closure, biomass volume or leaf area,
- The location of soil conservation structures, the capacity of ditches, or type of terraces that are required,
- The areas that should be protected from human activities (i.e. recreational use)

should be identified.

Benefits of a stepwise planning approach

The fragmentation of planning phase with a stepwise approach can provide the following benefits;

- Objectives on water in different time horizons can be identified clearly,
- Data, options, and constraints that involve water planning can be determined easily to enable more solid models,
- Experts related planning stage and water production function of the forest can be selected exactly and public participation can be arranged effectively,
- A detailed planning brings detailed outputs that can be supervised or inspected comfortably on water purposes for any forest,
- Efficiency of the evaluation and monitoring of the decisions on water sources may increase.

Concluding remarks

The term "sustainable forest management" was quickly accepted by professionals, scientists and societies in the last decades. However, not many people were aware of what this concept requires. Social needs and demands need to be provided with new management strategies, plans, and approaches in the long run. This is a hard task in industrializing countries where high population growth rates and degradation of natural resources are typical. The achievement of a sustainable forestry framework is the key of a sustainable water supply system considering the source of clean water. Best quality water is produced from forested watersheds even if managed primarily for timber production. Besides, importance of low flows has not been well understood yet. Considering the huge evaporation rates of reservoirs, the best way to supply water in dry season is to prioritize groundwater discharge, which is fed by vegetated surfaces.

Forested watersheds, producing high-quality water requires special attention and management techniques. Therefore, a portion of water income of the municipalities should be transferred to forest management agency in order to be used in improving forest resources. In fact, because timber is perceived as the only commercial product of forests, forest enterprises are considered to be non-profitable organizations in many countries. If water production was added to the incomes of forestry organizations than a real evaluation would be possible. With the proposed hierarchical approach, management of forests towards water production function would be more accurate. The objectives and management tools would be clearer with such a layered planning system. Besides, arrangement of required technical staff and their working schedules would be planned more systematically.

Alike timber, water is a tangible good for humans. It can be produced, transferred, and marketed. It also has an existence value that defines the role of water bodies as an ecosystem component. It produces habitat for other living organisms with its existence. Production of clean water in forested watersheds, on the other hand, is a public service of forests. Because water is essential for life, this value is the natural consequence of the existence of forests. Consequently, water production function of the forests is perceived different from different aspects, which sometimes cause confusion. To formulate the water production function of a forest area;

$$f\,(w) = \sum (V_F, V_T, V_A, V_S, V_L, V_E)$$

w: Total value produced by water production function,
V_F: Value of produced freshwater,
V_T: Value of decreased torrent and flooding,
V_A: Value of decreased avalanche hazard,
V_S: Value of decreased sedimentation,
V_L: Value of decreased landslide hazard,
V_E: Value added for provided ecosystem balance.

On the other hand, as seen Table 1, in each planning stage, different objective functions can be formulated for water production.

In a region of water scarcity and conflict, sustainable use of forest resources towards multiple objectives requires special attention. Traditional forest management plans or planning approaches may cause some modeling problems especially related for non-timber objectives. The best way according to us is to apply a stepwise planning approach, which would provide clear and solid tools that would facilitate the management. On the other hand, the greatest challenge for the implementation of this approach is the lack of information related to forestry treatments, which could be provided by long-term hydro-ecological research. Inclusion of this to the research master plans of the Ministry of Environment and Forestry seems to be the most feasible way of starting such a research program.

As mentioned above in Belgrad Forest example, even if forestlands are partitioned for different objective functions, there is not much to do according to current management plans. The plans must be revised to include at least some basic management tools towards water production. These basics can be extended in time with the arrival of new data and techniques.

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A NEW APPROACH TOWARDS FLOOD CONCERNED SPATIAL PLANNING

Planning and technical instruments for integrated planning and management

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The extreme increase of flood events and flood damages during the last decades makes it obvious that an integrated approach is crucial to flood protection. Many issues such as technical measures, aerial and spatial management, retrofitting, raising risk awareness etc. have to be incorporated into the complex field of integrated flood management (IFM). The designed EC framework directive for flood risk management underlines the demand of his comprehensive approach.

As far as spatial management is concerned, aspects of water and flood management are often either badly or too late included into the planning process. Another problem is that flood and planning issues are not regarded and handled on the level of river basins but on administrative boundaries.

At the same time aspects of geodata infrastructure and flood related data and information has to be considered as a crucial interface in a concept for integrated planning. In the context of a EU Interreg IIIb project which is named FLOWS (www.flows.nu) an interdisciplinary group of the University of Lüneburg, the Technical University of Hamburg-Harburg and the City of Hamburg was developing a planning instrument which integrates water management and flood aspects in spatial and city planning on the scale of a river basin with the aim of reducing flood impacts and improving at the same time the ecological situation. Meanwhile the interfacial requirements to technical and computer based tools like Decision Support Systems (DSS) are considered. The very urban area of City of Hamburg and rural parts of Lower Saxony in Germany serve as project areas. In this scheme a thorough process and structure analysis was accomplished to investigate data and planning structures, planning processes and cooperation between water management and spatial planning and planning deficits. By means of interviews and workshops with practitioners the planning instrument and the DSS were elaborated for an adapted implementation on the operational level for working out mid- and long term planning strategies.

Introduction

Flood risk is a working field with many different responsibilities. Analysing and management of flood risk has to be considered in the scope and natural context of catchment areas. Actually the handling is organised along administrative boundaries and by involving mainly water management, spatial planning and environmental planning apart from another. So no real comprehensive approach can be considered. It is obvious that the management has to be optimised concerning the working area and as well concerning the synergies and coordination of flood concerned objectives.

For an optimal management certain (digital) data and information are crucial. In this field some problems have been discovered like data quantity, data quality and interfaces, implementation different software applications and other more. In urban and rural areas we can state different priorities in flood management but these approaches have to be coordinated too to come to a common and concept.

Within the FLOWS project one research aspect was to deliver recommendations on how to integrate sustainable water management and flood information in the spatial development of a) urban and b) rural areas. For this purpose an appropriate planning instruments should be elaborated for unifying different planning aspects and levels concerning flood management in the scope of catchment areas.

For this complex problem field a Decision Support System (DSS) which combines different data, models and a purpose tailored user interface are extreme helpful. Two DSS (one for rural and one for urban area) were to be developed in the urban region of Hamburg and a rural region of northeast Lower Saxony along the river Elbe. Furthermore the requirements for these DSS are to be identified. For a sophisticated DSS a process analysis of the planning proceedings has to be accomplished.

Based on this process, data and user analyses a best practice concepts on how to integrate a DSS into the decision making process has been developed. For identification and integration of different flood related measures – supported by a DSS – a new planning instrument was intended to be developed.

Methodology

The project team consists of one steering group with representatives of all German FLOWS partners and as well several interdisciplinary sub-project groups which has a continuously and extensive exchange. The represented working fields are water management, city and environmental planning and Informatics. Altogether about twenty institutions and stakeholders were involved in the iterative process of process and requirement analysis and concept development.

To work out a concept which is both, general transferable to other regions and as detailed as possible for a good implementation two representative case study areas in the federal states Hamburg and Lower Saxony were chosen. In the beginning of the project an elaborated study due to literature, jurisdictions and regional information were realised. On this basis a thorough methodology was worked out. In order to build a sustainable and effective support system all flood concerned decision pathways and planning and decision structures must be studied and fully understood. An extensive inclusion of people from practice should guarantee both to include their knowledge and requirements and to improve the implementation phase in a later phase by raising acceptance.

In a first phase planners from different authorities like city planners, landscape planners, et cetera from city districts, ministries, city and county councils were interviewed with the help of a guidance questions. The main goal of the interviews was to find out the pathways of decision making, to identify shortcomings and to get to know what kind of flood related information are in use or are required. In parallel a data structure and quality analysis were accomplished to learn which kind of digital data are accessible and usable in a DSS.

Lots of data were gathered, some were assigned to produce and others were produced by the project itself (like maps about inundation duration along river Elbe). All these data were integrated in the DSS for flood related city and land use planning. The interviews served to draw a process structure for flood related planning proceeding. By doing this it became obvious that a gap of communication exist both between the different working fields and offices and between the different administrative levels (e.g. district-city, county-state). So information about flood risk of planned developments is communicated to a (and sometimes too) late date.

Furthermore it became evident that especially the city planning council is interested in a computer based planning tool for simulation of flood impacts of certain measures while the planners and water managers in the rural region of Lower Saxony were more interested to improve the accessibility of digital information via an appropriated and flexible tool. That had the consequence that for Hamburg a model based DSS was planned and for Lower Saxony a data based DSS was designed.

For a better coordination of flood related planning and measures a new catchment based planning tool was conceived. With this planning tool – the catchment-related development plan which will be portrayed later in detail – the maximum of synergies could be realised and communication across subjects and levels can be assured.

Two specifications of plans were designed: one for the regional level and one for the local level. The plan includes aspects as coordinated measures of water management, environmental planning and city planning. This concept was realised with regards to an interface with the DSS. These flood related DSS can be used as well for realising the catchment-related development plan as for analysing single local planning questions.

The new planning instrument in context of already existing law and attended law

During the last years a respectable range of laws with direct or indirect flood concern were enacted on national and European level.

In Germany a law concerning flood risk prevention has been adopted in 2005. This law is changing several national laws, such as the Federal Building Code and the Water Management Act to mention only the most important ones. A main change is the spatial definition of the expansion of a 100-year-flood for areas with high damage potential and consequently building restrictions for these areas. Another change is the obligation to develop flood risk management plans.

The European Commission has published the proposal for a directive on the assessment and management of floods in February 2006. One main aim is to establish flood risk management plans (containing flood risk maps), which shall integrate several aspects of flood influencing aspects as spatial planning, nature conservation, agriculture and so on.

"…on the reduction of the probability of flooding and of potential consequences of flooding to human health, the environment and economic activity, and taking into account relevant aspects: water management, soil management, spatial planning, land use and nature conservation"(article 9 para. 2 Proposal for a EC directive on the assessment and management of floods).

Another legal framework which should be mentioned in this context is the "Strategic Environmental Assessment". The purpose of the SEA-Directive which was adopted in 2001 is to ensure that environmental consequences of certain plans and programmes are identified and assessed during their preparation and before their adoption. The public and environmental authorities can give their opinion and all results are integrated and taken into account in the course of the planning procedure.

SEA shall contribute to more transparent planning by involving the public and by integrating environmental considerations. For example for urban development plan a SEA has to be assessed if a SEA has not taken place on a higher planning level (like regional planning). The aspects of flood risk have to be considered in these assessments as a part of environmental protection.

Catchment-related development plan: catchment-oriented, regional and local

A main problem in working on catchment areas is the scale of delimitation of catchment areas. Catchments areas are defined as rivers from the source to the river mouth with its catchment basin. These catchments are covering lots of hundreds and thousands square kilometres. Working on this scale is not possible with the aims and measures intended by the proposed development plans, but there are still organisations working on it (such as the International Commission for the Protection of the Rhine). Their aim is to coordinate measures of water management whereas the catchment-related development plan shall achieve an integration of both, catchment-related and spatial planning interests for one area. Thus it is necessary to work on a much more detailed scale, such as sub-catchment areas and even a defined settlement area. To make sure that both scales, with detailed and less detailed information and measures can be covered, it is useful to create a multi-level plan. One plan should be established on a regional level to keep an overview and to coordinate all measures in a sub-catchment area. This plan will respond to the existing national law and can be widened to respond to the needs of the proposed directive of the European Commission, probably voted by the European Parliament by the end of the year 2006. The proposal for the mentioned directive foresees in article 13 paragraph. 2 that if reasonable, the delimitation of catchment areas should be adopt from the reporting areas of the European Water Framework Directive (WFD) (Article 13(7) of Directive 2000/60/EC).

The second plan should be able to cover relevant flood areas as parts of a city or a whole town area for example showing districts with the possibility for new buildings by respecting the water balance and the risks of floods.

Integration into the planning system (example: Germany)

The proposed plans can be easily integrated into the planning system like in the German system. Both, the regional and the local catchment-related development plan is to be used as an information tools by the administration before starting any planning on a parcel or even for the whole urban development.

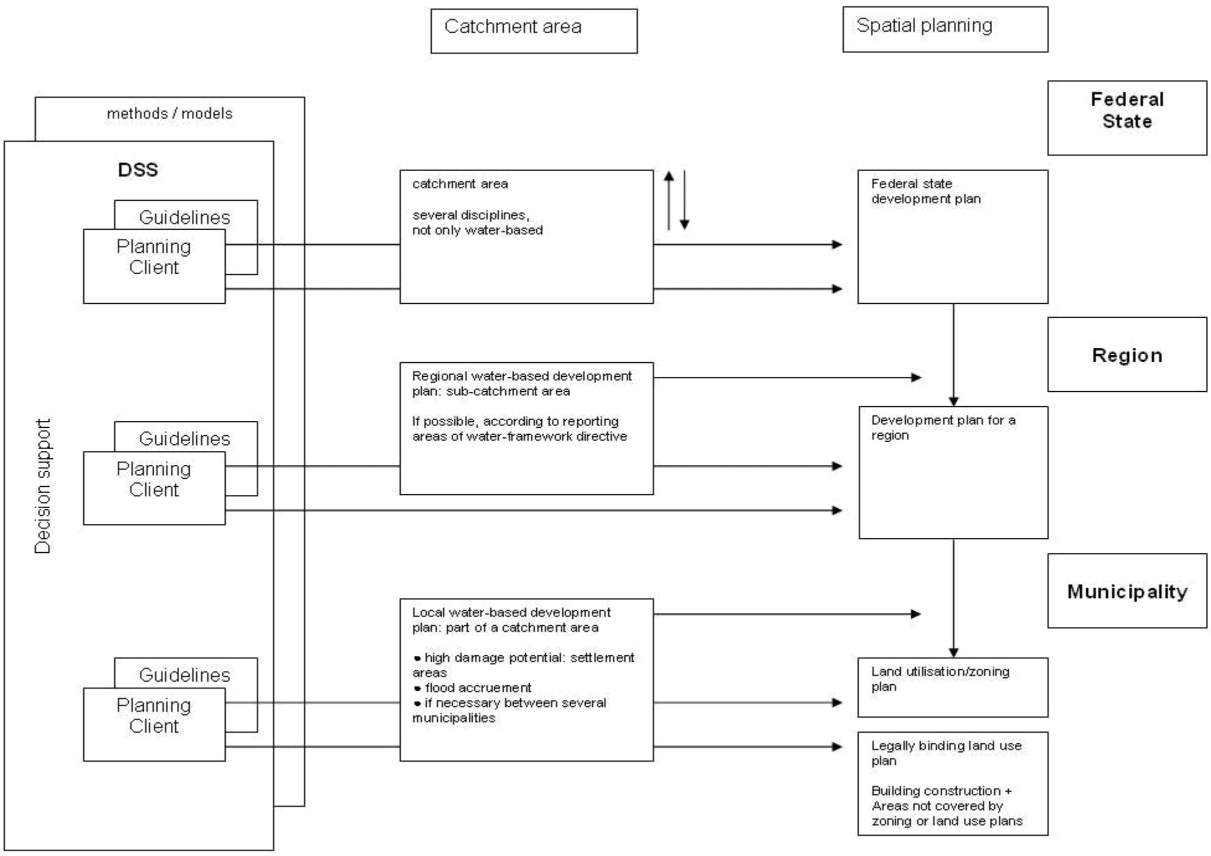

Fig. 1: Structure of existing planning levels, position of regional and local catchment-related development plan and interface with DSS.

The concept of the catchment-related development plan implies two levels of specification: the regional and the local level. Exemplarily the Regional catchment-related development plan will be presented here.

Regional catchment-related development plan

The regional catchment-related development plan should be elaborated for a sub-catchment area. It should comprise the following information:
According to the proposal of the directive of the European Council (as proposed in article 7):
- Floods with a high probability (likely return period, once in every 10 years); blue zones
- Floods with a medium probability (likely return period, once in every 100 years); blue lines across the rivers)
- Floods with a low probability (extreme events); (violet lines across the river)

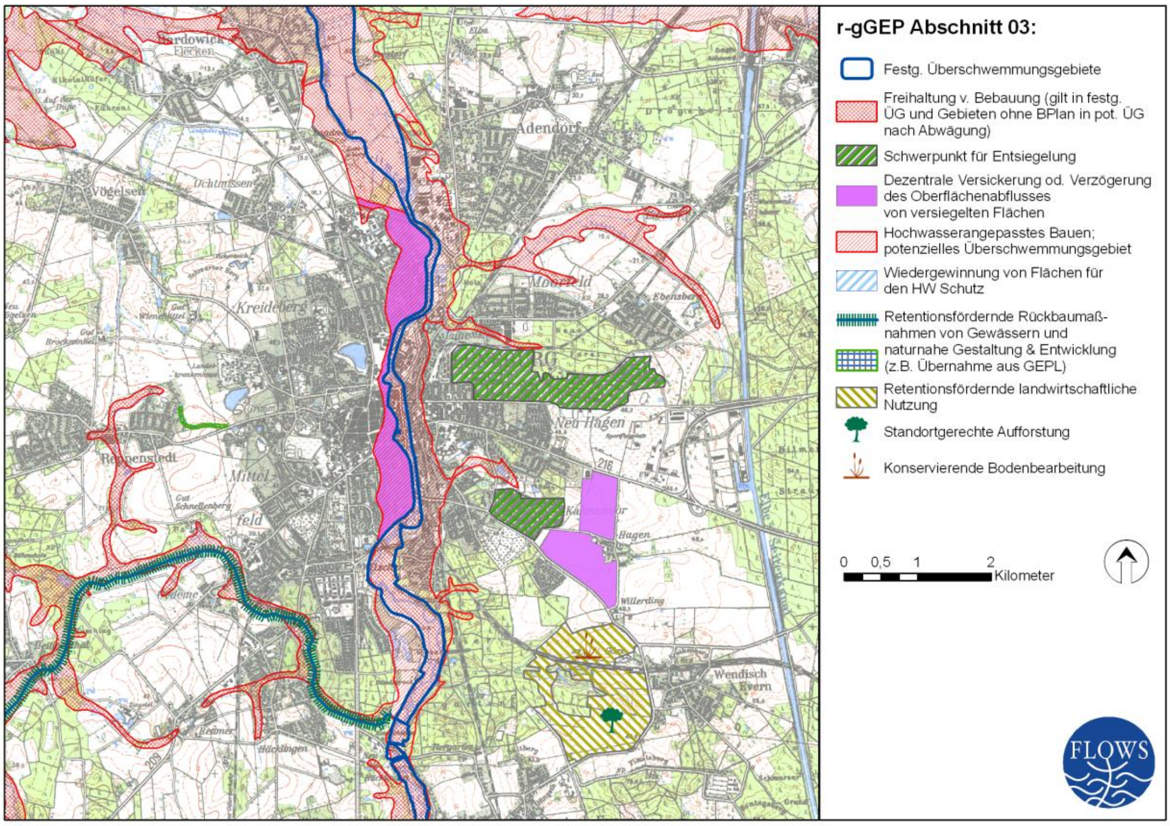

Fig. 2: Example for a regional catchment-related development plan

According to national law (e.g. Germany):
- Zones for conservation or defining new water retention areas (yellow lines)
- Water retention areas protected by German federal planning law (green areas)

Furthermore it could involve following measures, which could be either developed only for the catchment-related development plan or could be generated by other (digital) information for instance measures for restoration of rivers due to planned measures because of environmental impact assessment, eco-accounts, or river development plans:

- Limitations for further development
- Main areas for reduction of sealing
- Decentralised infiltration of surface water
- Flood appropriated constructions / measures for retrofitting
- Restoration of flood retention areas (flood plains, oxbows etc.)
- Restoration of rivers to raise the flood retention potential
- Creation of new retention areas (like polder)
- Land use measures for raising retention potential (land use patterns, plough less agriculture etc.)
- …

Implementation of a DSS to assist planners creating the catchment-related development plans

As information in analogue plans like the described catchment-related development plan needs to be permanently updated computer based techniques are eligible and dynamic to gather and analyse the numerous data and to keep the plan up to date. Decision Support Systems are especially suitable to provide these functions. The early involvement of multidisciplinary water, spatial and city planners into the conception process of a DSS revealed first and foremost the need of access to interdisciplinary data complemented by hydrologic data and the easy access to them and evaluation of them by DSS techniques. Additional a list of all required and desired data and information was questioned.

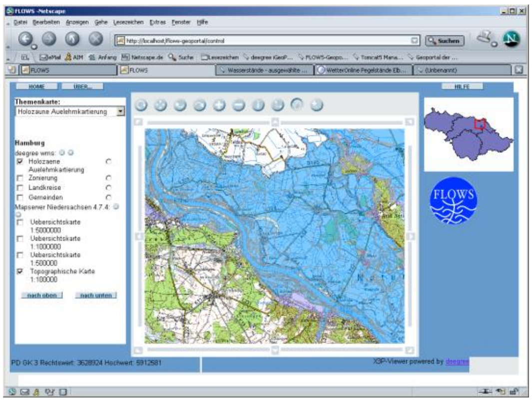

Fig. 3: FLOWS Geodata portal.

The main objective of a computer based DSS is to offer analysis, communication, management and learning functions to the user. These can be worked out by a data-oriented or model-oriented DSS. It is common to both, that there is a user interface, which aids the planner, to solve certain questions in an easy way.

As a matter of fact, the demands in urban and rural regions differ. Flooding in densely populated areas causes higher and different damage than rural and mainly agricultural formed areas. Conflict of aims and interests concerning land use are also higher in urban area which has to be taken into account and assessed by planners. It applies to both kinds of regions that a flood related DSS needs to inform about flooding events at certain return periods, extreme events, damage/risk maps, areas endangered of flooding in case flood protection measures fail. Furthermore these data are to be opposed to spatial data about land use, land owner, building, and nature conservation and especially to the demands of the WFD. As well as the model feeding data as all others, there has to be an infrastructure which provides and exchanges all the needed information. For that reason both the Hamburg and the Lower Saxony DSS developer where improving the spatial data infrastructure (SDI) by analysing existing services and extending these to the FLOWS-DSS relevant application and data.

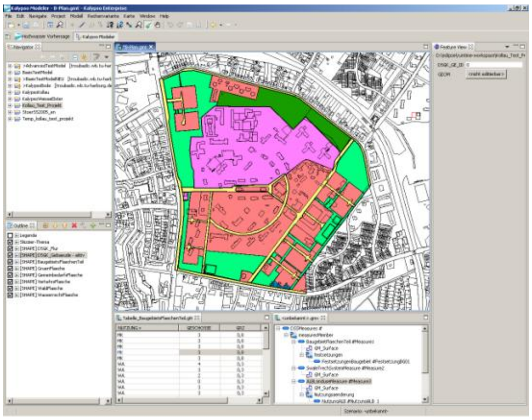

Fig. 4: Kalypso DSS with geodata interface

For the last years spatial data infrastructures are being developed by all administrative levels just to mention the EU-initiative INSPIRE the, “Bundes-“initiative IMAGI to build up the Spatial Data Infrastructure Germany (GDI-DE), SDIs on federal state level as well as for example the “inter federal state” SDI Metropolregion Hamburg (MRH) which includes the FLOWS Germany investigation sites. Especially the MRH was extended through the FLOWS projects which show innovative way of the substantiating philosophy of using OpenGIS techniques.

Thus the DSS in Hamburg (see Fig. 4) will use these available data and will be specified for the end user (town planner) in the Hamburg administration. The DSS Planning Client is able to show changes in the water run-off situation after a simulation of constructing new buildings or flood defence measures in an investigation site. It is able to include Geodata by Web Mapping or Web Feature Services in model-based DSS for simulations.

Figure 3 shows the Geodata portal and DSS which is used in Lower Saxony where a Web Mapping Service (WMS) is implemented. Further data can be loaded as well as all portal information is accessible via a WMS-URL which gives interested users the opportunity to load all the data to its own GIS. In the case of this DSS flood related information was pre-calculated in FLOWS project as for example flood events at certain recurrent periods, areas endangered of flooding in case of flood defence failure but also data about land use and land management. The infrastructure can be used to manage flood plains but also catchment areas and to set up catchment-related development plans.

With this concept a clear interface between the planning instrument of catchment-related development plan for a whole catchment and the supporting tools like DSS and Planer Client was created. Both can be used on its own as well. But together an innovative, appropriate and dynamic system for implementation of flood related information in spatial planning processes can be delivered.

Conclusions

First of all we have to consider that the FLOWS project created a greater awareness about flood related issues. Furthermore the potentials of collaboration between water management, spatial planning and environmental planning became more obvious. Common and coordinated goal seeking for mitigating flood risk took place and prepared a basis for sustainable flood management.

As well a common data concept was elaborated as the methodology of exchanging of data with agreed standards so that synergies in this field help for the daily work.

The concept of a catchment-related development plan delivers an instrument for Integrated Flood Management for the whole river basin. This comprehensive approach supports an Integrated River Basin Management with coordinated measures, identifies synergies and supports labour and cost efficiency. It combines newest computer tools for analysing and visualising with a sustainable data management concept. Furthermore the latest national and international/European jurisdictions are considered and integrated which helps to meet its objectives in a sophisticated way. It seems to be a sustainable approach because the tools are already implemented in relevant agencies.

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DECISION SUPPORT SYSTEMS FOR INTEGRATED WATER RESOURCES MANAGEMENT - REQUIREMENTS FOR A COMPREHENSIVE APPROACH

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Integrated Water Resources Management refers to the coordinated development and management of water, land and related resources for optimising economic and social welfare without compromising the sustainability of vital environmental systems. It is obvious that this is a complex issue where we need new approaches to the assessment, development and management. To assist processes in IWRM computer based tools as Decision Support Systems (DSS) can be very helpful. A DSS might be defined as a computer based instrument that can be used to support the planning, management and/or policy making process. In a DSS a structured approach towards river basin management is combined with eminent Information Technology, leading to an instrument that facilitates the processing, the analysis and the presentation of information. A DSS helps the end-user to assess which is the relevant information in the planning process and shows possible alternatives to meet development objectives.
There is a wide range of different DSS with diverse goals and functionalities. But what kind of DSS with which functionalities is necessary for IWRM? There are a series of requirements for a comprehensive approach with could be assisted by an appropriate DSS.

First of all the ecological systems and the legal requests have to be designed. Content and knowledge concerning aspects like the ecological, hydrological and land use system as well as operational goals as European Water Framework Directive, flood plain management and flood risk management has to be incorporated. As well the economic issues play a vital role. Certain goals have to be met in a certain timescale and in definite areas. All these aspects represent the kernel of a DSS, which we can call the knowledge base.

Furthermore the requirements of communication and participation have to be supported. How can a DSS help to involve people actively while incorporating regional or narrative knowledge? DSS information may enable the end-user to enhance the quality of the various actions that are to be taken. On the one hand these are actions
with respect to the contents of the policy like problem analysis, forecasting of future contexts, design and screening of alternatives, impact assessment and comparing
and ranking alternatives.

On the other hand these involve more actions like communication,interactive policy making, etc. And again it is crucial to assist the coordination and management across the working fields and administrative levels. So the DSS has to have a flexible and dynamic structure which fits to the relevant decision structure. However, integration remains a difficult issue. A number of gaps and barriers still need to be resolved. The paper will show how this and other requirements and functionalities might be realised in a DSS for IWRM. Considering as an example an evaluation about a DSS for the river Elbe catchment will describe possibilities and restrictions for a comprehensive approach based on a generic DSS.

Introduction

Since 1972 at the United Nations Conference on the Human Environment at Stockholm the global implications of water problems is voiced. During the last three decades this issue was raised continuously and discussed on national and international level. For example one of the eight principles and concepts concluded by the Agenda 21 and the Dublin Principles specifically referred to “integrated water resource management, implying an inter-sectoral approach, representation of all stakeholders, all physical aspects of water resources, and sustainability and environmental considerations” (UNCED 1992).

Despite these conceptual formulations, the term IWRM is more precisely defined by the Global Water Partnership (GWP) as attempted to consolidate the two broad conceptual requirements of “integration” and “sustainability,” and provide a comprehensive scope for IWRM, which was summarized as, “a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems” (GWP/TAC 2000).

So IWRM can be seen as a complex concept which embodies the integration of natural and human systems or we can say physical and societal world. Within the natural system, integration is sought between “freshwater and coastal zone, land and water, surface water and groundwater, water quantity and quality, and upstream and downstream”. Similarly in the human system, integration is required between demand and supply, across various water use sectors, among various stakeholders and in numerous socioeconomic considerations (Bandaragoda 2002). Following this broad definition the complexity of IWRM becomes more than obvious. So we have to raise the question how an appropriate approach can be realised?
For this kind of technologies, which are applied on an interdisciplinary basis, are more than helpful to understand the system’s behaviour and develop appropriate strategies and cooperative action programmes in response. Thus kinds of socio-technical instrument as Decision Support Systems (DSS) are required.

This paper will discuss requirements for DSS to support a comprehensive approach in IWRM along following areas as examples of the natural and human system:

1. Fresh water quality and quantity

Fresh water of sufficient quality is becoming a scarce resource in an increasing number of regions throughout the world. Water scarcity, and human interventions to handle it, has become a potential source of conflict, partly caused by competitive water uses between sectors and between geographic regions. The European Union adopted the Water Framework Directive (WFD) to manage this field.

2. Flood risk management

The extreme increase of flood events and flood damages during the last decades makes it obvious that an integrated approach of IWRM has to include flood protection. Many issues such as technical measures, aerial and spatial management, retrofitting, rising risk awareness as well as environmental and land-use management have to be incorporated into the complex field. A crucial point of course is to optimize the retention potential of the river basin. It depends mainly on:

- The expansion and the size of the effective flood plain respectively retention areas like polders;
- The land use of the effective flood plain;
- The land use across the whole catchment area.

3. Flood plain management

Flood plains are diverse landscapes where various requirements, which increasingly compete with one another, can be observed. Water related biotopes and especially flood plains are not only extremely important but also rich ecosystems with a huge variety of species and functionalities. “Freshwater ecosystems, when scored on the area they cover and the number of species they harbour, are in fact the most species-diverse habitats on Earth” (IUCN, 2005). The most important characteristics are the natural flood dynamics and gradual processes which are not influenced by human beings. The preservation of riparian landscapes, of course, but also of extensively used pastures and meadows in flood plains (the cultural landscape) can also be of great interest.

These areas belong to the natural system of IWRM. As part of the human system we can consider e.g.

4. Stakeholder involvement and public Participation

IWRM is a challenge for cooperation, integration and support. As known, water is rapidly emerging as a serious limitation on meeting human needs while protecting the environment. Cooperation between all stakeholders’ at all organizational levels is required to reach agreement on integrated management plans, as well as appropriate allocation strategies for available resource. Balancing water resources, including issues such as increasing use compared to the availability or deterioration of water quality is becoming increasingly complex and diverse. Appropriate decision making requires specific knowledge from both technical and non-technical perspectives (Abbott 2005).

These complexities create the need to understand and comprehend the more detailed technical components, as well as broader managerial and societal issues, therefore asking efficient integration of various disciplines, sectors, countries, and societies (Somlyódy et al. 1995).
Economic issues should be mentioned here as a extra issue in the human system which has to be recognised but which are not further discussed in this context. The framework of management processes of the different elements of IWRM are mainly based on legal regulations (acts, environmental standards, conventions et cetera) or other environmental or other goals (e.g. the concept of sustainable regional development). For IWRM purposes numerous regulations emerged during the last years. However, integration remains a difficult issue. A number of gaps and barriers still need to be resolved.

Management objectives and legal instruments of IWRM

Natural system

As described earlier relevant issues are, amongst others, the quality and quantity of water, the decline of water related ecosystems and flood risk managment.
One crucial problem in most European countries is, that there are too many actors responsible for and involved in water management. The jurisdiction over water is often very fragmented and there is not always a single institution ensuring coordination between the different managing agencies.

Water quality and quantity management is mainly the issue for the water management agencies. The coordination with agriculture and nature conservation actors is quite poor.

Wetlands management is considered as a nature conservation issue. This leads to uncoordinated actions in managing wetlands and missed opportunities for fully exploiting their positive role in water management. National wetland restoration policies are almost non-existent, although the international framework should lead to a national wetland protection policy (WWF 2003).

For flood risk management usually water management agencies are again responsible as for water quality and quantity. Although very often another department is concerned with this issue and coordination and collaboration between them often is not enough institutionalised but depends on personal contacts.

An increasing number of legal frameworks and guidance both on international and nation levels came into force during the last years. Table 1 shows an exemplary overview about legal frameworks and objectives in IWRM concerning water quality and quantity, flood risk management and flood plain management in Europe.

Table 1: Legal frameworks and objectives in IWRM (exemplary)

	Main legal framework	**General target**	**Environmental objective**	**Environmental standards**
Water quality and quantity	EC Water Framework Directive, National standards	Good status of water bodies	Good ecological status of surface waters (includes biological, hydro-morphological and chemical status) Good status of groundwater (includes quantitative and chemical)	e.g. reference status of river type e.g. max 50 ml N/l
Flood risk management	EC Directive for flood risk management (draft), German Act for mitigation of flood risk Guidelines	Minimising of flood risk	Raise Retention potential	HQ 100 / 1,0 % HQ 1000 / 0,1 %
Flood Plain Management	RAMSAR Convention, FFH Directive, National acts (e.g. Germany: BNatSchG)	Protection and development of wetlands and its biodiversity	Endangered biotopes Endangered species	Protection of FFH Appendix species and biotopes BNatSchG § 20c Red lists

All these jurisdictions are not implicit conflictive but the interlinkages can be considered as little. Water quality and wetlands are considered separately. Water quality and flood risk management tends to be coordinated by the new European directive which is planned to be agreed upon in 2007. The designed flood risk management plans which are one basic element in the designed Directive should include not only water management aspects but as well spatial planning, nature conservation and other spatial and land use relevant issues. But we have to wait for the final wording of the law to critic about is finally.

Flood risk management and floodplain management is handled more or less parallel. A little approach is done with the German Act for preventive flood management. With an instrument the "flood risk plans" it could be possible to include aspects of flood plain restorations and dike shifting. But this is not formulated explicitly thus it realisation will depend on the respective planning authorities.

Rather all biotope types of flood plains are protected by laws like FFH Directive and national nature protection acts. But what is missing is a comprehensive and mid- or long-term strategy for sustainable protection and development. For this paradigm a catchment based approach is crucial. The only catchment based approach is demanded by the WFD concerning water quality and quantity. The draft of the flood directive for flood risk management shall be abutted along this methodology and time structure (EC 2006).

Only rarely we can consider established organisations for IWRM in Europe. In general it is organised along administrative boundaries. With WFD the first catchment based organisation structure has been established. Theoretically these are the right structures to coordinate IWRM. Future will tell whether they have enough competences to achieve a successful collaboration. Despite these structures some transnational River Basin Organisations exist. They try to coordinate actions and measures in the catchment basin but very often they have not enough competences for effective coordinated management.

Another facet of IWRM is that synergies in data management are poor despite it would be more than useful to match up a common data pool. Since implementation of the WFD and its GIS guidance a big step is done towards common standards and exchange of geographical data. But a lot of other steps can still be done.

Human system

For integration the societal aspects of IWRM public participation is a crucial element which has to be considered. Public participation in water management is rather poor in Europe, especially in Southern and Eastern Europe. (UNEP GRID 2005). The most critical aspects of public participation are the lack of pro-active information provisions to non-governmental stakeholders and the quality of the means to enable the active involvement of interested parties in decision-making processes. Stakeholders often lack specialist knowledge and human capacity to get involved in decision-making for water management measures. It is difficult for non-governmental water stakeholders to contribute and influence the decision-making process because the issuing of consultation documents and the participation of interested parties often take place only towards the end of the process. There is often low transparency for specific projects.

Participation is more and more not only demanded by political and societal concepts for sustainable development. Participation aspects are integrated as a central part or declaration of legal frameworks as the Aarhus convention or Water framework Directive of the European Union.

The role of Decision Support Systems (DSS) in IWRM

Bringing together the natural and the human system is one crucial aspect of IWRM. However decision making in a river basin context is a complex process due to the many stakeholders involved, each with different interests, objectives, evaluation criteria, information needs and competency. Cooperation and sharing of information and ideas might enhance the harmonisation of water use and allocation. Sharing models and analytical methods, and the mutual exchange of information can be an appropriate basis for co-operation in research and analysis. Computer based systems for decision making processes are specially developed to support this multifaceted approach.

A wide range of possible DSS definitions and core functionalities exist. Hahn & Engelen (2000) distinguish two types of computer-based DSS:
1. *Data-oriented DSS* are primarily concerned with retrieval, analysis and presentation of data.
2. *Model-oriented DSS* include activities such as simulation, goal seeking and optimization.

They list the possible functions of DSS as:
- Analysis (holistic representation of the system – linkages between natural systems and socio-economy);
- Communication between policy makers and stakeholders in participating planning efforts (dynamic);
- Library (serve as a knowledge management infrastructure);
- Management (evaluation of general decisions and revealing of measures);
- Learning (linkage of processes, natural and user functions).

Normally a DSS consist of a Data base, models, GIS and other tools or services, and the user interface with all the central functionalities. It is a striking fact that many DSS exist but only a few are really taken into use in practise or used as intended. The reasons are very often not because the technical realisation is not good enough but because the needs of (potential) users were not met adequately.

During the last years some studies were undertaken to find out reasons for this phenomenon. In the following the analysis of three different studies and their key results and messages will be revealed and discussed.

The first source is based upon a workshop which took place in context of a European project, called *Harmoni-Ca* (see http://www.seecon.org). In line with this project a series of Workshops were held about “The use of Models to Support the Participatory Elements of the EU Water Framework Directive: Creating a dialogue between Policy Makers and Model Makers” (Hare, M 2004). This analysis deals mainly with models but the results can be considered as well for DSS as models are normally core elements of a DSS. The second source is an international workshop about “Success and failure of DSS for integrated water resources management” in Venice, Italy, 6 - 7 October 2005 (FEEM 2005). The organiser was the Fondazione Eni Enrico Mattei (FEEM) in Venice. During these workshop (mainly academic) experts from several fields as water management, IT and modelling, ecology discussed factors influencing the DSS failure and success. Last but certainly not least the results of an examination of Spatial DSS by Oddrun Uran (2002) will be included. In her Ph.D Thesis she ran an evaluation in the Netherlands of DSS which are made for the fields of coastal zone and water management.

Table 2: Overview about factors for failure of DSS (sources: Hare 2004, FEEM 2005, Uran 2002)

Study group	**policy makers, international focus on use of models**	**Users in general, international**	**participants of a DSS based process in the Netherlands**
Source	**Eurolimpics Workshop**	**FEEM Workshop**	**Evaluation of O. Uran**
	policy makers like models but there is obviously a lack of confidence in models, so they won't use them I their daily work	Lack of or wrong user involvement	the activity of specifying a number of alternatives are very often not supported or not easily enough to handle
	enough models are existing but they are not tailored for specific stakeholders	Over complexity/too specific, inadequate user-interface (not targeted enough) -> not adequate to use -> not tailor made	only limited or no support for analysing and evaluation generated by SDDS
	the integration of reliable data is very important	Problem of controlling integrated modelling / lack of transparency	not all SDDS are capable of supporting the decision problem that they were originally built to support. The decision problem got somehow lost in the developing process.
	models should be more oriented towards awareness rising than to predictive machines	Political constrains	The ranking of alternatives is not supported
	policy makers see in models only one source of information	Too much process orientation instead of problem orientation	Support for spatial evaluation is either poor or absent -> users have to perform too complex operations on the information
	policy makers want only one answer from one model and don't want to use various models	unwillingness /inability of scientists to adapt their models to the way of thinking of users	DSS often stop supporting when the goal is in sight (incomplete DSS)
		Not focused enough on most used tools (mobile phone, http, excel)	Considerable effort needed to build (S)DSS and make them functioning

The compilation makes obvious that the main reasons for not using DSS is to a lesser extend technical problems meaning the DSS is not running correctly. Instead of that the main killing factors can be found in the area of not enough appropriate functionality for the specific decision processes of the users. That is mentioned for the field of DSS and models as well.

It is interesting, that the main aspect for politicians concerning models is reliability, reliable data, transparency and quality of the models. Another point of importance is the high complexity of coupled models which makes decision makers sceptic across Models. Again it is remarkable, that models should be more oriented towards awareness rising than to predictive machines. Thus the information process is more important than the decision making process itself.

Looking at the results from Urans evaluations of DSS the factor inappropriate functionality is again the most important factor for failure of DSS. For example a limited or no support for analysing and evaluation is objected to known DSS. This is important because to use information in decisions the users have to be able to complex operations on the information or to look “behind” the results of DSS. But often the DSS seems too much process orientated instead of problem orientated.

As well the user interface is often criticised not having a sophisticated look and feel or the way from the start to the beginning is too complicated. A crucial aspect is again that some (or many) DDS are not capable of supporting the decision problem that they were originally built to support. The decision problem got somehow lost in the developing process. As central reason the lack or wrong user involvement is declared thus the system seems not adequate to user and not Taylor made to specific user demands.

Apart of all these user oriented aspects of developing DSS interface other problems has to be considered. Developing large-scale and complex catchment-based systems with integrated participatory tools is very time and money consuming. One of the reasons is a series of frontiers, for example:

- Unsatisfactory database (hydrological, digital elevation model),
- Administrative boundaries,
- Data availability, technical access, high costs,
- Different methodologies are used,
- Complex and costly models (understandable only for experts),
- Problems with language and communication (e.g. between water and environmental managers) exist so the exchange of information is suboptimal.

Therefore it is crucial to identify strategies, synergies and standards to minimize costs and optimize the use of flood-related technologies. This aspect will be resumed in the last chapter of this paper.

Requirements for a DSS (for a comprehensive approach)

To find out factors of success and failure of DSS from user's side several examinations were undertaken by the author. Here results of two evaluations will be presented. With different interdisciplinary groups from five North Sea region countries question guided table discussions as well as a questionnaire session were organised and evaluated. The groups of 100 or respectively 80 people consist of water manager, spatial and land use planners, computer system developers, and politicians. The participants were quite good informed about what a DSS is (or can be) and around 40% had somehow experiences with DSS.
Some key results of two discussed questions are represented here:

1 What is the most important added value of a DSS to spend time and money for developing?
2 What are the most important issues to be considered for a successful implementation of the DSS in your working environment?

1 What is the most important added value of a DSS to spend time and money for developing?
- The process of informing decision makers becomes more transparent, if the DSS combining information with maps to make complex issues accessible.
- The DSS will be like guidance through the planning process and give planners the opportunity to access relevant information in various purposes at the right time.
- An especially necessary element of visualisation is the development of scenarios and consequences.
- The support of decision making, provide clear information in different scenarios. For the user there must be an easy access and a reduction of complexity to save time and money, improve the quality of planning and speed up the planning process.
- Also it should be a system that can be updated easily so one has the most recent information. In addition a DSS provide standardised information available for everyone.

2 What are the most important issues to be considered for a successful implementation of the DSS in your working environment?
- The process of developing a DSS can be very beneficial in getting groups together.
- First of all it is important to delegate the responsibility for implementation and use of the DSS. The purpose of the software must be identified so you have clear objectives for use and content.
- The central assumption is that the user must have a positive effect on your work and beyond – e.g. increase efficiency and quality.
- …

By all evaluation studies it becomes evident that the crucial aspect in developing DSS is the close link between the developers and the users. Especially interdisciplinary development is stated as very important.

Another evaluation procedure which was undertaken by the author is the evaluation of the prototype of the Elbe DSS which was developed for the Elbe catchment. Water resources management on the river-basin scale is the purpose of this DSS. Elements of the natural, ecological and socio-economical systems and their linkage but also the interests of various stakeholder groups shall are taken into account in this system. It involves water quantity, chemical quality, flood management and ecological status of surface waters and flood plains. Starting from identification of user needs by repeated consultation of stakeholders by various workshops and meetings a list of management objectives, measures, and external scenarios turned out, which was taken as the basis for the DSS development. The system is build up by integrating only already existing models and data. System and software design are oriented on management tasks: starting from selected management objectives the effects of external scenarios of climate, agro economic and demographic change, and selected measures to achieve the desired state of good water quantity and quality can be investigated. Analysis tools are integrated to assist the user in evaluating the various management options (Berlekamp et al. 2005). Project results of ten years research activities in the river Elbe region funded by the federal Ministry of Sciences, Research and Education were integrated in this DSS. The DSS development is coordinated by the Federal Agency of Hydrology/Coblence (Germany).

During the second term of 2006 an evaluation of the Elbe DSS prototype were undertaken with different user groups who are concerned with IWRM on the strategic level like ministries, national or federal agencies. The objective was to test the system consistence for IWRM, the system performance, and the user friendliness by user tests and questionnaires.

The first results show that the natural system of the Elbe DSS is suitable designed and well developed and functioning. Users think that it will help to find appropriate measures on the catchment level. Critical aspects which were mentioned were mainly the performance for the end-user. The user interface has to be improved by optimizing functionalities mainly to compare and evaluate different measures. The results of the evaluation will give input for further development and optimization for users' purposes. Another step will be the establishing of a permanent end user working group to improve the system continuously and to adapt the system to actual subjects and management objectives. This example shows the importance of continuous evaluation and the establishing of permanent structures for maintenance of DSS.

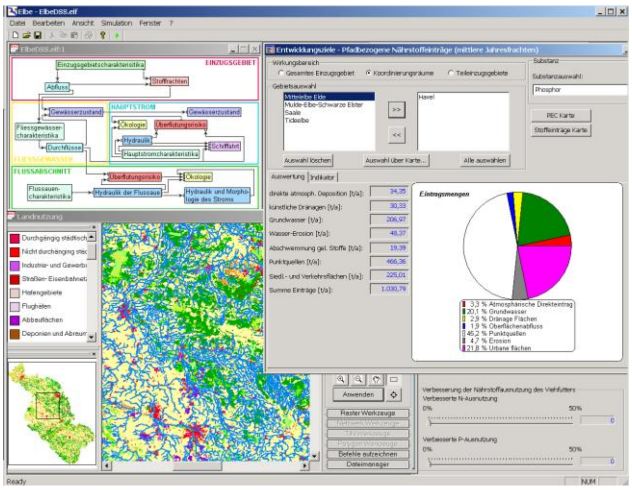

Fig. 1: Prototype of the Elbe DSS

Despite the fact that every DSS has its own and special purpose some general characteristics of a DSS for IWRM can be considered based on these and other evaluation results:

- A DSS is a computerised system which supports decision making processes in complex management fields/option development.
- A DSS is not only a technical tool, but can be defined as an interdisciplinary process where data, methodologies, models, software tools, and functionalities are worked out by users, scientists, developers and others. It serves as communication vehicle.
- The functions of the system are determined by specific needs of ones who want the DSS.

To sum up some key characteristics generated by a series of evaluation for DSS for IWRM:

- DSS for IWRM shall mainly generate knowledge about the complex system and for knowledge exchange
- Key characteristics are:
  - combine natural system/physical world with human system/societal world
  - is optimized to decision and management processes and helps to meet ecological (and others) objectives and standards
  - easy access to data and information and flexible actualisation
  - support information access, communication and participation for stakeholder and/or general public
  - (geo) data management from different sources
  - visualisation of interlinkages and correlations
  - identify appropriate and effective measures
  - information are easy to read/access/understand
- Key Functionalities are: visualisation, showing alternatives, scenarios, consequences of measures, evaluation of measures and generated results, ranking of alternatives, presenting effects, results, assessing, quality of alternatives, identifying differences between alternatives , improving alternatives, stakeholder analysis, generate and integrate narrative/local knowledge, role playing games etc, documentation, learning, showing alternatives, multi criteria analysis (MCA), documentation, library

Conclusions

IWRM is a broad and complex field which combines not only the elements of natural systems but as well the human system. In general Decision Support Systems can assist the integrated managing approach of IWRM but most of the developed systems are not used in practise or to whom it was designed for. Lots of DSS projects deal only with designing the natural world – which is often complex enough – but neglect the real user demands. Until now no standards exist that ensure that DSS have certain qualities and that missing functionalities would belong to the past.

There aspects shall be stressed to improve this situation: coordination of management objectives, regarding minimum user requirements for DSS development, and collaborated research and development work to generate more synergies in DSS development.

Divers legal frameworks have to be considered to meet the objectives of integrated water resources management as described in this article. It would be very helpful to coordinate these management fields on catchment levels. The clearer the management objectives are the easier the implementation in a DSS can be realised.

More emphasis must be given to optimise the user interface and certain users' requirements. Several evaluations were carried out to find out some key issues which have to be regarded by developing DSS for IWRM. One key issue which is trivial but rarely respected is to bridge the gap between users' purposes and the developers. A close link between the developers and the users and especially an interdisciplinary development and continuous evaluation of the system together with users is stated as extraordinarily important. The overall functionality of a DSS is to generate knowledge about the complex water recourses system, including societal and economic aspects. This knowledge has to be accessible for participation processes. One key functionality of DSS is creating scenarios to show consequences of measures respectively show how to meet certain objectives. For these purposes appropriate and sometime complex models are needed. Furthermore the management, actualisation and access of data and especially geodata play a central role for IWRM which can be supported by a DSS.

DSS has to be purpose driven and user oriented. But developing DSS are quite time and money consuming. To meet the requirements of IWRM-DSS a concept or framework with certain standards and interfaces are needed like:

– Calibrated and coordinated evaluation and data collection for the whole river basin, and a multilateral approach where international cooperation is needed on transboundary rivers.
– Collaborative use of water recourse related data is required, free exchange and application of geodata information and services across networks, different platforms and products by using international standards such as OGC conforming Web Mapping Service (WMS) OGC (less time, less cost, and more flexibility for data exchange)
– Free and unrestricted provision and transfer of meteorological data and products, as defined by World Meteorological Organization (WMO) in resolutions 40 and 25 of the twelfth and thirteenth WMO Congresses, respectively, and close cooperation between hydrological and meteorological services (UN, 2000).
– Because of the multi-purpose demands of integrating water, environment and socity, establishment of a network centred, modular structured system might be a solution for more cooperation and synergies in modelling (Tumwesigye *et al*., 2005). Web enabled agents (components) which are loosely coupled could communicate via the Internet. Within this approach, the clients would be able to access the modelling software via Internet facilities and to develop models, execute them and analyse their results in a more efficient and cost-effective way.
– In order to develop models and execute them in a more efficient and cost-effective way more open source products have to developed and coordinated (e.g. Waterknowledge Initiative).

With these approaches – and others of course - the requirements of an Integrated Water Resources Management will easier to be realise.

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CONSERVING WETLANDS BY WATERSHED MANAGEMENT, SAMPLE OF LAKE BEYSEHİR (KONYA)

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Wetlands, which have indispensable role on the continuation of the natural balance, are habitats that have to be conserved with their natural conditions because of their rich ecologic and biologic ecosystems. Nowadays wetland ecosystems are over against a serious threaten of disappearance and corruption. Dicrease of wetlands threatens living quarters of communities and biological diversity. But, nowadays, while the meaning of water is understood, this kind of approaches have to be changed. In this context, wetlands need conservation policies for their sustainable development.

Today, it is understood that, wetlands can not be managed without the objects forming the basin area. The intervention done to the any place of the basin effects all the basin area. By managing the basin, it will be possible to conduct the services effectively and find solutions for environmental problems rationally and preserve the natural sources in integrity.

Lake Beyşehir is one of the most important wetlands in Turkiye. Lake is threatened by fishing, cutting of the rushies and ensuring planting and drinking water. The scope of this paper is to state the importance of the wetlands by ecological and economical meanings and the ways of conservation policies effectively. It is concluded that the most rational approach to the wetlands' sustainability in the sample of Lake Beyşehir is "Watershed Management".

Key Words: Wetlands, Basin Planning, Watershed Management, Sustainability, Lake Beyşehir

INTRODUCTION

The socio-economic developments which have been lived and being lived in the world and the spatial dimension of these developments, have bought and continues to bring along the demand for utilization of natural resources on the production phases. This occurring demand having a magnitude beyond the capacity of natural resources have caused the destruction of natural values (Yalınız, 2003). As the 21st century begins, the issue of sustainable ecosystem management is providing humanity with one of its greatest challenges. The problem is particularly complex for freshwater systems, where humans and natural systems are inherently linked. Increasing water demands for an expanding human population competes with protecting aquatic ecosystems and ecological services.

Today, rivers and wetlands are among the most threatened ecosystems worldwide. As a consequence, restoration of rivers and wetlands has emerged as a worldwide phenomenon as well as a booming (Nakamura et al., 2006).

The Aim of the Study and the Methodology

This study identifies the importance of the wetlands by ecological and economical meanings and the ways of conservation policies effectively in the Basin of Lake Beyşehir (Konya). The aim of the study is to highlight the issues that need to be considered in planning within a sustainability framework and to emphasize that the most rational approach to the wetlands' sustainability in the sample of Lake Beyşehir is "Watershed Management".
The material of this study is the Watershed of Lake Beyşehir. The study is based on the literature rewieving and observation techniques.

1. WHY WETLANDS ARE IMPORTANT?

1.1. Wetland Definition

As to Ramsar Convention[1]"Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the dept of which at low tide does not exceed six metres".

Wetlands are the links between the land and the water. They are transition zones where the flow of water, the cycling of nutrients, and the energy of the sun meet to produce a unique ecosystem characterized by hydrology, soils, and vegetation—making these areas very important features of a watershed (http://www.epa.gov/owow/wetlands/facts/overview.pdf).

[1] Convention on Wetlands of International İmportance especially as Waterfowl Habitat (Ramsar, İran, 2.2.1971)

1.2. Wetland Functions and Values

Wetlands provide habitat for thousands of species of aquatic and terrestrial plants and animals. Although wetlands are best known for being home to water lilies, turtles, frogs, nakes, alligators, and crocodiles, they also provide important habitat for waterfowl, fish, and mammals. Wetlands do more than to provide habitat for plants and animals in the watershed. When rivers overflow, wetlands help to absorb and slow floodwaters. This ability to control floods can alleviate property damage and loss and can even save lives. Wetlands also absorb excess nutrients, sediment, and other pollutants before they reach rivers, lakes, and other waterbodies. They are great spots for fishing, canoeing, hiking, and bird-watching, and they make wonderful outdoor classrooms for people of all ages. (http://www.epa.gov/owow/wetlands/pdf/threats.pdf)

Wetlands are complex ecosystems that provide many ecological, biological, and hydrologic functions that society values. A wetland performs a biologic, hydrologic, or geologic function that produces a good or supports an ecological service. There are bioeconomic linkages among wetland functions, services generated by those functions, and socially valued outcomes (figure: 1) (Heimlich et al, 1998). Wetland ecosystems yield a wide range of goods and services, many of which have a high economic value. One of the most respected scientific journals in the world –*Nature*– reported recently that worldwide, wetlands are worth some $4.9 trillion a year (Nel, 2003).

Society does not necessarily attach value to all wetland functions, although greater scientific understanding of the roles wetlands play in ecosystems has increased our appreciation. The valuable functions wetlands provide and the aesthetically pleasing open space they create do enhance the quality of our lives. Many groups benefit from wetland functions: anglers, hunters, boaters, downstream property owners, public water supply and flood control authorities, and recreationists, among others. Protecting wetlands has become a recognized public interest (Heimlich et al, 1998).

Wetland	**Privete Values**		**Mixed Values**	**Public Values**		
	Forestry	**Fisheries**	**Recreation**	**Flood Control**	**Water Quality**	**Endangered Species**
Function	Tree growth medium	Fish habitat	Wildlife habitat	Flood retention	Water filtration	Wildlife habitat
Service	Commercial timber harvest	Commercial fish harvest	Recreational waterfowl harvest	Reduced flood flows	Cleaner water	Biodiversity
Economic Value	Net economic value of timber	Net economic value of commercial catch	Net economic value of hunting experience	Net economic value of reduced damages	Net economic value of reduced damages	Net option and existence values

Figure: 1 Wetland Functions: Physical Values and Economic Values

(Heimlich et al, 1998, p. 14)

1.3. Threats to Wetlands

When a wetland functions properly, it provides water quality protection, fish and wildlife habitat, natural floodwater storage, and reduction in the erosive potential of surface water. A degraded wetland is less able to effectively perform these functions. For this reason, wetland degradation is as big a problem as outright wetland loss (http://www.epa.gov/owow/wetlands/pdf/threats.pdf). Some of the uses that threaten wetlands are (http://www.panda.org/about_wwf):

- drainage for irrigation and agriculture
- as a source of drinking water
- using the wetlands waters for electricity generation
- human settlements
- dredging sediments and exploiting mineral resources
- intensive harvesting of wetland goods

As a consequence, wetlands all over the world are continually modified and reclaimed at great cost. Since, 1900 more than half the world's wetlands have disappeared.

1.4.Approaches Concerning Wetland Conservation

All life on Earth depends on water. Wetlands are vital, natural, living entities that must be preserved for the common good - the good of the human race and the good of the huge variety of animals and plants that survive in these unique habitats (http://www.panda.org/about_wwf).
Destroying or degrading wetlands can lead to serious consequences, such as increased flooding, extinction of species, and decline in water quality. We can avoid these consequences by maintaining the valuable wetlands we still have and restoring lost or impaired wetlands where possible (Heimlich et al, 1998).
Greater scientific understanding of the roles wetlands play in the ecosystem has increased public appreciation for wetlands. Public recognition of the value of wetlands has risen rapidly over the past 25 years. Today, scientists and environmental interest groups recognize how many different species and functions depend on wetlands and strive to increase public awareness of their importance in the natural order and to society.

As a result, society increasingly values conserving wetlands over converting them for private economic uses. Policies designed to balance public interests in wetlands with private benefits from conversion have been contentiously debated (Heimlich et al, 1998).

2. WATERSHED MANAGEMENT APPROACH

2.1. Simple Definition of a Watershed

A watershed is the area of land that catches rain and snow and drains or seeps into a marsh, stream, river, lake or groundwater. Homes, farms, ranches, forests, small towns, big cities and more can make up watersheds (Figure: 2). Some cross country, state, and even international borders. Watersheds come in all shapes and sizes. Some are millions of square miles, others are just a few acres. Just as creeks drain into rivers, watersheds are nearly always part of a larger watershed (http://www.conservationinformation.com/?action=learningcenter_kyw_whatisawatershed).

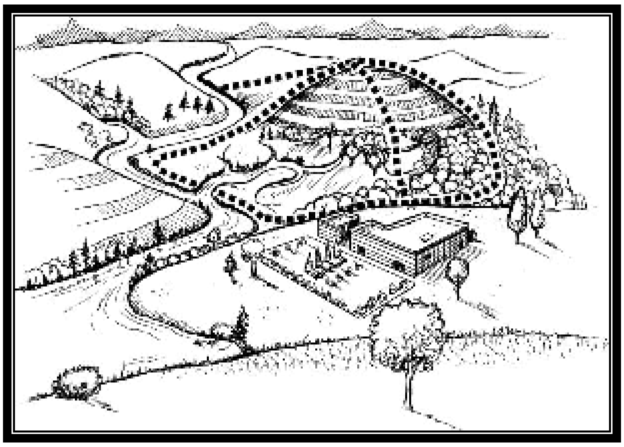

Figure: 2 A Watershed Illustration

2.2. The Necessity of Watershed Level at Wetland Conservation

The watershed management approach has been shown to be the best way to effectively restore, protect and manage water resources. Watershed-based management is the most effective way to enhance water quality and natural resources, protect critical wildlife habitat, prevent soil erosion, and sustain economic activities while managing the pressures of an urbanizing landscape. A watershed (synonymous with “catchment” or “basin”) is made up of the natural resources in a basin, especially the water, soil and the vegetative factors. The comprehensive development of a watershed so as to make productive use of all its natural resources and also protect them is termed “watershed management” (Eren, 1977). Using a watershed-based approach to wetland protection ensures that the whole system, including land, air, and water resources, is protected (http://www.epa.gov/owow/wetlands/facts/overview.pdf).

2.3. Watershed Planning and Management

Watershed management is the process of organizing and guiding land and other resource use on a watershed to provide desired goods and services without adversely affecting soil and water resources. Embedded in the concept of watershed management is the recognition of the interrelationships among land use, soil, and water and the linkages between uplands and downstream areas (Brooks et al., 2003). Watershed management includes improvements, rehabilitation and other technical works.

The watershed management approach is not a new concept, and several development organizations have adopted and implemented it since the 1970s, if not earlier. The success of this strategy is a debatable issue. Some argue that watershed management based on participatory approach has met with only a limited success (Lal, 2000). Watershed management provides a framework for integrated decision-making (i) maintain or icrease land and resource productivity (ii) ensure that adequate quantities of usable water are available to users (iii) ensure adequate water quality (iv) reduce flooding and the damage from flooding (v) reduce the incidence of mass soil movement and other forms of soil lost.

Watershed management involves an array of nonstructural (vegetation management) and structural (engineering) practices. Soil conservation practices and land use planning activities can be tools employed in watershed management, as can building dams, establishing protected reserves, and developing regulations to guide road- building etc. types of activities (Brooks et al., 2003).

A watershed based approach is becoming more popular in settling disputes about water use and water quality in river basins, particularly in the West. The watershed approach involves sitting all interested parties down, agreeing on goals, and together developing strategies to meet them. Water conservation can be a powerful tool in watershed management. In many situations, water conservation can make a significant contribution to resolving watershed issues (Dyballa, 2006).

3. CASE STUDY: WATERSHED OF LAKE BEYŞEHİR

3.1 The Location and the Importance of the Study Area:

Beyşehir Lake is at 1125 m elevation, and with its 730.3 km² area, the lake is the third largest lake in Turkey after Van Lake and Tuz Lake. Moreover, it is the largest fresh water lake, used for drinking waters, in Turkey (Yaşar et al. 2003). The basin is quite rich at wild life and plant variety (Anonymous, 1999).

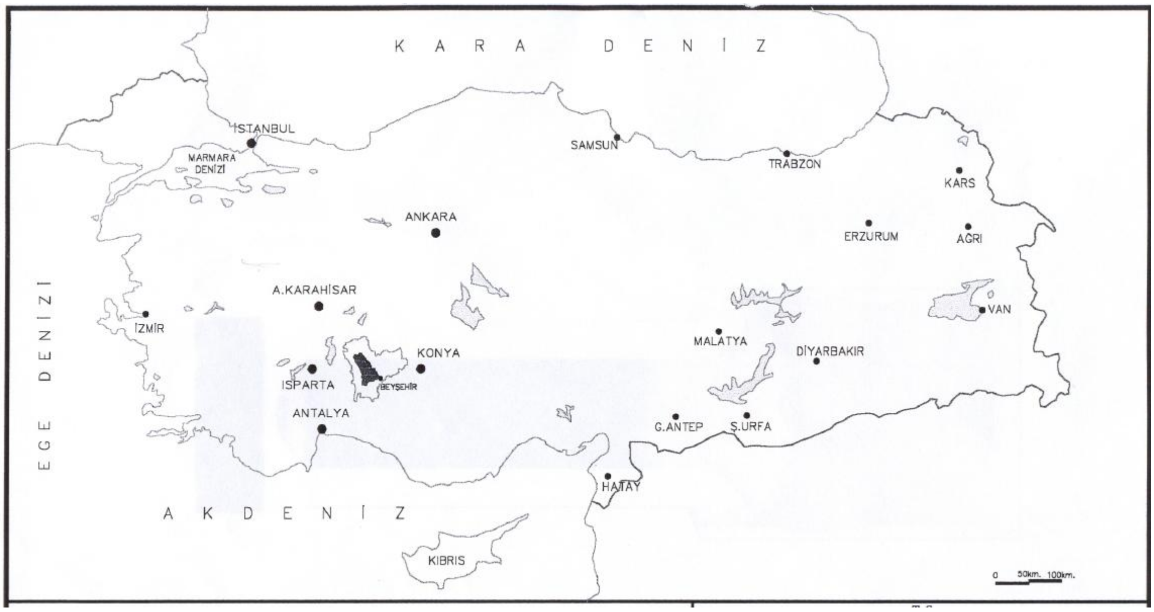

Figure: 3 Location of the Study Area in Turkey (Tüstaş 1999)

Due to its natural richness, the basin hosted many civilizations of different cultures throughout the historical development period. The Basin hosted different cultures and civilizations because of its natural values.

3.2 Threads of the Watershed

The lake is confronted with threats to its ecology such as the application of irrigation projects for more usage of water from the lake for irrigation, not being able to meet the infrastructure needs of the growing population, implanting new fish species into the lake other than the natural species, not taking the necessary preconditions for the fishery, reed cutting and diversity in the economic activities. The problems encountered in the lake and the basin can be counted as follows:

- **Problems Related to the Water Level**: Since Lake Beyşehir is the only freshwater resource in the Konya Basin, the primary effects about the lake are related to the water pumped from the lake. More than half of the water capacity of the lake is used for the local irrigation programs and as potable water for the residential areas around it (Özhatay et al. 2003, 53).
- **Diminishing of the Biological Diversity**: Since the samples of the natural flora in the basin are collected in excessive amounts, biological diversity has diminished significantly. Growing pressure from people, decreasing water level and contamination have given rise to eradication of bird colonies.

- **Uncontrolled Tree Logging and Reed Cutting**: There is not surface soil left in the west and southwest of the basin with steep slopes due to tree logging. The soil of the basin erodes as well as the water of the basin. Since the reed cutting is carried out in an uncontrolled way in the north, northeast, south and southwest where dense reed exists, the filtration characteristic of the reeds diminish and nesting and feeding sites important for the wildlife come to harm.
- **Agricultural Activities**: Fertilizers and chemicals that are used in intense agricultural activities directly flow into the lake through ground water, irrigation channels and rivers. The fact that especially the water coming through irrigation channels and rivers is not refined constitutes the primary reason for contamination.
- **Unsustainable Hunting and Fishery Activities**: In spite of all the protection regulations, illicit fishing around the basin is still perpetrated. There are more fishermen around the lake than there should be.
- **Shanty Settlements**: Since it is a potable water reservoir, detection of the shore borderline is compulsory and since it is a National Park, settlements along the shoreline is not allowed. Despite this, there are unauthorized settlements in and around the shoreline.

- **Insufficient Infrastructure**: The waste from Beyşehir city center that is a settlement located along the lakeshore is dumped at Beyşehir River; thus, it does not affect the lake. However, the sewerage of towns around, the chemicals from the agricultural fields and the wastes from the armament plants in the towns in south lead contamination in the lake.
- **Unapplied plans**: “The Lake Beyşehir Management Plan for the Surface Water Infiltration Basin” and “Long Term Development Plan for the Lake Beyşehir National Park” have not been put into effect yet.
- **Legal and Administrative Problems**: The primary reason why the operations for the protection of the basin cannot be implemented is that the institutions and associations responsible for the basin are not in coordination. The fact that municipality and village settlements in the basin do not make investments for the environment protection such as refinement and sewage on grounds that they do not have adequate resources is an important problem.

3.3 Watershed Management Studies in the Basin

In this study, the approaches oriented watershed management is grouped in 3 topics:

3.3.1. Conservation Statutes

Lake Beyşehir is a wetland which has an international importance with respect to its fauna and economic function. Consequently two areas have been designated "National Parks": Lake Beyşehir and Kızıldağ, thus a large proportion of the basin region is under protection. Various zones of the Lake are designated as "I., II. and III. Degree Natural Protected Areas". Also there are archeological conservation areas in the basin. There is an "Urban Conservation Area" in Beyşehir. Also as the lake is a supply of fresh water for human consumption. Its water quality is controlled by Turkish "Water Pollution Control Regulations". Lake Beyşehir has the statute of "Important Plant Area- IPA[2]. Important Plant Area of Lake Beyşehir (IPA) contains the third largest lake ecosystem in the southeast of Lake District in Turkey (Özhatay et al, 2003). Beyşehir Lake acquires IBA (Important Bird Areas) status[3] by its major number of wintering water birds (Yaşar et al. 2003).

3.3.2. Water Management Projects

Water management projects within basin have been developed against decreasing of the water level in the lake. The first one is "Gembos Derivation Project" proposed by State Hydraulic Works. The aim of the project is to transfer approximately 130 square hectometer water to the Lake Beyşehir from Gembos basin annually. It is also aimed that the irrigation facilities provide irrigation for an area of 3500 ha (8.600 acres) and drainage. The project has not been completed due to lack of financial resources. Another water resource-developing project for the Lake Beyşehir is the "Blue Tunnel Project". The Blue Tunnel Project aims to transfer 450 square hectometer water from three dams in Göksu Basin to Konya Basin annually (Mıhladız and Çabuk Kaya 2003).

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[2] Important Plant Areas (IPAs) have been defined as;*" natural or semi-natural sites exhibiting exceptional botanical richness and/or supporting an outstanding assemblage of rare, threatened, and/or endemic plant species and/or vegetation of high botanic value.".* The IPA concept recognizes that to be effective, conservation efforts must focus on plant communities and ecosystems - not only on imperiled species (http://www.plantsocieties.org/importan.htm).

[3] Important Bird Areas are sites particularly important for bird conservation because they regularly hold significant population of one or more globally or regionally threatened endemic or congregatory bird species or highly representative bird assemblages. IBA's are more than a bunch of sites, they aim to form a network sites ensuring that migratory species find suitable breeding, stop-over and wintering places along their respective flyways. Important Bird Areas were selected on the basis of internationally agreed standard criteria (http://www.birdlife.org/action/science/sites/european_ibas/index.html).

3.3.3. Watershed Planning Studies

The Lake Beyşehir Management Plan for the Surface Water Infiltration Basin:
The Lake Beyşehir Management Plan for the Surface Water Infiltration Basin was prepared for the protection of the lake and the basin by Konya Governorship and Ministry of Forestry and Environment. However, since the other institutions did not think that the plan fit their purposes and the changes they asked for were not made, they did not deliver opinion. Thus, the plan has not been put into effect yet.

Long Term Development Plans for Beyşehir and Kızıldağ National Parks:
Ministry of Forestry and governorships of Konya and Isparta carried out a protocol in 1997. At each stage of "The Lake Beyşehir Management Plan for the Surface Water Infiltration Basin" which was prepared by governorship of Konya, the opinion of the Ministry of Forestry was asked for. As a result of the Basin Management Plan, Long Term Development Plan for the Lake Beyşehir National Park was completed and presented to the concerned ministries for their opinions in the date of 21. 07. 2001. They expressed affirmative opinions about the plan. However, the plan is in the process of waiting for the approval of Konya Council for the Protection of the Cultural and Natural Assets.

Environmental Arrangement Plan:
Ministry of Environment and Forestry, Evaluation of Environmental Effects and General Directorate for Planning have been in the planning stage.

Project for the Wisely Use of the Lake Beyşehir:
_Project for the Wisely Use of the Lake Beyşehir constitutes one of the most important elements of Konya Closed Basin Project which is carried out by WWF Turkey (Global Environmental Conservation Organization). The aim of the project is to identify the threats against the ecology of the lake and to create alternatives and/or proposals for the present planning (http://www.wwf.org.tr). The Project is stil going on.

4. CONCLUSION

Wetlands, which has an indispensable role on the continuation of the natural balance, are habitats has to be conserved with their natural conditions because of being rich ecologic and biologic ecosystems. Poor ecosystem management of watersheds has and will result in the impaired functioning of the watershed, which in fragile environments can lead to ecosystem collapse (Samra and Eswaran, 2000).

As long as the natural resources can be used and preserved within their balance limits as a part of the ecosystem, sustainability can be provided. For this reason, to carry out the region planning studies according to the "basin" scale which is not changeable within its natural borders instead of regions whose borders are changing according to the socio-economic and technologic developments is a more realistic approach especially for sustaining the natural balances. Basin scaled region planning studies provide the opportunity of monitoring, directing and controlling the production and consummation activities eventuating with the natural resources within a holistic approach.

Sustainability requires a wide point of view from biological diversity, demographical structure, socio-cultural, economic, technological structure to planning. Sustainability within the basin scale can be obtained by not polluting or contaminating natural resources such as water, soil and air, and not pushing their limits while using them. Otherwise, it can result in adverse effects on the ecosystem. Production and consummation activities sustained on the basin and activities resulting from settlements push the limits to a larger extent. (Yalınız, 2003; 193).
Today, there are almost thirteen institutions responsible for the planning and management of the water resources and it is not possible to say that these institutions work and make decisions in coordination and cooperation. The water issue in Turkey is mainly the result of the fact that the limited water resources of our country are not well managed and properly used. As a result, our lakes drain and contaminated. In order to use the wetlands of our country in a sustainable and wise way, a planning approach that would gather the ones who administer the hydraulic works and the ones who use the water is needed.

The Basin of Lake Beysehir has considerably rich tourism potential with its natural, historical and archeological values, climate characteristics, rich folklore and cultural riches. Despite the fact that the region lying closer to the developed Mediterranean and Aegean Regions in terms of tourism, this potential could not be sufficiently evaluated yet. Considering the tourism potential of Beyşehir, this region should be immediately and significantly evaluated. The significant values of Beyşehir related with scientific, educational, aesthetical, landscape, cultural, functional and recreational point of views should be brought into foreground within the watershed management.

In order to solve the problems related to the water resources, the areas should be evaluated not as lakes, rivers and reeds but within the scale of basin. Studies that are carried out in order to preserve a wetland can be successful only if they are handled in an approach unifying all the sectors around the wetland. Accordingly, a solution for the Lake Beyşehir is only possible with the efficient work of basin management committee within the scale of the Lake Beyşehir basin and with the application of the administrative plan and/or the environmental arrangement plan.
In the studies to preserve the basin, the coordination among Ministry of Forestry and Environment, Ministry of Culture and Tourism, State Hydraulic Works, municipalities of the basin and the local institutions and associations is to be provided. In addition, there should be coordination and authority arrangement among all the institutions and associations responsible for the basin.

It is compulsory that the preparations for the 1/100000 Environmental Arrangement Plan on the agenda now is carried out within an integrated planning and management approach for the basin in order to provide the use and preservation balance and the development of the basin, that a planning bureau is established in the basin, that a plan should be prepared with the participation of the people of the basin and the local administrations and in accordance with the principles of the local agenda 21.

The problems in the basin of the Lake Beyşehir threatening the wetlands such as the change in the water flow and contamination result from the settlements in the basin. The presence of the settlements in the basin of the Lake Beyşehir is an important factor that should be taken into consideration. In order to provide the sustainability of the elements comprising the ecosystem of the Lake Beyşehir within the use and preservation balance, planning and management of only the reeds and the lake shall not be adequate. The sustainability of the resources can be provided only with a planning and management in the scale of the basin of the Lake Beyşehir.

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TRADITIONAL WATER MANAGEMENT; AN INSPIRATION FOR SUSTAINABLE IRRIGATED AGRICULTURE IN CENTRAL IRAN

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Central Iran is an arid area where all agricultural systems as well as human civilizations have always depended on the groundwater mostly obtained through *qanats*, but lack of an integrated management has thrown our groundwater resources into disorder. This paper investigates the ways through which we can incorporate some traditional methods into our modern water management. In fact there are two important things we might learn from the tradition:

1- accurate systems for division of water
2- preservation of groundwater resources

In central Iran, traditional knowledge provides informal education on water management that is passed from generation to generation. It concerns knowledge on division of water, maintenance of qanats and preservation of groundwater resources. This gives hope for the future, where both tradition and modernity can live side by side to promote our new water management.

Key words: *Traditional water management, modernity, division of water, preservation of water, water resources, qanat, sustainable agriculture*

Introduction

Central Iran is an arid area, so that its average rainfall does not exceed 250 millimeters a year. Therefore in central Iran all agricultural systems as well as human civilizations have always depended on the groundwater mostly obtained through qanats[4], some gently sloping subterranean conduits, which tap a water-bearing zone at a higher elevation than cultivated lands. But lack of an integrated management has thrown our groundwater resources into disorder. About fifty years ago, the total discharge rate of the qanats was approximately 18 billion cubic meters a year, which was 2 times more than the present amount. This problematic decline is attributable to the extensive pump extraction of groundwater and many wells drilled in the past few decades. Without regulation on water resources management this practice often depletes aquifers. The pumps are threatening our groundwater in central Iran and putting some economical-social systems in a real crisis, which make us think of other ways to improve our water management.

[4] There are 32164 qanats in Iran and an estimated the total length of their galleries is about 310800 kilometers (Papoli Yazdi & Labbaf Khaneiki, 2003). A qanat consists of a long horizontal tunnel which directs water toward the surface as well as lots of shaft wells in order to ventilate the tunnel and provide a way through which the excavated materials can be pulled up. To construct a qanat, first of all, an area near a mountain slope is usually chosen in order to dig the first well. The qanat practitioners continue to dig the first well as long as they come across the aquifer seeping into the bottom of the well. Then they stop digging the well because of the level of water coming up, but start digging a long tunnel crossing bottoms of all the wells, from the surface of earth to the last and deepest well. The tunnel is roughly horizontal, with a slop to allow water to drain out. The discharge rate of a qanat depends on its extent in the aquifer. Qanat has been an important part of a sustainable productive system, consistent with the environment of Iran, and used during the past centuries without damaging aquifer reserves.

This paper investigates the ways through which we can incorporate some traditional methods into our modern water management. In central Iran, traditional knowledge provides informal education on water management that is passed from generation to generation. It concerns knowledge on division of water, maintenance of qanats and preservation of groundwater resources. This gives hope for the future, where both tradition and modernity can live side by side without doing any damage to our water resources. Before getting to the point, I would like to bring the historical aspects of water management to the readers' attention.

The History of Water Management in Iran

Since the dawn of the Iranian civilization, water division system has played an important role and often lain behind the social and political processes. According to Wittfogel's theory, the water division system led to oriental despotism. In this arid region which has always been short of precipitation, people had to irrigate their lands, because they could not leave their cultivated lands only to such a little rainfall. On the other hand, the amount of water obtained through either rivers or qanats might not be quite sufficient for everyone to use without any need to economize on it. Therefore, some individuals gradually emerged to regulate water consumption and took charge of other water related affairs. In this region, whoever could take control over water would be able to gain a high social position and finally power to organize a political dictatorship or oriental despotism somehow.(Naghib zadeh A. 2000)

One can place a great importance on water division system during the history of Iran. As an instance, water authorities or water organizations trace back to Sasani era, about 1900 to 1400 years ago. That ancient water authority was responsible for managing water ownership, recording water shares, and calculating the amount of tax the farmers had to pay for their shares of water. Later, Abbasid caliphs reestablished the same water authority named *Divan al-Ma'*, and assigned some experts named *hassab/accountant* to all water related affairs (Papoli Yazdi M. and Labbaf Khaneiki M. 1998). All the Iranian governments used to place a high value on water, so they tried to do their best to look after water affairs. The more perfect water distribution and management, the more profit the governments could make. I would like to draw your attention to the fact that in some cases the taxes were only calculated based on the amount of water (Khosravi Khosrow. 1969), because our historical governments had derived from a traditional economical context which was quite different from the recent one resulting in some political systems that often fasten their hopes on some natural resources like oil. In the past, the Iranian governments used to intervene in water management to avoid any disorder in agricultural production systems which had something to do with the amount of taxes the government expected to charge people. Aboodalaf, an Arab historian, reports a fascinating dam in Damghan (in central Iran) constructed by Sasani kings in order to divide water into 120 shares each of which belonged to a village, then he admits that "he has never seen such a clever and accurate technique to manage water". (Aboodalaf. 1975) Also, what Maqdasi, an Arab geographer, reports on the Marv dam, in fact shows how much the Iranian governments were concerned about the irrigation systems and water management. According to Maqdasi's report the Marv dam was run by a staff of ten thousand persons who were hired to protect the dam or be in charge of its water management. To measure the amount of water, the dam had a special tablet in a standing posture with some horizontal lines cut into it. Should the level of dam water could reach the sixtieth line, it would imply that the coming year would be so wet and fruitful that the staff of dam no longer needed to be quite strict about the water division. But, it could be a bad omen predicting an upcoming drought, if the level of water could not exceed the sixth line.

There were some main outlets in the dam each of which belonged to a separate village to distribute water among them as fairly as possible, and then there were other outlets in every village to divide water among the quarters, and more outlets in every quarter, so on. If the dam would become short of water, the staff would do their best to decrease all the shares alike (Meftah E. 1992). If any problem threw the water division systems into disorder, the government was also in charge of solving it, as king Tahir did about 1000 years ago. A terrible earthquake struck Khorasan province and destroyed many qanats so that the qanat flows completely ceased. After renovation of the qanats, some serious disputes broke out between the owners of the qanats for more shares of water. Finally king Tahir mediated between the owners and settled the problem by means of calling in all the clergymen and lawyers from all over Khorasan to compile a book on the water division and water related laws (Salimi M. S. 2000).

Bearing in mind the importance of water management in Iran, it was only for king or his minister to confirm and sign the official proofs regarding the water division systems of big rivers. For example the proofs of Karaj River should have been authorized by Amir Kabir, Nasereddin Shah's famous minister (Enayatollah R. 1971). So, it would not be an exaggeration to say that most of the socio - political structures of Iran are still rooted in the history of water management.

Water Management in the realm of Modernity

Among the package of the modern reformation of the former Shah in 1963, the redistribution of agricultural lands which sheared the traditional landed elites of much of their influence has the most significant effect on water management systems in Iran. Before the land reform, most of the Iranian population resided in rural regions. Each village consisted of some agricultural units named *boneh*, cultivated by 8 to 12 farmers (share-croppers). The duty of each farmer was perfectly specialized. Two farmers were usually in charge of plowing and preparing the field, two other farmers were responsible only for irrigation, and the rest of them were involved in seeding, protecting and harvesting. Everybody worked and lived under the management and authority of a lord, who owned the whole village. According to the Law of Land Reform, the villages were purchased from the lords by the government one after another, and then were sold to a few farmers in the same village by installments.

The land reform law was finally carried out, without caring about the majority of the villagers who had no share in the agricultural units (*boneh*), not profiting from the land reform at all, and without caring about the complicated relationships between the production systems, environment and water management in Iran. So, the land reform law could lead to annihilation of many qanats which were only resources to supply water to central Iran, by means of a blind mechanization and confusing water management systems. Even if the motive for the land reform was making the lords' capitals move to the principal cities to be invested in the industrial section, the government should not have distributed the lands between the peasants yet. But, it was better for the government to retain the purchased lands and reconfigure the traditional management in a modern context by means of setting up some organizations in the rural regions being able to take the landlords' place. Doing so, the agricultural units *(boneh)* which could optimize irrigation so perfectly that sometimes the irrigated fields could be extended 1.5 times (Safinejad. 1989), would be left untouched.

In fact the land reform removed the lord's traditional position, because those agricultural systems carrying such a position were ruined, but anyone or any kind of organization did not exactly replace the lord's role. Therefore many qanats were abandoned for a while or even for ever. Because, within the agricultural system of *boneh*, the lord used to look after his qanat, and if a qanat would need to be repaired, the lord did not hesitate to call in the qanat practitioners and finance the whole project. After the land reform, the qanat practitioners could no longer work for any lord who used to finance the qanat and give them an opportunity to earn a living, so they were encouraged to immigrate to the cities or other regions. In central Iran, qanat practitioners were a professional community having no right to work on the lord's lands as some official and permanent farmers. In the rural regions, the society was divided into two casts locally named *Nasaqdar* and *Khoshneshin*. *Nasaqdar* meant the groups who had the right to work for the lord as his farmers on his fields, so they had priority over the second cast (*Khoshneshin*) who had nothing to do with the agricultural activities, and their jobs would only satisfy the other needs of the rural community such as masonry, carpentry, handicrafts and qanat-related activities. According to the land reform law, the lord's lands should have been distributed just among the *Nasaqdars* the people who worked on the lord's fields, so this program did not bring any profits to the qanat practitioners and made them let go of the agricultural areas.

On the other hand, the land reform raised a great demand for irrigation water because of a bad management. Before the land reform, whoever worked in an agricultural unit (*boneh*) was responsible just for a particular job such as plowing, seeding, irrigating or harvesting, and the farmers rarely interfered with each other's job. Therefore, each farmer could not be as good at all jobs as his own job, so most of them were not capable of irrigating the fields. In a traditional manner, someone who was not expert at irrigation might waste some water in many ways, so after the redistribution of the lands the consumption of water increased, and the demand for water quickly surpassed the supply of qanats mostly due to misusing water. Therefore, the farmers had to drill some deep well to pump the aquifer to provide the required water, doing so lots of qanats fell into decay.

As mentioned, according to the Law of Land Reform, the lords were forced to sell their lands to the government. But mechanized farms were the exception, and having pump extraction was legally considered as a proof of it (Azkia M.. 1994), so some of the lords were encouraged to replace qanat with pump extraction in order to save their own lands. Actually they did not want government to destroy their traditional position in the rural communities by means of removing their economical roots. The lords hurried to dig the well with extractive pump to avoid being included in the land reform law, even if their lands needed no well. Doing so, the number of the deep wells dramatically began to increase. As an instance, the first well with extractive pump, which took place in Neyshaboor region, was drilled in 1958. But the number of such wells reached 14 in 1960 just when the land reform law were approved and announced, and then amounted to 286 in 1970. Massive ground water extraction causes depletion of finite aquifer reserves, and it dramatically reduces the water table of the whole surrounding area. An estimated in Neyshaboor region the water table goes down about 0.2 meters a year on average, because of the massive groundwater extraction (Velayati. 1999). Therefore most qanats were drying one after another, due to the wells and their pumps, which took the water table away from the access of qanats. The comparison of qanat with well (extractive pump) can shed a light on the fact that such wells are not suitable for Iranian agricultural systems in many cases. Extractive pump empties the porous layers of water and cause some subsidence, which do lots of damages to the structure of soil and even buildings. If extractive pump empties karstic holes of water and destroy them, then a circular hollow appears within a radius of 100 meters on the surface of earth. But qanat never makes such a problem. The potential loss of fresh water, which makes salt water move towards up stream, is attributable to extractive pumps, whereas qanats never change the quality of water. According to some information related to Iran, the wells with extractive pumps could not last more than 30 years unlike qanats which last more than 2000 years without any defects. After all, water flows out of qanat only because of the force of gravity that is free of charge, whereas the extractive pumps consume an enormous amount of fuel per year. For example, in Yazd area there are 4340 wells with extractive pumps, which totally consume 205854880 liters gas oil a year in order to obtain 926350000 cubic meters water. But in the same area there are 2948 qanats, which withdraw 329870000 cubic meters water a year without any fuel (Baqeri & Roozbeh. 1999).

This land reform was an example and a bad experience that taught us the fact that development is not a simple concept we can import from the modern world into our own country, without taking our cultural economical and ecological conditions into account. Although the Iranian authorities tried to belittle all the traditional production systems, while carrying out the land reform program, in order to pave the way for a modern model. They believed that our country could never achieve a developed stage, unless we completely let go of the traditional sections of the society that appropriate most of our resources. Therefore, most of the Iranian scholars and politicians tried to exaggerate the technical defects in qanat and traditional water management to justify their own hasty programs and convince farmers to use pump extraction instead of qanat. As an instance, a report entitled “Economical Development of Soil and Water Resources” prepared in 1966 explains the amount of required water to irrigate an area equal to 10000 square meters or a hectare. Some parts of that report associated with modern techniques estimate the amount of required water for a hectare to be about 10000 cubic meters a year. But another part related to qanat and traditional irrigation makes contradictory statements, so that it estimates the amount of water needed for a hectare to be about 16400 cubic meters a year. In fact there is a thirty percent decrease in the required water in comparison with real estimate when the report explains modern irrigation, and a sixty percent increase when the report engages in qanat and traditional irrigation. Then the report concludes from such wrong estimates that qanat cannot supply the required water to irrigate our farms. Such exaggerating reports resulted in thousands qanats being destroyed. As an instance, only in the plain of Yazd there are more than 70 dried-up qanats, which have caused many villages and about 2500 hectares rich lands to be abandoned (Labbaf Khaneiki M.. 1999). The main reason why *qanats* started drying is that many deep wells were drilled in lower slopes to extract water with pumps depleting aquifer.

The depletion of aquifer not only makes *qanat*s dry, but also causes desertification especially in central Iran in which some plants such as Salsola Spp and Seidlitzia Sp usually grow depending on the water table (Ekhtesasi & Daneshvar. 1999). When I worked for Amirkabir institute in 1996, I came across an awful adventure explaining the role of pump extraction in some water and land management disasters as well as social – economical problems. There were some villages in southern Khorasan lying on the edge of central desert of Iran in which some peasants had settled and traditionally earned their living by camel husbandry. An organization had made a decision to help them start to cultivate their pastures in hopes that they could improve their economical situation. So the organization encouraged them to give up camel husbandry that was supposed to waste their time and energy. They started to drill many deep wells to pump water for the lands allocated to produce pistachio instead of camel husbandry. The extracted water contained some salt, and irrigation water that was not properly drained left a salt residue. The salt built up and finally led to a type of soil unusable for farming. According to the book Blue Gold, salinity has affected a fifth of the world's agricultural land, and each year it forces farmers to abandon a million hectares of farmland (Barlow & Clarke. 2003). As a result, the aforementioned farmers had to stop planting the pistachio trees, because of the salty soil not letting pistachio grow. So they desired to return to the camel husbandry, but the environmental condition had changed so much that no animal could feed on such poor vegetation. In fact the pumps caused depletion of aquifer as far as the roots of some plants such as Alhaji which was the main food to camels could not reach the water. Therefore, there is no enough plant in the field in which their camels were supposed to graze. Unfortunately the farmers lost both agriculture and animal husbandry, and they had to immigrate to some principal cities as a community of poor suburbanites. I believe that after water management broke up in disorder and lost its traditional function, we faced some multidimensional problems which would remain unsolved unless we would modestly learn some lessons from tradition.

Traditional Water Management

Here, traditional water management means all the actions the local farmers take in order to regulate water division, irrigation related subjects and preservation of water resources. They have traditionally established some complicated systems in order to divide water among the farmers or the shareholders of a water resource, and irrigation rights are based on landownership or time shares within a certain period of rotation. This water division system can match up with all likely changes in the volume of water during a year, while satisfying the farmers' irrigation needs. To measure the time every shareholder has for irrigation, they have invented a special type of water clock or clepsydra. Their clepsydra consists of two bowls made of copper one of which is so small that could freely float on the surface of water in the large one. The floating bowl has a tiny hole at its bottom through which water can enter the bowl and gradually fill it up. After being filled which may take a certain time, the small bowl sinks in the water and bumps into the bottom of the large bowl. As soon as the bump would be heard, a unit of time would be over, so the time between the two bumps equals a certain unit of time. One can also find some marks cut into the inner side of the small bowl which divide the certain unit of time into the shorter fragments. The time it may take the small bowl to be filled and sink varies from area to area in the central plateau of Iran. I examined some different types of clepsydra in some areas and summarized all the results in the following table.

Location	Time (hour: minute: second)
Kol-e Birjand	00: 24: 00
Shahik-e Qayen	00: 22: 30
Khor-e Birjand	00: 17: 00
Kadekan	00: 15: 00
Sarbisheh, Zirkooh-e Qayen, Darmian-e Birjand	00: 12: 00
Yazd	00: 11: 15
Zoozan, Boshrooyeh	00: 10: 00
Fakhrabad-e Bajestan, Eshgh abad-e Tabas	00: 09: 00
Bilond-e Gonabad	00: 08: 30
Gonabad	00: 08: 24
Dihook-e Tabas	00: 08: 00
Khanik-e Gonabad	00: 07: 30
Abiz-e Qayen	00: 07: 00
Aboojafari-e Boshrooye, Kakhk	00: 06: 00
Khosro Jerd-e Sabzevar	00: 05: 00
Serend-e Ferdows	00: 04: 44
Bajestan	00: 04: 36
Tabas	00: 04: 00
Ferdows	00: 03: 00

Sometimes, in a certain area, the unit of time may vary with the season and the period of rotation within which the irrigation rights have been defined. As an instance, In Bajestan area, the unit of time varies from 2.3 to 17.2 minutes between the months of March and February. In this area, there are three qanats named Mohammad abad, Golbid and nowkariz. Bearing in mind the location of farms and the distance between the qanats and the farms, each farmer may use either one of the three qanats or two/three of them mixed together. The joint flow of the qanats of Golbid and nowkariz is only considered as the standard flow to which all the official proofs refer. For example, if someone claims that he/she possesses ten shares of water, in fact he/she is entitled to irrigating his/her land for 46 minutes because every unit of time equals 4.6 minutes on the condition that the flows of Golbid and nowkariz are together. On the other hand, the rotation of irrigation rights may be based on 21, 14 or 10 days during a year. Within a period of rotation based on 21 days, every shareholder is allowed to irrigate only once every 21 days and so on.
Meanwhile, the length of the period rotation varies from season to season in order to adapt the available water to the existing climate condition. Therefore, there are 15 units of time all of which depend on the period of rotation and the source of water, as you can see in the following matrix. The gray part of this matrix shows 15 possibilities for unit of time from 2.3 to 17.2 minutes. As an example, the unit of time would equal 4.6 minutes, if the rotation of irrigation rights would be based on 14 days as well as both the qanats of Golbid and nowkariz would be taken into account.

10	14	21	period of rotation / source of water
2.3	3.2	4.8	Mohammad abad+Golbid+ nowkariz
3.2	**4.6**	6.9	Golbid+ nowkariz
8.2	11.5	17.2	Mohammad abad
8.2	11.5	17.2	Golbid
5.5	7.8	11.7	nowkariz

Due to the complexity of the water division, there are some professionals named *mirab* who are in charge of distribution of water among the farms, and are paid a definite salary by all the shareholders. While giving water to a shareholder, *mirab* also has to consider the time it may take the qanat flow to get to the given farm. For example, if someone has a right of 46 minutes irrigation, and if it takes the flow of water 4 minutes to arrive in his/her farm, then he/she should be allowed to use the water for 50 minutes. Therefore, *mirab* does his best to distribute the water among the farms in a way that as less water as possible would be wasted in the ditches. Doing so, *mirab* should be quite familiar with the locations and characteristics of all the ditches leading water to the farms. *Mirab* has a notebook too, including all the irrigation rights in detail, so if the shareholders want to sell or buy any right they should let *mirab* know about any transaction. Unfortunately nowadays this profession is fading but nothing is replacing it, so we witness some recent conflicts over water in rural areas these years.
Preservation of groundwater resources is also a good example of traditional Water Management which could be up for discussion here. Iranians traditionally used to live in harmony with their environment, so their techniques to supply water did not end up in annihilation of groundwater resources. They used qanats as a sustainable technique to extract groundwater, which was recharged in winters by some special dams constructed by the farmers. To prevent damaging aquifer, they designated the vicinity of qanat, which was the area defined surrounding the qanat and comprised between 1 and 3 km depending on the local conditions. The aforementioned dam is nothing but a pile of soil in upstream above the first and deepest well of qanat so that it can catch the floods in winter behind itself. The water accumulated behind the dam can gradually penetrate the earth and then seep into aquifer, so an increase in the discharge of qanat as well as the lack of erosion are two of the advantages of such dams. Nowadays, most of the dam are leveled and then cultivated with the help of pumping deep wells drilled in the vicinity of qanat. The fertile deposits of the dams tempted some farmers to change the dams into the farms at any cost, even though the qanat would dry up. As an instance, in Yazd a qanat named Chahok-e Nir was recharged by four dams which were located in the bound of another village named Pandar. The habitants of Pandar had some shares from this qanat, so not only they put up with the presence of dams in the middle of their lands, but also they helped the main owners of the qanat with renovating and protecting the four dams. After the Islamic revolution, the farmers of Pandar started selling their shares, and after a while they completely destroyed the dams and drilled some pumping wells in order to cultivate the whole area.

The lack of those dams caused the qanat to drizzle. But fortunately such traditional dams could provide inspiration for the Yazd Regional Water Authority which is very concerned about improving the groundwater resources in Yazd province. Doing so, they recently implemented some great projects to help recharge aquifer such as building 18 mud dams being able to inject more than 17 million cubic meters seasonal flood into aquifer. This gives hope for the future, where we would be equipped with both tradition and modernity to guarantee a sustainable agricultural system.

Conclusion

It is not wise to give up all modern technologies and revive tradition instead, but it is quite wise to adopt the sustainable relationship which has always existed between environment and the elements of the traditional production system. In the traditional agriculture, such an accurate water management perfectly met environmental conditions to make use of every drop of water in cultivating this arid region. Therefore, there are still many things we can learn from traditional water management to promote our new water affairs. Recently, in Iran some governmental centers' attention to traditional water management is tending upward. This gives glad tidings that future is not that disappointing if we learn how to have both tradition and modernity living side by side meeting a unique purpose, and it is the golden key of the sustainable water management.

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INTEGRATING ECONOMICS IN TO INVASIVE AQUATIC PLANTS (IAP) MANAGEMENT IN SRI LANKA: ALIEN AQUATIC PLANTS: IS AN ECONOMIC PROBLEM?

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Water is acknowledged to be critical resource for Sri Lankan agriculture and key constraint to economic growth. Inland waters are the only source for irrigated agriculture, domestic requirements and associated economic activities for over 19 million of the population. Recent observations revealed that, freshwater systems in the country have become infested with some of the worst invasive alien aquatic plants. There are about 22 noxious invasive plants in Sri Lanka of which more than 40% are associated with aquatic systems. Despite the scope and the magnitude of the problem, IAPs have received very little attention in political agenda. The hypotheses being tested is the concept of biological invasions are primarily an economic problem and as such, require economic solutions.

Study guides the future actions for resorting ecosystem services lost due to IAP, with effective mix of regulatory, economic and suasive policy tools. Poorly enforced, legislations are not effective. Instead study proposes viable policy mix for ecological restoration and sustainable management, assuring economic prospects to peripheral communities from the restored habitats to provide strategic financing for restoration and sustainable management. Cost effective habitat restoration and alternative utilization practices are some of economically viable suggestions to this phase of the study.

1. BACKGROUND

Water is acknowledged to be a critical resource for Sri Lankan agriculture and key constraint to economic growth of the country. Inland waters (15% of the land area) form the only source of drinking water, irrigating water for agriculture, water for domestic requirements, and many other associated economic activities for 19 million population (MENR, 2002).

There are some 50,000 reservoirs (known locally by tanks) in Sri Lanka ranging in size from 2 to 25 ha, which have been constructed over the past 3000 years mainly for irrigating rice. Moreover the last decade the number of dams in the country rapidly increased. Together with the reservoirs and canals, resulting from development of irrigation and hydropower generation projects worth over US$ 8 billion. Over 10 million of rural communities whose main livelihood is agriculture directly rely on this multitude of water reservoirs. Those water reservoirs currently becoming victims of the world's top drivers of the Global Environmental Change[5]; Invasive Alien Species and Drought.

Recent observations and reports have demonstrated that, both natural and artificial water bodies in Sri Lanka have become infested with some of the worst exotic aquatic weeds in the world. At present 58 invasive species (38 flora and 20 fauna) have been identified in Sri Lanka of which more than 50% (12 flora and 14 fauna) are associated with aquatic systems (*Pers. com.* Lalith Gunasekara). Most invasive aquatic plants species have been introduced to Sri Lanka from abroad, they do not have natural control agents or competitors and they tend to dominate the aquatic system to which they are exposed. Further, most of the invasive alien aquatic plants found in the country appeared as invasive several years after the first introduction. Therefore the problem of aquatic invasion has become more urgent and more complex today than in the past.

Despite the magnitude of the problem, aquatic weeds have received very little attention in Sri Lanka. There are no systematic aquatic management/research programs, and no aquatic weed scientists are working on the problem? This may be due to the decreasing availability of financial means for environment conservation and the crisis in public financing in Sri Lanka (Kotagama, 2000). However there is considerable pressure for efficient and sustainable use of the limited water resources. Thus there is an urgent need to address the problems of aquatic weed before it becomes dramatic.

Major Aquatic Weeds Threats in Sri Lanka

Floating Weeds ***a.*** **Water hyacinth *(Eichhornia crassipes)*** ***b.*** **Salvinia *(Salvinia molesta)*** **c. Pistia *(Pistia stratiotes)*** **These are the three most troublesome and widely spread floating weeds in Sri Lanka**	Immersed Weeds ***d.*** **Water cabbage *(Limnocharis flava)*** ***e.*** **Alligator weed *(Alternanthera philoxeroides)*** **f. Bulrushes *(typha spp.)*** **These are among the widely occurring weeds of this type in the country**
Submerged Weeds ***g.*** **Hydrilla *(Hydrillia verticillata)*** ***h.*** **Vallisneria *(Vallisneria gigantean)*** **These are the most common submerged weeds in Sri Lanka**	Bank Weeds ***i.*** **Taro *(Colocacia esculanta)*** **j. Giant mimosa (*Mimosa pigra*)** **k. Ketala (*Langenadra ovata*)** **These species are among others; commonly occur on the banks of water bodies in Sri Lanka**

"*Sri Lanka's inland waters include man-made lakes (tanks) and ponds and marshes, constituting one of the highest densities in the world*."

The area under water bodies is 2905 km 2 or 4.43% of the total land area. The major intentional (direct) causes for inland water pollution are agriculture, urbanization and industrialization that change land use patterns. Excessive use of agrochemical, release of industrial effluents, domestic waste and sewage and dumping of solid waste into waterways are the unintentional (indirect) causes.

(http://www.sacep.org/html/mem_srilanka.htm)

Due to above reasons majority of the wetlands including man made lakes become entropic and loaded with excessive levels of nutrients. Valuable ecosystem services like habitat provision for organisms are lost subsequently impacting on people's livelihoods.

Introduction

The global impact of IAS has been recognized by the Convention of Biodiversity (CBD), which calls for the control and monitoring of alien species that threaten ecosystems, habitats and species. Sri Lanka is a party to the CBD (singed on 05th June, 1992 and ratified on 23rd March, 1994), and has recognized the importance of IAS as a major threat to native biodiversity, especially as it is a small island nation.

Alien species invaded Sri Lanka's natural and agricultural ecosystems, causing tremendous damage. IAS entered into ecosystems by various means. Fast-growing alien plants encroach from populations established outside target ecosystems; invasive alien plants escape cultivation and become agricultural pests, infest lawns as weeds, displace native plant species, reduce wildlife habitat, and most likely alter ecosystem processes. Across Sri Lanka, as around the world, IAS has become one of the most serious threats to native species, natural communities, and ecosystem processes.(Marambe, et.al. 2001)

The importance of understanding the impact of IAS in Sri Lanka has been accepted recently. Several alien species are reported to be spreading at alarming rates, threatening natural and agricultural ecosystems of the country. Sri Lanka has considerable experience, where deliberate introduction of alien plants has finally resulted in them becoming invasive or weedy. It should be noted that plants that are now invasive or weedy, once appeared to be non-invasive when their populations were small, or when they occupied only habitats influenced by people.

Considerable efforts have been made by Sri Lankan scientists in the past to overcome threats from IAS on the some of the ecosystems of the country. Legislative measures, mechanical and physical control, and biological control were some of the strategies adopted and are still being used to manage IAS population in the country. Development of sound management strategies based on ecological principles, co-ordination between line agencies, and human resources development should be priority areas for successful management programmes for IAS in Sri Lanka. .(Marambe, et.al..2001)

Legislative Provisions in relation to control and management of IAS

Control and management of IAS need a strategic approach that encompasses prevention, eradication, control and containment. Prevention is the cheapest and most preferred option. The threat from IAS to local species, particularly in the sphere of agriculture, has been well understood for a long time. Several pieces of legislation have been enacted in Sri Lanka since the early 20th century to safeguard plants and animals in local habitats against these threats. That following is a list of this legislation.

- *Water Hyacinth Ordinance- This* ordinance, declared in 1909, restricts the introduction and dissemination of this aquatic weed in Sri Lanka. This act could be explained further to control and regulate other noxious species as well.

- *Plant Protection Ordinance (1924, amended 1956 and 1981, and wholly revised 1999)* - This ordinance restricts the introduction into Ceylon (now Sri Lanka) and spread therein of weeds, pests and diseases injurious to and destructive plants and for the sanitation of the plants. It was totally revised in 1999. (No.35) To provide adequately for currant trends on the movements of flora and fauna due to increased international trade and traffic.

- *Fauna and Flora Protection Act of 1937,* and its amendments, provides for the establishment and maintenance of national reserves, national parks and jungle corridors for the preservation of biological diversity.

- A revised *National Seed Policy* on the import of seed and planting materials to Sri Lanka was prepared by the Department of Agriculture in 1991, and *new seed Act of 1999* is pending formal approval.

These documents provide considerable legal support to act against the introduction of IAS. However, their interests and scopes are limited and they do not have the overall requirement to act against IAS. The plant protection ordinance of Sri Lanka aims at preventing introduction of alien pests (insects, diseases and weeds) which are harmful to agricultural, horticultural and forest-based industries. However quarantine laws give less emphasis to plant species that can have serious negative effects on biodiversity of natural habitats of Sri Lanka. Thus, it is clear that development of an appropriate legislative framework is a pre-requisite for effective prevention and subsequent control of IAS.

IAS have important influences on numerous economic sectors, beyond the obvious impacts on agriculture and forestry. Managing invasions successfully requires a coordinated strategy, based on corporation among all land managers (Marambe, 2001b).
The management strategies will rely upon the scientific expertise of cooperating research agencies and institutions, to develop sound scientific information for managing invasive alien plants. To overcome further detrimental impacts on agricultural and natural ecosystems, the policy makers of Sri Lanka must put management of IAS high on the list of national management priorities.

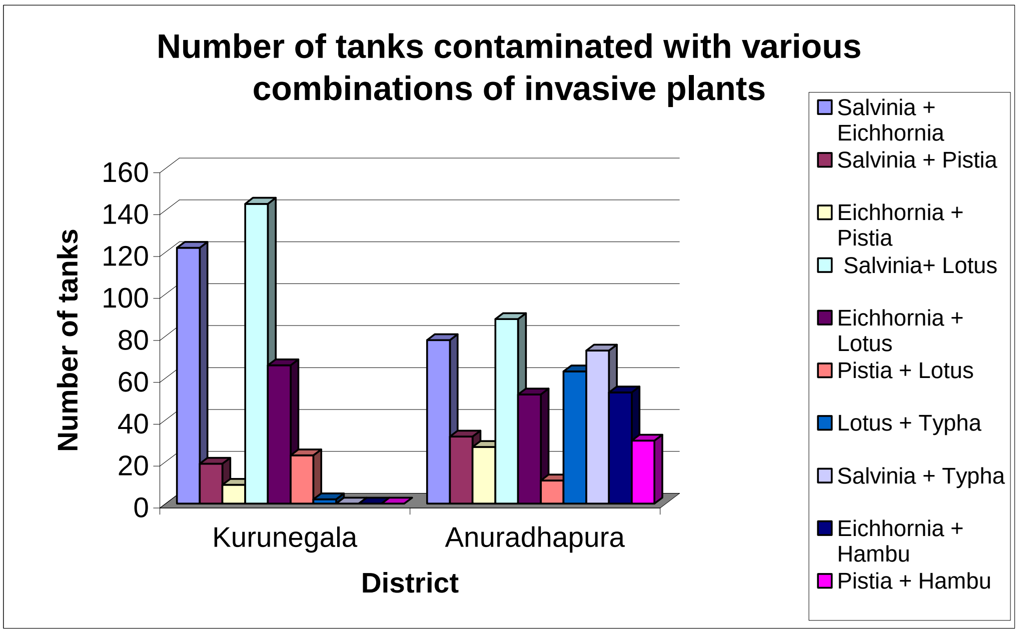
National Programmes Projects and Researches on Invasive Alien Plants in Sri Lanka.

Mainly aquatic weed control is done by manually. It is labor intensive and time consuming hence not proved as an effective strategy for eradication. In reason times different agencies tried some other methods.
There are two national programmes launched to control of the Invasive Alien Plants in Sri Lanka.

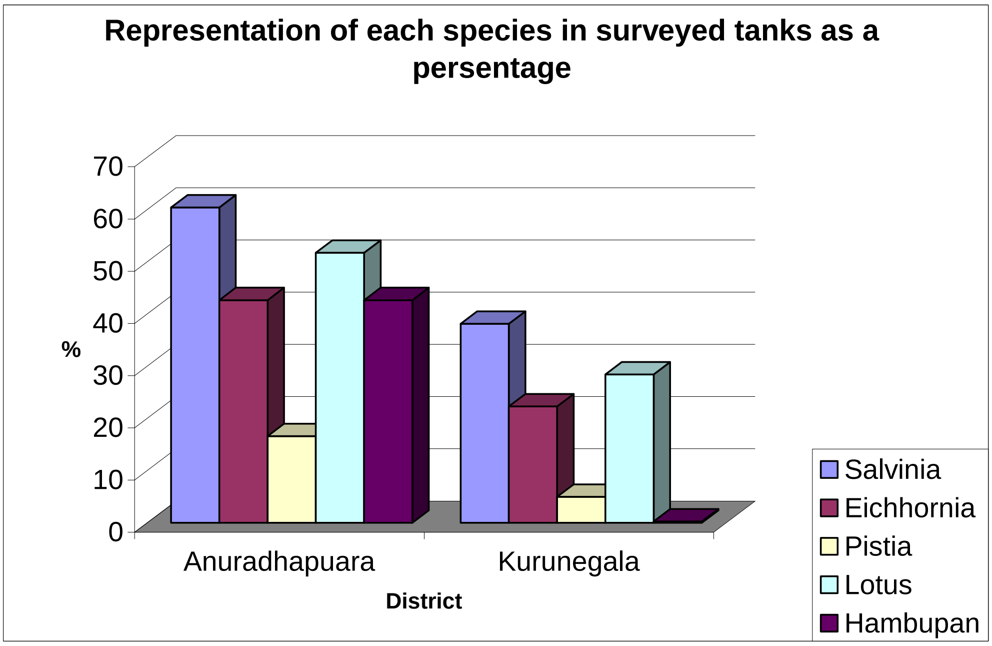
Rearing of Bio-control agents
Plant protection division of the Department of Agriculture has been involved in rearing of Salvinia bio-control agent,(*Cytobagous salvineae)* for the last 10-12 years with very limited resources. The project has been instrumental to bring down an adequate sample of *Neochatena bruchi*, the most essential bio-control agent for the control of water hyacinth. Samples of the insect were brought to Sri Lanka from Thailand in early 2005.
Salvinia bio-control agent was introduced to more than 200 reservoirs, and farmers learned to recognize the symptoms of damage of bio-control agents of the respective target weeds.
This pilot project on weed control by the insects has shown success. But its efficiency and effectiveness in large scale is not known. Some scientists argue of the danger on such insects as pests on agricultural crops. Although insects eat the weed plants the bio mass is not removed from the ecosystem and as the excreta is accumulated in the bottom. This creates fertile substrate for some other weed which can degrade the ecosystem. Integrated management strategy and ecological restoration is needed after bio control.

The biodiversity Secretariat of the Ministry of Environment has done a survey on aquatic plant species in 2005. The survey carried out in Anuradhapura and Kurunegala districts. These are two districts in the dry zone Sri Lanka where majority of the tanks are located. By using questionnaires data were collected from environmental officers of Central Environmental Authority, field level officers of Agrarian Services Department and Divisional Forest Officers. 28 Divisional Secretary's Divisions (DSDs) in Kurunegala district and 21 DSDs in Anuradhapura district were coverered. In Kurunegala district 785 recorded tanks were taken for the survey and in Anuradhapura District number of recorded tanks for the survey was 265. In two districts distribution of Aquatic Invasive Plants species were surveyed by name and percentage distribution in number of tanks.

The findings are as follows,



Source: Biodiversity Secretariat 2005



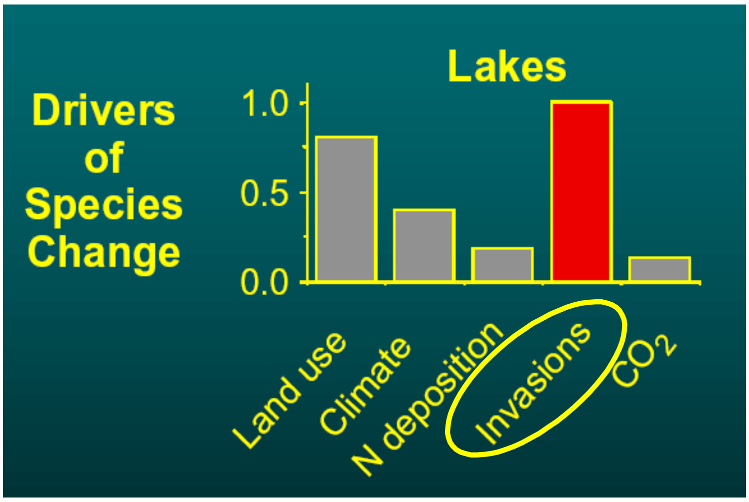
Source: Biodiversity Secretariat 2005

In this study Lotus is also identified as an invasive plant. In Anuradhapura District *Salvinia*, *Echonia* and lotus identified as more abundant Invasive plants. In Kurunegala District *Salvinia*, Lotus and *Echhonia* were abundant.

S. Vidanage and others estimated the value of traditional water schemes by conducting a research in the K*ala Oya* river basin in 2005. The study aimed to articulate the value of small tank systems in livelihood and biodiversity terms. - The first step was to determine the environmental and economic benefits associated with small tanks in the *Kala Oya* Basin. Range of direct livelihood values was identified. Important environmental services such as provision of the habitat and breeding ground for birds, fish and other aquatic animals were identified. Variety of valuation techniques were used to estimate the values and, study showed that Rajanganaya and Angamuwa sub catchments of the Kala Oya basin Yield an average value of US$ 425 per house hold per year in terms of water in terms of water and aquatic resources use, or almost US$ 3000 per hectare of inundated area. The valuation study also showed that, these benefits were particularly important for poorer households, who lack access to their own wells and for whom alternative sources of income subsistence were scarce. Further researchers found that the value of lotus flowers from 10% of the households, per household value as 106 US$ per year and annual value per hector as 72 US$. The value for Lotus roots per 7% of households were annual household value was 235 US$ and annual per hector value as 107 US$.

Alien Invasive Plants grows in entropic tanks loaded with excessive nutrients. AIPs affect habitats and biodiversity depleted. Costs and benefits of AIP control have not been looked at.

Causes of biodiversity Change in Aquatic Habitats During the 21st Century



Introduction of Alien Species is expected to be leading cause of biotic change in aquatic ecosystem during the 21st Century considered to be second most significant threat to global biodiversity following habitat destruction

Walker and Steffen 1997, Naylor 2000, Sala et al., 2000. 3

There is felt need to look into the economic aspects of Alien Invasive Plants.

Economic concerns of Invasive Alien Plants

As far as the Sri Lankan research on AIPs is concerned they are meant to explore Biological and Ecological components of this problem. No research done on the economic aspects of Alien Invasive Plants. Hap-hazed restoration work is done with out taking ecological aspects in to consideration. Most of such programs are not sustainable as there are no economic prospects to peripheral community. In overseas Invasive Species are management is backed by analytical case studies incorporated economic aspects of it.

Restoration of affected tanks with Aquatic Invasive Plants (AIPs) back to its' productive state is a long felt need by the people of diverse social roles. Lack of valid and reliable findings from scientific research to formulate a sustainable strategy for restoration is a gap to be filled by interdisciplinary, theme specific coordinated research.

This research project is concerned with the economic prospects for dry zone tank habitats, which are infested with invasive alien aquatic plants and become a major problem in inland aquatic ecosystem in Sri Lanka. Recent observations and reports have demonstrated that, both natural and artificial water bodies in Sri Lanka have become infested with some of the worst alien aquatic invasive plants in the world.

Good understanding of total economic value of AIP infested tank habitat is needed by decision-makers like government leaders, natural resources mangers and scientists to prioritize their NRM issues and allocate scarce resources to sustainable management of aquatic resources. Initial prioritization for mainstreaming sustainable NRM action into economic development process, the two main questions to date is:

(1) What and where are the priority areas?, and

(2.) How effective are different management interventions to achieve conservation, sustainable use and poverty reduction goals?

In this regards natural resources mangers have to tackle certain decision problems: *WHEN, WHERE,* HOW *to control, manage and restore* AIP infested tanks. These questions are becoming more challenging and interesting, when dimensions of the economic sustainability are inherent with inter-temporal characteristics of invasion and control/management strategies, the possibility of irreversibility's and uncertainty and the degree of livelihood dependency of the peripheral community.

Tank restoration to be economically justified and assure sustainable outcomes, above questions need to answered early with evidences. Economics deals with scarce resources and their trade offs on alternative uses in allocating efficiently in the markets. In terms of social equity, restoration benefits need to be distributed and shared among wider human populace. On the perspective of ecosystem health and environmental justice, people need to respect the rights of affected tanks to repair ecosystem services lost and maintain natural equilibrium. The research is designed to identify economic prospects in terms of measurable outputs and their sustainability for tank habitats restored from AIP infestation.

Research Objectives

The broad objective of this research is to identify, define and quantify in terms of measurable out comes, economic prospects for tank habitats which are infested with Aquatic Invasive Plants (AIP) and propose tank specific sustainable management strategy. In its broadest sense addressing the sustainability challenge in incorporating local Traditional Ecological Knowledge, practices and institutions and possibilities to adopt best practices elsewhere in the world will be looked at. To achieve this broad objectives the following specific objectives to be perused;

1) To identify and map infested and affected cascade system in a dry zone river basin with Aquatic Invasive Plants

2) To assess the tank habitats by using appropriate habitat indicators. Identified habitat indicators are Habitat Evaluation Index (HEI) and Habitat Suitability Index (HIS)

3) To survey of tank habitat utilization with respective economic value estimated e.g. Lotus harvesting, Fresh water fish culture, Water extraction, Habitat provision for wildlife, Recreational amenities and any other economic uses)

4) To estimate the economic values of ecosystem services lost by the Alien Invasive Plants.

5) To peruse extended benefit-cost analysis for different management scenarios of no-action alternative and ecological restoration coupled with habitat prospecting.

6) To conduct choice experiment to estimate the willingness to pay/accept "economic prospecting mechanism" as non-market public good for tank based stakeholder community.

7) To develop tank specific "*sustainable management strategy"* for ensuring economic prospects.

Research Methodology

Four phases of the research project are follows,

1. **Identification and mapping of infested tank sites due to aquatic invasive plants, which has ecological, economical and social significance.** Research methods to be adopted are review of technical reports, consultation of the experts and field visits. This is the primary step of the project to find out the prospective research sites. Appropriate criteria, indices and indicators will be developed to explain the tanks based on the degree of infestation due to aquatic invasive plants. Tanks in dry zone river basins are located and differentiated according to the degree of infestation. Already available secondary data and information will be assembled into GIS to identify the prospective tanks. At the end of the 1st phase critically AIP infested cascade tank system in a critical river basin will be identified for detailed investigation.

2. **Identification of Ecological-economic and Ecological- socio cultural linkages of the cascade tank ecosystem**

   Habitat Evaluation Index (HEI)/Habitat Suitability Index (HIS) developed for selected tanks. Identification of ecosystem services by observation, expert advice, primary data collection, interviewing of key stakeholders and resources users. Alternative habitat utilization and the economic value for different practices will be estimated. Where direct market prices unavailable non market valuation tools will be used. In this phase applied social research methods such as Participatory Rural Appraisal (PRA), Rapid Rural Appraisal (RRA), and Participant Observation will be extensively used in exploring the relationship and dependence of the peripheral community on the ecosystem services of the tank. Cascade tank basin will be spatially defined (zoning) on ecological-economic characteristics and ecological-socio-cultural linkages revealed by the study.

3. **Valuing ecological impact of the Aquatic Invasive Plants (AIP)**

   Impact of invasive plants on tank ecosystem can be **negative or positive**. But before incorporating the impact in economic model they need to be identified, defined and valued using appropriate valuation technique. Impacts will be identified and differentiated as positive or negative and listed. Significant impacts will be screened. Significant impacts, which are too small to be quantified, will be separately listed for quantitative ethno-botanical assessment. Quantifiable impacts will be reflected in financial terms using appropriate valuation techniques.

4. **Perusing Extended Benefit-Cost Analysis**

Estimate the quantities of various tank habitat uses (use and non-use values) under different scenarios. The scenarios can be,

a. No action alternative- with the presence of aquatic weeds
b. With the absence of aquatic weeds
c. With ecological restoration option 1 coupled with " Sustainable Prospecting Mechanism"
d. With ecological restoration option 2 coupled with " Sustainable Prospecting Mechanism

Damage or impact of the weeds and the benefit of the management strategy will be estimated by using Economic Impact Metrics. Per unit habitat value of the damage/ benefit or annual values of the unit habitat damage/benefit will be estimated using variety of valuation methods. Total economic value i.e. damage/benefit in to unit habitat value will be estimated.

Future benefits and the costs of different alternative scenarios for 25 years will be discounted to get the respective present values. Measures of project worth such as Net Present Value (NPV), Benefit Cost Analysis (BCA), will be estimated. A sensitivity analysis will be done under variable discount rates.

5. **Conducting Choice Experiments (CE)**

Choice experiment workshops are designed to test the hypothesis that demand of the individuals of the peripheral community, for tank habitats will change (increase/decrease) with the introduction of the package of prospective practices- "Economic Prospecting mechanism" for ecological restoration of the tank.

6. **Sustainable management strategy**

Most suitable "Economic Prospecting Mechanism" with maximum welfare measures, which was revealed by the study, will be made use for the Sustainable *management strategy*. Using appropriate methods, equity concerns will be incorporated in to the strategy.

In each analytical step, appropriate econometric analytical techniques will be used to analyze the data for interpretation.

Findings Discussion and Conclusions

The study is an on-going study. Being the first ever study on AIP which incorporate economic principles in to decision making. The research concept was promising to policy planners and implementing personnel. Review of past research findings and papers completed as a desk study. Research sites identified. A cascade system in dry zone Sri Lanka known as *Kalawewa* river basin was identified. A series of stakeholder meetings were organized. Preliminary surveys have been conducted. Map preparation activity by using GIS software is in progress**.** Ex-ante benefit cost analysis, choice experiment, and multi criteria analysis to done. For the application of precautionary principle & ecosystem approach this is a good example. High uncertainties of the damage of the aquatic weeds justify the application of precautionary principle. It is evident that aquatic weeds infected in to the dry zone through the Mahaweli diversion scheme. On pilot basis it can be suggested precautionary principle to control Invasive aquatic weeds to be applied for Mahaweli area. Mahaweli Authority of Sri Lanka can be the regulatory and implementing agency. There is tendency of people prefer regulatory tools over economic or suasive measures. But a combination of policy tools to use the power of multiple agents and provide multiple incentives will be the optimum mixture.

Following conclusions can be made

1. In both districts of Anuradhapura and Kurunegala *Salvinia*, *Echonia* and lotus are identified as the most abundant Invasive plants.
2. Considering Lotus as an invasive weed is debatable as it generates fair economic returns.
3. Ineffective and out dated legislative enactments and even they are not enforced
4. Excessive use of agrochemicals and silt sediments transported due to soil erosion increase the entropy of the tank water creating fertile medium for invasive aquatic weeds to proliferate.
5. Break-down of traditional management systems is one critical socio-cultural reason lead to further erosion of social capital for tank management. Hence regular tank cleaning not functioning.

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PARTICIPATORY APPROACH TO SUSTAINABLE WATER RESOURCE MANAGEMENT IN A WATERLOGGED AREA

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Water Resource Management, as a part of environment has now been accepted as a strong component of Economic Development. The study has been conducted to analyze the problems that are being faced by the rural people in their day to day life. The study enable us to critically examine Water Resource Development and Management, in the specified areas of drinking water and rural sanitation, drainage, irrigation, health aspects of animals, plants and human beings etc for the upliftment of rural society.

This paper deals with the case study of Allahabad that is substantially rich in water resources and is one of the most fertile plains of the Ganges. But, since the coming up of Sharda Sahayak Canal in the area, waterlogging has emerged for the past sixteen years. The surplus water from canal, rainwater, absence of effective drainage system and low capacity of river Varuna all adds up to contribute high level of waterlogging in the crop fields. Land area of about 600 hectares is waterlogged in rural areas of Phulpur Block in Allahabad.

Thus, the study aims in identifying the impact of waterlogging on plant, animals and livestock and its management in the identified areas of Phulpur Block. The first part of the paper deals with the problems faced by the people in the rural agglomeration due to waterlogging. The waterlogging has affected the status of drinking water, sanitation and drainage, creating problem of shelter and transportation etc. People are affected by number of diseases like malaria, filaria, boils and ulcers, gagarin and others. Since waterlogging, three fourth livestock populations have extinct so far and the fertility behavior of cattle are also affected.

The high water table has engulfed vast areas thereby affecting the agricultural production to a larger extent. It is about seven to eight months of waterlogging in the agriculture fields often extending to eleven months with a height of four to six feet. The waterlogging starts with the advent of rainy season in the month of July and August thus spoiling the paddy crops and remains their in the agriculture fields during November-December making farmers helpless in sowing wheat also. Only half number of big trees like *Neem, Jamun*, and Mango etc has survived by now since waterlogging. This study throws light on water availability in agriculture, showing a picture of landuse pattern, extent, height and duration of waterlogging in crop fields, extent of crop loss, expected and actual production etc.

The paper finally deals with recommendations and policy implications. This paper proposes a model for participatory approach to water resource management in a waterlogged area. The roles of institutions, formal and informal, are redefined. The study helps in the promotion of self-generating income activities on one hand and solving water related problems on the other hand at the village level. The study is of the view that if the proposed strategy is worked out, it can lead to sustainable water resource management with a view to rural development in a waterlogged area.

Introduction

The significance of water for the survival of mankind is traditionally acknowledged and scientifically verified and few would have imagined in the 18th-19th century that mankind would be facing the challenge from the scarcity of something, which lies in abundance. In the light of the World Development Report on Development and the Environment an alarming voice can be heard (WDR, 1992 p.15). Domestic water use in developing countries will rise six times than its present level in the coming four decades. Water, which is the basic need of human beings, is also vital in the same manner for plants as well as animals. Thus, balance is to be effectively designed between its availability, use and preservation.

The world's six billion population appropriates just half of all the accessible freshwater contained in rivers, lakes and underground aquifers and by the year 2025 humankind's share will go upto 70 percent If per capita consumption were to rise at its current rate. Humankind shall be using over 90 percent of all available freshwater within 25 years, leaving just 10 percent for the rest of the world species (Population Report, 2001, p.13). In the developing country like India, the demand for water in urban and industrial sectors is projected to rise by 135 percent in the next 40 years (World Resources Institute, 1996, pp 64)

Irrational exploitation of natural resources, especially of water, by continuous growing population has generated multiple problems related to fresh water. The process of urbanization and industrialization has added further burden to it. Critical evaluation about the availability of natural resources and its effective management for its optimal utilization in the process of the development of those activities need expedition. In such circumstances, management of natural resources requires a deeper analysis.

In case of canal irrigation, the failure to take the groundwater into account and inadequate attention to drainage and soil condition have led to emergence of conditions of waterlogging and salinity in many areas, resulting in valuable agricultural land going out of use (Dhawan, 1988 p.2217). In 1991, the estimated extent of waterlogging in India was 2.46 million hectares and that of salt affected land was 3.30 million hectare (Iyer, 2001 p.1118). At times, the waterlogging in agricultural fields forced the farmers to go for single cropping whereas other farmers go for multiple cropping. The farmers have to wait for the water to subside and then to resume their work. In year 2000, the waterlogged land in India increased to around 6 million hectares (Brahmanand, 2000 p.29).

Case Study of Phulpur Block in Allahabad: A Waterlogged Area

Allahabad presents a paradoxical picture in the sense that it is very rich in water resources with nearly all the sources of water for different purposes like wells, taps, tubewells, borewells, and traditional forms like lakes and ponds, surface water, rivers. Presence of all types of perennial and non-perennial sources in abundance had generated its own problems.

The main cause of waterlogging in Phulpur block has been the river Varuna whose source is Mailahan lake. The river follows its path in Allahabad, crosses district Bhadoi and later falls into the Ganges in Varanasi district. The river has been callously dumped and silted because of which it flows below its normal capacity. There are other four smaller lakes that also falls into Mailahan lake and subsequently the water of the Mailahan lake exceeds beyond its carrying limits, thus causing waterlogging in the area.

The other reasons notified behind waterlogging were the rainwater, the absence of drainage system and surplus canal water. Approximately 75 percent area of Phulpur Block was under imperfect or poorly drained category. The two factors i.e. absence of proper drainage and rainfall play a higher role in contributing to the problem of waterlogging in rural agglomeration. In addition with this, other factors like construction of new road, bridges and barrages, growth of weeds in nallahs, ponds and lakes, etc. were hampering the natural watershed of the region. The effect of waterlogging was seen in two different locations- first its impact on rural population in the human settlement areas and secondly its impact on agricultural development.

Impact of Waterlogging in Rural Agglomeration

The study showed that almost 60 percent of the total household faced waterlogging in the residential areas. Approximately 33 percent and 19 percent households had waterlogging for about a month and for 2-4 months respectively. In some cases, it exceeded even nine months in the settlement areas. Extreme cases of waterlogging were noticed in areas where the water accumulated to a height of 4-7 feet in settlement areas.

Certainly, waterlogging in the residential areas has a greater impact on the life of rural people in different forms. It has contributed to the contamination of the drinking water with sand, mud, foul smell and worms, etc. The other problems being faced by the villagers in day to day life was the problems related to sanitation, transportation, housing and shelter, affecting livestock population, occupation structure, etc. Even people are affected with water borne diseases like cholera, filaria, malaria, cough and cold etc. The agricultural workers also get infected with boils and ulcers, leg gangrene etc by working in waterlogged fields for sustained period. It also had a larger social impact on the people of these villages, which also had affected their consumption pattern, lowered rate of marriages, and of course had contributed to higher incidence of poverty.

Impact of Waterlogging on Agriculture Development

It was found that the landholdings of the households were not only small but also often uneconomic. Of the total agricultural households, around 69 percent landowners were found to be marginal farmers having land less than a hectare whereas only 21 percent and around 10 percent agricultural households have 1-2 hectare and 2-4 hectare land. Consequences of waterlogging could well be reflected on the social-economic conditions of the agricultural households where a majority of them belonged to either marginal or small category.

Canal was found to be the major source of irrigation for agriculture households in the selected area, followed by wells, tubewells, river and ponds. It was not the insufficiency but surplus canal water that created problem. It happened because rostering is in practice without taking into account water requirement period of various crops. Huge investment made in surface irrigation projects had so far yielded disappointingly low returns in terms of yields as well as benefits.

Due to high level of waterlogging, almost 13 percent crop fields of the respondents got completely submerged in water. The extent of waterlogging was so high that 80 percent of agricultural households had fields waterlogged for four to seven months and even some crop fields became waterlogged for whole year. The intensity of waterlogging was well depicted by the high level of water in operational fields where 76 percent of agricultural households had water to a height of four to seven feet where the crops were sown. The waterlogging had severely affected the productive land in the form of salinity, further leading to infertility.

The study on the nature of landuse showed that only 60.49 percent of total lands of agricultural households were left for cultivation and the rest is waterlogged (36.86%) and fallow land (2.65%). By taking out the expected production of waterlogged land on the basis of actual produce on the net operated area, the estimated production of wheat and paddy suffered 37 percent loss in total production. In the value based analysis on the basis of market price prevailing in the district, a total loss for wheat and paddy for 600 hectare (total waterlogged land in Phulpur Tehsil) was worked to be Rs. 81.04 lakh and Rs. 118.71 lakh respectively for a single year.

Social Benefit Cost Analysis of Draining the River Varuna

To make the study area free from waterlogging, it becomes utmost necessary to clean the river Varuna so that it could have a larger carrying capacity smoothly till it reaches the Ganges in Varanasi. The draining of the Mahlahan lake and other adjourning small lakes should also be carried out simultaneously, which they have not being doing till now. People should be discouraged from dumping their waste in the river and lakes callously. The total estimated investment cost for draining river Varuna for the same year was worked out to be Rs. 200.98 lakh, projected by the Engineers of Sharda Sahayak Khand, Phulpur (Source: Project Economist, District Rural Development Office, Allahabad). The investment cost includes the cost of material and the labour cost in mandays. The total loss for just two staple crops i.e. wheat and paddy was somewhat equivalent to the estimated investment cost of draining the river Varuna in that respective year and that excluded other crops, viz. the oilseeds, cash and leguminous crops.

Participatory Approach to Water Resource Management

The dimensions and components of a socially and ecologically responsible ways of governing water resources require a comprehensive elaboration. The first dimension pertains to the necessity of using an integrated method for water resource management that takes the interaction among different sectors into consideration viz. the links among environment and food sectors, water and land interest, agriculture and non-agriculture sectors, upstream and downstream sectors and like. Integrated Water Resource Management (IWRM) is a process that endorses the coordinated development of water, land and related resources, it thus aims at taking a broader perspective on the governance of water, encompassing a more complete range of solutions and considering in explicit way interaction between actions.

The second dimension that the water governance should take into account is the negotiation of different and possibly contradictory interests. One of the main issues is of designing the management of water among various uses and various users. The set of decisions to be made includes calculations of consumption levels of current and future generations at the level of pollution permissible of surface and underground water sources, the allocation of water among different sectors, and the allocation of water between different users of the same sector.

The third issue that water governance should be addressed is the Institutional set up, and the corresponding legislation and enforcement mechanism that are needed for an effective and sustainable policy. Accountability and transparency need to be considered as the two sine quanon elements of a successful institutional body.

Thus, the participatory decision-making procedures and process, socially and environmentally embedded governance of water management should be enacted. Communities and societies should search for the most suitable way of formulating and shaping their own institutional framework. The participatory approach for sustainable water management requires coordination among the governmental institutions and community institutions.

A: Coordination among Various Government Bodies

Coordination among institutions like Block Development Functionaries, Panchayati Raj Institutions (PRI), Irrigation Departments, Agriculture Development Office, Jal Nigam, District Rural Development Agencies (DRDA) etc with the Community Institutions is a necessity for rural development and water management. Government needs to involve user representatives in a system management and reduce its role in field level management by delegating a substantial part of the responsibility to user groups and creating incentives to induce them to assume this responsibility.

1. Panchayati Raj Institutions
According to the 73rd and 74th Constitutional Amendment Act, the Panchayats, as a local self-government have been given full autonomy in deciding their priorities and also determining the allocations to different programs. The Gram Panchayat have six subject committees, which include water management committee to execute all works. Item listed under the Eleventh Schedule are the minor irrigation, water management, watershed development, drinking water and sanitation. However, the Gram-Panchayats in the sample area that is a basic entity was found non-functional. It does not utilise the fund in village-level development or make arrangements for drinking water, sanitation and other water-related matters, which comes under six subject committee. The PRI institution which is lying in defunct state needs to be mobilised by local user groups and other Non Governmental Organisations to make it more viable.

2. Block Development Office
The block headquarters office (BDO) is the primary management unit in India. These generally operate local management systems within boundary set by the State. The Block level functionaries are responsible for the village level development, agricultural development, water resource development etc for rural areas. The BDO should look after the socio-economic condition of the people living in rural agglomeration, should help in provision of safe drinking water, sanitation facilities and step forward to stop endemics related to water borne diseases. The BDO has the power to utilise technical information on water resources conditions. The BDO should invite substantial local representation on their governing boards, and empower 'identified people' in decision making from users group. Thus, a potential for enforceable and socially viable management can be established.

3. Agriculture and Irrigation Department
There should be water management committees at the District, Block and Panchayat levels involving District Agriculture Officer, Block Development Officer, Tehsildar, Irrigation Field Functionaries, Agriculture Engineers, Economists and Farmers Representatives. The committees will take decision on (a) Timing of canal closure for annual repair and maintenance (b) designing of suitable cropping pattern for each block within the irrigation command (c) delineating the waterlogged and high water table areas for rice and fish farming (d) avoiding mismatch between timing of water delivery and crop needs in canal command areas, and (e) laying out field channels and drains and making suitable provisions for their maintenance at the Gram Panchayat level.

Irrigation through canal is operation in study villages for the past few years continuously. So it is recommended that the Agriculture Department should install the tubewells in a waterlogged irrigation command area to lower the water table and pass the pumped water in canals to supplement its supplies. Construction of private as well as state wells/tubewells and cutting of canal supply and providing irrigation from groundwater pumped from well and tubewells should also be undertaken further. Conjunctive use of water and plant for ecological balances should be taken into consideration. The farmers need to be be encouraged to grow water friendly plants such as Water berry, Sugarcane, Bamboo, Mushroom, Eucalyptus etc in their fields. Cultivation of cash crops should also be encouraged.

The work of the Command Area Development Authority and Irrigation Officers were found unsatisfactory in the study area because of poor farm level development and absence of drains in crop fields that became a major cause of waterlogging. The farm level has to be properly developed for irrigation through command area development. Appropriate surface drainage technology needs to be evolved in integrating preventive and curative measures. Adequate research backup with appropriate cost-benefit assessment is required for the development of efficient drainage systems.

The rostering of canal water should be done at times of need. The Sharda Sahayak Canal System should keep the records correctly pertaining to the time of sowing. When there is sufficient rainwater, supply of canal water should be stopped. Canal water needs to be supplied at the time of monsoons when the water is already available. A system of stoppage should be developed so that unrequired amount of water may be retained in the main canal itself.

Modernization of the existing irrigation projects with selective lining in the canal distribution system and field channels should be undertaken to stop water seepage. It will also help in reducing the leakage of canal water due to which a high percentage of water is lost. The canal branches have abrupt open ends, which does not meet any natural drains. The canal escapes should be linked with big rivers and small check dams can be made in between the main branch of the canal and small branches to manipulate water according to needs.

In the canal system, for instance, it should be possible to construct small reservoirs in the command area to which water is supplied and the control over quantity and timing of water release to the users be left at the local level (Bharadwaj, 1990, pp4). The nodal centre at the Panchayat level should also have a link with the Sharda Sahayak Command Area authorities so that the problem is focused at village level to make the canal project more viable.

B: Community Institutions

1. Water User Associations and Farmers Irrigation Cooperatives

It is contemplated to delegate some responsibility to the Water Users Association (WUAs), which include distribution of canal water among water users, operation and maintenance of the canal and collection of water rates. So in accordance with the spirit of the National Water Policy (1987) of GOI, farmers should be made partners in management and distribution of water. This can be realized by organizing farmers into registered "Water User Association”. However, no such Water User Associations and Farmers committees were found in sample villages. The farmers' irrigation co-operative movement should be encouraged. The operation and maintenance of irrigation minors and subminors must be entrusted to the farmers' cooperatives.

Confronting water problems, farmers individually as well as collectively had come forward for initiating welfare activities of different forms like cutting bunds, cleaning drains, weeding ponds, removing garbage, changing water directions etc but the intensity of waterlogging is so severe that safety measures did not matter. It required certain strategies on collective scale to counter the menace of waterlogging.

2. Self-Help Groups and NGOs

India today needs a people's movement to meet its water requirements and to protect its water resources. We should make every household and every community to participate in the provision and protection of water resources. So water literacy is a must for the people to generate awareness among the society. There is a need for the participation of the NGOs, Government, and professional and representing bodies' interaction with the local people to generate awareness in the society. Efforts should be made to seek people's participation in maintaining and controlling pollution of water bodies by formation of consumer's forum, wards wise water users committee etc.

The government and user groups should provide credits to marginal sections at minimum interest rate for self-generating activities for livelihood sustenance. Some self-generating activities preferred in waterlogged areas are-

1. *Rice Fish farming-* There is a good prospect of Pisciculture and Aquaculture activities in certain villages where vast land remains perennially waterlogged. Training to farmers could be imparted for Pisciculture and Aquacultural activities.

2. *Makhana-Fish Cultivation-* Makhana (Euryale Ferox Salisbury) is known as "Gorgon Nut" or "Fox Nut" of the oldest aquatic cash crop of Muthilanchal. Air breathing fish like *clarius batrachus* (magur), *chana punctatus* (Murrels), and *anabus testrodinus* (koi) could be combined for Makhana fish cultivation for better monetary prospects.

3. *Tree Cultivation-* A more dynamic way of reclaiming such areas would be to utilise the surplus water through afforestation by planting suitable tree samplings. It is quite feasible and possible that the planted samplings would absorb the water, utilise part of it for their growth and transpire the rest in atmosphere.

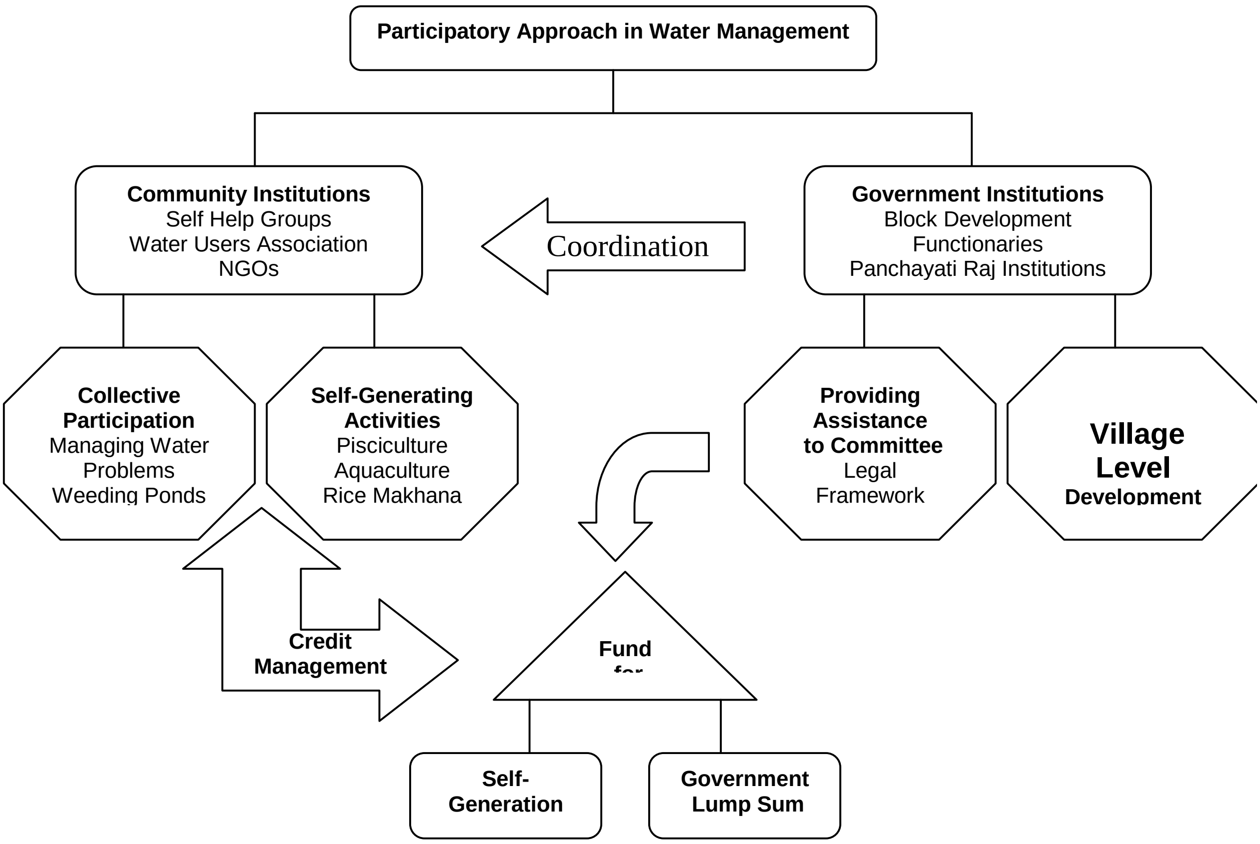

Figure 7.1: Participatory Approach in Water Resource Management

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THE EFFECT OF MINING WORKS ON A WATER COLLECTION BASIN: ÇATALAN EXAMPLE

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Majority of mining operations are in mountainous area and many of them stay in the water collection basins near and far from water protection area. Environmental pollution is inevitable in mining operations whether open pit or underground (galleria) system. Ore residues, oils and grease from heavy machinery and human activities are the main pollutants. If ores do not contain poisonous minerals or country rocks have no heavy metals, pollution is only limited to domestic wastes. If there are easily dissolved harmful elements in the ores and country rocks, it is possible that these elements can reach to the nearest surrounding environment and to the water collection basins.

Wastes produced from ore processing plant built nearby mining works may create bigger problems due to the chemicals used as catalysers. In this project, environmental effects of three (3) chromium processing plants in the Çatalan water collection basin, 100 km away from Adana city were studied. Water samples were taken from sedimentation pools, discharge outlets and inlet processing water systems. The water samples were analyzed for Cr_{total}, Cr^{+6}, Ni, Co, Mg, Pb, Zn, Cu, Cd, Hg and for dissolved solids, chemical oxygen demand (COD). The results of water analyses are compared with 'Classification of Land Based Water Standards'. Adana city drinking water is supplied by Çatalan dam on the Seyhan river. The characteristics of water from Çatalan dam are also compared with 'Drinking Water Standards'.

Some of water characteristics found in this study may cause trouble in the future. Because of this, it is suggested that water treatment plants should be built before discharging to Seyhan river creeks or processing water should be reused.

Introduction

This region which is between the Pozantı-Karsantı ophiolite and has served for more than 200 pits and small- and medium-sized chromite mines also resides within the long-distanced protection area of the Çatalan dam water collection basin. There are numerous mining facilities and still-in-operation five upgrading plants in this massif zone which is the 4th most significant chromium region of Turkey. While the massive, nodular, banded, and disseminated chromite with more than 35% Cr_2O_3 grades seen in chromium mines are directly marketed, the others with 9-35% Cr_2O_3 grade content are not directly assessed. These low grade chromites are exported only after upgraded to 48% Cr_2O_3 content.

Since the high grade (35-52% Cr_2O_3) chromium ores have been mined for 50 years, the low-grade but sustainable chromium ores are marketed today after concentration. In the plants built for this purpose, chromite separated from the gangue minerals by crushing, grinding, and using shaking tables with water based on differences in density. Water use in these processes and its release into streams causes environmental pollution at a high extent. The fact that these concentration plants are open to Çatalan Dam Long Distance Protection Region (Figure 2) requires some precautions to be taken. The analysis carried out on the Çatalan water which is a significant water source indicates relatively higher contamination levels. In this study, three mining plants open to this water collection basin were investigated and the results were evaluated. In order for Çatalan basin to be non-polluted and be able to serve as a water supply while meeting the international water quality criteria, the discharges from these plants should not be made to nearby streams. The reuse of process water in a closed circuit and the storage of sediment (settled material) in old mine pits are strongly advised.

General Characteristics and Operating (Mining) Conditions of Chromium Occurances in Pozantı-Karsantı Ofiyolit Complex

There can be seen more than 200 points for chromium ore in the rock formation starting from Pozantı until Faraşa spread over 110 km in the NE – SW direction with a maximum width of 30 km at the largest (see Figure 1). The ore mining has continued even though it has been partially decreased since the 1950s [1-5]. Due to high grade chromite production at the early stages, the chromite was transported to ports (Mersin and İskenderun) as lump ore via trucking. Therefore, there was not any significant environmental pollution. Due to dramatic changes in the topography, the materials were taken away with the rivers during precipitation in winter and spring seasons whereas the chromium in natural rock formations of dunite, harzburjit, and serpentine-dunite remained in the natural form and chromite placers did not highly develop along the streams. Since the solubility of chromite is low and the distance is long, the chromite could not reach the lake of Seyhan dam. Nevertheless, hydroelectric power plant and Seyhan Lake with its irrigational use did not suffer from pollution from these mining facilities. After 1980, along with high grade chromite ore formations, the idea of mining low grade areas was proposed and upgrading plants were built in the region.

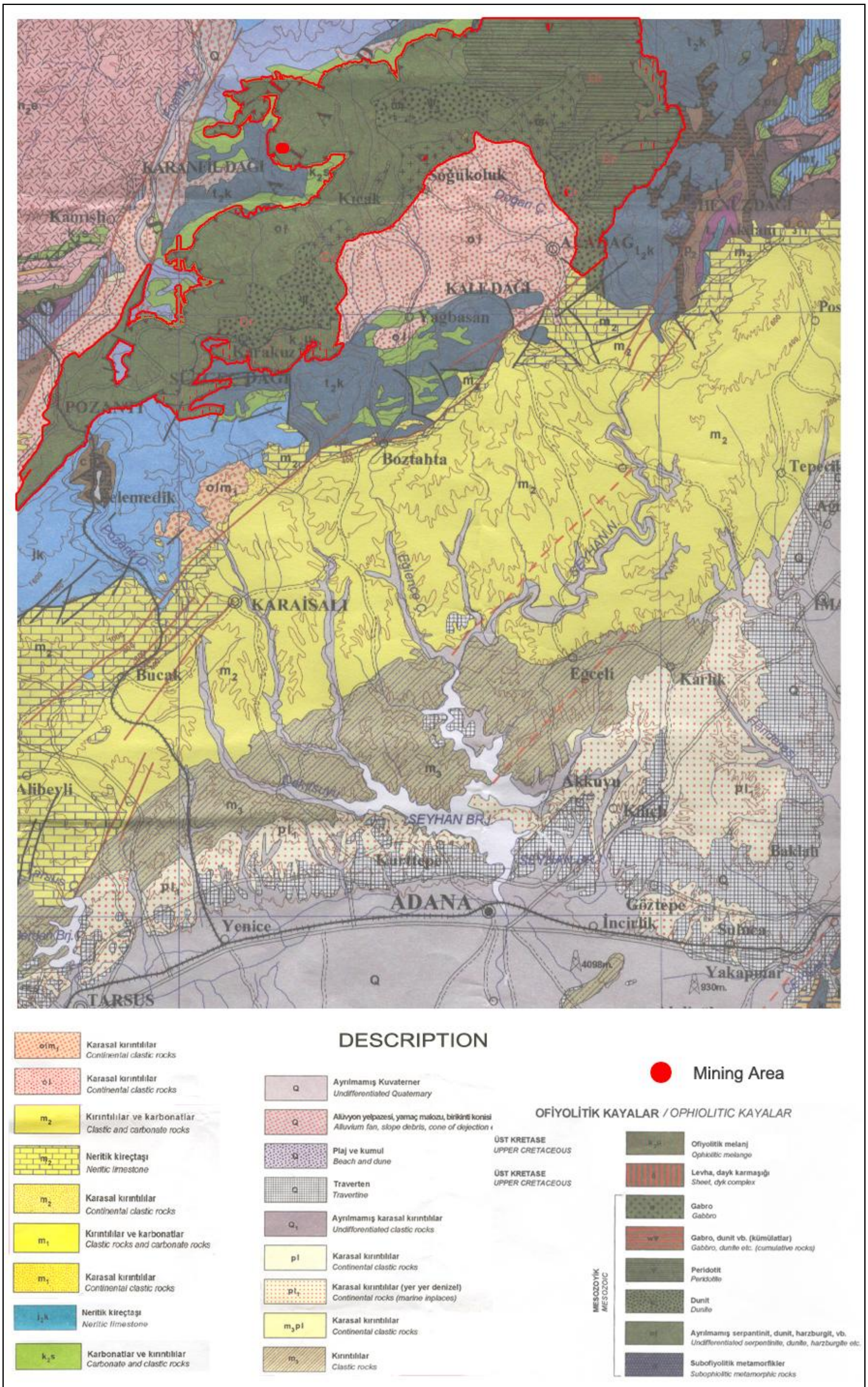


Figure 1. Layout map for chromium sheds and plants located between Pozantı-Karsantı ophiolite main rock [6].

Plant A built around Doğançay Creek was followed by Plant B which takes water from the same river. Ten years later, Plant C located 20 km southwest of Plants A and B was built as to discharge wastewaters to Sofulu Creek. Meanwhile, Çatalan dam was built on Seyhan River which was delayed for various reasons although it was planned long time ago. The difference between Çatalan and Seyhan dams is that Çatalan was also designed to meet the drinking water requirements for Adana City. Environmental pollution prevention has become a major issue for this basin supplying drinking water to the city since 2005.

The chromite ore mined from open-pit or underground mines are crushed and ground to 2-mm in dimension in all three plants located within the long distance protection area of Çatalan basin. The ore is later upgraded by shaking tables using water crushing broken under dry and grinding in wet conditions. Thus, after separating from rocks, rich chromite is dried and sent off to ports for export. A general operational scheme is provided in Figure 3. When the operations in this scheme are followed step-by-step, it can be seen that there are no chemicals involved in the process. It is apparent that naturally-mined ores are separated from the rocks with physical means and no chemical process. There is an increase in fine particles content due to breaking and grinding. Since there is a relative increase in dissolution from the settled materials and liberated chromites in the waste pools, their concentration levels in the wastewater are increased creating pollution initially in the streams and finally in Çatalan basin.

Pollution Due to Mining and Its Legal Status

Chromium concentration plants are the major reason for pollution as compared to chromium mining among the mining activities between Pozantı-Karsantı ophiolite where there are many mining facilities open to Çatalan Long Distance Protection area. All three plants investigated in this study share similar characteristics. As seen in the generalized diagram (Figure 3), there are no chemical processes involved. There even no baking or roasting which changes the chemical characteristics of the ore. The chromite ore is crushed and ground to 2-mm in dimension after it is naturally dug out in the mines. Except for the crushing process, there is no dusting occurring in these wet processes. The chromite concentrate separated from the rocks at the shaking tables with the aid of density differences is collected in the stocking pool and then separated from water. The rocks, on the other hand, are sent to the solid waste pool. Intermediate products are diverted back to the beginning of the separation process.

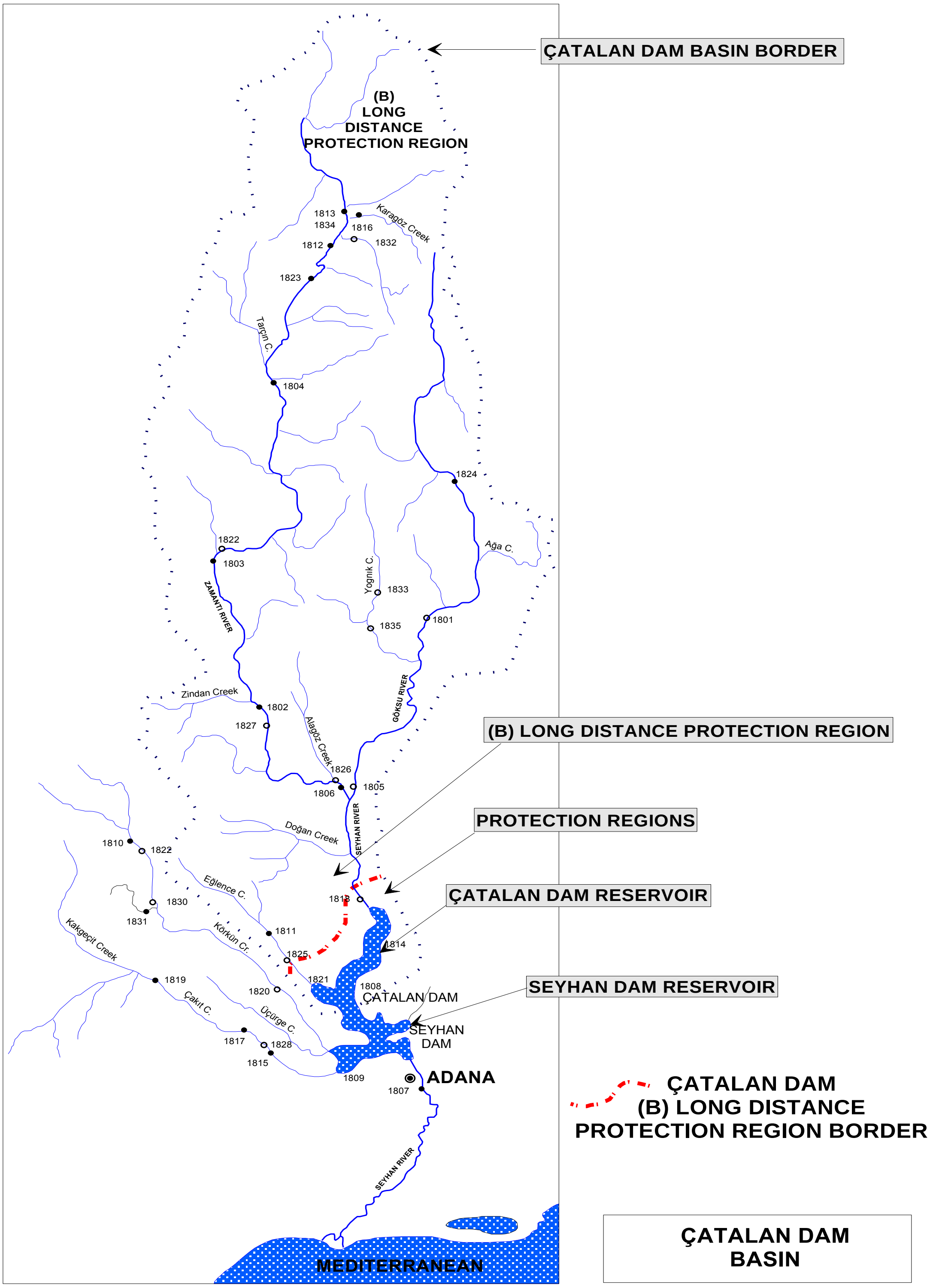


Figure 2. Çatalan dam basin protection area and distances.

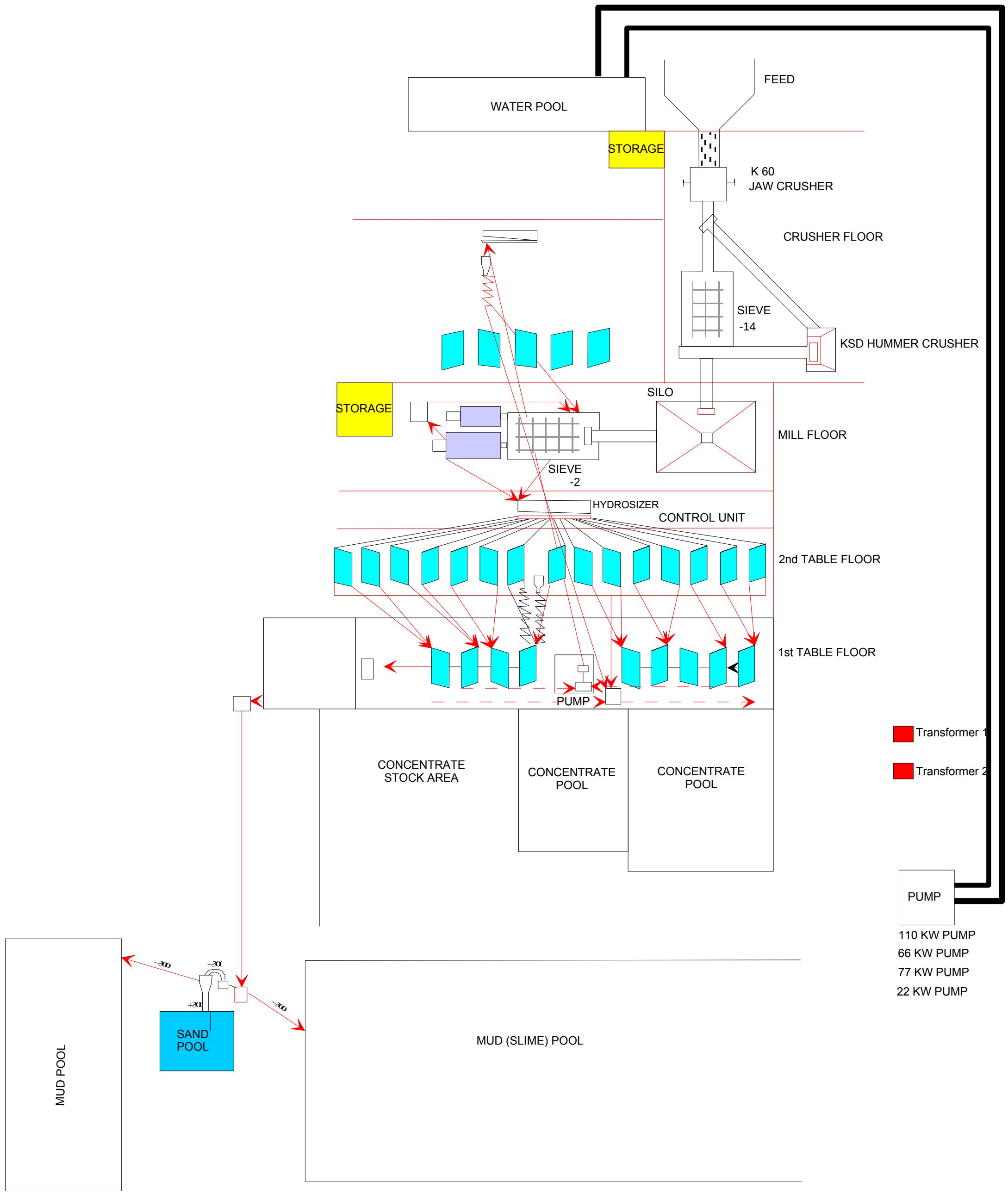


Figure 3. Generalized flow-scheme for chromite concentration.

In this process, the polluting matter is highly serpentine-fine olivine (at silt dimensions) and relatively increasing total Cr, Cr+6, Ni, Co, Cd, Zn, Cu, and Fe contents. Therefore, the direct discharge of neither solid wastes nor wastewaters to the streams is restricted by regulations. The three plants (A, B, and C) were found to be operated in a similar method, the Adana city Environmental Administration ordered the companies to stop the operation and to be in accordance with the environmental regulations. Based on Water Pollution Control Regulation Part 20.b, the wastewaters may be discharged into the streams after treatment by using advanced treatment technologies which brings the water quality level to II. Class level (Table 1). Therefore, the wastewater is not suitable to be discharged into the streams without treatment. It is technically possible to bring to II. class water using chemical processes. However, it does not seem to be economical for the investors. Therefore, other alternatives should be considered.

Assessment of Pollution Within Wastewater and Solid Wastes at The Plant

When in full operation, samples from both process water and materials after settled in the waste pools were taken and analyzed chemically. The analytical results for A, B, and C plants of this study were tabulated in Table 1. These results found are expected in such chromite processing plant without any chemical processes. It is possible to detect Ni within the crystallized structure of chromite and Co especially accompanying serpentine minerals partially transferred to the solution. These mineral concentrations were able to be tested in the wastewater analyses only after these metals were solubilized using acids. Since there is no acid-breaking, heavy metals dissolve very little and are seen at very low concentrations.

General layout of the plants and their location with the streams are illustrated in Figures 4-6. Process water used in these three plants (A, B, and C) are supplied from the nearby streams. Stream water pumped to the plants with motor-pumps are used as process water without any treatment. Chemical analysis in the influents of three plants revealed significant pollution due to soluble solids, chemical oxygen demand (COD), Pb, Hg, Cd, Cu, and Cr6+ concentrations. There were apparently high concentrations of Fe in the influents of the three plants. The reason is possibly that all three streams are passing through serpentinized peridotites as the dissolution of Fe is easier compared to the other metals released during serpentinization. Although many chromium mines are open to streams, the dissolution of Cr into the solution remains low under natural conditions. As can be seen from the results of the solid waste analysis (see Table 2), the suspended solids settled in the pools during dewatering contained dunite and serpentine minerals as well as 0.39 – 0.98 mg/kg Cr, 0.95 – 2.54 mg/kg Ni, and 0.14 – 18 mg/kg Co among the heavy metals.

Table 1. Chemical analysis results of process water, effluent water, and waste pool samples at A, B, and C plants discharging into Çatalan Long Distance Protection Region

Parameters Plant A		Analytical Result				Table 1: Land based water standards			
		Doğançay Plant Influent	Wastewater	Waste Pool Effluent	Abdullah Creek	I.Class	II.Class	III.Class	IV.Class
pH		8,78 (24,6°C)	9,94 (24,5°C)	9,18 (24,5°C)	8,78 (24,4°C)	6,5-8,5	6,5-8,5	6,0-9,0	Outside 6,0-9,0
TDS	(mg/L)	229	215	230	280	500	1500	5000	>5000
COD	(mg/L)	5	5	10	9	25	50	70	>70
Pb	(µg/L)	<10	31	<10	<10	10	20	50	>50
Fe	(µg/L)	1649	267100	18590	1252	300	1000	5000	>5000
Zn	(µg/L)	358	301	270	548	200	500	2000	>2000
Hg	(µg/L)	<2	<2	<2	<2	0,1	0,5	2	>2
Cd	(µg/L)	<5	<5	<5	<5	3	5	10	>10
Cu	(µg/L)	8	79	13	<5	20	50	200	>200
Cr(Total)	(µg/L)	17	4779	187	19	20	50	200	>200
Cr^{+6}	(µg/L)	<5	<5	<5	<5	Very low	20	50	>50
Parameters Plant B		Analytical Result				Table 1: Land based water standards			
		Plant Influent	Waste Pool Effluent	I. Process Effluent	Doğançay Creek	I.Class	II.Class	III.Class	IV.Class
pH		8,70 (24,5°C)	8,91 (24,7°C)	8,88 (24,5°C)	8,74 (24,6°C)	6,5-8,5	6,5-8,5	6,0-9,0	Outside 6,0-9,0
TDS	(mg/L)	234	280	276	225	500	1500	5000	>5000
COD	(mg/L)	13	4	14	3	25	50	70	>70

Table 1: Cont.

Pb	(µg/L)	<10	<10	<10	<10	10	20	50	>50
Fe	(µg/L)	106	9605	15470	6230	300	1000	5000	>5000
Zn	(µg/L)	143	171	365	153	200	500	2000	>2000
Hg	(µg/L)	<2	<2	<2	<2	0,1	0,5	2	>2
Cd	(µg/L)	<5	<5	<5	<5	3	5	10	>10
Cu	(µg/L)	12	<5	<5	<5	20	50	200	>200
Cr(Total	(µg/L)	126	161	221	184	20	50	200	>200
Cr^{+6}	(µg/L)	<5	11	7	<5	Very low	20	50	>50
Parameters Plant C		Analytical Result				Table 1: Land based water standards			
		Plant Influent		II.Class	II.Class	I.Class	II.Class	III.Class	IV.Class
pH		8,75 (24,3°C)		9,44 (24,7°C)	9,03 (24,4°C)	6,5-8,5	6,5-8,5	6,0-9,0	Outside 6,0-9,0
TDS	(mg/L)	171		162	161	500	1500	5000	>5000
COD	(mg/L)	6		5	5	25	50	70	>70
Pb	(µg/L)	23		35	25	10	20	50	>50
Fe	(µg/L)	2144		2361	958	300	1000	5000	>5000
Zn	(µg/L)	189		456	385	200	500	2000	>2000
Hg	(µg/L)	<2		<2	<2	0,1	0,5	2	>2
Cd	(µg/L)	<5		<5	<5	3	5	10	>10
Cu	(µg/L)	12		<5	<5	20	50	200	>200
Cr(Total	(µg/L)	13		31	20	20	50	200	>200
Cr^{+6}	(µg/L)	<5		<5	<5	Very Low	20	50	>50

(<) indicates lower concentration than the lowest limit the apparatus can read
(-) Pretreatment for metal analyses: SM 3030 C
Metal analyses: SM 3120 B methods were used.

Table 2. Heavy metal analysis results of solid wastes in the plants

<table>
<tr><td>Parameter
Plant A</td><td colspan="2">Waste Pool Outlet</td><td>Waste in the Creek</td><td>Standards Applied</td><td colspan="2">Heavy Metals Limits in Soil</td></tr>
<tr><td>Cr
(mg/kg)*</td><td colspan="2">0,98</td><td>0,62</td><td>TS 12088 October 1996</td><td colspan="2">100 mg/kg</td></tr>
<tr><td>Ni
(mg/kg)*</td><td colspan="2">2,54</td><td>2,25</td><td>TS 12088 October 1996</td><td colspan="2">50 mg/kg</td></tr>
<tr><td>Co
(mg/kg)*</td><td colspan="2">0,18</td><td>0,05</td><td>TS 12088 October 1996</td><td colspan="2">-</td></tr>
<tr><td>Cu
(mg/kg)*</td><td colspan="2">-</td><td>-</td><td>TS 12088 October 1996</td><td colspan="2">100 mg/kg</td></tr>
<tr><td>Mg
(mg/kg)*</td><td colspan="2">112,92
% 0,0113</td><td>117,17
% 0,0117</td><td>TS 12088 October 1996</td><td colspan="2">-</td></tr>
<tr><td>Parameter
Plant B</td><td>Waste Pool Outlet</td><td>Waste Solid from 2.Pool</td><td>Waste from 3. and 4. Pools</td><td>Final Pool</td><td>Creek Bed</td><td>Limits in Soil</td></tr>
<tr><td>Cr*
(mg/kg)</td><td>0,50</td><td>0,62</td><td>0,37</td><td>0,72</td><td>0,23</td><td>100 mg/kg</td></tr>
<tr><td>Ni*
(mg/kg)</td><td>2,05</td><td>2,39</td><td>2,32</td><td>1,96</td><td>1,67</td><td>50 mg/kg</td></tr>
<tr><td>Co*
(mg/kg)</td><td>0,14</td><td>0,09</td><td>0,09</td><td>0,09</td><td>0,04</td><td>-</td></tr>
<tr><td>Cu*
(mg/kg)</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100 mg/kg</td></tr>
<tr><td>Mg*
(mg/kg)</td><td>103,85
% 0,0104</td><td>130,26
% 0,0130</td><td>146,15
% 0,0146</td><td>62,49
% 0,0063</td><td>99,92
% 0,0100</td><td>-</td></tr>
<tr><td colspan="2">Parameter
Plant C</td><td>Cr
(mg/kg)*</td><td>Ni
(mg/kg)*</td><td>Co
(mg/kg)*</td><td>Cu
(mg/kg)*</td><td>Mg
(mg/kg)*</td></tr>
<tr><td colspan="2">Mikro Mining Co. Waste Pool Content Sand</td><td>0,39</td><td>0,95</td><td>0,15</td><td>-</td><td>53,12</td></tr>
<tr><td colspan="2">Mikro Mining Co. Sofulu Creek Final Effluent, Creek</td><td>0,60</td><td>1,60</td><td>0,14</td><td>-</td><td>107,11</td></tr>
</table>

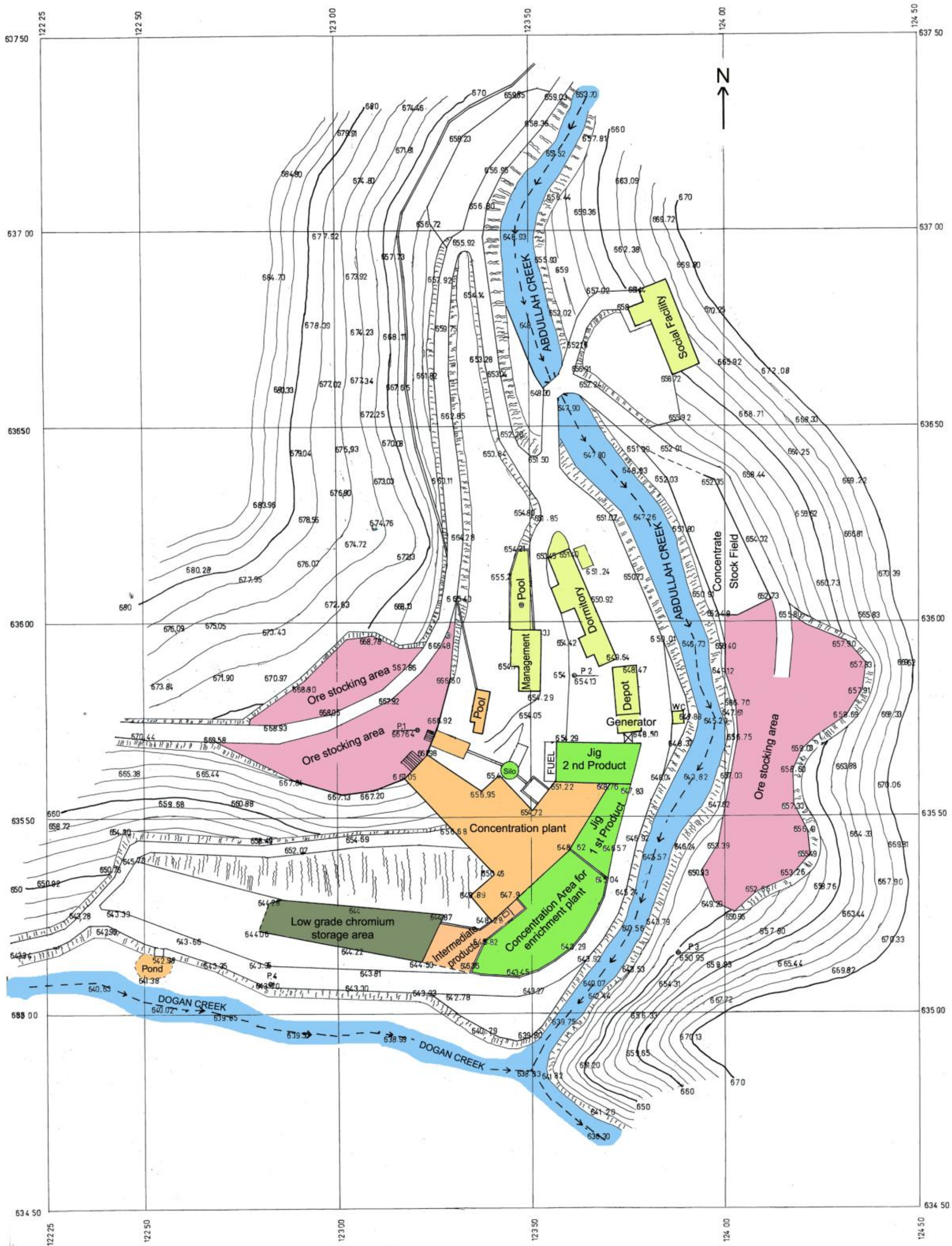


Figure 4. Chromite Plant A located around Doğan and Abdullah Creeks.

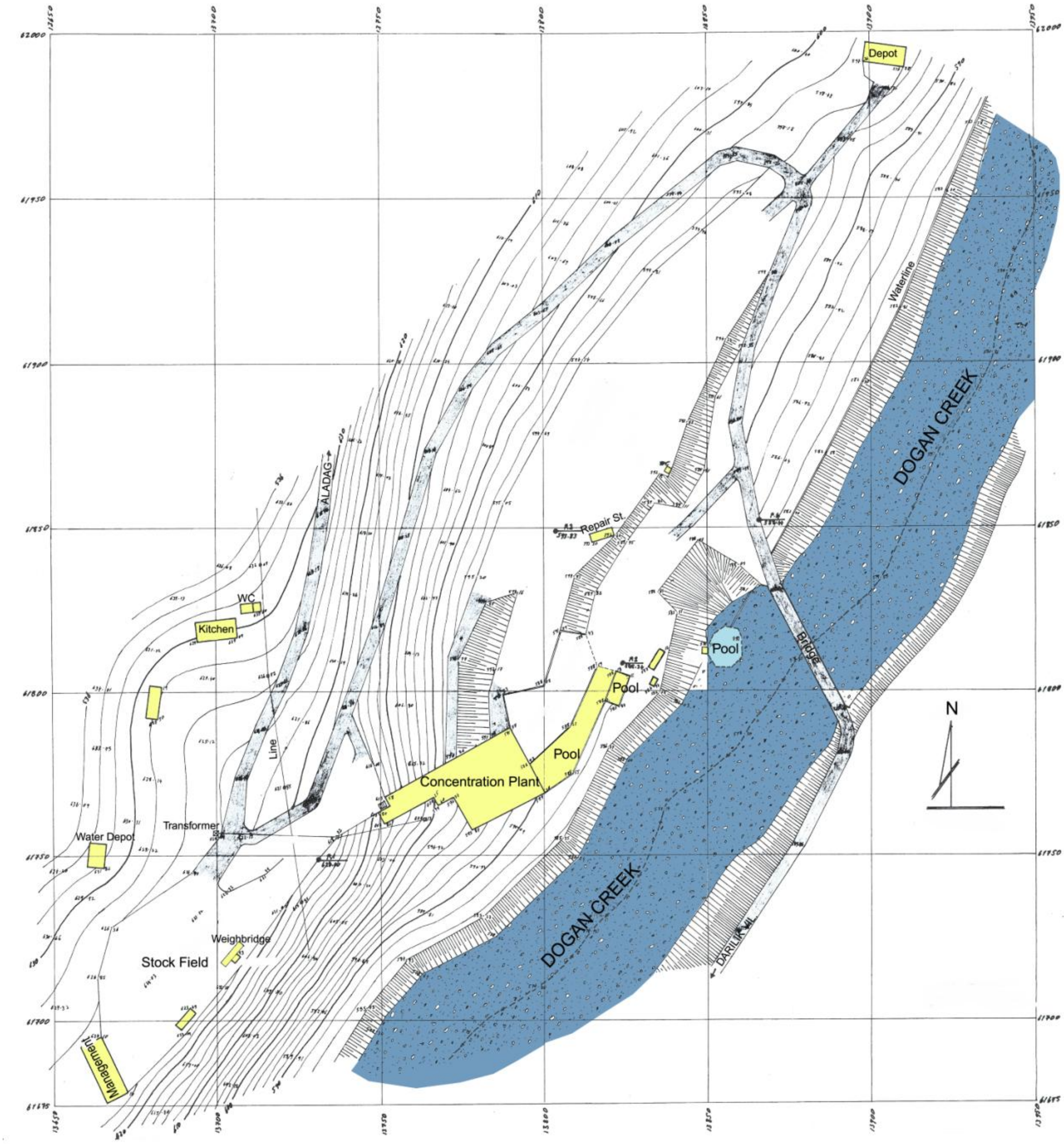


Figure 5. Chromite Plant B located around Doğan Creek.

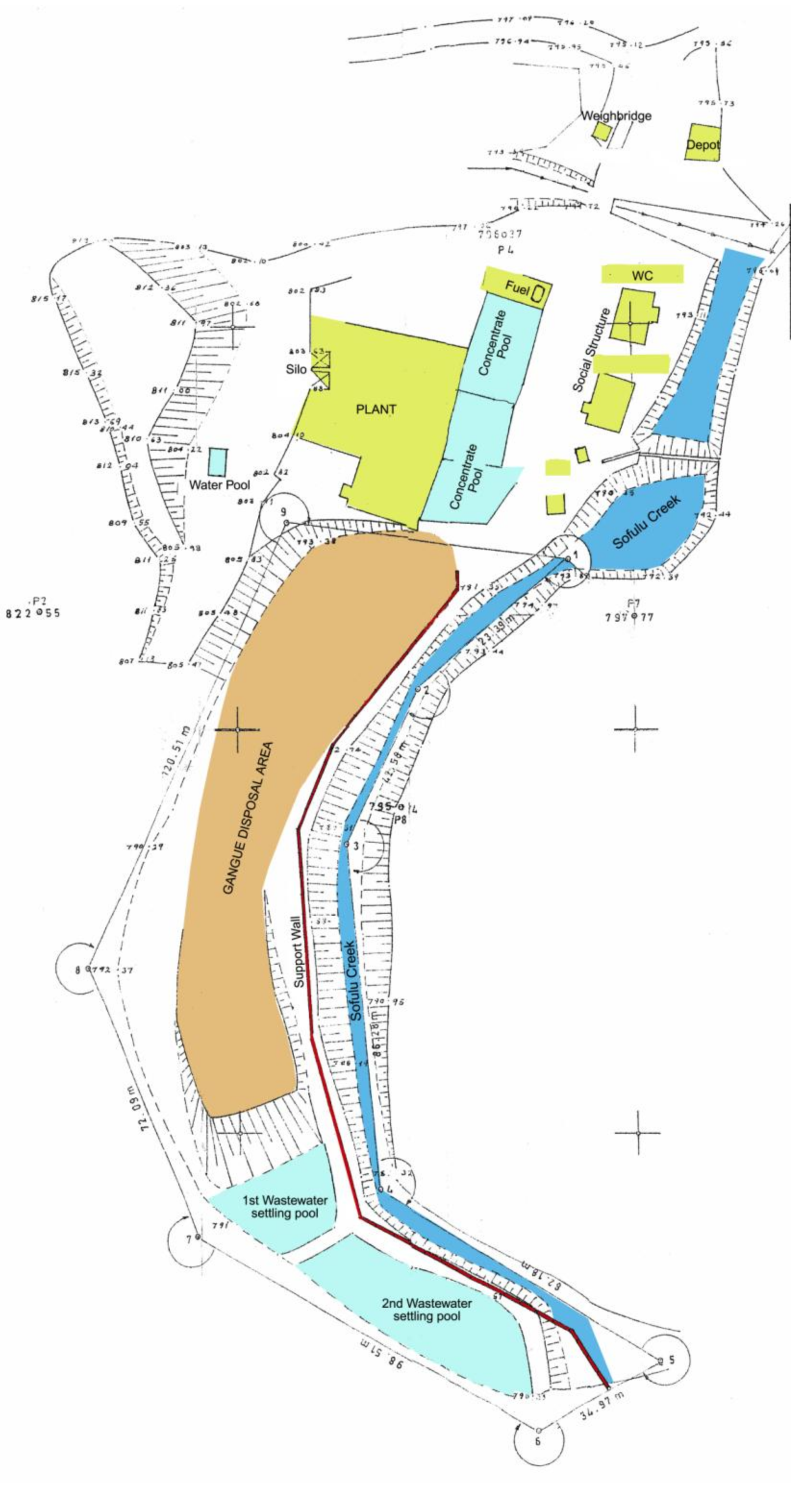


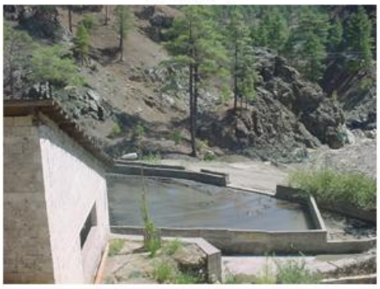
Figure 6. Chromite Plant C located around Sofulu Creek.

While Mg content was around 0,011 – 0,012 %, Cu was not detected. This can be clearly observed in the sedimentation pools with whitish color. Mg in olivine crystals easily dissolves and the pool walls are lightly colored with MgO. The general conditions of the plants and the waste pools are shown in Tablet 1. All three plants in the Çatalan Long Distance Protection area are located in the rural area. There is relatively rich forest vegetation within this area where there is no other industries. The walls of solid waste and concentration pools at these plants operating for over 25 years were not built according to the regulations.

Tablet 1. General views from the plant units

Plant A

Crusher unit entrance



Wastewater Pool

Concentration and Wastewater Pools

Plant B

A general layout of the plant and waste pools

Concentration Pool

Pump Station for Wastewater Pools

Plant C

Settling Pool

Waste Pool Divider

Wastewater

The plants take water from Doğançay and the Sofulu Creeks. The heavy metal concentrations in the creeks are higher than the limits. It is against the regulations to discharge the waste pool contents and settled process water into these creeks in order to prevent pollution in the aforementioned creeks which flow through ophiolite massif. Because no matter how long the waste is settled, Class II water quality levels are hard to reach. Therefore, the wastewater is reused within the process and the water deficit is supplied from the streams. Solid waste (sand and silt dimensions) accumulated in the pools cannot be discharged into the streams. It is difficult to prevent the runoff of the waste accumulated material into the streams during wet seasons. Therefore, it is favorable to haul and store the materials in mine pits in the area during dry seasons. Thus, as long as stored in gallerias, these inert materials are not expected to reach and contaminate groundwater.

Final Status in Çatalan Water Supply

The water supply of the city is analyzed periodically by Adana Metropolitan Municipality. The analytical results for July, August, and September months of 2006 for the water samples are tabulated in Tables 3 – 5. When the tables are studied, it can be seen that the water is good quality to use and there is no pollution detected.

Table 3. Analytical results for the water samples taken on 07.07.2006 by Adana Metropolitan Municipality

Parameter		Analytical Results	Regulation for Water for Human Consumption, App.1	Remarks	Test Method
Arsenic (As)	µg/L	<2	10	Favorable	SM 3120 B
Boron (B)	mg/L	0,422	1,0	Favorable	SM 3120 B
Cadmium (Cd)	µg/L	<5	5,0	Favorable	SM 3120 B
Chromium (Cr)	µg/L	<5	50	Favorable	SM 3120 B
Copper (Cu)	mg/L	<0,005	2,0	Favorable	SM 3120 B
Cyanide (CN)	µg/L	<1	50	Favorable	SM. 4500- CN^- - F
Fluoride (F)	mg/L	0,3	1,5	Favorable	DIN 38 404-D4-2
Lead (Pb)	µg/L	<10	10	Favorable	SM 3120 B
Nickel (Ni)	µg/L	<5	20	Favorable	SM 3120 B
Nitrate (NO_3)	mg/L	0,7	50	Favorable	SM. 4500- NO_3 D
Nitrite (NO_2)	mg/L	<0,005	0,5	Favorable	DIN 38 404-D 10
Total Hardness	°F	15,8	-	Favorable	SM. 2340-C
Aluminum (Al)	µg/L	<5	200	Favorable	SM 3120 B
Ammonium (NH_4)	mg/L	<0,01	0,5	Favorable	SM. 4500- NH_3 – B, C
Chloride (Cl)	mg/L	23,9	250	Favorable	SM. 4500- Cl^- -B

Table 3. Cont.

Color	mg/L Pt	<5	Acceptable by consumers and no abnormalities	Favorable	DIN 38 404-C1-2
Connectivity	µS/cm	380	2500	Favorable	SM. 2510- B
pH		7,72	6,5 - 9,5	Favorable	SM. 4500- H^+ B
Iron (Fe)	µg/L	<5	200	Favorable	SM 3120 B
Manganese (Mn)	µg/L	<5	50	Favorable	SM 3120 B
Oxidation Capacity	mg/L O_2	1,4	5	Favorable	SM 2580 B
Sulfate (SO_4)	mg/L	24	250	Favorable	SM. 4500 SO_4^{-2} – E
Sodium (Na)	mg/L	1,448	200	Favorable	SM 3120 B
Turbidity	TE/F	<1	Acceptable by consumers and no abnormalities	Favorable	DIN 38 404-C2-4
Escherichia Coli (E. Coli)	Count/ 100mL	0	0	Favorable	S.M. 9225 C
Enterococcus	Count/ 100mL	0	0	Favorable	S.M. 9230 C
Total Coliform	Count / 100mL	0	0	Favorable	S.M. 9222 D
Fecal Coliform	Count / 100mL	0	0	Favorable	S.M. 9221 E

Note: (<) indicates lower concentration than the lowest limit the apparatus can read

Table 4. Analytical results for the water samples taken on 25.08.2006 by Adana Metropolitan Municipality

Parameter		Analytical Results	Regulation for Water for Human Consumption, App.1	Remarks	Test Method
Arsenic (As)	µg/L	<2	10	Favorable	SM 3120 B
Boron (B)	mg/L	0,695	1,0	Favorable	SM 3120 B
Cadmium (Cd)	µg/L	<5	5,0	Favorable	SM 3120 B
Chromium (Cr)	µg/L	<5	50	Favorable	SM 3120 B
Copper (Cu)	mg/L	0,008	2,0	Favorable	SM 3120 B
Cyanide (CN)	µg/L	<1	50	Favorable	SM. 4500- CN^- - F
Fluoride (F)	mg/L	0,3	1,5	Favorable	DIN 38 404-D4-2
Lead (Pb)	µg/L	<10	10	Favorable	SM 3120 B
Nickel (Ni)	µg/L	<5	20	Favorable	SM 3120 B
Nitrate (NO_3)	mg/L	0,5	50	Favorable	SM. 4500- NO_3 D

Table 4. Cont.

Nitrite (NO_2)	mg/L	<0,005	0,5	Favorable	DIN 38 404-D 10
Total Hardness	°F	17	-	Favorable	SM. 2340-C
Aluminum (Al)	µg/L	<5	200	Favorable	SM 3120 B
Ammonium (NH_4)	mg/L	<0,01	0,5	Favorable	SM. 4500- NH_3 –B, C
Chloride (Cl)	mg/L	25	250	Favorable	SM. 4500- Cl^- -B
Color	mg/L Pt	<5	Acceptable by consumers and no abnormalities	Favorable	DIN 38 404-C1-2
Connectivity	µS/cm	380	2500	Favorable	SM. 2510- B
pH		7,72	6,5 - 9,5	Favorable	SM. 4500- H^+ B
Iron (Fe)	µg/L	<5	200	Favorable	SM 3120 B
Manganese (Mn)	µg/L	<5	50	Favorable	SM 3120 B
Oxidation Capacity	mg/L	28,3	250	Favorable	SM. 4500 SO_4^{-2} –E
Sulfate (SO_4)	mg/L	1,756	200	Favorable	SM 3120 B
Turbidity	TE/F	<1	Acceptable by consumers and no abnormalities	Favorable	DIN 38 404-C2-4
Escherichia Coli (E. Coli)	Adet/100mL	0	0	Favorable	S.M. 9225 C
Enterococcus	Adet/100mL	0	0	Favorable	S.M. 9230 C
Total Coliform	Adet/100mL	0	0	Favorable	S.M. 9222 D
Fecal Coliform	Adet/100mL	0	0	Favorable	S.M. 9221 E
Arsenic (As)	µg/L	<2	10	Favorable	SM 3120 B

Note: (<) indicates lower concentration than the lowest limit the apparatus can read

Table 5. Analytical results for the water samples taken on 28.09.2006 by Adana Metropolitan Municipality

Parameter		Analytical Results	Regulation for Water for Human Consumption, App.1	Remarks	Test Method
Arsenic (As)	µg/L	<2	10	Favorable	SM 3120 B
Boron (B)	mg/L	0,688	1,0	Favorable	SM 3120 B
Cadmium (Cd)	µg/L	<5	5,0	Favorable	SM 3120 B
Chromium (Cr)	µg/L	<5	50	Favorable	SM 3120 B
Copper (Cu)	mg/L	<5	2,0	Favorable	SM 3120 B
Cyanide (CN)	µg/L	<1	50	Favorable	SM. 4500- CN^- -F
Fluoride (F)	mg/L	0,3	1,5	Favorable	DIN 38 404-D4-2
Lead (Pb)	µg/L	<10	10	Favorable	SM 3120 B
Nickel (Ni)	µg/L	<5	20	Favorable	SM 3120 B
Nitrate (NO_3)	mg/L	0,2	50	Favorable	SM. 4500- NO_3 D
Nitrite (NO_2)	mg/L	<0,005	0,5	Favorable	DIN 38 404-D 10
Total Hardness	°F	17,7	-	Favorable	SM. 2340-C
Aluminum (Al)	µg/L	<5	200	Favorable	SM 3120 B
Ammonium (NH_4)	mg/L	<0,01	0,5	Favorable	SM. 4500- NH_3 – B, C
Chloride (Cl)	mg/L	40	250	Favorable	SM. 4500- Cl^- -B
Color	mg/L Pt	<5	Acceptable by consumers and no abnormalities	Favorable	DIN 38 404-C1-2
Connectivity	µS/cm	431	2500	Favorable	SM. 2510- B
pH		7,56	6,5 - 9,5	Favorable	SM. 4500- H^+ B
Iron (Fe)	µg/L	<5	200	Favorable	SM 3120 B
Manganese (Mn)	µg/L	<5	50	Favorable	SM 3120 B
Oxidation Capacity	mg/L	31,4	250	Favorable	SM. 4500 SO_4^{-2} – E
Sulfate (SO_4)	mg/L	2,029	200	Favorable	SM 3120 B
Turbidity	TE/F	<1	Acceptable by consumers and no abnormalities	Favorable	DIN 38 404-C2-4
Escherichia Coli (E. Coli)	Count /100mL	0	0	Favorable	S.M. 9225 C
Enterococcus	Count /100mL	0	0	Favorable	S.M. 9230 C
Total Coliform	Count /100mL	0	0	Favorable	S.M. 9222 D
Fecal Coliform	Count /100mL	0	0	Favorable	S.M. 9221 E

Note: (<) indicates lower concentration than the lowest limit the apparatus can read

Conclusions

Investigations and analytical results indicated especially heavy metal pollution by the waste pools and stocking areas of three plants upgrading low grade chromite ores between Pozantı – Karsantı ophiolite in Çatalan Long Distance Protection Area. There were no chemical or metallurgical operations and there were only crushing, grinding, and concentration at shaking tables under density differences. During this operation, the release of heavy metals and fine particles content of the ores contaminated the process water and prevented the discharge into the nearby streams due to regulations. On the other hand, the height of the walls needs to be increased with concrete to prevent any heavy metal containing fine particles to reach the streams and the pools need to be insulated to prevent run-off of fine particles. Storing the restricted waste materials in the galleria previously mined contributes to pollution prevention during the stream floods. It is imperative to reuse the process water repeatedly in a closed-circuit and supply the water deficit from the streams. Discharges into streams should be prevented at all times. The Water Pollution Control Regulations Criteria for Water Quality Planning and Prohibitions Part 20b indicates the wastewaters from mining facilities operating in the Long Distance Protection Areas to be treated to meet the discharge requirements depicted in Tables 5 – 21. Alternatively, the wastewaters should be discharged outside Çatalan basin or reused. It does not seem economical for the investors to reach Class II water quality by using advanced treatment technologies.

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A SURVEY OF RELATIONSHIP BETWEEN EVAPORATION AND WINDS BY USING CLUSTERING TECHNIQUES

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Clustering deals with finding a structure in a collection of uncategorized data and can be examined the most important unsupervised learning problem and the other problems as kind of this. The aim of this study is to cluster the monthly wind speed and the monthly evaporation losses of Eğirdir Lake, one of the most important fresh water storage of Turkey. For this aim, wind speed and evaporation data depend on hourly and daily mean records measured in Eğirdir Lake Catchment, are used. Hierarchical clustering algorithm and partitional algorithm can be successfully applied for clustering at different similarity stages.

Keywords: *Clustering, hierarchical clustering, partitional algorithm, Eğirdir Lake, similarity stages, wind speed, evaporation.*

1. Introduction

Clustering is a division of data into groups of similar objects. Each group, called cluster, consists of objects, similar between themselves and dissimilar to objects of other groups. By representing data with fewer groups, indispensable certain details can be lost but a simplification state can be achieved. Clustering can be considered as an unsupervised method for classification. If there is no prior information on the labels of the data (i.e. in which class they are), clustering algorithms determine the data to a usually pre-specified number of clusters (each cluster represented by a different stage). Clustering algorithms have been applied to a wide range of topics and areas. Uses of clustering techniques can be found in statistics, pattern recognition, machine learning [1], compression, classification and various disciplines as psychology, business, marketing, biology, libraries, insurance, city-planning and earthquake studies. [2, 3]

Many data clustering algorithms have been proposed in the literature. These algorithms can be classified into hierarchical clustering, partitional clustering algorithms, artificial neural networks for clustering, statistical clustering algorithms, density-based clustering algorithm, evolutionary approaches for clustering, search-based approaches and so on, [1, 4, 5, 6]. In these techniques, hierarchical and partitional clustering algorithms are the primitive approaches for data clustering. Hierarchical clustering algorithms can usually find pleasure clustering results. It is able to find different clustering results for different similarity or dissimilarity requirements.

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The aim of this study is to determine the effects of the winds on the evaporation losses and to demonstrate whether according to the winds,(i.e. monthly mean wind speed and/or wind blow number) and evaporation loses, the months for each year can be clustered climatologically. For the aim, the data of (1) monthly mean wind speed obtained from hourly mean wind speed, wind blow number measured for one day and of (2) monthly mean evaporation obtained from daily measuring data, in the area of Eğirdir Lake have been used. Hierarchical clustering algorithm was used for clustering.

2. Hierarchical Clustering Algorithm

A clustering result established by a hierarchical clustering algorithm has a hierarchical structure. “The operation of a hierarchical clustering algorithm is illustrated using the two-dimensional data set in Figure 1. This figure depicts seven patterns (or observation, datum or feature vector) labelled A, B, C, D, E, F, and G in three clusters. A hierarchical algorithm yields a *dendrogram* representing the nested grouping of patterns and similarity levels at which groupings change. A dendrogram corresponding to the seven points in Figure 1 (obtained from the single-link algorithm [Jain and Dubes 1988]) is shown in Figure 2. The dendrogram can be broken at different clustering of the data, [4]”.With the hierarchical structure different clustering results can be obtained for different similarity requirements as shown in Figure 1. For instance If the similarity requirement is set at level 1, the input dataset is partitioned into three clusters, i.e., {(A, B, C)}, {(D, E)} and {(F, G)}.

Most hierarchical clustering algorithms are variations of the single-link and complete-link algorithms. The both of them characterize the similarity between a pair of clusters in different way. In the first method the distance between two clusters is the minimum of the distances between all pairs of patterns obtained from two clusters. And in the other, the distance between two clusters is the maximal distance of all pair-wise of patterns in the two clusters. These algorithms are also explained superficially [5] and comprehensively in [4] studies.

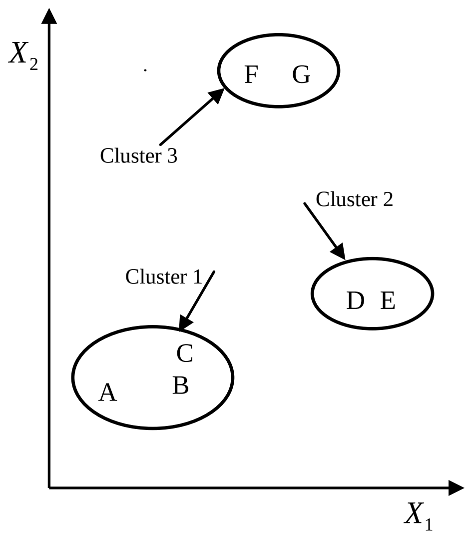


Figure 1. Points falling in three clusters, [4].

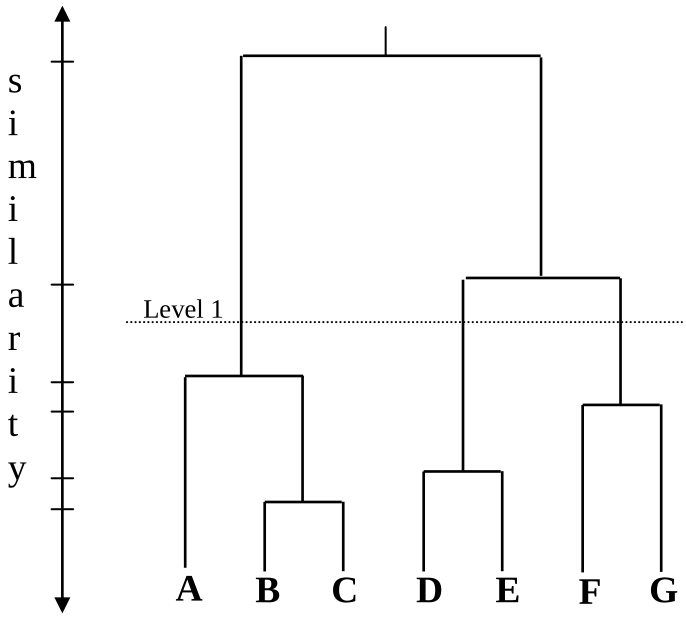


Figure 2. The dendrogram obtained using single-link algorithm, [4].

3. Similarity Measures

A measure of the similarity between two patterns derived from the space, having same characteristic, is essential to most clustering procedures. Hence, similarity is fundamental for determining a cluster. The distance measure/measures must be chosen carefully due to the variety of feature types and scales. For calculating the dissimilarity between two patterns, the most popular method is to use a distance measure defined on the feature space.
The well-known distance measure, used for patterns of which features are all continuous, is the *Euclidean distance* which is a special case of: [7]

$$d_{ij} = d_m(x_i, x_j) = \left(\sum_{k=1}^{n} \left| x_{ik} - x_{jk} \right|^m \right)^{1/m} \quad (1)$$

where; m varies in case of a distance measure to assign similarity. For m=1, 2 and 3, the eq.(1) gives the City block distance, the Euclidean distance and the Minkowski distance, respectively.
The Euclidean distance is commonly used to evaluate the proximity of objects in two or three dimensional space.

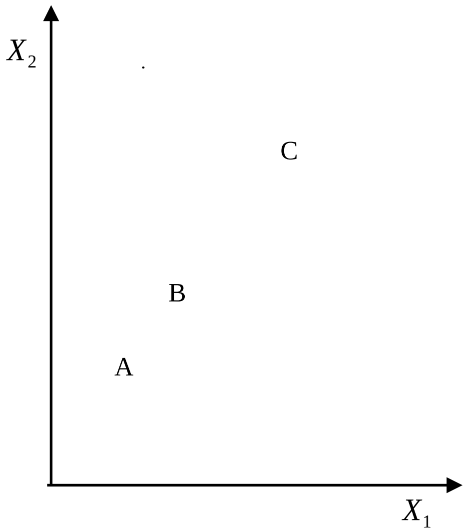


Figure 3. A and B are more similar than A and C, [4].

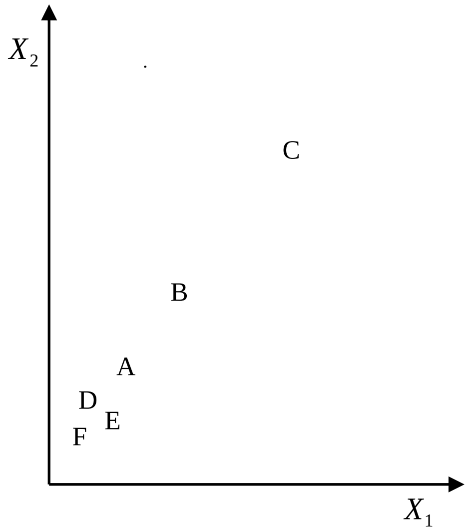


Figure 4. After a change in context, B and C are more similar than B

There are some distance measures reported in Gowda and Krishna [4] that take into account the effect of surrounding or neighbouring points. The set of surrounding points is called *context*. A metric defined by using context is *the mutual neighbour distance* (MND), proposed in Gowda and Krishna [1977]. It is explained comprehensively in [4]. This measure is given by;

$$MND(x_i, x_j) = NN(x_i, x_j) + NN(x_j, x_i) \qquad (2)$$

where $NN(x_i, x_j)$ is the neighbour number of x_j with respect to x_i. Figure 3 and 4 give an example. In Figure 3, the nearest neighbour of A is B, B's nearest neighbour is A. So, $NN(A,B) = NN(B,A) = 1$ and the MND between A and B is 2. However, $NN(B,C) = 1$ but $NN(C,B) = 2$ and therefore $MND(B,C) = 3$. Figure 4 was obtained from Figure 3 by adding three new points D, E, and F. Now $MND(B,C) = 3$ (as before), but $MND(A,B) = 5$. The MND between A and B has increased by introducing additional points, even though A and B haven't moved.

4. Available Data

The data used in this study were obtained from the Regional State Hydraulic Works [7] and State Meteorological Works' [8] meteorological stations in the basin of the Lake area, situated about 917 meters above sea level on the south western part of the Mediterranean Region in Turkey, at about $30^0 18'$-$31^0\ 22'$ eastern longitudes and $37^0\ 48'$-$38^0\ 26'$ northern latitudes. It is the fourth largest (second largest freshwater) lake in Turkey and it has been operated for multiple purposes.

The wind climate of the region is normal but in summer, especially, north winds blow intensively. These effective winds are in direction with the south-north, which is the longer part of the Lake (i.e., it is about 50 km length). Also, in summer, evaporation losses gain more importance with respect to the reservoir of the Lake and water demand.

Based on the records of the one wind gauge station and two Class-A evaporation pans situated near the Lake, the monthly data sets were obtained from the hourly and daily records of 1930-1999. For simplicity, the monthly evaporation loss was directly obtained from the daily observation data near the lake as the mean value of them, by multiplying the measured rate by the pan coefficient.

5. Application

Hierarchical clustering algorithm is used for clustering. Also, in clustering, the similarity is determined by mutual neighbour distance (MND) algorithm. The winds have two important characteristics, increase the lateral transport as well as turbulent diffusion in the vertical direction and therefore have an important effect on the evaporation rate. These are speed and direction. The first characteristic has been represented by numerical values such as monthly mean speeds. Because of the lackness monthly mean values of directions, practically, the effective wind direction can be chosen for the general wind direction to determine the effect of the winds on the evaporations. In the survey, (1) the wind speed and evaporation data sets (2) wind blow number and evaporation data sets were clustered in different stages. And for the different similarity levels, the relationships between winds and evaporation loss were illustrated.

The main parameters of clustering for monthly mean records are given in Table 1.

Table1. The mean values of the data sets

MONTHS	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Wind speed (m/sn)	2,4	3,6	3	3,2	3,5	3,3	3,3	2,9	3,2	3	2,9	2,7
Wind blow number	407	375	388	438	364	422	319	424	577	799	732	599
Evaporation (mm)	112.1	48,3	0	0	0	35	124	182,8	235,9	305,5	287	200

The hierarchical clustering algorithm is applied to three dataset. One of these is the wind speed, the second is the wind blow number and the last one is the evaporation loss. In the first process the wind speed and in the second process the wind blow number were accepted as a first dimension and evaporation was chosen as a second dimension in all process.

In all of the surveys, the values of these dimensions are plotted on x and y axis. The distance between each point in both dataset is calculated by using the Euclidean distance, a special case of equation 1. The distance measures which were obtained from the proximity matrixes of the wind speeds-evaporation losses and wind blow number-evaporation losses with 12x12 dimensions are ordered from the smallest to highest. The neighbour degrees of each dual point $ND(N_i, N_j)$, represent dual months, are determined. It can be clearly perceived that the nearest neighbour is itself for each point. So, $ND(N_i, N_i) = 0$ and the neighbour degree of the furthest point from the current point will be 11 subject to the number of proximity objects or the surrounding points. Relatively, for each 12 points, the total neighbour number of the dual points $N(ND)$ is equal to 144. To make easy to generate the dendrogram, the neighbour degree of each point with itself is taken into account as 1 and the MND between x_i and x_j is calculated by summation of $ND(N_i, N_j)$ and $ND(N_j, N_i)$. Also, the MND is the sum of the number of the combinations of the different proximity objects in which there are sub-clusters. In both of applications or surveys, the $MNDs$ are 78, (i.e. $C\binom{12}{1} + C\binom{12}{2} = 78$). The dendrogram for each group, depends on hierarchical single linkage, were generated independently and given in Figures 5 and 6. In these dendrograms, the dataset can be grouped for different similarity levels.

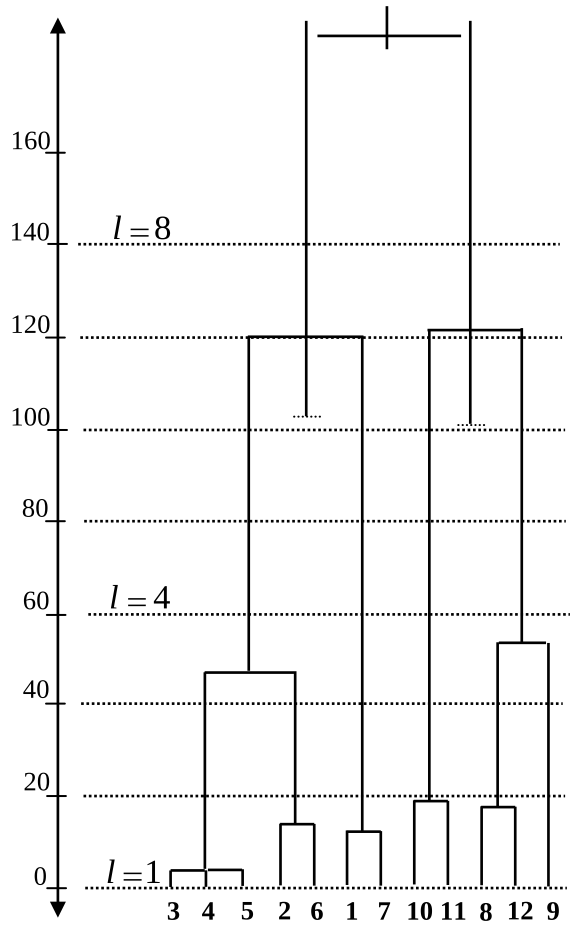


Figure 5. The dendrogram depends on hierarchical single-linkage for the first application.

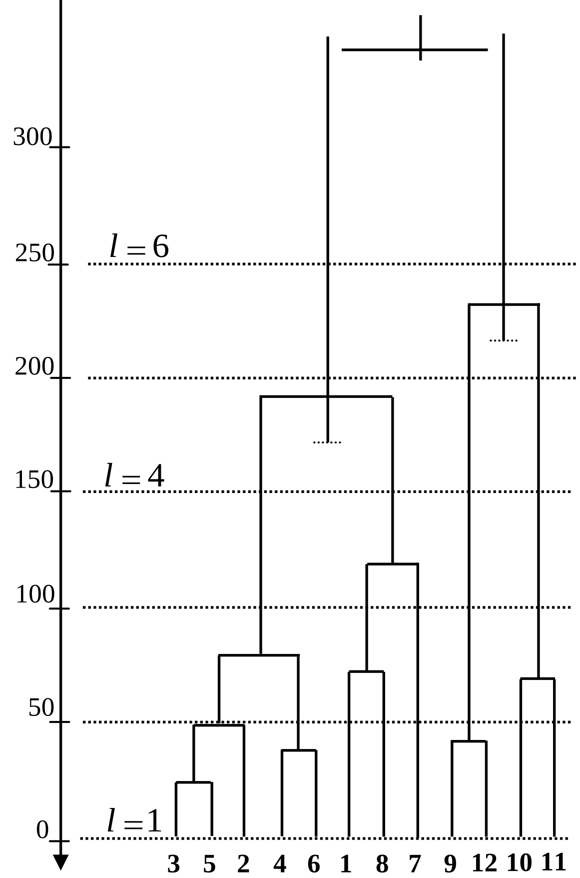
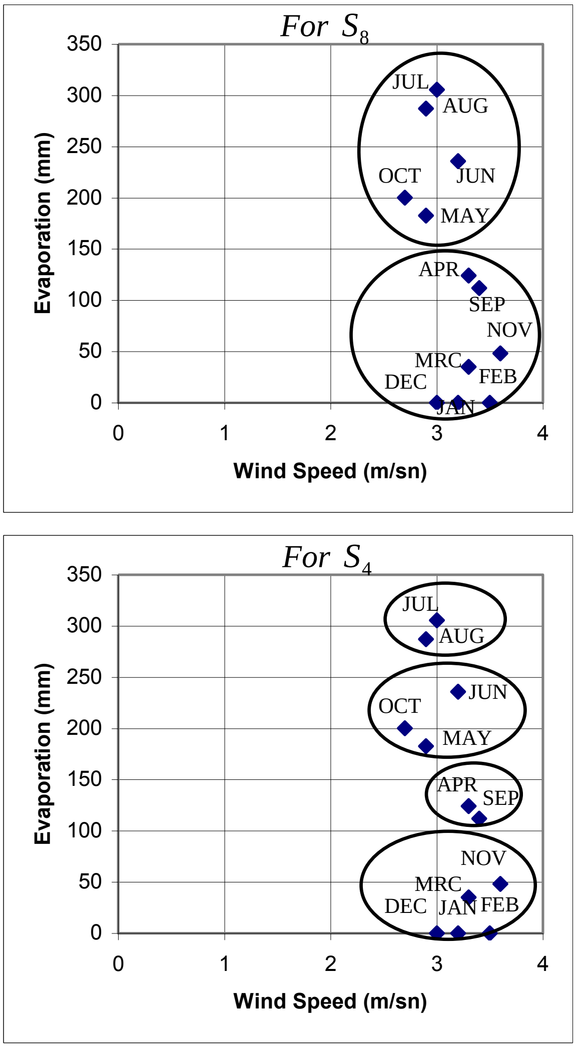


Figure 6. The dendrogram depends on hierarchical single-linkage for the second application.

The similarity level is represented by $S_l\,; l = 1,2,3,\ldots,m$. As it can be seen from both Figures 5 and 6, the dendrogram can be broken at any similarity level to yield different clustering results. For wind speed-evaporation the similarity level (l) varies from 1 to 9 and for wind blow number-evaporation it varies from 1 to 7. S_1 means that there is no cluster. In other words, each cluster has only one pattern. For instance, for the wind speed-evaporation dendrogram there are 4 and 2 clusters at S_4 and S_8 , respectively, whereas these clusters can be seen at S_4 and S_6 for the wind blow number-evaporation dendrogram. For S_7 and S_9 in both dataset there is only one cluster. This means that all the patterns belong to only one cluster. The clusters of various similarity levels for the first ($l = 4 and 8$) and second ($l = 4 and 6$) surveys, are shown in Figure 7 and Figure 8.



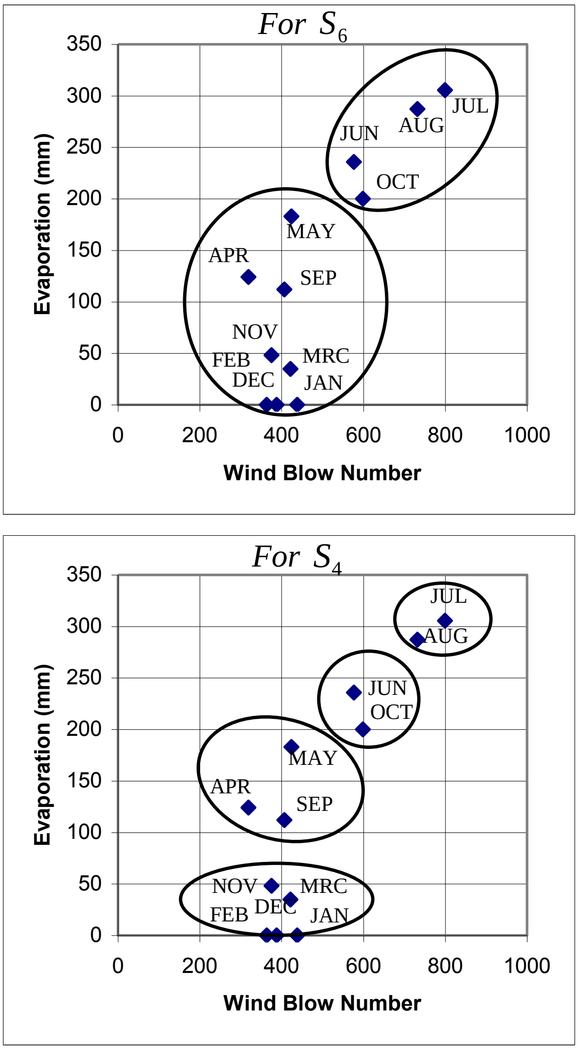


Figure 7. The cluster for $l = 4$ and $l = 8$.

Figure 8. The cluster for $l = 4$ and $l = 6$.

6. Result and Conclusion

It is known that, in general, any change in the wind speed causes the change in evaporation rate when the other meteorological factors, effecting on the evaporation rate, are the same. In this study, a survey to determine the effects of the winds on the evaporation losses was investigated. The following implementations were concluded from this study.

(1) It can be considered that the clustering at S_1 (i.e. all the patterns belong to only one cluster.) for the first data set shows that there can not be seen a statistical relationship between the change in the wind speed and the change in the evaporation amount ($R^2 = 0{,}02$), however, for the second data set, the same similarity level indicates that the effects of winds on the evaporation rate ($R^2 = 0{,}69$) has a quite important, statistically.

(2) Although the first concluded item, it is thought that the clustering for a second data set from the same data source, for instance; at S_8 ($l = 8$) similarity level (in July, August, Jun, May and October) for wind speed-evaporation rate and at S_6 ($l = 6$) similarity level (in July, August, Jun, and October) for the wind blow number-evaporation rate, states the above relations strongly ($R^2 = 0{,}85$ for the wind blow number-evaporation rate; $R^2 = 0{,}29$ for wind speed change and evaporation rate.).

(3) It can be possible that making some critical analyses by clustering method for resolving the problems such as there can't be seen clearly a correlation between two or more patterns selected for examination related to the problem analyses. For instance, in this study when looking into the wind blow number-evaporation rate data set it cannot be asserted any statistical statement exactly about the relationship between these two patterns (Figure 9) however, by clustering at $l = 6$ (the cluster which consists of June, July, August, September) a strong relationship (Figure 10) can be easily stated, ($R^2 = 0{,}96$).

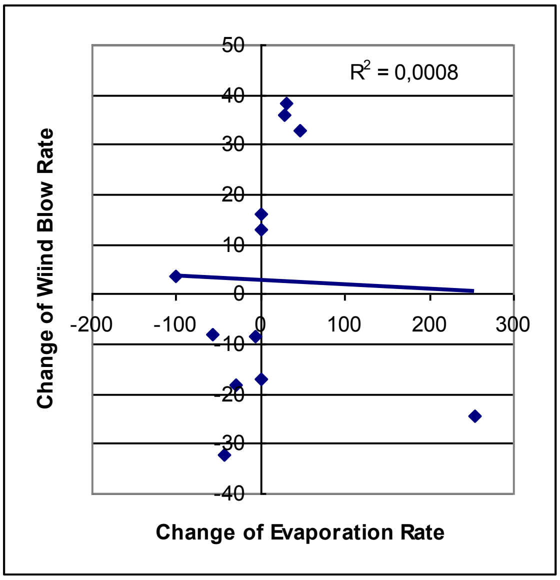


Figure 9. The scatter diagram of wind blow-evaporation rate for S_1

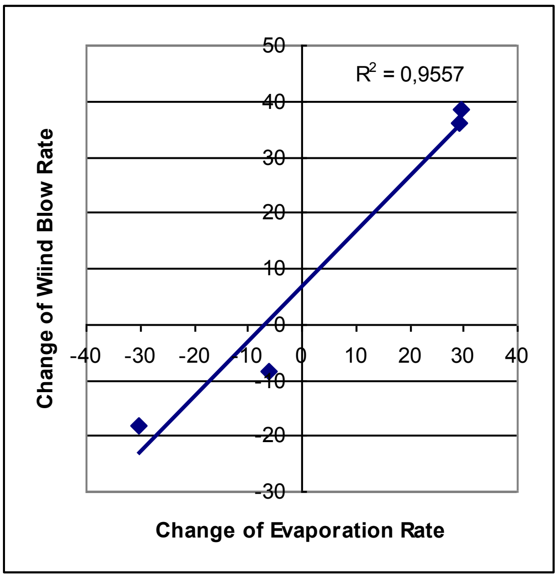


Figure 10. The scatter diagram of wind blow-evaporation rate for S_6

(4) It is considered that the clustering should be used in determining of the different operation level for each similarity level or in making efficient operating decisions and making accurate prediction.

(5) In general, in order to introduce the determination of a stress relation between anyhow two objects or patterns, having a scientific or statistic meaning, the clustering method presents that what data types and groups represents the objects in the best way.

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A MANAGEMENT MODEL FOR RIVER WATER QUALITY CONTROL USING A GENETIC ALGORITHM

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In water quality management, the treatment cost may be as important as the achievement of water quality goals. In the actual circumstances of a developing country, it is difficult to control non-point source pollution.

Conventional mathematical programming methods, such as linear programming, non linear programming, dynamic programming and integer programming have been used to solve the cost optimization problem for regional wastewater treatment systems. To achieve water quality goals and wastewater treatment cost optimization in a river basin, a water quality management model was developed through the integration of a genetic algorithm (GA). Genetic algorithm (GA) optimization applied to water systems with multiple contaminants and several contaminated sources is presented.

The dissolved oxygen content (DO) is one of the most important water quality parameters in rivers and streams. The oxygen concentration is a prime indicator of the quality of the water. In this study, the degree of treatment (%BOD removal) required of each wastewater discharge source in a given river system to minimize the cost of treatment while maintaining defined levels of water quality was determined.

Key Words: *Self purification, Genetic algorithm, Dissolved oxygen, Treatment cost optimization, River pollution.*

1. Introduction

Water quality modeling is the development of abstractions of phenomena of river systems. The main objective of river water quality modeling is to describe and to predict the observed effects of a change in the river system. The usual application of a water quality model is for forecasting changes in water quality parameters resulting from changes in the quality, discharges or location of the point or non-point input sources (Mohamed, 2000).

In water quality management, the treatment cost might be as important as the achievement of water quality goals (Cho et al. 2004). For this purpose, some optimization methods, such as linear programming (Revelle et al. 1968), non-linear programming (Fujiwara 1990), dynamic programming (Klemetson and Grenny 1985), were used. On the other hand Genetic Algorithms (GA) (Cho et al. 2004; Pelletier et al. 2005) were introduced to solve the cost optimization problem for regional wastewater treatment. Cho et al. (2004) used various water quality parameters such as total nitrogen and total phosphorus in the optimization problem in addition to biochemical oxygen demand (BOD), dissolved oxygen (DO), which was adopted by Revelle et al. (1968). Pelletier et al. (2005) used GA to find the combination of kinetic rate parameters and constants that result in a best fit for a model application.

Revelle et al. (1968) developed a WQMM using linear programming. The aim of their study is to determine the degree of treatment (% BOD removal) that should be required of each waste water discharger to minimize the cost of treatment for the system while maintaining defined levels of water quality (dissolved oxygen). They expressed mathematically a simplified problem based on linear programming formulation to show how a linear programming problem is structured and to illustrate graphically the characteristics of its solution. Then, an optimization problem having more realistic objective function were discussed and developed by them.

The main objective of this research is to investigate a water quality management model (WQMM) using genetic algorithm (GA) in comparison with the linear programming proposed by Revelle et al. (1968).

2. Water Quality Model

The cost optimization problem given by Revelle et al. (1968) is as follows; A river basin, Figure 1, have three treatment plants located on the river. The total cost for treatment in the basin is the objective function (Eq. 1) to be minimized

$$Cost = a_1\,\varepsilon_1 + a_2\,\varepsilon_2 + a_3\,\varepsilon_3 + (c_1 + c_2 + c_3) \qquad (1)$$

Where, ε_i= efficiency of treatment Plant *i*, a_i and c_i are slope of the linear portion and intercept of linear portion of the cost curve (Revelle et al. 1968), respectively (*i*=1..3). Since it is assumed that each plant will be required to provide at least primary (%35) treatment, constraints on efficiency, ε_i, are

$$0.35 \le \varepsilon_i \le 0.90 \quad i = 1..3 \qquad (2)$$

It is seen that the minimum cost occurs when all plants provide only %35 treatment. However, this solution, while producing a minimum cost, may not necessarily meet the specific stream quality requirements (Revelle et al. 1968). In addition to treatment constraints presented above.

The relation between plant efficiency and BOD discharge, an inventory equation which is essentially a mass balance and an explicit restriction on water quality written in terms of maximum allowable oxygen deficit are the adopted three groups of constraints in the optimization problem by Revelle et al. (1968). All linear programming formulation given by Revelle et al. (1968) is based on the oxygen-sag equation.

The mathematical expression of optimization problem (Revelle et al., 1968)is as follows;
Find the minimum value of objective function, (Eq. 1), under the constraints;

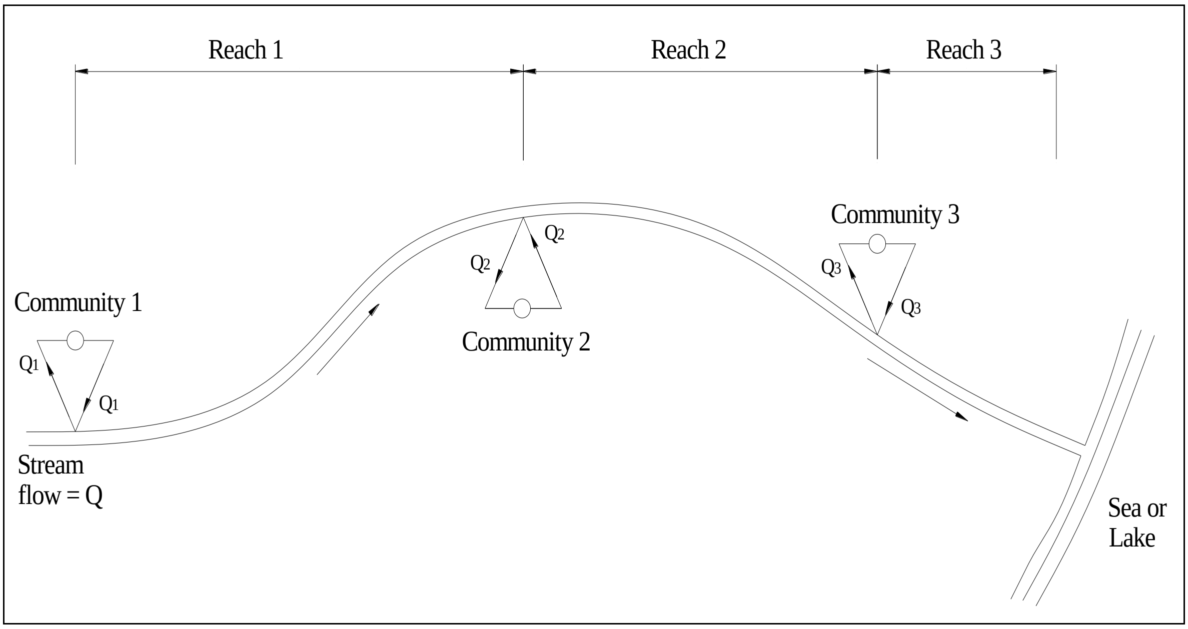


Figure 1. River basin

- Efficiency constraints

$$\varepsilon_1 + \left(\frac{1}{P_1}\right) M_1 = 1; \qquad \varepsilon_2 + \left(\frac{1}{P_2}\right) M_2 = 1; \qquad \varepsilon_3 + \left(\frac{1}{P_3}\right) M_3 = 1 \tag{3}$$

- Inventory constraints
    1. At beginning of first reach:

On deficit
$$QD_1 - (Q - Q_1)E_0 = T_1 Q_1 \tag{4}$$

On BOD
$$QL_1 - (Q - Q_1)F_0 - Q_1 M_1 = 0 \tag{5}$$

2. At beginning of second reach:

On deficit
$$E_1 - \alpha_{II} L_1 - \left(e^{-r_1 x_{II}}\right) D_1 = 0 \tag{6}$$
$$QD_2 - (Q - Q_2)E_1 = T_2 Q_2 \tag{7}$$

On BOD
$$F_1 - \left(e^{-k_1 x_{II}}\right) L_1 = 0 \tag{8}$$
$$QL_2 - (Q - Q_2)F_1 - Q_2 M_2 = 0 \tag{9}$$

3. At beginning of third reach:

On deficit
$$E_2 - \beta_{II} L_2 - \left(e^{-r_2 y_{II}}\right) D_2 = 0 \tag{10}$$
$$QD_3 - (Q - Q_3)E_2 = T_3 Q_3 \tag{11}$$

On BOD
$$F_2 - \left(e^{-k_2 y_{II}}\right) L_2 = 0 \tag{12}$$
$$QL_3 - (Q - Q_3)F_2 - Q_3 M_3 = 0 \tag{13}$$

- Quality constraints
  1. in first reach

$$D_1 \leq D_A\,; \qquad \alpha_I L_1 + \left(e^{-r_1 x_I}\right) D_1 \leq D_A\,; \qquad \alpha_{II} L_1 + \left(e^{-r_1 x_{II}}\right) D_1 \leq D_A \tag{14}$$

  2. in second reach

$$D_2 \leq D_A\,; \qquad \beta_I L_2 + \left(e^{-r_2 y_I}\right) D_2 \leq D_A\,; \qquad \beta_{II} L_2 + \left(e^{-r_2 y_{II}}\right) D_2 \leq D_A \tag{15}$$

  3. in third reach

$$D_3 \leq D_A\,; \qquad \gamma_I L_3 + \left(e^{-r_3 z_I}\right) D_3 \leq D_A\,; \qquad \gamma_{II} L_3 + \left(e^{-r_3 z_{II}}\right) D_3 \leq D_A \tag{16}$$

Where E_0=known oxygen deficit, in the stream just above the top of Reach 1, mg/l; E_i=deficit at end of Reach i (i=1,2), mg/l; D_j=deficit in the stream at the beginning of Reach j (j=1..3), mg/l; M_j=BOD concentration released from the treatment plant at the beginning of Reach j, mg/l; T_j=known deficit of wastewater flow, mg/l; L_j= BOD concentration in the stream at the beginning of Reach j after mixing with the wastewater effluent, mg/l; F_0=known BOD concentration in the stream just before the beginning of Reach 1, mg/l; F_i=BOD at end of Reach i, mg/l; P_j=concentration of BOD entering Plant j, mg/l; r_j= reaeration coefficient in Reach j, days^{-1}; k_j=bio-oxidation rate constant in Reach j, days^{-1}. $\alpha_{I,\ II}$, $\beta_{I,\ II}$, and $\gamma_{I,\ II}$ are coefficients defined as follows;

$$\alpha_I = \frac{k_1}{r_1 - k_1}\left(e^{-k_1 x_I} - e^{-r_1 x_I}\right) \qquad \alpha_{II} = \frac{k_1}{r_1 - k_1}\left(e^{-k_1 x_{II}} - e^{-r_1 x_{II}}\right) \tag{17}$$

$$\beta_I = \frac{k_2}{r_2 - k_2}\left(e^{-k_2 y_I} - e^{-r_2 y_I}\right) \qquad \beta_{II} = \frac{k_2}{r_2 - k_2}\left(e^{-k_2 y_{II}} - e^{-r_2 y_{II}}\right) \tag{18}$$

$$\gamma_I = \frac{k_3}{r_3 - k_3}\left(e^{-k_3 z_I} - e^{-r_3 z_I}\right) \qquad \gamma_{II} = \frac{k_3}{r_3 - k_3}\left(e^{-k_3 z_{II}} - e^{-r_3 z_{II}}\right) \tag{19}$$

3. Genetic Algorithms (GA)

Since the 1960s the researchers are interested in imitating living beings to develop powerful algorithms for difficult optimization problems. A term now is in common use to refer to such techniques is evolutionary computation. One of types of evolutionary computation methods is Genetic Algorithms (GA) which is a stochastic method inspired by the theory defined as survival of the fittest briefly. GA initiates a search within the design space to determine the fitness value of the points constituted as randomly under the constraints that mimic the environment in which the individuals compete each other for limited resources. GA finds out the information about the new points within the design space in the light of the search explained above. GA also aims to reach the fittest one among the points determined in the light of this information. GA repeats searching until a satisfying solution ensuring the design criteria is reached (Goldberg, 1989).

In the GA, each possible solution of a optimization problem is represented by a string of genetic factors called chromosomes. A set of chromosomes makes up a generation. The generation evolves through the genetic operations called selection, crossover and mutation.

3.1. Optimization of a WQMM using GA

If one examines the optimization problem given by Revelle et al., (1968), it is worthy said that the selection of ε_i as a design variables is appropriate and reasonable. Therefore, a chromosome represents the efficiency of treatment, ε_i, at each plant and it consisted of the combined string of real values of the treatment level in the given ranges (Eq. 2). The fitness value of the chromosome is evaluated from the results of the water quality and treatment cost. The fitness value is the sum of the total treatment cost, Eq. 1, and the penalty for a chromosome. In the GA, the penalty is used when the constraints given optimization problem, Eq. 3…16, are violated.

Java Genetics Algorithms Package (JGAP), which is free software, was used for the optimization problem given by Revelle et al. (1968) and summarized above. JGAP is a genetic algorithms component written in the form of a Java framework. It provides basic genetic mechanisms that can be easily used to apply evolutionary principles to the solutions of the optimization problems.

JGAP has various kinds of genetic operators and code scheme for the chromosome. As mentioned before, double or real code scheme is preferred for representing the treatment level at each plant called design variables as follows.

```
Gene[] sampleGenes = new Gene[3];
for (int i = 0; i < sampleGenes.length; i++) {
        sampleGenes[i] = new DoubleGene(0.35,0.90);
}
```

where sampleGenes represents a chromosome composing of three genes which is the total of the number of the design variables, DoubleGene(0.35,0.90) specify the lower and upper bound of design variables (genes). The initiating of the design variables are formed by JGAP randomly. Since the double code scheme is used there is no need to decode of the chromosome. Linear scaling is adopted for the proper selection of the individuals. In the JGAP, the crossover operator randomly selects two Chromosomes from the population and "mates" them by randomly picking a gene and then swapping that gene. Crossover operator supports both fixed and dynamic crossover rates. The mutation operator runs through the genes in each of the chromosomes in the population and mutates them in statistical accordance to the given mutation rate. The adopted crossover and mutation operator among the support of JGAP libraries are as follows for this study.

```
conf.addGeneticOperator(new CrossoverOperator());
conf.addGeneticOperator(new MutationOperator());
```

It is set the default crossover rate to be populationsize/2. The mutation rate is automatically determined by the mutation operator based upon the number of genes present in the chromosomes.

The data used to start the optimization process were given in Table 1 (Revelle et al. 1968). The results obtained from the solution of WQMM using GA are presented in Table 2. Table 2 also shows the results obtained by Revelle et al. (1968) using linear programming. In the GA process, the population size and maximum iteration number are adopted as 150 and 500 respectively. At least 20 runs are performed and Table 2 presents the best result of 20 runs.

Table 1. Data for the optimization problem

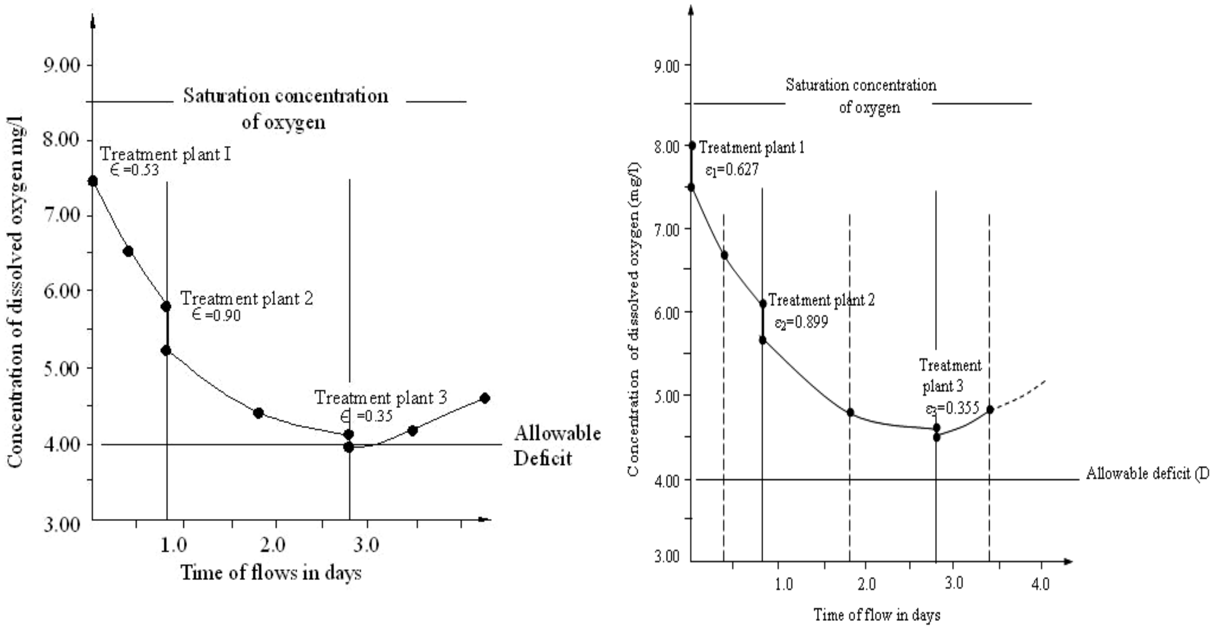
Parameter	Value		
	Reach 1	Reach 2	Reach 3
Bio-oxidation constant (days^{-1})	k_1=0.30	k_2=0.27	k_3=0.25
Reaeration constant (days^{-1})	r_1=0.40	r_2=0.45	r_3=0.65
Half reach length (days)	x_I=0.40	y_I=1.00	z_I=0.60
Reach length (days)	x_{II}=0.80	y_{II}=2.00	z_{II}=1.20
	Plant 1	Plant 2	Plant 3
Cost function	$y_1=a_1\varepsilon_1+c_1$	$y_2=a_2\varepsilon_2+c_2$	$y_3=a_3\varepsilon_3+c_3$
Slope of cost curve ($) degree of efficiency	a_1=425000	a_2=352000	a_3=451000
Intercept of cost curve ($)	c_1=347000	c_2=425000	c_3=28000
Discharge flow (mgd)	Q_1=31.3	Q_2=36.8	Q_3=12.9
BOD concentration entering plant (mg/l)	P_1=284	P_2=408	P_3=121
Deficit of discharge (mg/l)	T_1=7.00	T_2=7.00	T_3=7.00
Stream flow	Q=400 mgd		
Deficit above first reach	E_0=0.50 mg/l		
BOD above first reach	F_0=1.00 mg/l		
Allowable deficit	D_A=4.0 mg/l		
Saturation concentration of oxygen	C_s=8.5 mg/l		

Table 2. Results of the optimization problem

	Lineer Programming*			Genetic Algorithm		
	Reach 1	Reach 2	Reach 3	Reach 1	Reach 2	Reach 3
BOD at begin. of reach (mg/l)	L_1= 11.31	L_2=11.83	L_3=11.27	L_1= 9.21	L_2=10.37	L_3=8.36
BOD at end of reach (mg/l)	F_1=8.90	F_2=9.03	_	F_1=7.25	F_2=6.04	_
Deficit at begin. of reach (mg/l)	D_1=1.01	D_2=3.17	**D_3=4.50**	D_1=1.01	D_2=2.83	**D_3=3.99**
Deficit at middle of reach (mg/l)	$D(x_1)$=2.04	$D(y_1)$=4.25	$D(z_1)$=4.34	$D(x_1)$=1.82	$D(y_1)$=3.76	$D(z_1)$=3.66
Deficit at end of reach (mg/l)	E_1=2.78	E_2=4.42	_	E_1=2.40	E_2=3.89	_
	Plant 1	Plant 2	Plant 3	Plant 1	Plant 2	Plant 3
Efficieny	ε_1 = 0.53	ε_2 = 0.90	ε_3 = 0.35	ε_1 = 0.627	ε_2 = 0.899	ε_3 = 0.355
BOD concentr. Dischar. (mg/l)	M_1=133.0	M_2=40.7	M_3=78.7	M_1=105.93	M_2=41.21	M_3=78.04
Total cost ($)		**1501000**			**1543028**	

* Revelle et al. (1968)

As seen in Table 2 and mentioned Revelle et al. (1968) there was a small violation of the standard in the third reach (D_3 is greater than D_A). However, there is no violation on the results obtained by GA. Form the point of view of the treatment cost, the total cost obtained from linear programming is cheaper than the total cost obtained in this study with GA. Linear programming showed the violation on the graphical representation of the solution. However, it is not encountered violation on the graph drown the concentration of dissolved oxygen versus time of flow in days according to the results obtained in this study (Figure 2-3).



a.) obtained by Revelle b.) obtained by GA

Figure 2. Dissolved oxygen profile of river basin in the optimization problem

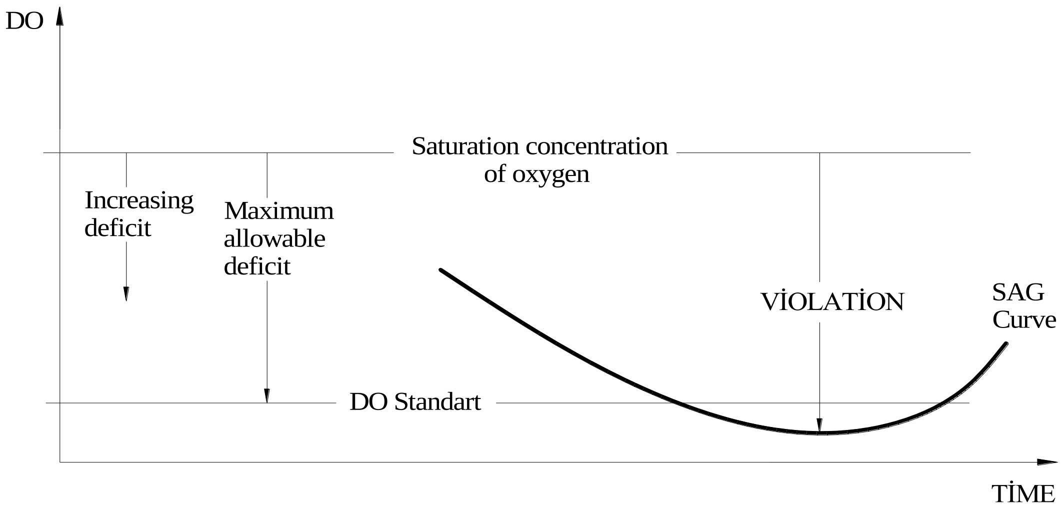


Figure 3. Meaning of violation and allowable deficit

Figure 4 shows genetic process of the optimization of WQMM. JGAP finds the minimum value of objective function for the optimization problem among the candidate solutions which are created and tested by GA until the algorithm reaches the maximum iteration number adopted as 500 in the design. Due to this, although JGAP finds the optimum design in early generation, it continues the optimization process to the maximum iteration, Figure 4. So, there is a difference between the classical convergence plot in GA and the convergence plot in JGAP.

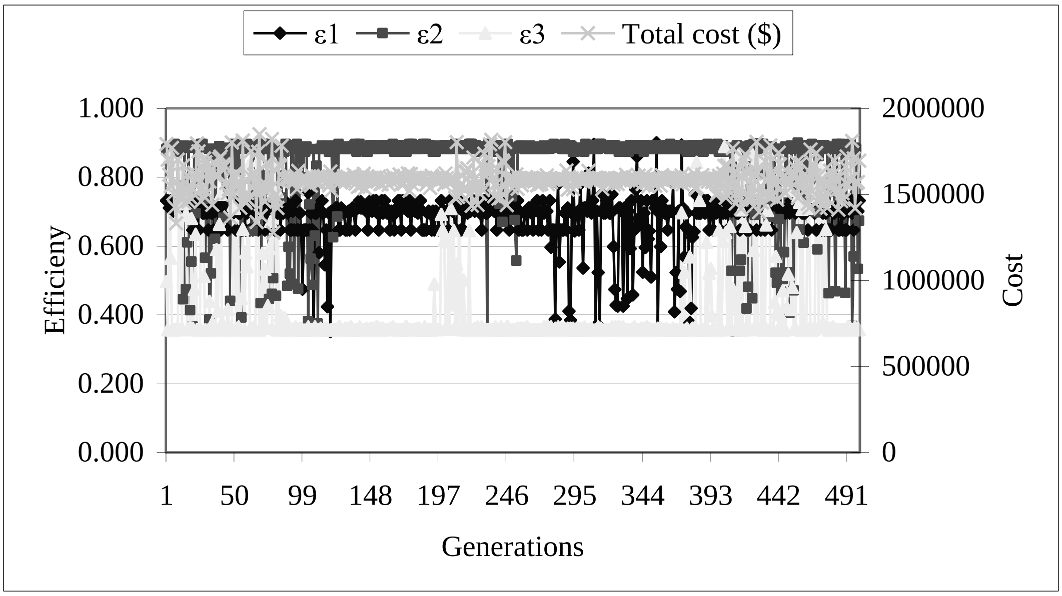


Figure 4. Histories of genetic process

4. Conclusions

A water quality model based on optimization was presented using genetic algorithm and the oxygen-sag equation to determine the degrees of wastewater treatment so that the total system cost is minimum.

The GA solution, describes the treatment plant efficiency to be provided by each of the three communities such that the cost of wastewater treatment for the entire river basin is minimized while the water quality constraints in each reach are satisfied. This study also showed that the JGAP can be applied for river water quality modeling studies.

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OBSERVATIONS ON SUSTAINABLE WATER RESOURCE MANAGEMENT IN TURKEY: THE NEED FOR A COLLABORATIVE APPROACH

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Misuse and mismanagement of fresh water resources create serious problems for the environment. With a population of 72 million people and 1830 m³/year of water per capita Turkey is not a water-rich country [1]. A large urban population, limitations in preventing soil and water pollution, land degradation mainly caused by deforestation, agricultural mismanagement, overgrazing and less precipitation than the world average require authorities and the residents of Turkey to be more diligent regarding more available water resources.

Varied emphasis is made concerning the sustainable use of water resources in the available literature. Economic, social and environmental aspects of water resource usage and management are discussed. However, a framework that gathers all water related organizations at both the regional and national scale is required to provide an effective water management system.

In this study the tasks and responsibilities of water related organizations and the institutional frameworks utilized in Turkey are studied. Conflicts and difficulties faced by the organizations in the application of water management aspects are examined. As a result the need for a collaborative approach bringing all water related organizations together and the redefinition of their work fields at both the local and national level are identified.

INTRODUCTION

In Turkey a great number of institutions with governmental and non-governmental organizations have responsibilities and duties on the development, management and conservation of water resources. Although these institutions work well in their own fields of expertise uncertainties on the distribution of responsibilities and the gaps in the institutional framework cause waste of time, financial sources as well as irrational use of water resources. Thus, identification of these problems and rearrangement of water institutions and regulations are important measures that would form a better and more effective water resource management in Turkey.

1 Main Water Organizations in Turkey: Tasks and Problems

1.1. Tasks of main water organizations in Turkey

In Turkey water related ministries and institutions are: Ministry of Environment and Forest (MEF), Ministry of Tourism and Culture (MTC), Ministry of Energy and Natural Resources (MENR): The General Directorate of State Hydraulic Works (DSI) and General Directorate of Electrical Power Resources Survey and Development Administration (EIE), The Ministry of Agriculture and Rural Affairs (MARA): General Directorate of Rural Services (GDRS), Ministry of Public Works and Inhabitance (MPWI): The General Directorate of Bank of Provinces (GDBP), The General Directorate of Agrarian Reform (GDAR) and the water and sewage administrations connected to the various metropolitan municipalities.

Ministry of Environment was founded in 1991 with the task of protection and remediation of the environment, effective management of rural and urban lands and the natural resources, protection and improvement of natural resources of Turkey as well as prevention of all kinds of environmental contamination. The Ministry of Environment was unified with the Ministry of Forest under a single name (MEF) in 2003 [2]. MEF is responsible for setting policies, principles and rules, inspecting activities, coordinating studies, and enhancing public awareness on environmental aspects of water resources [3].

-MTC is involved in the potable water supply, sewage collection and similar infrastructure of all facilities located in tourist regions [2].

-MENR is charged with setting up policies for energy production, transmission, distribution, consumption and pricing. The ministry is also responsible for assessing the management and investment plans of its affiliated organizations, for supporting them and monitoring their activities [3]. General Directorate of State Hydraulic Works (DSI) and Electric Power Resources Survey and Development Administration (EIE) are affiliated institutions of Ministry of Energy.

-DSI, established in 1953, is the main executive agency of Turkey for overall water resources planning, execution and operation [4]. DSI has been charged by law to serve for public with the development of water and land resources for nation's social and economic progress optimal utilization of surface and groundwater resources and elimination of their adverse effects [5]. In addition, DSI is responsible for performing basic investigations such as, flow gauging, soil classification, water quality monitoring, and preparation of river basin development plans and formulation of proposals for construction financing and subsequent operation of these works [6, 7].

-EIE, founded in 1935, performs investigations, survey and engineering services on hydrology, mapping, foundation surveys, grouting, drilling for coal and other mines, design of dams and hydropower [2].

-GDRS is an affiliated institution of the MARA and it is responsible for construction of small reservoirs and small-scale irrigation schemes and for supplying drinking water to rural communities [3].

-Within the MPWI the GDBP is financially related to water issues. It is a development and investment bank and its responsibilities include developing urban plans, supplying municipal water, constructing sewerage systems and treatment plants, and providing loans to municipalities for the financing of such projects [3].

-GDAR is responsible for certain land consolidation projects in areas declared “Reform Regions” by a Cabinet Decree [8].

-The Water and Sewage Administrations connected to the metropolitan municipalities (15 out of 80 provincial capital municipalities) have also taken part in the implementation of pollution control policies, including water supply and construction and operation of wastewater treatment facilities [9]. They were founded with special law.

1.2 Problems in the application of water laws and share of responsibilities

Institutional frameworks can be categorized into three main levels, namely, decision making, executive and users levels. At the decision making level the Prime Ministry, The State Planning Organization and different ministries take part. Governmental organizations under the ministries work on the executive level. There are also both governmental and non-governmental organizations on the water user’s level for the operation and maintenance of projects [10].

The basic legislation for the water sector is the Turkish Constitution, which states that water resources are natural wealth of country under the authority of the state and to be used for the benefit of the public [8]. The Turkish civil code covers water issues in two categories: as common waters and private waters. Except for some privately owned small springs, the development of water resources, including groundwater, is in general under the responsibility of the state. The major systematic process for water related activities in Turkey is central planning [2]. On the national level, five-year development plans are the main instruments which aim at ensuring the optimum distribution of all resources among the various sectors of the economy [5].

A number of governmental and non-governmental organizations have direct and indirect responsibilities and interests in the development and conservation of water resources in Turkey [2]. When the responsibilities and authorizations of the organizations are examined it is observed that some of the works and work fields need to be redefined and redistributed among the concerned organizations. For instance, some works, such as building reservoirs and dams, are carried out by both DSI and GDRS.

The application of laws such as Groundwater Law Code No: 167 may be confusing or incomplete in terms of what level it is performed at. According to Law all groundwater works come under the authorization of DSI but in practice MEF, GDRS, Bank of Provinces, etc also undertake some work as well.

In some forested areas there might be more than one organization responsible for the protection of water resources on the same piece of land. In Istanbul, for example, The General Directorate of Forest has reserved some areas where water production was supplied in “steady protected lands” status. The General Directorate of Nature Conservation and National Parks is responsible for protecting these areas while Istanbul Water and Sewage Works (ISKI) is responsible for the management of dams and lakes on these protected forestlands. As a rule these two organizations must be in collaboration. However, there is no agreement between these organizations on water production and protection [11]. Therefore, precise parameters must be set for any project to be undertaken by the ministries and organizations.

Another problem with water resource management arises with the jurisdiction boundaries of municipalities. Many river basins in Turkey are located in more than one municipality’s border. In this case decisions on the same river basins require involvement of all water related municipalities, stakeholders and other interest groups.

2 Understanding the Role of Ecosystem Services in Sustainable Water Resources Management

Sustainable water resource management requires consideration and understanding linkages between environmental, economic and social aspects of a nation’s natural resource management structure. It also includes present and future generations’ water use rights and security in the sense that the use of ecosystems and their resources may yield the greatest continuous benefit to present generations while maintaining their potential to meet the needs and aspirations of future generations [12]. This draws attentions to the maintenance of the natural properties of ecosystems in terms of their safeguarding and the making of benefits available to society on a sustainable basis. To provide an uninterrupted service to society the importance of the ecological services supplied by forests and other ecosystems should also be well understood. The regulatory services of forests on climate, water quality, water flow and floods should be considered in the water management systems and valuations [13]. Achouri [14], points out that well managed forests have direct impact on the high quality of water yield from watersheds and on the lower storm flow peaks and volumes for a given input of rainfall. They also contribute to soil erosion control and consequently to reducing the levels of sediment downstream. Dudley and Stolton [15] state that some natural forests appear to increase flow rates. The most significant example is cloud forest, where leaves collect water from clouds and this additional water may exceed transpiration losses. They also add that many municipalities and other users already cite maintenance of water supply as a reason for introducing forest protection or reforestation. Understanding the role of ecosystems service in providing sustainable water resources management will also assist in more effective policies.

With the realization of the need for the rational use of water resources many developed countries have built new advanced approaches for managing and using their water resources. Long term and integrated watershed management is widely accepted and practiced by these countries. New ecological criteria have been formed in order to guarantee protection of water systems. These include water saving and pricing components as well as protection-usage balance of water resources. The results of these applications in many European Countries are quite satisfactory so far.

CONCLUSION AND RECOMMENDATIONS

In the near future Turkey will experience water problems if procedures are not implemented. Irregular distribution of resources and precipitation in many regions already adversely affect the management of water resources. In addition, the application of short term, small regional projects also cause irrational use of water and financial sources. The severity of these problems is likely to increase if the need for a collaborative approach among the various institutions and organizations and the need for new management approaches for Turkey are neglected. Therefore:

-A watershed approach that considers all activities within a landscape and their interrelationships should be drawn up.

-Managing resources in a watershed context promotes collaboration, facilitates greater balance among competing water uses, and accommodates resource leveraging toward achievement of common watershed goals. In such a system, each interest group's or institution's work field must be redefined [16].

-Because an Integrated Water Resources Management practice highlights a collaborative approach concept it might be a solution in overcoming authorization and work distribution problems among institutions/organizations in water management.

-The role of ecosystem services in providing clean and secure water should be well-understood and financially supported in order to supply continuous water to the society. For instance, in the upstream section of a watershed the Ministry of Environment and Forest may be given more responsibilities than the other organizations. In fact, in the upper section of a watershed the forest operations including silvicultural interventions (thinning, cleaning of litter and competitive vegetation, change of tree species) and decisions such as determination of rotation length and reforestation play important roles in the water yield collected in the watershed.

-Water related data stored in different organizations should be gathered and collected in one unit and access to the resources should be open to all those who work on water issues.

-Raising public awareness for water resources and environmental issues is as much important as setting coordinated and comprehensive policies and strategies for water resources management.

-In some cases when water quality and quantity are negatively affected international collaboration may also be required.

-Development plans of water and other related natural resources (forest, soil, natural touristic values) should also be arranged.

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REVISION AND MODIFICATION OF WATER QUALITY MONITORING STUDIES IN TURKEY

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Resolving conflict situations in water resources management is possible only if solutions are properly denoted in all important aspects, from understanding of physical and chemical aspects to the implementation of sound institutional arrangements in order to formulate national and international policies. State Hydraulic Works (SHW), which is responsible for inland water resources development of Turkey has great responsibility in a contemporary watershed based management among all stakeholders. At present, SHW is the only organization, which has regular systematic surface and ground water quality monitoring network all over Turkey. SHW operates 1150 stations, at which about 35 physical, chemical and bacteriological water quality parameters are measured. According to the outcome of water quality monitoring studies of SHW, water quality has deteriorated in most of the inland water resources mainly due to the lack of appropriate pollution control mechanisms, coupled with failure to enforce efficient legislation. In most of the basins significant pollution increase is reported due to domestic, agricultural and industrial discharges. Furthermore, in some instances, deterioration has reached an alarming level for surface water situated in large metropolises. Resolving conflict situations within water resources management context is possible only if solutions are properly denoted in all important aspects. With this intention, it is the purpose of this paper to present water quality monitoring practices of SHW with present and potential future constraints and opportunities.

Keywords: Water quality monitoring; effective watershed management; roles and responsibilities of separate stakeholders

INTRODUCTION

Turkey, which lies in a semi-arid region is increasingly faced by water shortages and degradation of water quality. Depletion of surface and groundwater resources is the result of growing water demands and sometimes-inefficient water use of the domestic, industrial and agricultural sectors. Flood control and water management in densely populated regions are often characterised by a strong interaction between hydrology, land use, nature conservation and environmental protection. Water is increasingly becoming the binding element between nature conservation, soil and land use.

Many watersheds are subject to pollution as a result of discharge of untreated wastewater, dumping of hazardous wastes, or excessive use of pesticides and fertilizers. Formulating effective water and environmental action plans, designing pollution control measures, or building complex wastewater treatment plants therefore have crucial importance in water resources management. A comprehensive consideration of the problem requires an integrated approach, with expertise from a variety of disciplines, applying systems analysis to describe the hydrology, water quality, and water use of a river basin system.

Resolving conflict situations in water resources management is possible only if solutions are properly denoted in all important aspects, from understanding of physical and chemical aspects to the implementation of sound institutional arrangements in order to formulate national and international policies. In the present day, water monitoring is used to help water resource managers understand and avert potential negative impacts of anthropogenic or natural factors on water resources. Consistent and comparable long term water quality and quantity monitoring data are needed in order to, for example: (1) describe the status and trends of a water resource, (2) identify existing and emerging water quality issues, and (3) determine compliance with regulations.

The data must lead to information that is provided in a manner that adds value and relevance to the water management community and the public. The basic principles of a monitoring program include understanding the system to be monitored, designing the monitoring program to meet set objectives, paying attention to details early, monitoring source activities, and building in ongoing program evaluation processes (USEPA, 1993). In this paper, monitoring objectives, monitoring design, data collection (field and laboratory methods), water quality data management, accession and interpretation of data (comparing data to a standard, comparing data under differing conditions, detecting trends, summarizing spatial patterns, forecasting to unsampled times or places [modelling]), as well as conveying results and findings will be discussed as main parts of the present water quality monitoring system of SHW.

WATER QUALITY MONITORING STUDIES OF SHW

Requirement for a Water Quality Monitoring System

SHW, Primary Executive State Water Agency is responsible for water resources development in Turkey. It ensures the long-term supply of drinking and industrial water and also plans, executes and in most cases operates works for flood protection, irrigation, drainage and hydropower generation. In this context, SHW is responsible for performing basic investigations such as flow gauging, soil classification, water quality monitoring, preparation of river basin development plans and formulation of proposals for construction, financing and subsequent operation of these works.

One of the primary purposes for conducting long-term monitoring projects is to be able to detect trends in the measured parameters over time. In response to these phenomena, a network of water quality monitoring stations was established in 1979 to explicate both spatial patterns and temporal trends in water quality in an effort to elucidate mechanisms behind the recent ecological change. This way, SHW, which is responsible for water resources development in Turkey, would be able to conduct its water supply, energy and irrigation projects considering not only quantity but also quality of water. In addition, probable negative impacts of SHW projects on adjacent water bodies have been tried to be minimized in the context of EIA studies. Starting from mid 1980’s, one other aspect mostly faced has been the impact of other investments on SHW projects. Especially development in domestic residences or industrial facilities in the catchments of drinking water supply reservoirs had serious impacts on the quality of water and so health of people drinking these waters.

With the help of the water quality monitoring network, SHW tried to acquaint responsible organizations on this aspect. So far, data produced by SHW has been used in determining baseline conditions, determining patterns and trends, identifying emerging issues, and monitoring changes by governmental and non governmental organizations, private sector, as well as academia.

The number of stations has been gradually increased from 65 in 1979 to 1150 in 2006. Water quality monitoring stations are set according to the requirements of present and planned SHW projects in line with the requests of different Departments in General Directorate, as well as Regional Directorates. The location of stations, sampling frequency and parameters to be measured are examined annually in the General Directorate and annual programs are sent to the laboratories situated in the Regional Directorates to be implemented.

Properties of Present Water Quality Monitoring System

Present water quality monitoring program covers running waters as well as ground waters. Each of the stations is monitored on a month after month basis on average. The number of monitoring may increase up to 12 in a year especially for surface waters planned to be used as drinking water. However, this number may be as low as 2 in a year for ground waters, which have been used for irrigation and with no pollution stress on. At present 82% of the stations are running waters, and remaining 18% are groundwaters. 246 running water and 142 ground water stations are monitored for the present and planned drinking water projects.

At present, 45 different parameters, including inorganic parameters (e.g. nitrate, nitrite, ammonium, phosphate, boron, alkali metal and alkaline earth metal such as potassium, calcium, magnesium), organic parameters (e.g. biochemical oxygen demand, total organic carbon), heavy metals (e.g. arsenic, mercury, cadmium) and bacteriological parameters (e.g. total coliform) are monitored.

Sampling and Analysis of Data

Water samples are collected and analyzed using standard methodology in the laboratories of 21 Regional Directorates of SHW. In the studies carried out at the Regional Directorates, samples are collected using specialized equipment and methods, while trained staff are assigned for collecting waters from pre-determined locations in rivers or groundwaters and analyzing these waters. Locations are determined at the General Directorate by considering present and probable future requirements, and work programs are noticed to the Regional Directorates annually. So far, various elements of quality assurance have introduced in the monitoring programme for best quality assurance of analytical results. Systematic laboratory control visits of two related departments of General Directorate, namely the Planning-Investigation Department and Technical Research Department, to the Regional Directorates; compulsory participation of Regional Directorates in sampling courses arranged by these two departments; permanent measurements of reference samples prepared by Technical Research Department in Regional Directorates are performed for this purpose.

Storage and Interpretation of Data

The water quality data produced are stored in the Water Quality Database maintained by cooperation of Planning-Investigation and Technology Departments. This will be a sub-system of water database which is under developing stage and which will include other data produced by SHW, such as data on waters released from reservoirs, data on water quantity, and land use. Water database will include a large amount of nationwide information and therefore serve as the major water data source available for investigating and assessing environmental problems.

At present, the stored water quality data are analyzed for spatial and temporal trends, as well as for freshwater loading effects. Spatial analysis are performed on data of relatively short period of record, however, time series analysis usually requires a minimum 3 years before significant trends can be recognized over the background noise of inter-annual variability. Therefore, the type of analysis performed is determined by the length of the record.

One of the purposes of the current monitoring program is to use the data gained by routine sampling to extend understanding of the system by developing new hypotheses as to the underlying processes which drive it. Much inference into the behavior of water systems is made from the observed magnitude and distribution of water quality parameters. This type of multivariate approach such as forecasting of unsampled times and places, that is modelling, is also used as a useful tool for interpreting large water quality datasets. The monitoring program has been very useful in defining restoration targets of water ecosystems and even more valuable in determining whether these goals are met.

In the water quality management studies conducted in the river basins by SHW, generally the water quality classes are obtained by comparing 90% values of the parameters with the standards given in the Turkish Water Pollution Regulation. Then, the colored water quality maps are drawn as stated in the regulation. The sites, which are under the treat of pollution are easily designated in the maps. Water quality models are used to determine probable future changes in the water quality under different scenarios, especially in these designated critical zones. Finally, suggestions for better river basin management in the short and long term are stated.

Threshold levels in the Turkish Regulation adopted by 75/EC/440 and 79/EC/869 is used to determine quality of surface water resources intended for human consumption. In case of waters used or planned to be used for domestic water supply, any treat which can cause a change in the water quality is designated according to the Turkish Water Pollution Regulation, and noticed to related organizations in charge with pollution protection.

Apart from this defined frame for investigations the possibility for so-called “extra-investigations” exists. These investigations are intended to cover chemical parameters not mentioned in the ordinance on water quality monitoring. Two years THM investigation at the inlet and outlet of drinking water treatment plants is an example for these investigations. For rivers biological studies are also carried out on the project basis. Moreover, some special projects, which in turn will be parts of water management, are carried out with other organizations, as well as universities.

Water quality data is indispensable component of Environmental Impact Assessment studies of water related facilities. Any EIA Report prepared by SHW is open to the public, and supplied when requested.

Share of Data

Information gathered from the water quality monitoring results has been published in national and international scientific publications, seminar proceedings and reports both in English and Turkish. Reports prepared have been delivered to national governmental and non-governmental organizations, universities as well as the Parliament.

Raw water quality data obtained from regular monitoring studies are shared with national organizations and individuals when requested. Samples brought by individuals are also analized with the cost payment in the SHW's laboratories. As international organizations are of concern, data from eight large rivers, four of which are at the inlet of lakes are submitted to the OECD every two years. European Environment Agency (EEA) will also be supported with data as soon as the database modification studies will be completed.

EFFICIENCY ANALYSIS AND MODIFICATON OF SHW'S EXISTING WATER QUALITY MONITORING SYSTEM

In Turkey, SHW is the major institution that performs water quality monitoring on a network basis. SHW started systematic monitoring practices in 1979 at 6 Regional Directorates with 65 sampling points. Currently, the number of monitoring stations has increased to 1150 points scattered in different basins in the country. This rapidly development and monitoring intensity necessitated assessment of the existing system in order to cope with the obstacles. The existing system was assessed for its performance and efficiency by a series of joint projects in collaboration of Dokuz Eylul University and SHW.

The purpose of such revision projects was the assessment and redesign of the SHW's water quality network. In this framework, monitoring network in a sample basin, namely Gediz river basin was assessed and optimization analyses were carried out to evaluate network performance. Network evaluation was carried out with respect to spatial and temporal sampling features, using entropy and other statistical methods. This process is applied to the Gediz river basin where the analysis cover, not only the technical properties of the system, but also a detailed breakdown of cost elements. Revision of the existing system was carried out with respect to information produced, as well as cost effectiveness.

As mentioned above, water quality monitoring network, established by SHW arose from its requirements. Measurements are on monthly basis at the newly established drinking water monitoring stations and the sampling frequency is either on month after month basis or seasonal basis for others. Core set of parameters, namely physical, chemical and biological parameters is enlarged with heavy metals and bacteriological parameters in case of monitoring on water resources used for drinking purposes. According to results of the pre-mentioned joint Project (1999), monitoring network is good enough in determination of trends; however, if a systematic national network is of concern, there is need for modification especially in the number of parameters and sampling frequencies.

To meet the demands of the Water Framework Directive, water quality monitoring network should be improved as soon as possible. For example, as stated in the EC Directive 75/EC/440, monitoring of inland water quality which is used or planned to be used as drinking water, measurement of some special parameters such as polycyclic aromatic hydrocarbons and salmonella is necessary. In order to meet with the requirements of EC Directives related to SHW's activities, our laboratories should be supplied with the necessary equipment. Increments in the number of sampling sites, sampling frequency and parameters in accordance with national and international requirements, as well as research and development studies will result in increase in funding requirements of water quality monitoring programs. Moreover, the employment of additional skilled staff to conduct these requirements will be indispensable. A standard procedure for inter-laboratory comparisons should be prepared and undertaken on an annual basis under the control of an acreditated laboratory.

Water quality database is currently under modification in order to meet with recent technical and legislative requirements. Data management serves a critical function in both preserving information and making that information available. SHW's existing quality management system is under modification through greater use of electronic technology to record and report water quality information and easy access. This way, the functional share of present data to other organisations in order to meet with the mission requirements will be allowed.

The upgrade of the current monitoring system is a dynamic process, which needs continuous improvement depending on the requirements arising from development of new parameters and/or new methodologies in measurements, as well as application of new technologies in production of goods and treatment of waters. Therefore, follow up of international agenda related to this issue and support of research and development studies in this area has crucial importance. In this respect, any possibility for technical assistance from experienced international bodies should be investigated.

CONSTRAINTS AND RECOMMENDATIONS IN THE NATIONAL SCALE

It is also important to understand that water quality data produced by SHW alone will not necessarily provide cause and effect relationships in the river basins. Much of the monitoring in Turkey is conducted by different governmental and non-governmental organizations. For example, in the context of water quality management, it is very important to consider all potential sources of contamination and ensure appropriate observing methods are being used to measure them. In Turkey Ministry of Environment and Forest (MoEF) is responsible for designation of contamination sites as well as pollution loads inflowing into the water bodies through these sites. MoEF is also responsible for collection of meteorological data. Moreover, it coordinates monitoring studies in the inland waters for special projects. Ministry of Health is responsible for monitoring waters intended for human consumption. There exist many other organizations, which collects data useful in river basin management. So, comprehensive use of all these data is necessary when water quality management is of concern.

As water quality data produced by different organizations is of concern, there is considerable variation in the ways of selection of monitoring sites, the kinds of tests performed, the methods used to determine causes and sources of pollution, and the analytical approaches chosen to evaluate water quality. As a result, reports on the quality of a particular water body often differ depending on the organization prepares it. These disparities diminish the usefulness of different monitoring programs for regional or national assessments. Accuracy and precision are crucial when comparing data sets. There is a strong need for integrating data and identifying gaps and addressing them. Greater interagency cooperation and cooperation with state and local agencies is required. To be fully effective, regional and local folks including industry should be involved and provide specificity.

The main objectives of the biological surveys are to obtain a general overview of river water quality in the country and to detect long-term trends both in individual rivers and at national level. Such information forms a major input to water quality management and is of major importance in assessing the effectiveness of remedial measures in pollution control and as an aid in the selection of priorities in pollution abatement programmes. So, biological monitoring studies should be conducted as soon as possible.
Because of the inherent overlap between inland, coastal, and open-sea monitoring and observing, the national monitoring network should be closely linked with the sea observation system. The national monitoring network should provide the capability to observe, analyze, and forecast natural and human-induced changes that affect watershed, estuarine, and coastal ecosystems.

Because the land, air, and sea are all interconnected, increased monitoring of atmospheric deposition will be critical to any monitoring network. Monitoring atmospheric deposition in coastal areas is particularly important because these areas receive significant input of toxics and nutrients.

DISCUSSION

Present water quality monitoring studies of SHW arose from its requirements. However, its system is the only systematic inland water quality monitoring system executed with a skilled staff working at 21 Regional laboratories all over Turkey. So far, continuously increasing demand arising from national and international requirements has an increasing stress on establishment of a national monitoring network. To meet the demands of the Water Framework Directive, a National water quality monitoring network should be established as soon as possible. Specifically, the national monitoring network should include the following elements:

-clearly defined goals that fulfill user needs and provide measures of management success,
-a core set of variables to be measured at all sites, with regional flexibility to measure additional variables where needed,
-an overall system design that determines where, how, and when to monitor and includes a mix of time and space scales, probabilistic and fixed stations, and stressor- and effects-oriented measurements,
-technical coordination that establishes standard procedures and techniques, and
-periodic review of the monitoring network, with modifications as necessary to ensure that useful goals are being met in a cost-effective way.

Main obstacles in establishing a national monitoring network include adoption of new technologies, engaging all user groups, liability and regulatory issues, accounting for all pollution sources, and data collection, integration, and sharing issues. In any wise, with a 25 year past experience, and with an already existing infrastructure, including laboratories, skilled staff and equipment, SHW will be the pioneer organization in this stage. With this intention, it is the main purpose of this paper to remind other organizations and decision makers about to come together and cope with the main constraints, which are the major milestones in the EU accession of the country in the environment title.

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RIVER BASIN ORIENTED URBAN WASTEWATER TREATMENT IN TURKEY

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More detailed and reliable identification of the prevailing situation of water resources, wastewater treatment & reuse in Turkey is necessary to promote sustainable water and wastewater management efforts and to comply with the recent environmental regulations adapted from Water Framework Directive (WFD). A detailed data inventory has been realized on population distribution being served by the Turkish municipalities both in terms of water supply as well as wastewater collection & treatment. Such an investigation was initially based on the 81 provinces of the country. However, the gathered data of December 2003 are applied to Turkish river basins as EU Water Framework Directive (WFD) relies on the values based on basin-wide approximations rather than provincial calculations. The findings are expected to form a reliable database on both water resources and wastewater treatment status of the country. As a developing country, Turkey faces certain difficulties in having a well-organized and systematic database concerning especially infrastructure facilities. Lack of information and/or reliance on available data together with data scattered among various governmental organizations make the task of partly improving and re-establishing a sustainable water and wastewater management strategy for the country. There are a total number of 129 urban wastewater treatment plants (UWWTPs) in Turkey serving a grand total of 30 374 000 capita constituting almost 45% of the overall population among which 28 plants are located in the 12 Greater Metropolitan cities, 62 in provinces with population greater than 15 000, and 39 in towns and communities with population less than 15 000. The distribution of these plants according to the treatment technologies applied is 40% physical, 55% biological, and 5% advanced. The effluent discharge methods are either discharge to coastal waters, to inland waters, or on land depending on the location of the plants. The effluent quality of the UWWTPs in the country has to obey the discharge standards stated in the National Water Pollution Control Regulation (WPCR).

In the full manuscript, survey results will be presented and discussed on the river basins. The possible contributions of the established water & wastewater database on more efficient management & monitoring scheme will also be discussed.

Keywords: *Turkish river basins, sustainable water management, urban wastewater treatment, water resources.*

INTRODUCTION

The paper is devoted to the outcome of part of an ongoing project which aims to strengthen wastewater management and utilization of the treated effluent for relevant purposes in a sustainable manner. The main objectives of the project are to identify the prevailing situation of water resources, wastewater treatment and management in Turkey, to develop tools and database for the promotion of sustainable urban wastewater treatment, to improve the already existing national policy, and to establish guidelines to be utilized by the responsible authorities on the most efficient solutions regarding the operation of the wastewater treatment systems. The expected results will be the formation of a reliable database representing the prevailing situation in the country regarding water resources and wastewater treatment practices, transfer of knowledge within the entire country through establishment of a network, acceleration of public awareness and increase the educational level on the probable problems, strengthening of the active involvement of all related actors concerned in water planning and wastewater management. It is then that a successful national management strategy can be set and accomplished.

The part that forms the basis of this paper will be on the first and the most important step leading to management strategies which is, the identification of the existing situation regarding water resources and wastewater management applications in the country. A sustainable management strategy will be built upon the information database that will be formed through a detailed survey reflecting the current situation. Development of such a healthy database relies upon considering both the available water and wastewater resources. River basins are the most logical scales on which management of both resources are undertaken (Reimold, 1998). Management strategies and approaches are actually a conscious social decision that provides the long- term well-being of the environment. The finite capacity of a basin’s natural capital cannot meet the ever increasing demands of the socioeconomic system without a strategy of sustainable management. Therefore, the study will be based on river basins of the country. Unfortunately, the administrative boundaries of the provinces do not usually coincide with river basin boundaries, and other institutional constraints can make the management at the watershed scale difficult, as is accepted universally (UNESCAP, 1997).

The principles considered and the assumptions done during the development of the river basin map of the country, and of the related tables on population, population density, water resources, wastewater generated, and existing wastewater treatment applications based on the river basins will be referred following a brief description of the country regarding water and wastewater resources at the national scale. The results will be discussed and evaluated for continuation of the task towards sustainable water and wastewater management.

WATER RESOURCES AND WASTEWATER TREATMENT SYSTEMS OF TURKEY

Turkey is a country located between the two continents, Europe and Asia. She has an approximate area of 770 000 km2, houses a total population of around 68 million with an average population density of 87 capita/km2. Turkey possesses 177 714 km of river, 203 599 ha of natural lakes and 179 920 ha of constructed dams and artificial lakes, the latter area being continuously increasing. The country's geographical and climatic variety reveal that its water supplies are not often to be found in the right place and at the right time to meet the ever increasing demand. Turkey can be classified as a country facing potential water stress, considering the fact that there might be serious water scarcity where the expandable annual drinking water reserves are around 1000 m3 per capita. The available amount of water per capita is 1735 m3; however, the overall potential is around 3690 m3 per capita (SHW, 2002). The overall situation of water supply within the country, according to year 2000 data states that Turkey is divided into 3227 municipalities, of which 2359 have a drinking water network and only 143 of these municipalities have a drinking water treatment facility. Lacking of sufficient infrastructure, treatment facilities, water leakage (32% of the total supply), and illegal water consumption (37% of the total supply) hinder the efficient use of municipal water facilities (SPO, 2001). The responsibility of constructing, operating and monitoring the sewage collection and treatment systems has been given to the municipalities since 1930. The law dated 1981 on Municipalities Income has brought the concept of constructing sewage treatment plants being financially supported by land and construction owners, which has been further revised in 1985 through the Law of Public Works. The National Water Pollution Control Regulation dated 1988 and revised in 2004 dictates the receiving water standards of wastewater that are collected through sewage systems and that are treated either by means of dilution or through satisfactory treatment (WPCR, 2004).

Till late 1990's, the National Bank of Provinces has been in charge of realizing wastewater treatment plants within the framework of annual investment programs according to instructions of the related municipalities. Those constructed plants were then transferred to the municipalities for operation and maintenance. However, nowadays many associations like Greater Metropolitan Municipalities, Water and Sewerage Administrations, The Ministry of Tourism, Southeast Anatolian Project (SAP) Administration, The General Directorate of Special Protection Areas, and General Directorate of Massive Housing deal with the investment of wastewater treatment plants. The Greater Metropolitan Municipalities especially those with high urban populations prefer to solve their wastewater treatment problems by utilizing foreign credits and by managing the investment period. In the year 2001, a total number of 118 wastewater treatment plants have been in operation in Turkey with a total annual wastewater capacity of 2548 million m3. Even though the total capacity has been stated as 2548 million m3, the calculated amount of treated sewage was 1245 million m3 which accounts to 49 % of the total treatment capacity. 38 % (468 million m3) of the total treated amount has been subjected to physical treatment, whereas 50 % (618 million m3) to biological treatment and the rest 12 % (159 million m3) to advanced treatment. According to a detailed survey conducted by the municipalities, 4523.3 million m3 of water has been supplied to the residential sites of 2991 municipalities in the year 2001. The total amount of annual wastewater originating from the whole country has been registered as 2737 million m3. Almost 93 % (2 532 million m3) of this amount arise from urbanized districts having a population over 15 000 is discharged to the corresponding sewage system, whereas the remaining 7 % (205 million m3) originate from rural areas with population less than 15 000 (SIS, 2001).

Within the context of adapting EU legislation to Turkey, two new regulations are issued; one is stated in late 2005 on the quality required of surface water intended for the abstraction of drinking water (QSWADW, 2005). This regulation is identical to EUs directive 79/869/EEC; 75/440/EEC. This regulation in current use in Turkey classifies surface water intended to be used as drinking water in three categories A1, A2, A3 and defines the standard methods of treatment for transforming surface water of these categories into drinking water. The other one is stated in early 2006 is the Urban Wastewater Treatment Regulation (UWWTR, 2006). The originality of this regulation lies in the fact that for the first time this directive defines sensitive and less sensitive water regions, and indicates consents related with the monitoring and reporting of wastewater discharge into receiving water bodies. Therefore, the related items referred in WPCR (2004) for the surface waters from which drinking water abstraction is practiced and/or planned are invalid and the items stated in this new regulation are to be considered from 2006 onwards. This regulation also declares the construction and operation of urban wastewater treatment plants that are required with deadlines set according to population equivalences. The related item also refers that year 2022 as the final date when the requirements of the regulation have to be fulfilled. Thus, there is a necessity to form a reliable database of the existing UWWTPs of the country and also to determine the lacking ones.

Underlying the Principles and Assumptions for Data Inventory and Evaluation of Water and Wastewater Potential

The State Hydraulic Works (SHW) categorizes Turkey into her river basins according to their respective drainage areas and has already prepared basin-wide master plans. Hence, the country is divided into 26 main hydrological basins as presented in Figure 1. In order to calculate the population of each basin and the population served by municipalities together with the corresponding population densities, Table 1 was established by overlapping the administrative and river basin maps of the country. The population values are based on the data of the final census of year 2000. The total inhabitants in each basin are not fully served by the related municipalities. Therefore, the population that is served by municipalities and the percent distribution of the non-served population constitute the last two columns of the table. The corresponding values are gathered from the registered data of the municipalities and highly being confirmed through the recordings of the State Institute of Statistics (SIS, 2003).

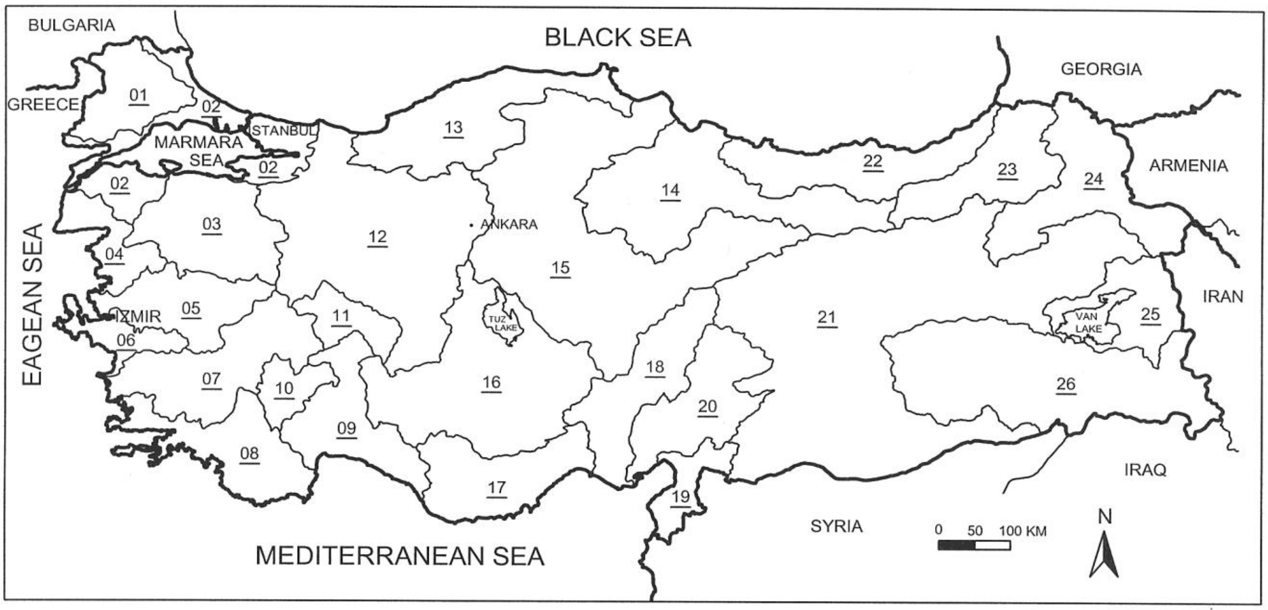

Figure1. River Basins of Turkey

Table 2 refers to information on the available water resources of the country. However, data on various kinds of water resources are lacking, and the only officially registered data belongs to the stored water resources in each basin through the operation of dams (SHW, 1999). The total number of dams and their percent distribution among the basins together with the annual amount of stored water and its corresponding percent is presented in the table. Table 3 presents data on produced and treated wastewater in each basin. Population values of year 2000 are used to calculate the wastewater generated in the basins. The unit wastewater flow rate per capita per day has been estimated according to the population of the residential areas. For example, in smaller communities with a population up to 5000 inhabitants, the unit load is assumed to be 80 l/capita/day, and for cities over 1 million of population, the respective unit load is estimated as 160 l/capita/day (Erdogan, 2004). The annual treated amount of wastewater is calculated by considering either the full capacity of the existing wastewater treatment plants that are in operation or the capacity of the sewerage systems. However, these values still need to be continuously controlled by obtaining more reliable data from the Ministry of Environment and Forestry and from the individual municipalities in charge of operating the treatment plants. There exist a total number of 129 wastewater treatment plants, out of which 55 are only physical treatment, 71 biological and 7 advanced treatment systems as of December 2003.

Table 1. Turkish river basins and their population characteristics

Basin Nr.	Basin Name	Basin Area (km^2)	Population (2000)	Population Density (capita/km^2)	Population Served by Municipality	Population not Servec by Municipality (%)
1	Meric Ergene	14560	980.905	67	660.992	33
2	Marmara	24100	12.481.311	518	11.830.954	5
3	Susurluk	22399	2.637.131	118	2.074.227	21
4	Kuzey Ege	10003	751.113	75	479.919	36
5	Gediz	18000	1.581.398	88	1.124.713	29
6	Kucuk Menderes	6907	3.142.603	455	2.859.583	9
7	Buyuk Menderes	24976	1.929.397	77	1.346.321	30
8	Bati Akdeniz	20953	1.066.630	51	665.995	38
9	Antalya	19577	1.882.851	96	1.562.103	17
10	Burdur Goller	6374	292.840	46	199.113	32
11	Akarcay	7605	500.979	66	409.266	18
12	Sakarya	58160	6.101.234	105	5.356.166	12
13	Bati Karadeniz	29598	1.959.308	66	1.051.372	46
14	Yeşilirmak	36114	3.003.142	83	1.912.931	36
15	Kizilirmak	78180	4.167.766	53	2.629.720	37
16	Konya Kapali	53850	3.048.395	57	2.549.023	16
17	Dogu Akdeniz	22048	1.768.047	80	1.467.997	17
18	Seyhan	20450	1.544.830	76	1.335.974	14
19	Asi	7796	1.332.737	171	1.024.437	23
20	Ceyhan	21982	2.286.178	104	1.729.562	24
21	Firat	127304	6.910.866	54	4.784.750	31
22	Dogu Karadeniz	24077	2.882.208	120	2.020.864	30
23	Coruh	19872	432.259	22	203.747	53
24	Aras	27548	808.570	29	344.713	57
25	Van Kapali	19405	874.524	45	531.326	39
26	Dicle	57614	3.349.716	58	2.391.857	29
Total		779452	67.716.938	87	52.547.625	22

Table 2. Stored water sources for Turkish river basins

Basin Nr.	Number of Dams	Distribution of Dams (%)	Annual Stored Water (hm^3)	Distribution of Stored Water (%)
1	21	2.88	1817	*
2	58	7.95	2894.5	1.17
3	26	3.56	3848	1.56
4	15	2.05	797	*
5	16	2.19	3565.9	1.44
6	17	2.33	1697.7	*
7	22	3.01	2739.9	1.11
8	25	3.42	1830	*
9	14	1.92	2858	1.16
10	9	1.23	161.7	*
11	3	0.41	172	*
12	45	6.16	6827.9	2.77
13	28	3.84	2784	1.13
14	44	6.03	6194.9	2.51
15	78	10.68	23774.3	9.63
16	25	3.42	2800.8	1.13
17	11	1.51	10173.5	4.12
18	18	2.47	6124.5	2.48
19	8	1.10	1086.5	*
20	27	3.70	8229.3	3.33
21	89	12.19	112193.2	45.45
22	41	5.62	1491.6	*
23	21	2.88	7467.3	3.02
24	20	2.74	4085.2	1.65
25	7	0.96	608.7	*
26	42	5.75	30630.5	12.42
Total	730	100	246853.9	100

Table 3. Information on generated and treated wastewater in Turkish river basins

Basin Nr.	Generated Wastewater (m^3/year)	Total Wastewater Generated (%)	Treated Wastewater (m^3/year)	Total Treated Wastewater (%)	Treated Wastewater of Individual River Basin (%)
1	34 985 936	1	0	-	-
2	668 796 450	22	375 194 855	26.6	56.1
3	121 645 665	4	65 626 316	4.7	53.9
4	26 701 962	1	9 235 400	0.7	34.6
5	63 024 085	2	16 848 520	1.2	26.7
6	161 026 061	5	159 019 518	11.3	98.8
7	76 572 439	3	17 989 408	1.3	23.5
8	39 557 224	1	7 649 315	0.5	19.3
9	84 488 023	3	33 581 405	2.4	39.7
10	9 901 552	0	4 460 000	0.3	45.0
11	19 914 542	1	16 425 000	1.2	82.5
12	299 262 969	10	253 319 680	18.0	84.6
13	73 862 371	2	11 172 260	0.8	15.1
14	119 380 424	4	12 592 800	0.9	10.5
15	158 258 043	5	76 969 390	5.5	48.6
16	126 132 159	4	26 688 639	1.9	21.2
17	84 956 440	3	69 032 315	4.9	81.3
18	84 300 305	3	65 590 163	4.7	77.8
19	54 031 081	2	10 950 000	0.8	20.3
20	102 192 614	3	34 618 223	2.5	33.9
21	287 974 298	10	120 212 039	8.5	41.7
22	106 213 180	4	9 914 504	0.7	9.3
23	14 678 971	0	0	-	-
24	28 467 730	1	2 185 620	0.2	7.7
25	34 783 493	1	8 822 031	0.6	25.4
26	138 735 392	5	0	-	-
Total	3 019 843 409	100	1 408 097 401	100.0	

EVALUATION OF THE OBTAINED AND GENERATED DATA

Out of the 26 river basins, the smallest and the largest ones are number 10 and 21, respectively. The largest one is expectedly the one that involves GAP Region – SAP - where the largest dam of the country, the Ataturk Dam which is at the same time ranked in the top 10 largest dams of the world. Besides this dam, there are on the whole a total number of 89 dams in this basin. In terms of population, number 2 which presents Marmara Region, that is the leader with an approximate value of 12.5 million inhabitants. The basin governs the industrial development thus in turn, has the highest share in the economical power of the country. Istanbul, being the most crowded province of the country, is located in this basin that houses 45% of the industries in its vicinity. While the average population density of the country was calculated as 87 capita/ km2, this value is 518 capita/ km2 in the Marmara Region. Such a high density points out that the region is attractive for residing basically due to the ease of transportation and existence of the major industries. The second crowded basin is the Firat Basin with an approximate value of 7 million which is in proportion with its area. The Sakarya Basin is ranked in the third row in terms of population load where Ankara, the capital city, being the second crowded province of the country is located in the basin. Similarly, this basin also bears some major industrial districts. Regarding the population densities, the second ranked basin is the Kucuk Menderes, with a value of 455 indicating overpopulation. Izmir, the second crowded and highly industrialized province of the country located at the Aegean Sea coast is located in this basin. The least population densities are observed in the basins of Coruh and Aras with values of 22 and 29 capita/ km2, respectively. The other highly less population densities are shared by basins Van Kapali and Burdur Goller with values of 45 and 46 capita/ km2, respectively. Such regions with the lowest population densities are regarded as under populated regions compared to the average population density of the country. Burdur Goller with a comparatively lower density profile is a consequence of its smallest area. However, the remaining 3 basins, Van Kapali, Coruh and Aras, are located at the eastern part of the country that face certain constraints like unsuitable geography, unfavorable climatic conditions, and lack of sufficient industrial activities.

As mentioned previously, the water demand of the population in the country is supplied by the municipalities, but as Turkey is still a developing country, not all the population is served by the local municipalities due to lack of infrastructure and sufficient financial support. Almost 80 % of the whole population is benefited from municipal service. The maximum water supply systems attained through the municipalities belong to those basins that are highly populated and industrialized like Marmara and Kucuk Menderes Basins. Basins that were listed as having the least population densities receive the least municipal aid with around 50 % in terms of water supply. The water demand of the population has not been officially calculated, but some researches have been carried out, stating that the demand varies between 110 - 200 l/capita/day (Erdogan, 2004). The Firat Basin bears the maximum number of dams and shares almost 50 % of the total annual water stored in the country. The Dicle Basin near Firat Basin consists of a number of 42 dams. All the dams constructed in these basins are those located on the two significant trans-boundary rivers of Firat (Tigris) and Dicle (Euphrates). The longest river of the country, Kizilirmak, is located in Kizilirmak Basin and consists of a number of 78 dams. The dams on Kizilirmak, Firat and Dicle have a total water storage capacity of almost 70 % of the country. There exist only three dams in Akarcay Basin, followed by Van Kapali Basin with seven dams. Even though there are 58 dams in the Marmara Basin, the water storage capacity contribute to only 1 % of the water storage capacity of the country.

Wastewater production values basically depend on the population and industrialization load, which is also reflected in Table 3. The river basins Marmara and Sakarya that are ranked as over-populated and highly industrialized generate the maximum amount of wastewater. These two basins account for one-third of the total wastewater generated. Firat Basin contributes to 10 % of the total wastewater, which is due to its high population attributable to its basin area. Two basins Burdur Goller and Coruh have insignificant contribution to total wastewater generation. Burdur Goller, being the smallest and the least populated basin is expectedly ranked as the least effective basin regarding wastewater amount. Coruh River basin has been accounted as the basin with the lowest population density.

Almost 50 % of the wastewater generated in the country has been managed to be partly and fully treated. Kucuk Menderes basin is the only basin that completely treats its urban wastewater. This basin is followed by basins number Akarcay, Sakarya and Dogu Akdeniz that treat more than 80 % of their wastewater. These three basins are those that are highly populated and industrialized indicating the socio-economic welfare of the regions. There appear 3 basins, Meric Ergene, Coruh and Dicle that do not have any wastewater treatment facility. Comparatively negligible wastewater is generated in Coruh and Meric Ergene Basins. The highest amount of treated wastewater belongs to Marmara Basin which also accounts to the highest amount of wastewater. However, almost 40 % of its wastewater still needs to be treated. Despite the intensive efforts of the Greater Municipality of Istanbul to improve its sewerage systems, it cannot cope with its huge wastewater generation.

Out of the 129 treatment plants in Turkey, 51 of them are preliminary treatment systems equipped with grit chambers and settling tanks, 71 of them are biological treatment systems containing activated sludge units and extended aeration tanks, and 7 of them are advanced treatment systems. Advanced biological treatment facilities are only being operated in river basins namely Marmara, Kucuk Menderes, Antalya and Konya Kapali. Generally speaking, no significant correlation exists between the number or type of treatment plants and the population density of the respective river basins. On the other hand, one may conclude that most treatment facilities are located in Istanbul and Izmir, i.e. the more industrialized regions with high population density, as well as in Antalya -centre of tourism- and Konya Region of huge agricultural activities. Another noticeable fact is that most of the treatment facilities located in the river basins of the Black Sea Region are just preliminary treatment systems with only physical treatment units. Sea outfall discharges are preferred at the Black Sea Coast of the country due to the geographical structure of the region and to the suitability of the sea to receive preliminary treated wastewater. Those located in the Mediterranean Region are mainly biological treatment systems. The region is quite sensitive and known as an area of tourism activities. It receives financial support from the authorities to deal with sewerage systems.

CONCLUDING REMARKS

In order to fully understand a country's particular water and wastewater issues and to have an overall picture of the facilities, a detailed research on the prevailing situation should be conducted. This study forms an example on such an identification procedure for Turkey. During the data inventory stage of the study, the difficulties faced rather contribute to the fact that the required data and information were highly scattered among the state authorities and not collected at a single organization. It was a time consuming task to gather all necessary available data. Besides, some of the data have to be estimated based on literature survey and personal contact with the related governmental personnel. Part of the data necessitate confirmation and are considered to be less reliable. Proper recordings of data still lack and needs formation of a systematic database that can easily be accomplished even by public. Infrastructure developments should be immediately involved in the databank and all the obtainable information must be continuously updated.
Regarding the findings of the survey, it can be seen that there is an imbalance in population distribution of the country, making the water and wastewater issues a difficult task. Most of the population is settled around the coasts of the country and the highly industrialized regions. Among the many reasons of this fact, the most important ones may be referred as climatic conditions, geographical structure, existence of transportation network, fertility of land and political aspects.

In conclusion, sustainable wastewater management can be promoted provided that the existing situation is well defined. It also necessitates the investigation of the national monitoring and control acts, as without an idea of the national water and wastewater policies it is very hard to establish a healthy and satisfactory management strategy.

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GENERAL PLANNING APPROACH TO THE LAND USE AT THE RIVER BASIN IN THE CASE: ALTINAPA BASIN IN THE MIDDLE OF ANATOLIA

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Altınapa Basin is very important for Konya sub- region because of its drought climate zone. Recently using of water and supply is much more vital for the ecosystem. The decision of land using based on the management and planning of river basin should be considered in that perspective. Altınapa is not only a natural river basin but also it supplies fresh water to the Konya Metropolitan by Altınapa Dam. Konya having one million people live in the city centre is one of the sixteen metropolitans in Turkiye. Since the usage of land use in watershed effects metropolitan and river basin ecosystem directly this are therefore it is chosen for surveying. This survey is aimed to reveal the socio economic lifestyle and land using on the river basin. There are seventeen villages, two towns, a lot of scattered upland and com settlements in the river basin. Watershed planning is evaluated by using the adequacy of the natural resources protection standards in limiting impervious cover at full-build out under current zoning. The method of this research grounds on the basis of comparison impervious cover values with site plans and knowledge of building density.
In conclusions, depicting the present and future health of river basin will aid in planning development locations.

Key words: *River Basin, Land Use, Basin Planning, Basin Management*

1.Introduction

Using a watershed approach to manage water resources requires sustainable land use planning. Watershed land uses has effected on environmentally sensitive areas such as either loss of the natural resources or need to protect areas (Van Lier et al., 1993). Watershed based approach assists with protecting natural resource. Especially one of the purposes of watershed framework is to provide planners aid when reviewing sub-division plans to minimize impacts on water resources (EPA, 2005). There are various methodologies which have been developed for determining a rational use of existing resources that anticipates the possible long term effects on the environment of the decisions taken and takes into consideration all the existing relations between the natural resources and the planned operations (Giulio and Toccolini,1998).Some of these methods use the threshold concept to establish the limits of environment's ability to support the planned development. Objectives of this research is to evaluate the adequacy of the natural resources protection standards in limiting impervious cover at full-build out under current zoning at the sample of Altınapa River Basin in Konya. For instance; as under article 10 of New Castle County Unified Development Code is defined resource protecting standards which is aimed at protecting natural resources by requiring the preservation of a minimum amount of the resource as open space (Schnick, 2006). The second objective is to depict the present and future health of river basin that will aid in planning development locations. The area studied is chosen to observe various human activities compatible with the demands of conservation and protection of natural resources present. The method of this research grounds on basis of comparison impervious cover values with site plans and knowledge of building density.

2. For planning land use analysis and evaluation of resource

Konya city urban area and its vicinity has approximately a population of 830 000, according to the results of 2000 census. The present land using rates of Konya urban area totally contain 22 800 ha (25% dwelling, 13% transportation, 8% recreational area, 9% industrial area,4.5% agricultural area for the remainder of rates relate to services.). Konya is situated on the grassy plain lands but the area is studied on the Toros Mountains. The area studied is called Altınapa River Basin which is a dam settled that is built to control flooding and supply water. The project of water supply and distribution system of Konya city is aimed at 2015 (Su yapı müşavir mühendisler, 1984). The city has obtained water for its requirements from springs at west, by means of conveyance lines which are improved and renewed during centuries (Fig.1). The inadequacy of these springs was lately felt and underground water consumption has started thereon. The numbers of deep wells are directly pumping water to distribution network in majority, has been totalled around 95 (Bilgiç et al., 1999). Apart from these wells, various institutions, persons and industrial plants have developed deep wells and utilised groundwater for their demand.

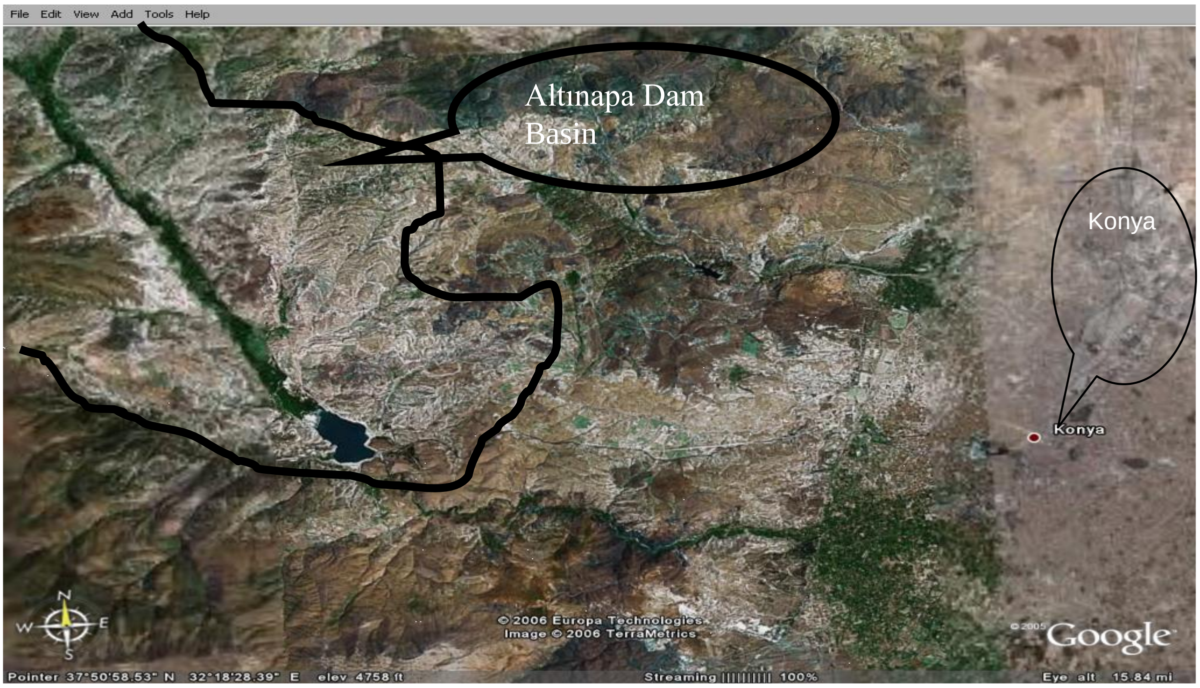

Figure 1. Altinapa Watershed is located approximately 20 km far from Konya metropolitan region.

The area studied, around 1250 km^2, represents a geographical and cultural unit characterized by strong agricultural sector (around 35% of the land is used for agriculture, 25% forest, 20% meadows, 10% rocky land 5% urbanized areas and 5% natural vegetation) (Fig 2).

During this phase of the research, the territory of the Altınapa River Basin was studied with the aimed of identifying and classifying the characteristics of the resources present, with particular reference to following ones (Toccolini and Angileri, 1990).

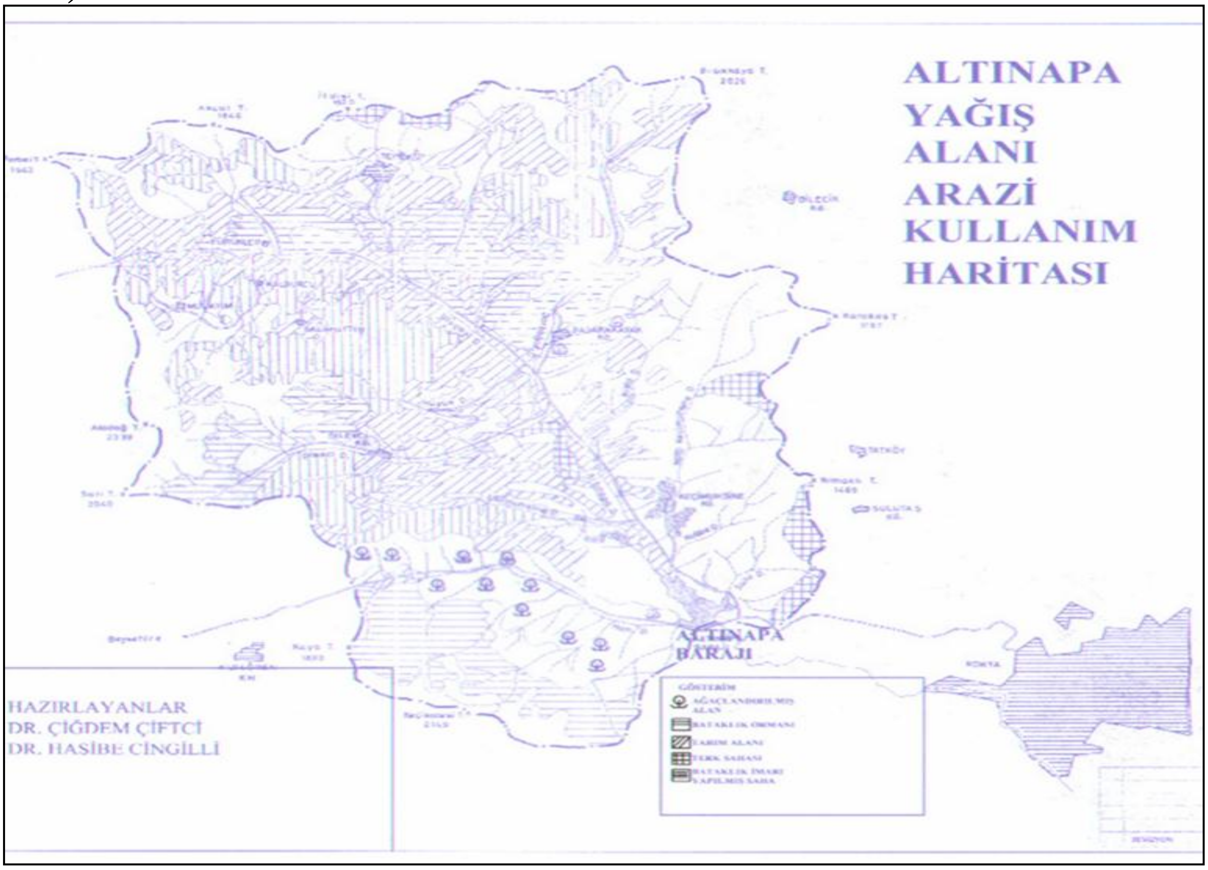

Figure 2.Altınapa River Basin Land Use Map (Çiftçi and Cingilli, 2004)

2.1 Soil

The soil resource was classified in relation to the factors of fertility and stability. Konya is generally located on good class- fertile alluvial soil. The soil class of area studied second rate-stable alluvial soil (Taşçı, 1999).

2.2. Water quality

In consideration of some of the creeks on which are settled towns and villages at both creeks and puddle are found to violate Drinking Water Standards with coli form activities (Cingilli and Çiftçi, 2004). Heavy metals were not found in samples taken from these streams. Other parameters such as Calcium, Chloride, Sulphur, Sulphate, Nitrogen, Alkalinity, COD, BOD, Dissolved Oxygen and pH are below the limits given in water Quality Classes Table for inland water resources.

Several factors were identified as possible causes of poor water quality in the creek. Two major reasons why urban waterways show degraded water quality are untreated storm water run-off and improper use of pesticides, herbicides and fertilizers. These factors combined with reduced vegetative buffers have been blamed for the poor water quality.

2.3. Natural vegetation

Although the watershed territory has been profoundly modified by agricultural activities that have led to the almost total replacement of the natural vegetation with crop vegetation, it is nevertheless possible to find in certain areas specific environments with evidence of a fluvial landscape that has not been modified by man and that retains an appreciable degree of naturalness and in which interesting flora is to be found. The natural vegetation has been classified in relation to the frequency with the various forms of vegetation occur in the area (common, rare and unique vegetation) and their ability to resist the effects of various types of human intervention (high or low resistance).Because of a substantial portion of the watershed land being steppe, it widely contains scrub and tuber plant classes as a vegetation. Also upland habitats comprise approximately 20% of study area and include pine flatwoods, oak flatwoods, and scrubby flatwoods. Perifluvial area contains poplar cultivation, cereal cultivation and fishing.

2.4. Fauna

Although following the serious deterioration of the natural environment, considering it's predominately agricultural spread and developing highly urbanized, Altınapa watershed contains a surprisingly rich diversity of the animal life. The highly developed nature of the upland habitats is conducive to the support of various birds, and small reptiles and urban mammal species (Squirrel, rabbit specious, rat specious, etc. mammals, turtle specious, terrestrial snake specious, etc reptiles, sparrow, stork, crow specious, etc. bird various). The analysis carried out was restricted to vertebrates given the lack of data and specific investigations. This is not to say that in certain sectors of the territory examined animal species of undoubted value are not present.

2.5. Landscape

The landscape features of the area under examination have been strongly conditioned by the morphological aspects of the terrain and the human activities in the area. As far as the morphology is concerned, being generally flat, the region is stably uniform but there is in certain areas a degree of variability determined by the presence of escarpments and knolls where residual evidence of the perifluvial and coast of puddle. With regards to man's influence over character of the landscape, one can observe anthropcal intervention with the aim of preparing the land for agricultural use. Only in a few perifluvial areas can one see a landscape that approaches the natural state, due to presence of spontaneous woodland and herbaceous vegetation.

The agricultural landscape is strongly conditioned by the crops adopted and the consequent use of the soil. The predominance of arable farming, frequently associated with the disappearance of windbreaks hedgerows, lends certain monotony to the landscape. It is articulated where permanent fields and relative features such as hedges, windbreaks etc. In this respect, an important visual element is provided by the presence of poplar plantation that can be seen, above all, along the flood plain of the river. The mass and volume of these plantations enrich and render more varied the landscape.

2.6. Land use

There are 19 settlements and a number of uplands in the Altınapa river basin. The two of them are towns which are called Basarakavak and Tepekoy. In population ranging of 17 villages in field survey is drawn attention six settlements which are called Akpinar, Kucukmuhsine, Ulumuhsine, Selahaddin, Saraypinar and Mulayim (Fig 3). Especially in the last decade it is testified to move from big cities to rural area in close vanity of the metropolitan area. The nearest of these is Kucukmuhsine which is far from Konya about 20 kilometres. The furthest of these Tepekoy is about 50 kilometres away from Konya. Furthermore, Tepekoy is the most crowded settlement. The second crowded settlement is Basarakavak which has a number of archaeological sites that at one time was a thriving native population existed (Karauğuz et. Al., 2004).

Settlements / Years	Akpinar	Basarakavak	Küçükmuhsine	Ulumuhsine	Tepekoy	Selahaddin	Saraypinar	Mülayim
1990	1869	2049	559	56	4118	329	1098	829
2000	417	2409	409	119	4609	314	305	426
Pop.Growth Rate (%)	-0,49	+0,12	+0,14	+0,21	+0,11	-0,10	-0,36	-0,19

Figure 3. Some of the settlements' populations in the Altınapa river basin (DIE,042,1998-2002)

The created by state the land use map was used to define present land use on which is shown that land impervious value as to soil classes (Fig.4).

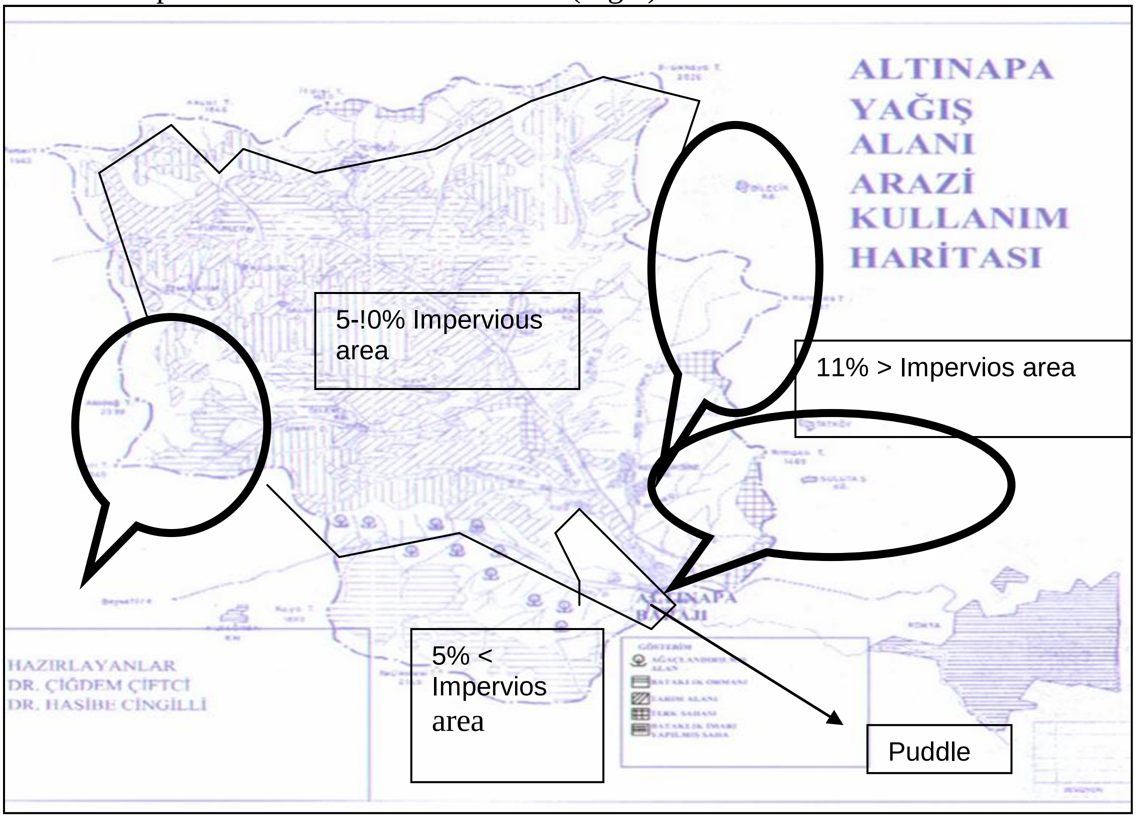

Figure 4. Impervious Cover's values of Altınapa River Basin

On the other hand for healthy using watershed terrain in the future, it must have been designated in limiting impervious cover at full built out under current zone. The impervious cover values which are used in this field survey is composed of site plans, building density and the other case studies' values by comparing.

Impervious surfaces which are consisted of urban land use classes has derived percent values for each land use classes. Final impervious cover values are showed that following ones (Fig. 5).

Land Use	**Impervious Cover %**
Single family residential	20
Multi family residential	45
Commercial	70
Transportation	75
Institutional	30
Industrial	85
Agriculture	3

Figure 5. Final impervious cover values in Altinapa river basin.

Sustainable land use planning has restricted impervious cover on selected natural resources. As to these restrictions 100 % protection must have been made wetlands, 100 year floodplains, riparian buffers, slopes > 25 % and class A wellheads. Also partially protection restrictions must have been made forests, recharge areas, slopes 15-25 % and critical natural areas. Watershed land uses has effected on environmentally sensitive areas such as either loss of the natural resources or need to protect areas (Van Lier et al., 1993). The area studied, around 1250 km^2, represents a geographical and cultural unit characterized by strong agricultural sector (around 35% of the land is used for agriculture, 25% forest, 20% meadows, 10% rocky land 5% urbanized areas and 5% natural vegetation). Finally the percents forest, riparian buffers and public/private open spaces on the watershed theoretically means the higher score the healthier the watershed but on the contrary the percent impervious cover on the basin means the lower score the healthier the basin. The area studied showed 85% has healthy used. The urbanization area which are Basarakavak and Tepekoy have Construction Plans are generally seen single family residential that the building construction type is separated. Only business district areas have adjacent type of building construction. All of the driveways, sidewalks are high level impervious cover' value. So urbanization negatively effects on the watershed land use in Altınapa dam basin.

3. Future potential land uses

The area suitable for hosting the development of the various human activities were identified in relation to the limits imposed by resources of natural and human environment present in the territory. For achieving this objective it needs comprehensive planning for environmentally sensitive areas all levels of the government. At state level environmentally sensitive lands, places restrictions on surface waters, is regulated to activities which are conforming with planning policies for sensitive areas such as wetland and flood plains. The adopted plan must have been relied on carrying capacity analysis to delineate different ecological communities. This plan also establishes density limits and performance standards for different zones on the watershed. As to densities and performance standards in the plan developed for allowable land uses decisions must have been based on individual environments transactions reports and official documents.

The Altınapa dam basin has some weaknesses to comprehensive planning for environmentally sensitive areas. Since every local government has authorization to direct itself, there have no comprehensive plans for this region so far. It means that river basin habitat could not been protected environmentally.

Some of pollutants which can be concerning with agriculture or industry (stone quarry etc) are threatened to the ecological communities of river basin.

All of the settlements are located on the side of the creeks. At the Altinapa dam basin as well as it caused to increase at percent of impervious cover, destroyed ecological stability. One of basin villages is nearest to the located dam, is called Degirmenkoy, is purchased compulsorily to move an other far from dam place. It could be achieved by state water management (DSI).

Low income is of a great threatened the to majority of basin residents, therefore poverty is very common at the Altinapa dam basin. For basin property system is broken into small pieces is caused to increase arable field and building density. This case is the other threatened for the healthy watershed land using.

The majority of the basins residents have low education upbringing. With unconsciously using the fertilizer, pesticide and herbiticide it threatens the healthy watershed land use. They could not accept to integrated watershed management.

4. Conclusions

This research demonstrate that the amendment of Altinapa Dam basin needs presence comprehensive environmental data and also for predicting future environmentally sensitive land use needs detailed carrying capacity analyses at natural and human environments. So the conclusive results of the application can indicate the restrictions and the potential for the development of human activities in relation to the existing environmental resources and the ecological stability of basin.

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NEW TECHNOLOGY TO MEASURE THE WATER LEVEL AND THE SEA STATE

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A considerable proportion of the world population lives and works on the coast or near the coast. Therefore, the knowledge of the physical processes which interact on the coast is very important. The physical processes are driven by several factors like tidal forces, hydrological and meteorological phenomena. As result of these processes, the variations of water level and waves can be observed very easily. Water level is measured by gauging stations, and the waves by special devices. In the late 1990s radar devices, which were mainly used in process technology, were introduced in hydrometry. This paper presents results from a field test to give the reader help and support by choosing the right radar gauge to measure water level and the sea state. The physical background and the application of radar in distance measurements are not discussed here.

Introduction

Nearly any kind of engineering activity in coastal area relies on information about water level. The classical way of reading the water level is by a staff gauge and a float. These measuring systems have been used for very long time and have been upgraded in various ways to store the recorded data. Measuring the water level in this way it is reliable and widely used. But this system requires some construction work and a building to protect the instruments. Furthermore, the site and the instrumentation have to maintained, what is time- and cost-intensive. As the sea level is one of the environmental parameters that are easily recognised and widely used in both scientific and non-scientific applications it needs to be observed in a simple and reliable way. Radar sensors are widely used in process technology and were introduced in hydrometry in the late 1990s.

The Federal Institute of Hydrology (BfG) made the first investigation in this regard in the beginning of 2000 [1]. As technology of these devices was rapidly advancing additional tests were made. These tests were part of a research project [2] with the aim of finding the best methods for measurements of waves, sea state, water level, and the thickness of ice. One of the main parts of the project was the measurement of waves in a broader sense. Therefore much attention was paid to the theory of the detection and measurement of water level as part of waves under different conditions. Different tests were undertaken under both laboratory and field conditions to assess the measurement. This aim of this paper is to show the results from the field test to give the reader help and support in choosing the right radar gauge to measure water level. The physical background and the application of radar in distance measurements are not discussed here. As mentioned before, there were both tests in the hydraulic laboratory and as well in the field. The laboratory tests, investigated the back-scatter from different radar devices for various wave types and water surfaces to assess the suitability to measure waves and water levels.

The Field Test of Radar-Sensors

With this information from the laboratory tests, four different devices were selected for the field test. The gauging station ‘Borkum Südstrand’ was chosen as the testing site. This gauging station is located on the island of Borkum and is very close to the border of the Netherlands. This location has all required conditions such as tidal range, different types of waves, the sea state, change of salinity, rough sea, saline air, and annual temperature variation. Furthermore the gauging station ‘Borkum Südstrand’ is an official gauge of the Federal Waterways and Shipping Administration (WSV). The location of the gauging station and the setting up of the radar sensors are shown in Figure 1 and Figure 2.

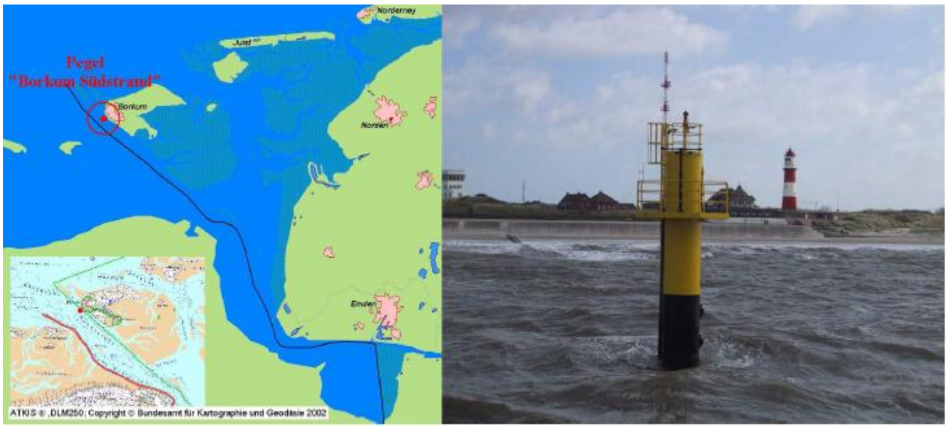

Figure 1: Location of the testing site and general view of the gauging station ‘Borkum Südstrand’ during high water

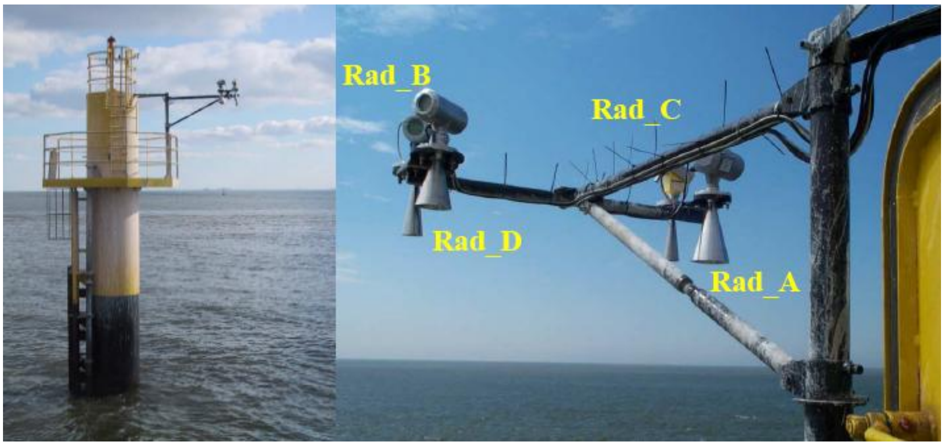

Figure 2: The gauging station and the installation of the radar-sensors

The devices are designated as Rad_A to Rad_D under an agreement with the manufacturers. If detailed information is required, the reader may contact the author. For reference of the four radar sensors, the official and calibrated gauging-station data were used. The calibration was done after a national directive. In addition a magneto-strictive-sensor (a special kind of float gauge) was installed for reference. It is worth to mention that the magneto-strictive sensor is the only sensor officially authorised for the calibration of water-level measuring devices. In general, all radar gauges work after the same principle. A radar signal with a frequency of approximately 1- 30 GHz is sent from the antenna to the water surface. After reflection on the water surface the signal is received again with a certain time lag. The characteristic of the radar devices are given in Table 1.

Tab. 1: Characteristics of the tested radar gauge

		Rad_C	Rad_B	Rad_D	Rad_A
Method	[-]	Pulse	Pulse	Pulse	FMCW
Microwave frequency	[GHz]	26	26	5,8	8,5-9,9
Microwave length	[m]	0.015	0.015	0.0517	0.035-0.030
Antenna diameter	[inches] [cm]	4 10.16	4 10,16	6 15,24	8 20,32

The Rad_A gauge works with the frequency-modulated continuous wave (FMCW), all other devices use the pulse-method with different frequencies. As all radar gauges collect data in a very high frequency, an efficient and reliable statistical software tool is required. The daily data volume is approximately 56,000 signals for one radar sensor. Different statistical tests for outliers were made with MATLAB ©. In addition to the standard tools from MATLAB © special subroutines from the WAFO project [3], where similar work was done, were used.

Figure 3 give an impression of the daily data volume of a particular radar gauge.

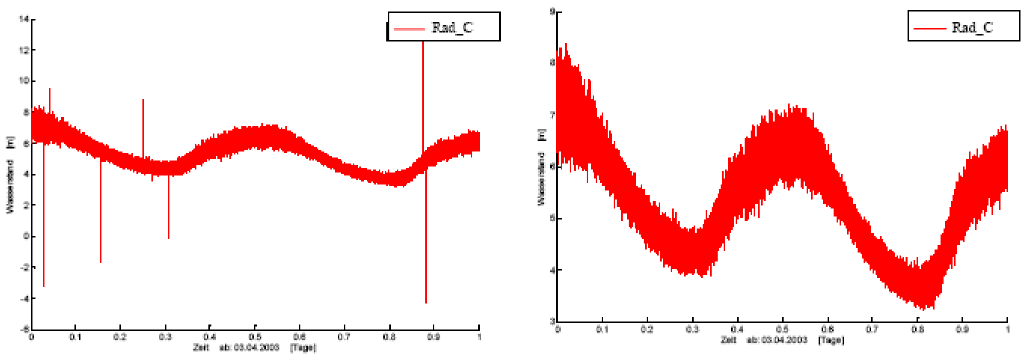

Figure 3: Collected data over a time period of 24 hours. Left hand side with outliers, on the right hand side after statistical treatment of outliers.

The graphic presentation shows the great effect of the removal the outliers. It is obvious that the outlier test is necessary for further hydrological investigations. The official gauging station measures the water level with a float within a stilling well, what means that the enclosed water level is smoothed, and waves and the sea state are not registered. Radar gauges work in a different way: they do not need a stilling well, they measure the sea surface of a particular area with high frequency. Thus the smoothing of the radar signals has to be done by mathematical methods. Mathematically speaking this is a low-pass filter like a moving average or exponential smoothing. All these methods are well known and are described in good text books. It was found that the exponential smoothing fits the hydrological requirements. The equation for smoothing is given by $x_{i(smoothed)} = \alpha\, x_i + (1-\alpha)\, x_{i-1(smoothed)}$; with $\alpha = 1\ldots0$

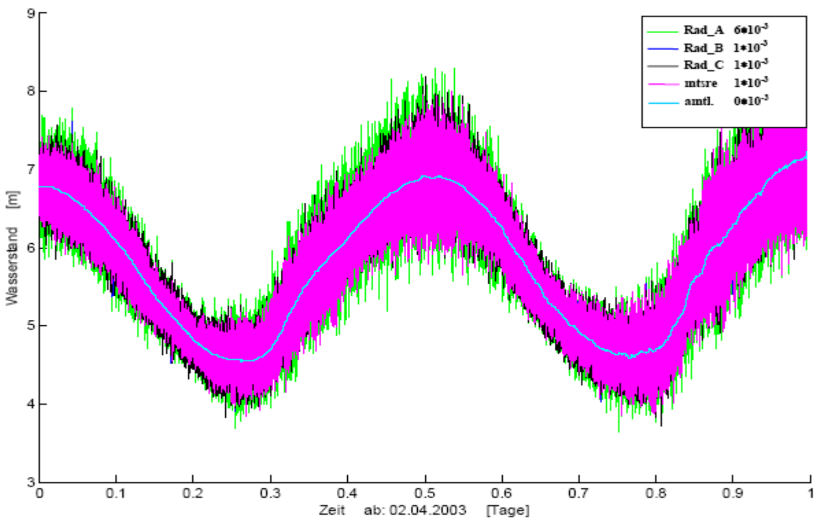

Figure 4: Graphical presentation of all tested radar gauges including the reference magneto-strictive sensor and official gauging-station data.

As mentioned above, the radar gauges measure the water level in very high frequency. The collected data have to be treated by statistical methods, and the time series have to smoothed. Figure 4 shows an example of all tested radar gauges and the reference devices after removing outliers. The blue line is the official gauge which measures the water level within the stilling well. All radar sensors and the magneto-strictive sensor show high variations due to the measuring methods. After applying the exponential smoothing, the hydrographs of the radar sensors appear like the official gauge data.

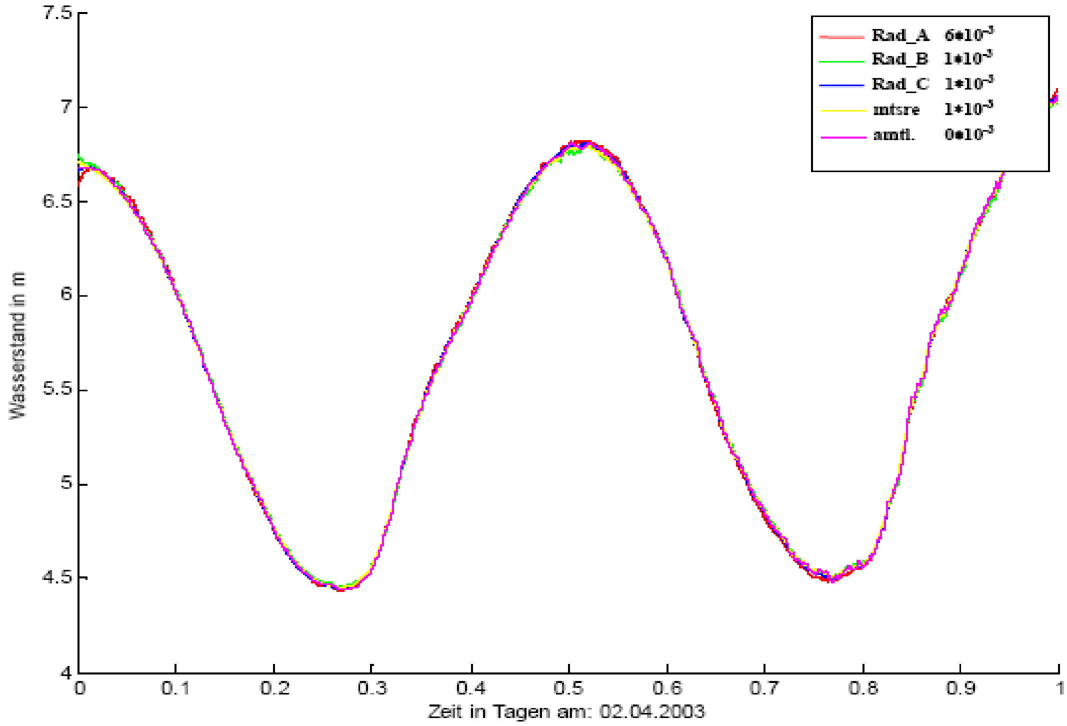

Figure 5: Hydrograph of all tested gauges after exponential smoothing

It can be stated that exponential smoothing of the radar signals achieves the same shape of the hydrograph like measurements with the float gauge, where the water level is measured in a stilling well. Therefore the whole construction effort like stilling well, intakes and float can be replaced by exponential smoothing. A weighting factor α of 0.001 at a sampling rate of 1.3 Hz achieved the best results. High- and low-water values and time of occurrence an important issues in further hydrological investigating.

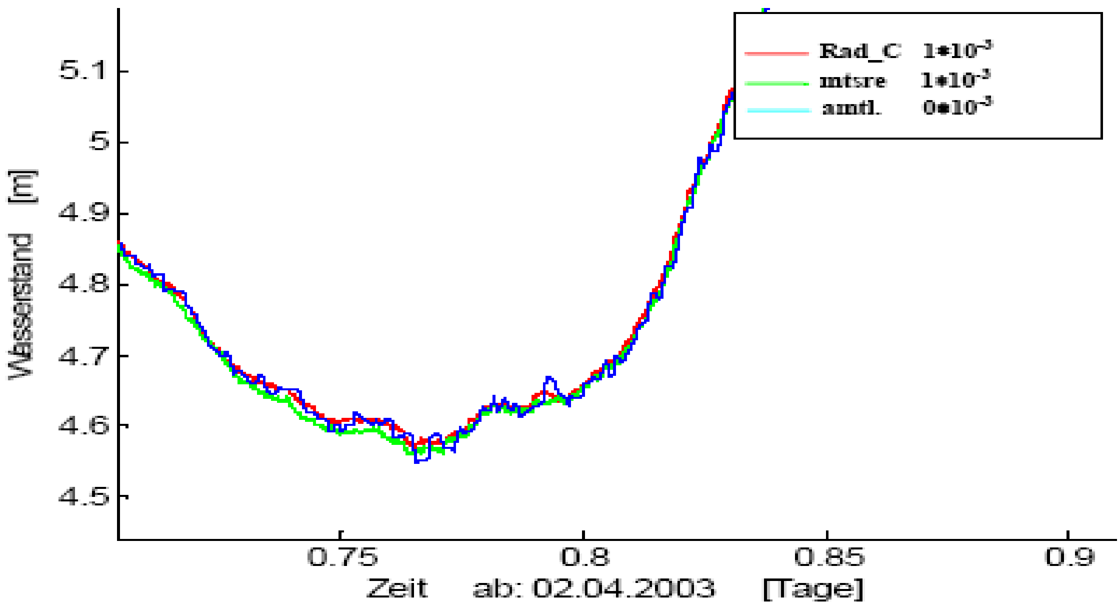

Figure 6: Comparison of the radar gauge RAD_C with official gauge data and the magneto-strictive sensor in the low- water part

The following Figure shows the low water data of Figure 5 in more detail. It is clearly to be see that even in these parts of the hydrographs radar sensor and the applied smoothing give very good results in comparison with official gauge and magneto-strictive sensor. Up to now the comparison of the radar gauge was only made by examination of the graphic presentations over different periods of time.

Figure 7 shows the error distribution of the official gauging station and of the radar gauges in relation to the reference

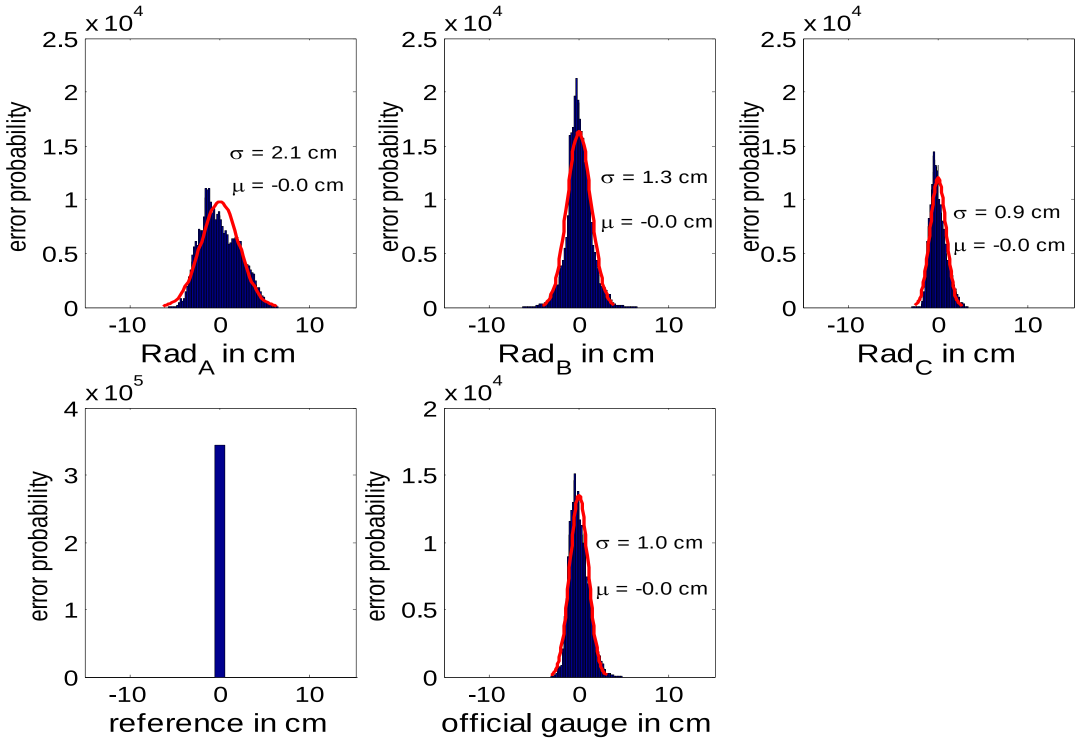

Figure 7: Comparison of the measured differences between radar gauges and the magneto-strictive sensor on a particular day

The radar gauges Rad_C and Rad_B are the most suitable devices for measuring the water level [4]. The error is in the same range like that of the official gauging station *(amtl.)*. Rad_A is also suitable for determining the water level, as its error is still in the range of the German directive for measuring the water level. To complete the graphic presentation, the 'error distribution' of the authorised gauge magneto-strictive sensor was also shown. Rad_D has been tested since summer 2003 but there were problems with the data communication of the sensor. Therefore the analysis as show in Figure 7 was not done in this case. Furthermore, it can be stated that in comparison with the classical gauge the maintenance requirement for radar gauges is much less and they have delivered data since summer 2003. Even interferences of different kinds, like bird entremets or saline air have no influence on the measurements at all.

As mentioned before, radar gauges measure the sea level of a particular area with high-frequency. With these high-frequency data we are able to estimate the spectral intensity of the sea state. To estimate the spectral intensity in the right sense, a radar sensor with a very high sampling interval and low noise is required. It was found that the radar sensor Rad_C fulfils the criteria of the project. In the field test itself, it turned out that the noise level of this particular sensor was rather high. Waves with amplitude of about 20 cm could not be properly detected. In this context the question arises whether we have to measure all small waves. Figure 8 shows the noise behaviour of the sensor RAD_C and the reference (magneto-strictive sensor).

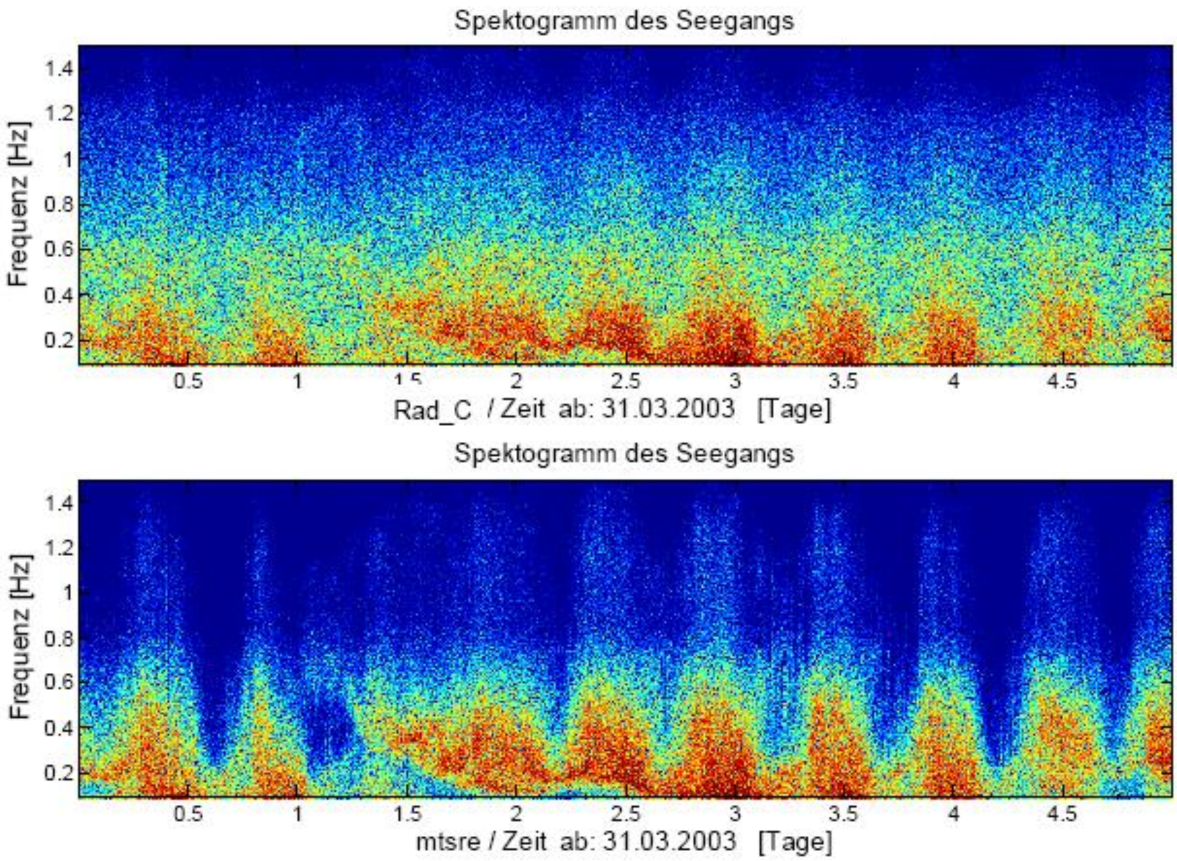

Figure 8: Spectrogram of the sea state and the reference (Magneto-strictive-Sensor)

The spectral intensity of the sea state is represented by different colour dots in 15-minute intervals over a time period of five days. The frequency of sea state is in the range of 0 to 1.4 Hz. The upper picture shows the spectrogram of the sea state obtained by the use of the RAD_C sensor. The spectral intensity is easy to detect, and the noise behaviour can also be observed as the yellow dots over the whole period of time. In the lower part of the picture the sea state of the reference can be clearly seen by the red dots in the frequency range from 0.2 to 0.6 Hz. Dots in deeper red colour indicate that the sea state is more intensive.

Conclusion and Outlook

The field test showed that the radar gauge is an efficient and reliable device to measure the water level. It is worth to mention that the radar gauge measures the water level in a completely different way than the traditional float gauge. At the moment, the Federal Institute of Hydrology (BfG) is undertaking more field tests. Another test site is in the Baltic Sea on the island of Rügen. Together with the Federal Agency for Cartography and Geodesy (BKG) we are investigating the combination of radar gauges with GPS. To this end, the radar gauge is installed in the usual way, and on the top of the radar device the GPS-device is mounted. With the combination of both these devices we are able to measure the movement of the water level and have permanent control of the gauge zero. Up to now it is usual to get the tide-gauge zero control from levelling.

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ECOLOGICAL CONTROL OF A CONDITION OF WATER BODIES IN LARGE CITY

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Permanent deterioration of a condition of urban environment is a global ecological problem. Aquatic ecosystems, especially water bodies, rank among the most vulnerable media with respect to anthropogenic and technogenic pollution. Conservation and management of urban water bodies have always been a challenge in case of megalopolis with numerous water bodies. One of such megalopolis is St. Petersburg (north-west Russia) where about 20 % of the city area is covered by water. There are 265 water bodies in the city, most of them are small and shallow ponds located in parks and gardens and in the interior of residential areas. Only limited number of them is under ecological control in the frameworks of the system of State Monitoring. That is why a special system of express diagnostics of ecological crisis on urban water bodies has been developed.

The system of express diagnostics is based on the limited number of characteristics under control which give an integrated knowledge on negative processes of eutrophication, pollution and acidification, developing in the water body. The system is not labour-consuming and does not require significant financial investments. All these make possible controlling of a lot of water bodies during short time period.

Since 2002 the system of express diagnostics has been applied to the assessment of ecological state of about 130 water bodies of St. Petersburg. The results of the study have shown that over the all characteristics under control, the ecological situation on 53 % of water bodies studied can be assessed as satisfactory, and on 47 % - as stressed. Ecological crisis has been revealed in none of the water bodied, though few of them are very close to the crisis. For most of the studied water bodies the complex of applied characteristics is quite enough for adequate assessment of ecological situation. Based on the results of the study the recommendations aimed at improvement of the situation have been worked out and forwarded to the Administration of the City. It has been concluded that the developed system of express diagnostics of ecological crisis on urban water bodies works quite well and can be recommended for practical use.

Introduction

Permanent deterioration of a condition of urban environment is a global ecological problem. Aquatic ecosystems, especially water bodies, rank among the most vulnerable media with respect to anthropogenic and technogenic pollution. Essentially all urban water bodies, in one degree or another, are subjected to anthropogenic pressure that is reflected negatively on quality of water and bottom sediments, vital functions of hydrobionts and aquatic plants, condition of water surface and waterside zone. In order to control the ecological state of urban water bodies a system of State Monitoring is elaborated in many countries. Since the system is based on the periodical control of wide range of chemical, biological and hydrological characteristics of the water bodies, it is labour-intensive and requires significant financial investments. As a result, in practice only limited number of water bodies is covered by State Monitoring. Meanwhile in most cases it is quite enough to have less information in order to reveal an ecological crisis at its early stage in the water body. Moreover, in many cities most of water bodies are small and shallow ponds, which have no serious social importance. That's why it seems inefficiently to invest much money to get full information on characteristics of such water bodies. It is clear that there is a need to improve the system of State Monitoring by creating special sub-systems. One of the ways of such improvement is a development of a system of express diagnostics of ecological crisis on urban water bodies.

The purpose of the study was the development and verification of the control system which enables one to assess an ecological situation on great number of urban water bodies adequately, in short time period and with low financing, and to work out recommendations aimed at improvement of the situation.

Study area

Conservation and management of urban water bodies have always been a challenge in case of megalopolis with numerous water bodies. One of such megalopolis is St. Petersburg (north-west Russia) where about 20 % of the city area is covered by water. There are 265 water bodies in the city, most of them are small and shallow ponds located in parks and gardens and in the interior of residential areas. The water area of 47 % of the water bodies is more than 1 ha, and only 12 % of them are characterized by mean depth more than 2 m. At present, only a limited number of them (about 20) are under ecological control in the frameworks of the system of State Monitoring.

System of express diagnostics of ecological crisis on urban water bodies

Structure and main principles of the system

The system of express diagnostics consists of three main components:

- set of characteristics under control;
- methods of measurements;
- method for assessment of ecological situation on water bodies.

The main principles of the system, resulted from the condition of efficiency of the ecological control of numerous water bodies during short time period, are the following:

- system is not labour-intensive;
- system does not require significant financial investments;
- system provides an adequate assessment of the ecological state of water bodies.

Water bodies subjected to strong anthropogenic pressure are usually characterized by high nutrient and/or pollutant load. As a result, negative processes of eutrophication and/or pollution and/or acidification start developing in them. Hundreds of chemical substances come into water bodies at urban area, however, it is not feasible to make complete chemical analysis of water. In order to reveal developing of each of the negative processes, in practice, there is a certain set of direct and indirect variables under control. The efficiency of ecological control can be successively achieved only when the system is based on the limited number of characteristics under control which give a generalized idea of the development of the negative processes of eutrophication, pollution and acidification in the water bodies.

Characteristics under control

Taking into account the main principles of the system of express diagnostics, the following characteristics have been chosen for the control:

Characteristics of water:

- pH;
- characteristics of gas regime (O_2, CO_2);
- concentration of total phosphorus (P_{total}) as a main nutrient which limits primary production in most water bodies in study area;
- presence of toxic gases (CH_4, H_2S);
- intensity of odour;
- concentration of Chlorophyll “a” (Chl “a”).

Visual characteristics of water surface and waterside zone:

- presence of floating contaminants (surface films, oil spots, social refuse etc.), remains of aquatic plants, “carpets” of duckweeds;
- water “blooming”;
- pollution degree of waterside zone;

Aquatic plants (specific composition, biodiversity, distribution pattern, biomass, condition of aquatic plants).

In addition to the set of main characteristics listed above, temperature and conductivity of water should be also measured when taking samples from the water body.

The results of practical application of the developed system have shown that for most water bodies it is quite enough to control the above set of characteristics in order to reveal negative ecological situation and reasons which have lead to such situation. In case it is impossible to explain the situation on the water body, some additional study is needed.

Methods of measurements

Field studies should be carried out 2 times during the year: in winter (by the end of ice-covering period – usually in March - April) and in summer during the period of highest activity of vegetation processes (July - August). It was found, in the course of survey of more than 50 water bodies, that field studies in spring and in autumn periods are less representative. Number of water samples to be taken on the water body is determined by its morphometric characteristics. On small water bodies, samples should be taken at one site located approximately in the center, it is generally a deepest zone. In case, there are relatively isolated bays, or different parts of the water body are subjected to various external load, water samples should be taken at 2 or more sites. If the depth of the water body is less than 1 – 1.5 m, it is enough to take sample only from the surface layer, in deeper water bodies samples should be taken from 2 horizons – surface and near-bottom ones.

Analytical methods applied should be as simple as possible and are wide-used in the practice of laboratory studies. Besides, the methods should not be expensive – they should not require expensive equipment and chemicals.

Method for assessment of ecological situation

The ecological situation on the water bodies is assessed as satisfactory, stressed or crisis. For each characteristic under control the criteria for correspondence to the ecological situations have been developed (Table).

Table. Criteria for assessment of ecological situation on water bodies

Characteristics	Parameters of ecological situation		
	Satisfactory situation	Stressed situation	Crisis
Characteristics of water mass:			
• pH	6.5 ÷ 8.5	4.5 ÷ 6.5; 8.5 ÷ 10.0	4.5 > pH >10.0
• O_2 before midday, mg l^{-1} (% saturation) during period of open water	7 ÷ 10 (80 ÷ 115 %)	1.5 ÷ 7 (15 ÷ 80 %); 10 ÷ 14 (115 ÷ 160 %)	1.5 > [O_2] > 14 (15 % > [O_2] > 160 %)
during ice-covering period	> 11 (> 80 %)	2 ÷ 11 (15 ÷ 80 %)	< 2 (< 15 %)
• CO_2 in surface water layer, mg l^{-1}	< 3	3 ÷7	> 7
• Total phosphorus, mg P l^{-1}	< 0.05	0.05 ÷ 0.6	> 0.6
• Toxic gases (CH_4, H_2S)	Absence	Absence	Presence
• Intensity of odour, grade	0 – I	II – III	IV - V
• Chlorophyll "a", μg l^{-1}	< 10	10 ÷ 30	>30
Visual characteristics of water surface and waterside zone:			
• Floating contaminants (surface films, oil spots, social refuse etc.), remains of aquatic plants, "carpets" of duckweeds	Absence	Presence	Presence
• Water "blooming"	Absence	Presence	Presence
• Pollution of waterside zone	Absence	Presence	Presence
Aquatic plants	Absence of duckweeds on water surface; moderate area covered with aquatic macrophytes	Single duckweeds on water surface and filamentous algae; moderate area covered with aquatic macrophytes; decrease in biodiversity	"Carpets" of duckweeds on water surface; plenty of blue-green and filamentous algae; apparent departure from the natural growth; signs of degradation

Nowadays, quite many indices for assessment of pollution degree, water quality and ecological situation on the water bodies are developed, however, they call for numerous variables under control and long time of laboratory studies that makes them inapplicable in case of express diagnostics. Moreover, application of generalized indices “depersonalizes” specific reasons and signs of negative processes in the water bodies. For these reasons it seems inexpedient to apply such indices within the framework of the system of express diagnostics.

Practical application of the system of express diagnostics

Since 2002 the developed system of express diagnostics has been applied to the assessment of ecological state of about 130 water bodies of St. Petersburg, located in different regions of the city. Only 14 % of them are of natural origin, 54 % are stagnant, about 90 % are used only for recreation.

In winter, pH values in all except two water bodies corresponded to satisfactory situation (Fig. 1). In summer, due to high photosynthesis, pH values in surface water layers distinctly increased. In 33 % of the studied water bodies pH values were in the range of 8.5 to 10.0 that corresponded to stressed situation, in one pond pH 10.18 corresponded to ecological crisis.

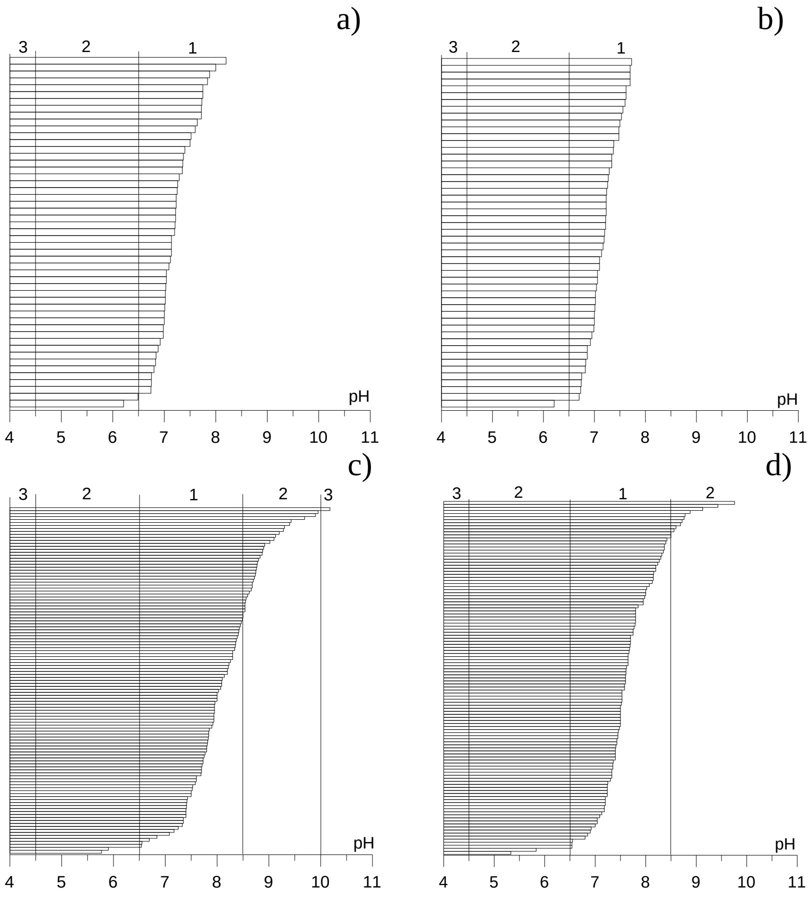

Fig. 1. Distribution of pH values in water of the studied water bodies: a) winter, surface layer;
b) winter, near-bottom layer; c) summer, surface layer; d) summer, near-bottom layer (ecological situation: 1 – satisfactory; 2 – stressed; 3 - crisis)

Most studied water bodies are characterized by extremely unfavourable oxygen regime. Dissolved oxygen content less than 15 % of saturation (crisis situation) has been found in the whole water mass in about 60 % of the water bodies in winter, by the end of ice-covering period, in a half of them an utter absence of O_2 has been registered (Fig. 2a, b). Only in two lakes oxygen content in surface water layer, just below the ice, was more than 80 % that corresponded to satisfactory situation. In summer, total absence of O_2 in the whole water mass has been found only in two small ponds (Fig. 2c, d), in 4 % of the water bodies the crisis situation (O_2 < 15 %) has been registered. However, in the period of highest activity of vegetation processes a supersaturation by O_2 was more typical. The supersaturation has been found in the surface layer of 55 % of the water bodies, in 15 % of them oxygen content was more than 160 % (crisis situation). The highest O_2 values have ranged up to 350 and 376 %, correspondingly in surface and near-bottom layers. In some water bodies oxygen content in the near-bottom water was higher than in the surface layer due to production of macrophytes.

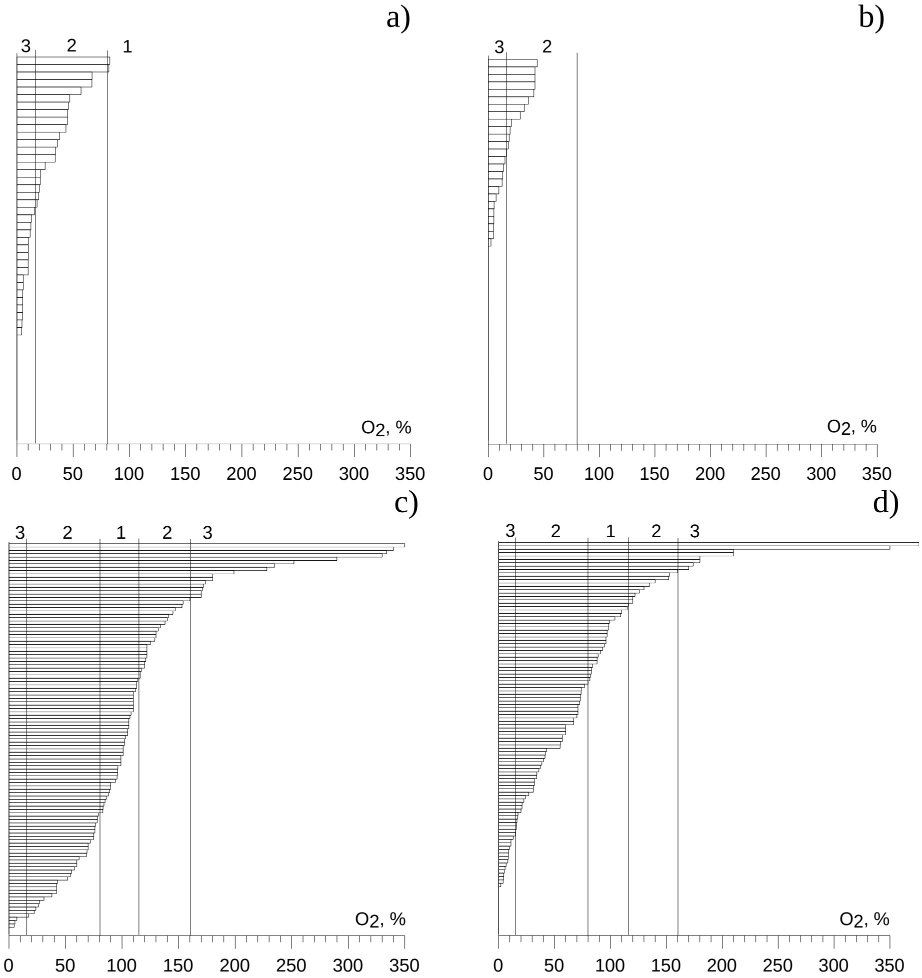

Fig. 2. Distribution of dissolved oxygen content (% saturation) in water of the studied water bodies: a) winter, surface layer; b) winter, near-bottom layer; c) summer, surface layer;
d) summer, near-bottom layer (ecological situation: 1 – satisfactory; 2 – stressed; 3 - crisis)

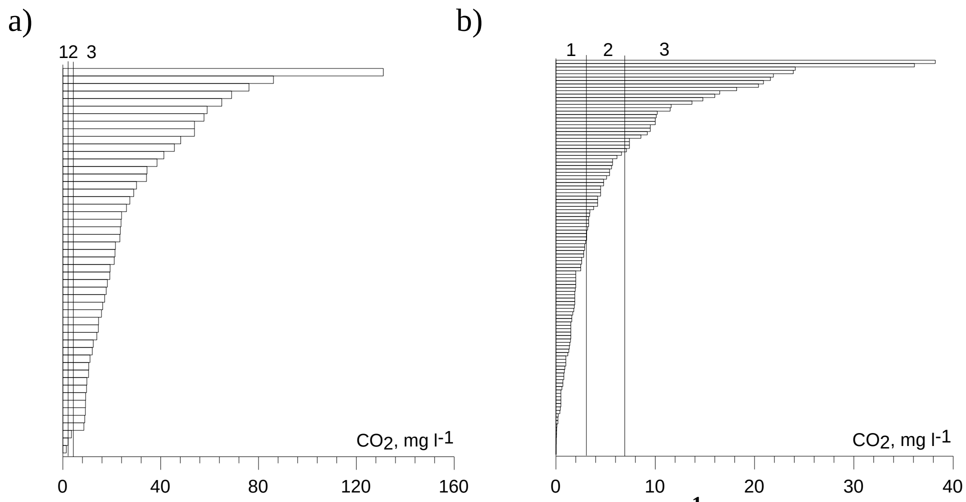

Fig. 3. Distribution of carbon dioxide concentration (mg l^{-1}) in surface water layer of the studied water bodies: a) winter; b) summer (ecological situation: 1 – satisfactory; 2 – stressed; 3 - crisis)

The values of CO_2 content corresponding to crisis situation (> 7 mg l^{-1}) have been found in the surface water layers of 94 % of water bodies during the ice-covering period and of 24 % in summer (Fig. 3). Such high concentrations are evidence for intensive decomposition of organic remains. The lack of balance between processes of production and destruction is a result of anthropogenic eutrophication developing in most studied water bodies. In summer CO_2 concentrations were distinctly lower than in winter, in 56 % of water bodies they corresponded to satisfactory situation.

Concentrations of P_{tot} in the studied water bodies varied over a wide range from 0 to 6.984 mg P l^{-1} (Fig. 4). As a result of intensive release of P from bottom sediments in anaerobic conditions, near-bottom concentrations were generally 2 to 13 times higher than in the surface water layers both in winter and in summer periods. P_{tot} concentrations higher than 1 mg P l^{-1} have been found in 4 and 12 % of the studied water bodies, correspondingly in the surface and near-

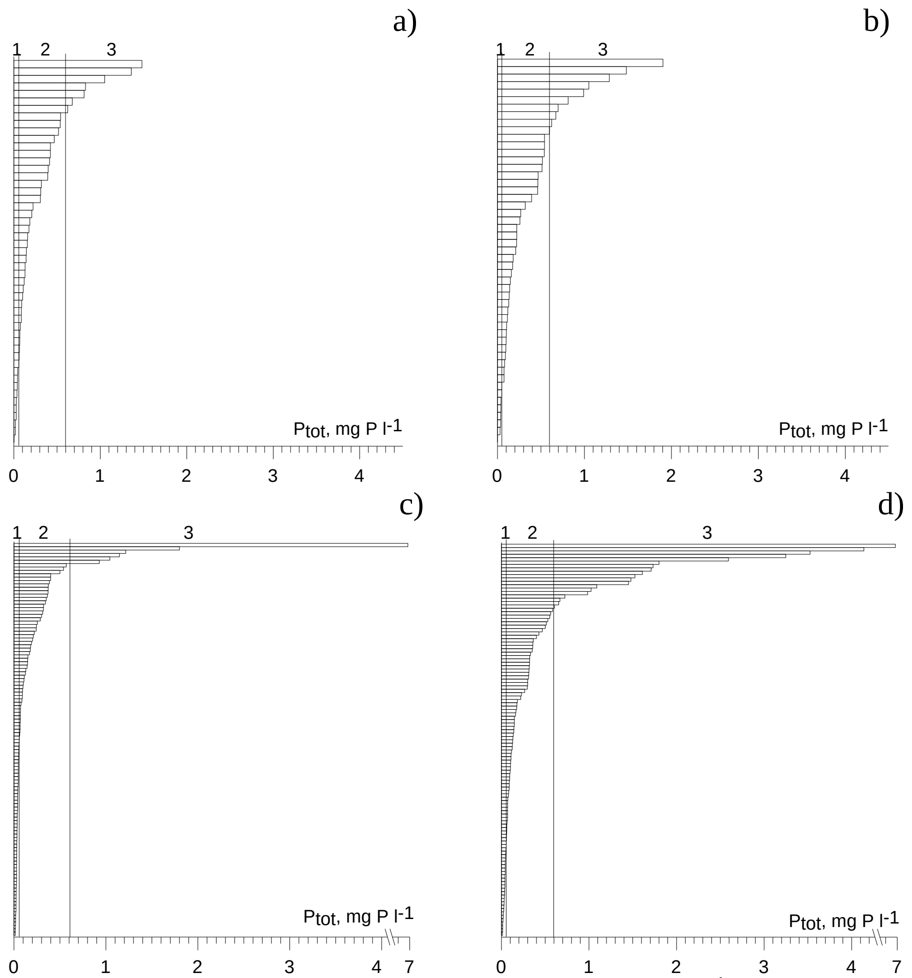

Fig. 4. Distribution of total phosphorus concentration (mg P l^{-1}) in water of the studied water bodies: a) winter, surface layer; b) winter, near-bottom layer; c) summer, surface layer;
d) summer, near-bottom layer (ecological situation: 1 – satisfactory; 2 – stressed; 3 - crisis)
bottom layers. Only in 16 % of the water bodies in winter and in 20 % in summer P_{tot} concentration corresponded to satisfactory situation. The crisis situation (P_{tot} > 0.6 mg P l^{-1}) has been revealed in 18 % of the water bodies in winter and in 16 % in summer.

Presence of toxic gases (H_2S) has been registered in 67 % of the studied water bodies in winter and in 23 % in summer. In some of them, in anaerobic conditions, a gas ebullition from the bottom sediments has been observed.

Water of about 50 % of the water bodies had a perceptible odour. The intensity of odour corresponding to the crisis situation has been revealed in 14 % of the water bodies, most of them were characterized by mass vegetation of blue-green algae in summer as a result of anthropogenic eutrophication.

In winter concentration of Chlorophyll “a” in surface water layer ranged from 0.48 to 30 µg l^{-1}, in 40 % of the water bodies it was less than 1 µg l^{-1} (Fig. 5a). In summer concentrations varied within wide limits from 0.66 to 395.7 µg l^{-1} (Fig. 5b). In about a half of the studied water bodies (49 %) the ecological situation by Chl “a” was characterized as satisfactory, in 30 % as stressed and in 21 % as crisis. The species of phytoplankton typical of pure waters have not been found. Mass growth of blue-green algae, mostly in toxic forms and α-mesosaprobes, e.g. *Planktothrix (Oscillatoria) agardhii*, *Aphanizomenon flos-aquae*, *Microcystis*, *Anabaena*, etc., has been observed in most water bodies with concentration of Chl “a” more than 10 µg l^{-1}.

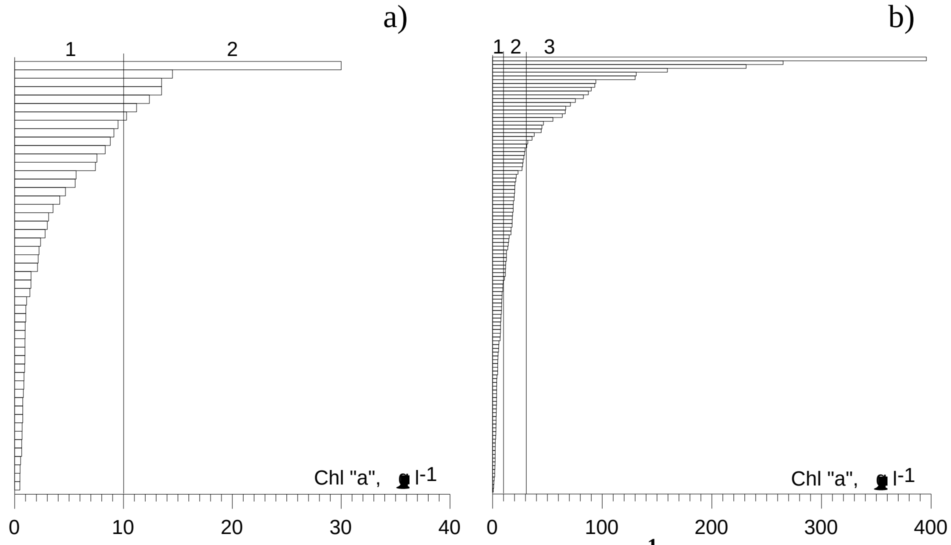

Fig. 5. Distribution of Chlorophyll “a” concentration (µg l^{-1}) in surface water layer of the studied water bodies: a) winter; b) summer (ecological situation: 1 – satisfactory; 2 – stressed; 3 - crisis)

The surface of 24 % of the water bodies was relatively clean. Social refuse (plastic and glass bottles, paper and plastic bags, cigarette-butts, etc.) has been observed at the surface of 70 % of the studied water bodies. Industrial and builder's rubbish has been found only on some water bodies. During the period of open water the surface of 4 water bodies was covered with film, the remains of aquatic plants have been found at the surface of 25 % of the water bodies.

Water “blooming” was observed in 14 % of the studied water bodies. Visually it manifested itself either in opalescence or in presence of suspended green flocks (in case of aggregates of blue-green algae *Planktothrix (Oscillatoria) agardhii* and *Aphanizomenon flos-aquae*) in the surface water layer.

Waterside zone has been polluted to different extent in all studied water bodies, with one exception. In most cases the pollution was a result of their use for recreation. Most favourable situation has been observed on the water bodies located in large parks of the city, where executive services try to keep the parks' areas clean.

By characteristics of aquatic plants, ecological situation on 33 % of the studied water bodies can be assessed as satisfactory and on 31 % as crisis. The “carpets” of duckweeds were specific to 12 % of the water bodies, in 8 % the filamentous algae, typical of highly productive water bodies, have been found.

The values of conductivity varied from 8 to 2415 μS cm^{-1} in different water bodies. High values were mainly resulted from the features of landscapes, only in about 15 % of the studied water bodies they could be a sign of chemical pollution. The conductivity values higher than 400 μS cm^{-1}, measured in more than 50 % of the water bodies, determine high buffer capacity of the water, therefore, high ability to resist external influence.

Based on the results of the study it was concluded that anthropogenic eutrophication seems to be a main ecological problem for most water bodies in St. Petersburg. Among the studied water bodies, 48 % are classified as hypereutrophic, 36 % eutrophic, 8 % meso-eutrophic and 8 % mesotrophic. Signs of pollution have been revealed only in 19 % of the water bodies, in most cases main source of pollutants have probably been bottom sediments, which have been accumulating pollutants for the last few decades. In none of the studied water bodies signs of acidification have been revealed. Obviously, acidification is not typical of the studied region.

Only in 23 % of the studied water bodies no one characteristic under control corresponded to crisis situation according to the criteria presented in Table. Most of these water bodies are located in the forest-park zone of the city's outskirts, in the nearest suburbs and in large city's parks. In 11 % of the water bodies the crisis situation has been revealed by most of the characteristics under control. Despite negative processes progressing in the studied water bodies, none of them has not still lost the ability for self-regulation and self-purification.

Conclusion

Water bodies are an integral part of small and large cities, however, as a result of strong anthropogenic pressure natural functioning of most ecosystems has been disturbed. In order for urban water bodies to be conserved regular scientifically based control must be carried out. For urban areas with numerous water bodies main requirement to the control system is an efficiency of ecological control. The developed system of express diagnostics of ecological crisis on urban water bodies meets this requirement since it enables one to assess an ecological situation on great number of urban water bodies adequately, in short time period and with low financing. One of the merits of the system is that it provides a means of assessing not only water quality, but also state of the water body as a whole including water surface and waterside zone, and a "response" of biological communities. During the period of 2002 – 2005 the developed system of express diagnostics has been applied to the assessment of ecological state of about 130 water bodies of St. Petersburg. It was found, that the obtained data in most cases were quite enough in order to reveal main reasons, which had led to developing of negative processes, to find main sources of eutrophication and pollution, and to work out the recommendations aimed at improvement of the situation. The recommendations have been forwarded to the City's Administration. It has been concluded that the developed system of express diagnostics of ecological crisis on urban water bodies works quite well and can be recommended for practical use.

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INVESTIGATION OF PUMPING EFFECTS ON GROUNDWATER IN TORBALI

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In this study, a first approach is performed to model groundwater flow in order to describe effects of pumping rates in Torbalı region. The system is analyzed by using the flow system approach; MODFLOW, which is based on finite differences method, is selected to model the groundwater flow in the region. The observed groundwater levels are used to calibrate the system.

The hydraulic conductivities for different materials constituting the local geologic formation are determined and, the decreases in groundwater levels are evaluated. According to numerical results the decrease of groundwater level in the region is approximately 4 to 5m. Actually, this value should be higher since the observed average value is 0.9 m/year. This disagreement is probably due to the existence of the unlicensed pumping wells in the region.

Introduction

Torbalı is a region of Turkey with rich groundwater resources which are mostly used for drinking water and agricultural purposes. There are also many industries (tobacco, automobile, oil, textile) which are growing and due to this development water demand increases significantly. Precautionary measures have to be taken to prevent excessive withdrawal of groundwater and to safeguard its quality.

In this study MODFLOW (McDonald and Harbaugh, 1988) was adopted to investigate the pumping effects in the region. Two steady state models are constructed without and with pumping rates, respectively. Then the results of the models are compared and interpreted.

Governing Equations for Groundwater Flow

The three dimensional groundwater flow for transient simulations can be described in (x,y,z) cartesian coordinates by

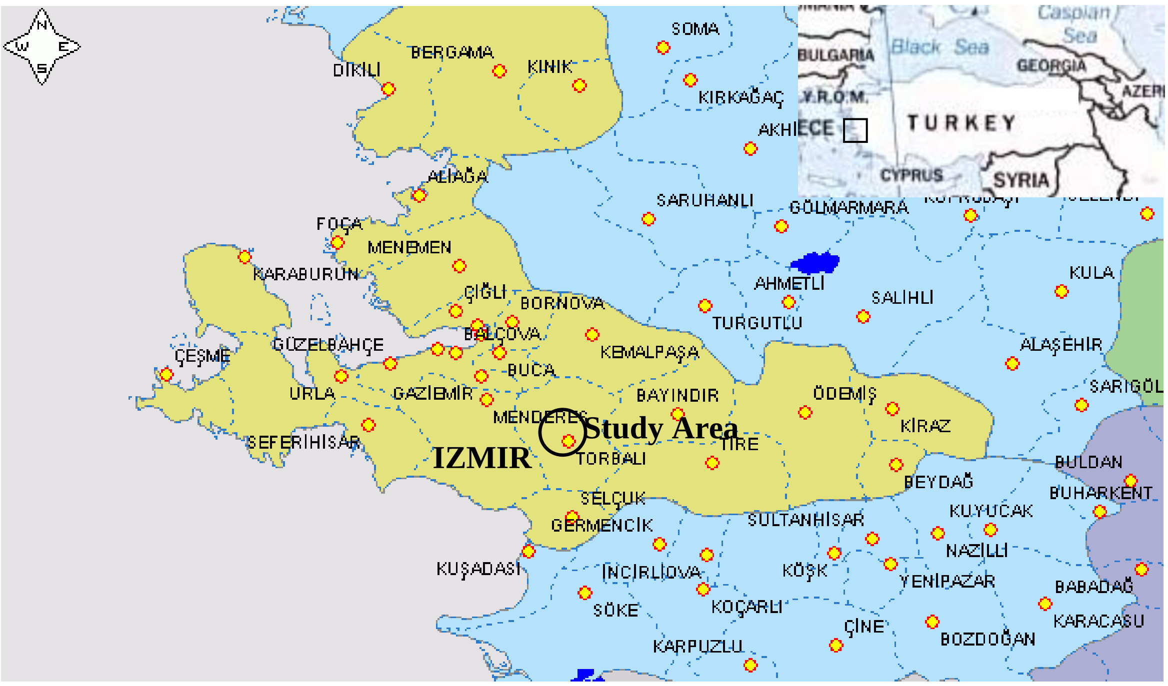
$$\frac{\partial}{\partial x}\left(K_x \frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(K_y \frac{\partial h}{\partial y}\right)+\frac{\partial}{\partial z}\left(K_z \frac{\partial h}{\partial z}\right)-W=S_s \frac{\partial h}{\partial t} \qquad (1)$$

where K_x, K_y and K_z are the hydraulic conductivities of the porous media, h is the hydraulic head, S_S is the specific storage, t is time , and W is the volumetric flux per unit volume representing sinks or sources of water (Anderson and Woessner, 1992). For steady-state simulations, the storage term and, therefore, the right-hand side of Equation 1 is set to zero.

MODFLOW software package which is based on finite differences method is used to model the groundwater flow. In this method the area is divided into a grid of cells in which aquifer properties are kept constant and head values are computed.

Description of Torbalı Region and Application of the Model

Torbalı region is located between 38^0 114' – 38^0 225' north latitude and 27^0 336' – 27^0 413' east longitude, in the western part of Turkey (Figure 1). The region is bounded in the north-east and the south-west by mountains. Industrial activities such as tobacco, automotives, oil and textile have started approximately 20 years ago and cause increase of the population of the region. According to general census schedules, average annual population growth rate at the center of the city is calculated as 59% between the years 1990 and 2000. In respect of the observation of static levels in the region, groundwater level decreases in average nearly 90 cm per year since 1996.



temperature is 17°C. According to drilling wells (METU 2000), there exist 6 different materials in the region. The boundary of the studied area and the simulated vertical cross-section are shown in Figure 2a and 2b, respectively.

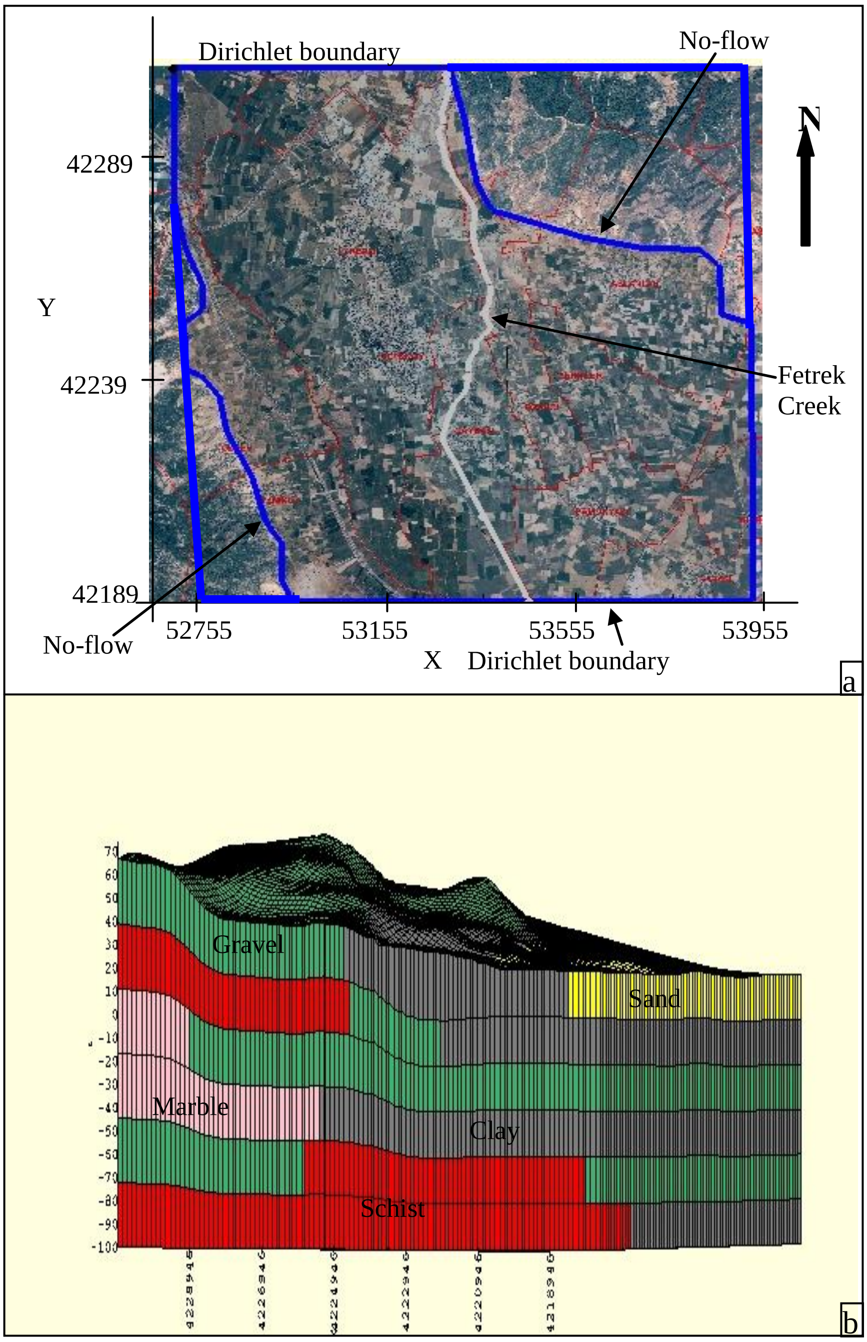


Figure 2. The boundary of the area and vertical

The three-dimensional model has been established as grid of 100 rows and 100 columns and 6 layers. The average hydraulic conductivity values of the materials which are taken from the studies realized by Simsek are given in Table 1 (Simsek, 2002).

Table 1. The Average values of Hydraulic Conductivity

Materials	Hydraulic Conductivity (m/sec)
Gravel	$5*10^{-4}$
Sand	$1*10^{-5}$
Clay	$1.7*10^{-7}$
Marble	$1.5*10^{-2}$
Limestone	$1*10^{-2}$
Schist	$1*10^{-7}$

Groundwater is recharged by precipitation and infiltration of surface water from the river and discharged by pumping wells. The recharge rates due to precipitation and infiltration are estimated as $3*10^{-4}$ m/day and $7.8*10^{-2}$ m^3/day, respectively. While taking into consideration the pumping wells which are used by factories, municipality and farmers, the total pumping rate is assumed to be $25*10^6$ m^3/year. Pumping wells are screened in Layers 3 and 5.

The constant head boundary condition (Dirichlet boundary) is simulated on north and south boundaries (Figure 1). The water table elevations which are determined after the calibration process along north and south are 47 m. and 4 m. above sea level, respectively. No flow condition is defined on north-east and south-west parts which are bounded by mountains. Since the Fetrek Creek intersects the groundwater system the river package is applied.

The model is calibrated until the compatibility between the observed and calculated head values was acceptable in observation wells (Figure 3). The so obtained final values of hydraulic conductivities are given in Table 2.

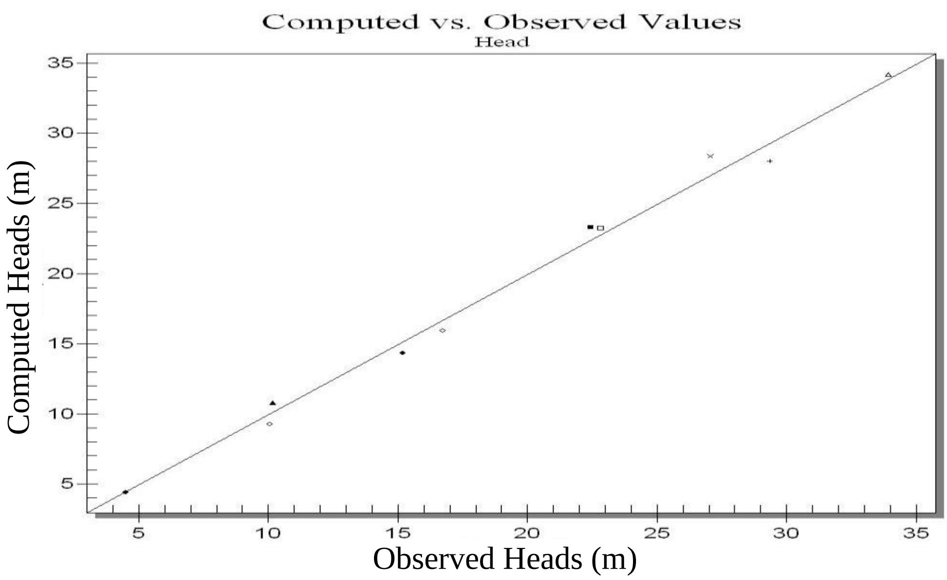


Figure 3. Computed and Observed head

Table 2. Hydraulic Conductivity values after the calibration

Materials	Hydraulic conductivity (m/sec)
Gravel	$7*10^{-4}$
Sand	$3.6*10^{-4}$
Clay	$4.85*10^{-7}$
Marble	$1.5*10^{-4}$
Limestone	$5*10^{-3}$
Schist	$1*10^{-8}$

The calibrated hydraulic conductivities values for gravel, sand and clay are found higher than the average values determined by Simsek, whereas conductivities of marble, limestone and schist are revealed lower than those proposed by Simsek. That's for marble that the biggest difference (a ratio of 100) between average and calibrated values is observed.

To demonstrate the model sensitivity related to changes in model input parameters, a sensitivity analysis is performed. This analysis is based on the change of one parameter keeping the others constant. Sensitivity analyses are carried out for hydraulic conductivity, recharge and pumping rates. Figure 4 shows the model results in the cases of 20%, 40% increase and decrease in permeability, recharge and pumping rates. The average changes in groundwater level are found as -1.6 m, -0.6 m, 0.35 m and 0.65 m, when the percent changes of hydraulic conductivities values are taken as -40%, -20%, 20% and 40%, respectively. With the same percent changes in recharge values, the average groundwater level changes are -0.35 m, -0.15 m, 0.16 m and 0.37 m, respectively. The effects of pumping rates are also investigated in the cases of -40%, -20%, 20% and 40% and the average changes in groundwater level are computed as 1.4 m, 0.69m, -0.77 m and -1.5 m, respectively.

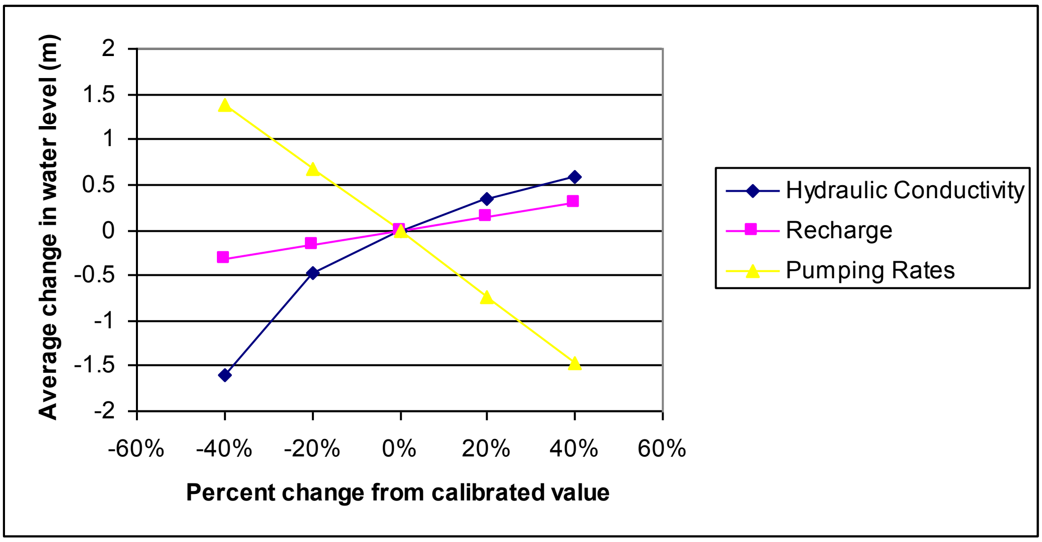


Figure 4. Changes in hydraulic head resulting from change in parameter value

The contour maps of the computed heads for different layers of the simulated models without and with pumping are given in Figure 5. According to the results of the steady pumping simulation the average decrease of the groundwater level is approximately 4 to 5 m. Since the forth layer is formed from impermeable material, pumping in the well screened in Layer 5 does not affect the groundwater level at upper layers, as expected.

It is revealed that there is no change in the general groundwater direction during the simulation with considered pumping rates. According to a previous study, lots of unlicensed pumping wells are observed in the region. Therefore, the decrease in groundwater level must be more than that obtained from the model.

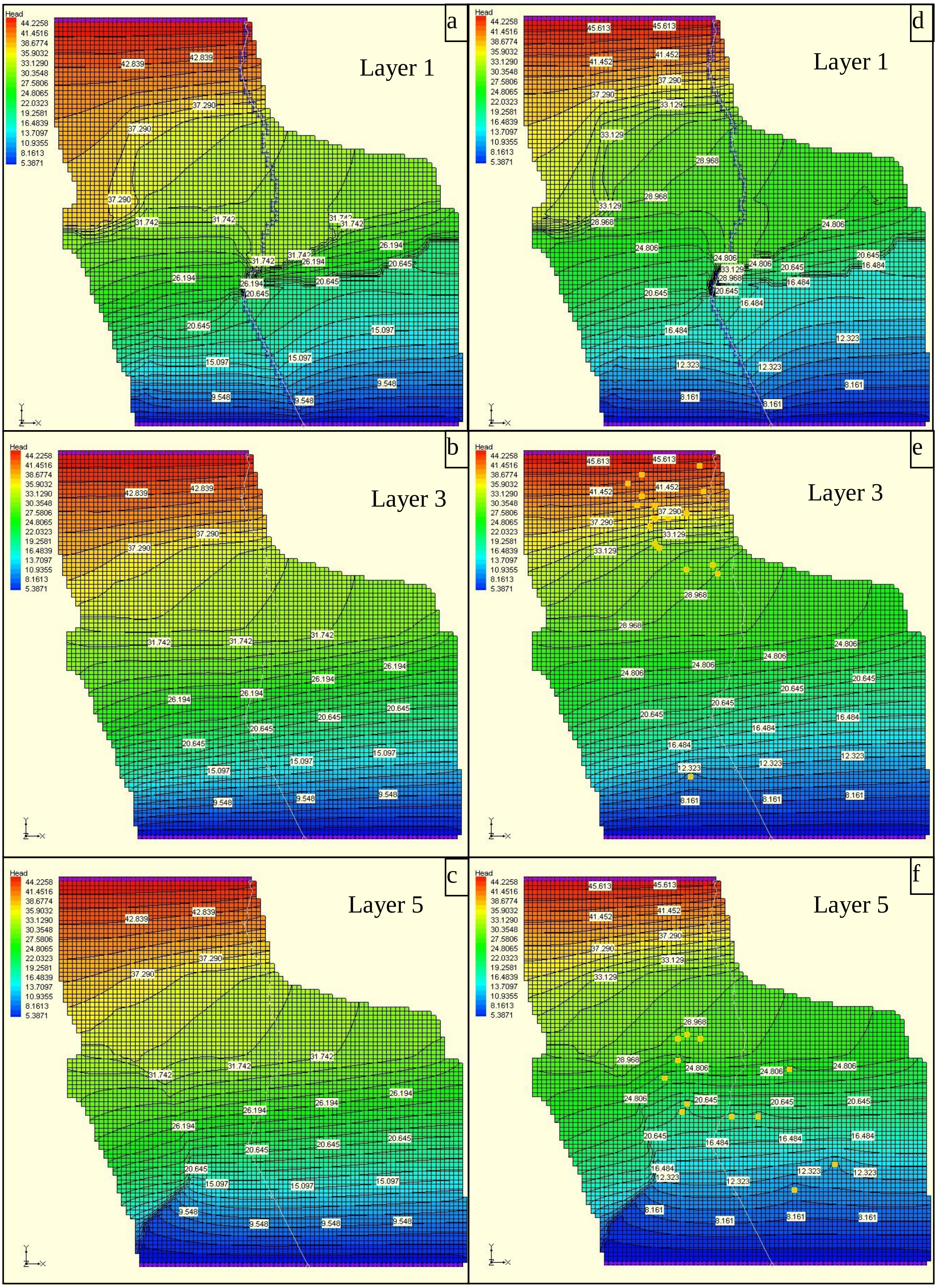
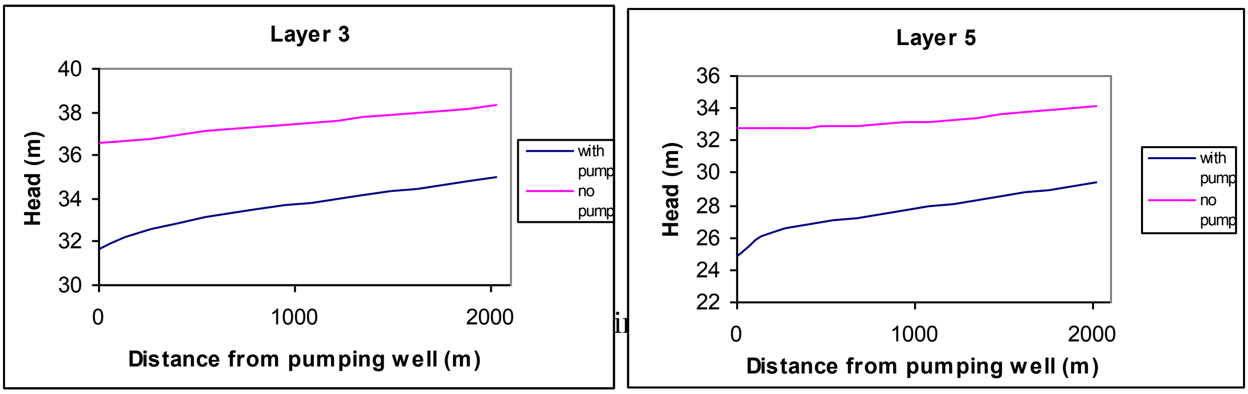


Figure 5. The contour maps of the computed heads for layers 1, 3 and 5

(a), (b), (c) : simulation without pumping, (d),(e),(f) : simulation with pumping

In the first and third layer, the effect of pumping is mainly felt in the north part of the region since most of wells are located in the north part. For the pumping wells located in fifth layer, their effects are larger in the south part of the studied area, due to the location of wells.

The simulated water table configurations for selected wells having the pumping rates 4167 m^3/day and 4500 m^3/day for layers 3 and 5 are given in Figures 5a and 5b, respectively.



(a) (b)

Conclusion

In this study, the pumping effects in Torbalı Region are investigated. Most of the factories in the region exist since 1996. According to the comparison of the results of the numerical model simulated with pumping rates with those obtained from the model without pumping, one can conclude that the groundwater level is decreased approximately 4-5 m. Actually, this value should be higher since the observed average value is 0.9 m/year. This disagreement is probably due to the existence of the unlicensed pumping wells which are used for irrigation purpose in the mentioned region. It is necessary to do some additional field works and perform a transient simulation to predict, as accurate as possible, the groundwater pattern in Torbalı region for forthcoming years.

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TONLE SAP ECOSYSTEM FISH SPECIES BIOLOGICAL GROUPS AND HYDRO-ECOLOGICAL INDEX

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Tonle Sap ecosystem in the lower part of Mekong River basin, the largest and the most bio-diversity wetland ecosystem in Southeast Asia, was influenced by Mekong River hydrological regimes. Lake water level probably rose up to 14 m deep in the wet season, and fell down 1 m deep in dry season. The drastically seasonal change of lake area was considered strongly influenced on the hatching and nursing grounds of Tonle Sap fish communities. The purposes of this study were to find out the relationship of the Tonle Sap ecosystem fish communities and the hydrological parameters to develop a hydro-ecological index from these parameters, and then this index would be used to assess the condition of the Tonle Sap ecosystem hydrology to fish community structure and production. In this study, four fish species groups were identified in the rank of k and r species and their contributions in the yearly catches by clustering analysis of nine fish biological attributes from FishBase source and fish catch data during the period 1995-2002. Five of eight potential hydrological parameters were identified by the multi-parameter analysis: positive relationships between total “dai” fish catch and parameters of “maximum flood inundated area”, “average drought inundated area” and “receding duration”; the negative relationships between the fish catch and parameters of “drought duration” and “flood timing”. The synthesized Tonle Sap hydro-ecological index showed significant correlation ($P<0.05$) with total “dai” fish catch during the period 1995-2002 indicating that the index was potential as hydro-ecological monitoring tool in fish catch/production assessment and hydro-policy decisions.

Keywords: *Tonle Sap ecosystem, Hydro-ecological index, “Dai” fish catch, Fish biological attribute and Multi-parameters analysis.*

INTRODUCTION

Tonle Sap (TS) ecosystem, including Tonle Sap River and Tonle Sap Great Lake in the central part of Cambodia, situates in the lower part of Mekong River basin (Fig 1). TS ecosystem is well known as the largest and most biodiversity wetland in Southeast Asia, approximately 197 phytoplankton, 46 zooplankton and 57 zoobenthos species (Nguyen and Nguyen 1991), 200 species of tall trees and at least 149 fish species are recorded (Ian et al 2005 unpublished). Recently, 178 species are recorded from fish catch during period 1995-2003 (source from Department of Fisheries, Cambodia). TS ecosystem, especially TS lake functions as the hatchery and grazing grounds for both migrant and non-migrant fish species (Sarkkula et al 2003), it is the fourth most productive captive fishery in the world (Rainboth 1996) and contributes about 60% of total inland catch of Cambodia (WB 1995 and Csavas et al 1994). The Cambodian Department of Fisheries figures out about 138,600 ton of fish catch annually, however, the total yearly catch, which includes rice field fishing and family scale, is estimated from 177,000 up to 400,000 tons (Van Zalinge and Thouk 1999, Mok et al 2001 and Van Zalinge et al 2003). Importantly, the TS fisheries contributes 60% protein intake of entire Cambodian population and the average fish consumption is about 65.6 kg per capita of Tonle Sap residents, especially for over one million poor people surrounding TS lake (Ahmed et al 1998 and Keskinen 2003).

TS ecosystem's hydrological regimes are mostly determined by over 4000 km long of upper Mekong River, sixty percent of lake water volume is from Mekong River. The TS lake water level probably rises up to 14 m deep at the maximum peak in the wet season (Jun- Oct) due to Mekong river flow, and falls down to 1 m deep by receding to Mekong delta in dry season (Mekong Secretariat 1992, Rainboth1996, Hak and Piseth 1999 and Lambert 2001). The lake itself can store about 72 Gm^3 yearly (Hak and Piseth 1999) and drains an area of 85,065 km^2 of Mekong delta during 5-6 months, that is about 10.7 percent of the total drainage area for the Mekong and contributes 6.4 percent of the average annual flow of the Mekong (Mekong Secretariat 1992 and Sarkkula et al 2003). The extensive flooding is reportedly increasing from about 2,500 km^2 to over 10,000 km^2 even to almost 16,000 km^2 of the lake surface area (Mok et al 2001 and MRC 2003).

However, there is high pressure on water resource uses for hydropower, irrigated agriculture, water supply and flood control for 65 million (1995-2000) of Mekong River basin population (Hoang et al 2003) and for the nearby extended areas of six riparian countries (China, Myanmar, Thailand, Laos, Cambodia and Vietnam). Among over 40 hydropower dams (MRC 2003) thirteen projects with over 10 MW have been operating since 2001 within Mekong River basin, of which, two biggest Chinese dams locate in the main upper Mekong River (Kristensen 2001). These constructed dams have led to water abstraction diversion, retention, trapping sedimentation and increased water evaporation (MRC 2003). Approximately five percent of the annual flow of the Mekong is regulated by dams (Piper et al 1991).

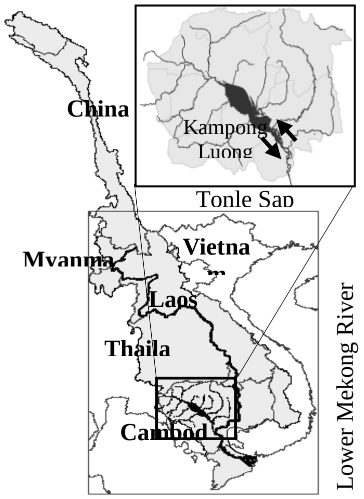


Figure 1. Mekong River Basin and Tonle Sap

Dams change rivers and streams and also change the timing, duration and quantity of flooding further downstream (MRC 2003). In the downstream, aquatic habitats have been lost, modified and fragmented or fish migration routes are blocked. Example, in 1996, after completing Nam Song weir in Laos, 40 fish species disappeared and 20 trans-boundary migratory fish species were lost from catches in neighbouring countries (MRC 2003). The positive correlations between yearly "dai" fish catch with maximum water level at Kampong Luong station and between the average length (cm) of *Henicorhynchus sp*, the most dominant small-species in "dai" fish catches, with the number of days since beginning of flood during the period 1995-2002 are figured out by many researchers (Van Zalinge et al 2003 and Lieng et al 1995).

The influences of water level and fish ecology are hypothesized by Bran et al and Welcomme et al (Baran et al 2001, 2003 and 2004 and Welcomme 1985 and welcome and Halls 2003) as following: i) Flood timing is important to many fish species because of the synchronization between readiness to spawn and flood phase, especially for the one shot spawning species; ii) The discontinuity of flood may be particularly damaging to white and grey fishes, whose eggs and larvae are unable to colonize the floodplains; iii) Rapidity of rising water can affect the fish more directly because their nets are rapidly submerged to too great depth, while the rapid falling water can increase the risk of standing fish in the temporal pools and channels of the floodplain; iv) Flood duration influences the time available for fish to grow and shelter from predators and also influences on floodplain vegetation decomposition, which can make the depletion of environmental oxygen condition; and v) The longer dried duration is the more stress condition to major of river fish species and the higher water level during dried season is the more refuge for fish species. However, according to Welcomme, it is difficult task to combine all these parameters into hydrological index. Then the purpose of this study is to develop a hydro-ecological index, which combines various hydrological parameters and then can be used as the hydro-ecological monitoring tool in fish production assessment and management.

To achieve this purpose our research objectives are: 1) to study about TS fish biological and ecological attribute groups and their catch/ production changes; 2) to identify the potential hydrological parameters, which affect on fish ecology and production and to combine these parameters into the hydro-ecological (HE) index; 3) finally, to evaluate the applicability of the index in fish catch/ production assessment.

METHODS

Data Sources and Software Application

The fish biological attributes was downloaded from FishBase database. The hydrology and fish catch data were collected from MRC (Mekong River Commission) and (DOFI) Cambodia Department of Fisheries. The water level at Kampong Luong station (Fig.1) was used for hydrological parameter calculations and analyses. The "dai" fish catches, which being stable in the sense of "fishing effort" during period of 1995-2003, were used to test the correlation between HE index and TS fish production. Noticeably, "dai" fish was one kind of small mesh size and large fishing net operated along TS River during water receding season. TS River, unique way connecting TS Lake with Mekong River, was important as the transition zone for migrant fish species. PRIMER software was used for clustering and Nonmetric Dimension Scaling analyses (NMDS). STATISTICA software was used for Principal Component Analysis (PCA) and missing value analyses. SPSS software was used for statistical test. EXCEL application were used for parameter value and threshold calculations.

Database Development, Data Analyses and Index Development

Among 20 biological attributes of TS ecosystem fish species in FishBase database, nine attributes were selected as the representatives accordingly to fish catch species, because some attributes were in the same groups such as "standard length", "yield length", "maximum length" and "mature length"; while some other attributes were not available data measurement such as "reproductive guild" or "fecundity". Potential hydrological parameters were compiled from literature review, the most important criteria to delineate the drought and flood situation was of 2 m deep bankfull. The hydrological parameter values were calculated from hydrological data from 1995 to 2003 at Kampong Luong station. The inundated area was calculated based on the equation: Flooded area (in 1000 km^2) = 0.0814 WL2 + 0.4078 WL + 1.9795 *(IDRISI formula)*.

The clustering and NMDS analyses were used to group fish species into different *k* and *r* biological species. PCA technique was used to analyze: 1) the predator and prey and or habitat relationships among "dai" fish catch species; and 2) the multi-relationships among hydrological parameters and fish catches. The negative or positive relationships between individual parameter and fish catch were used for parameter scoring and narration. Accumulation analysis was used to identify the parameter value thresholds lower a_i and upper b_i individually. The parameter values between two thresholds a_i and b_i were scored as 3 and narrated as the fair hydrological condition, while the values less than a_i or more than b_i values were scored as 1 or 5 and narrated as the poor or good conditions depend on the positive or negative relationships between fish catch and each particular parameter. The yearly HE index was calculated by the average of total parameter score and the number (n) of parameters as followed: HE index = $(\text{Score}_{\text{parameter 1}} + \text{Score}_{\text{parameter 2}} \ldots + \ldots \text{Score}_{\text{parameter n}})/n$. The Pearson correlation tests were used to test the significant correlation between fish catch and hydro-ecological index and among *k* and or *r* species fish families. The overall methodology was described in Fig 2.

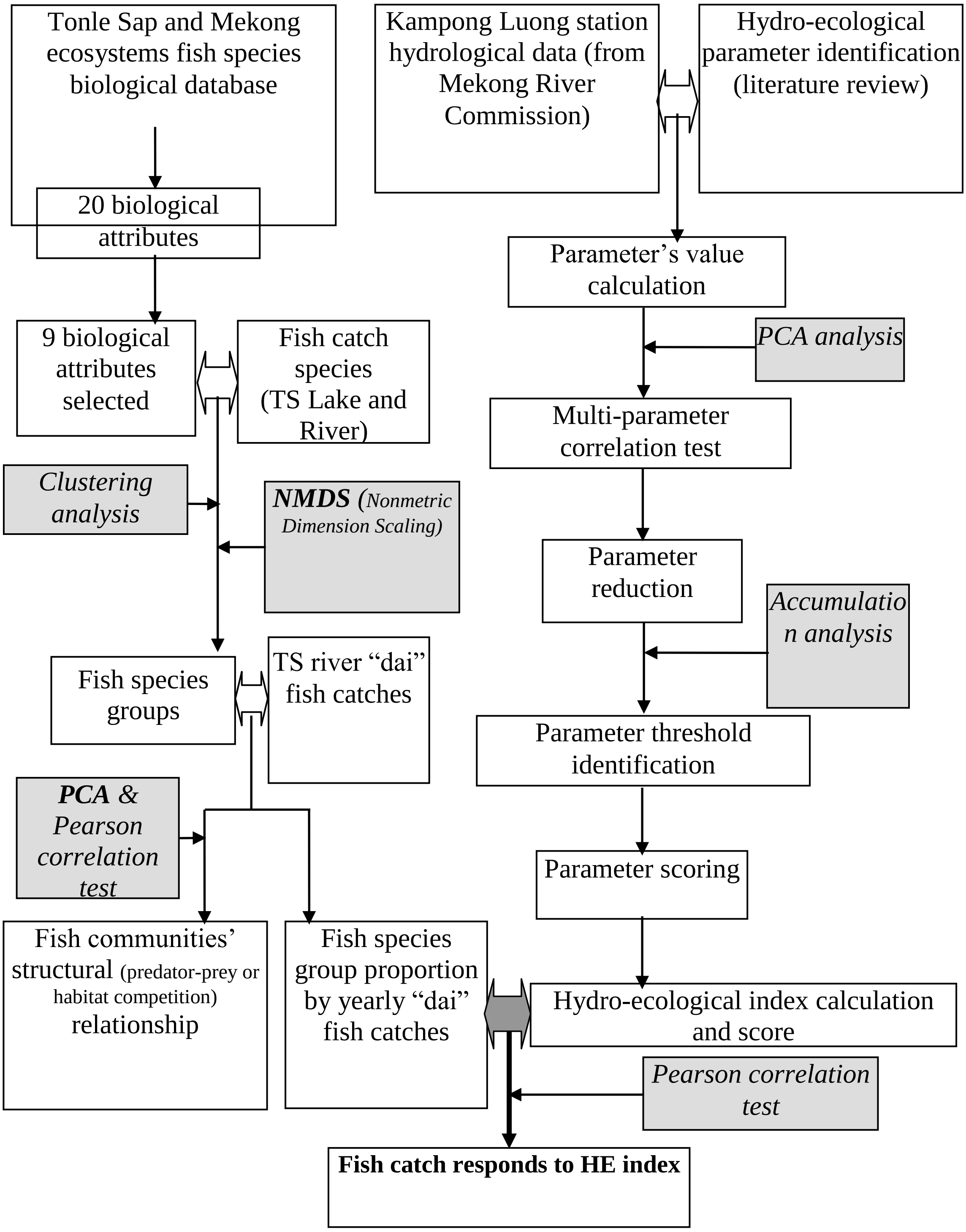


Figure 2. Tonle Sap ecosystem fish biological groups and hydro-ecological index development

RESULTS

Tonle Sap Ecosystem Fish Biological Groups and Yearly Catches

From 178 TS ecosystem fish catch species (154 species from "dai" fish catch in TS River during period 1995-2003, and 104 species from TS Lake catch during period 1994 -1997) and nine biological attributes, four fish biological groups (at 85% of Bray-Crutis similarity on dendrogram and 0.11 stress coefficient on NMDS) were identified in the rank of *k* and *r* species (Fig 3), nine *k* and *r* species biological attributes of four fish groups were described in Fig 4.

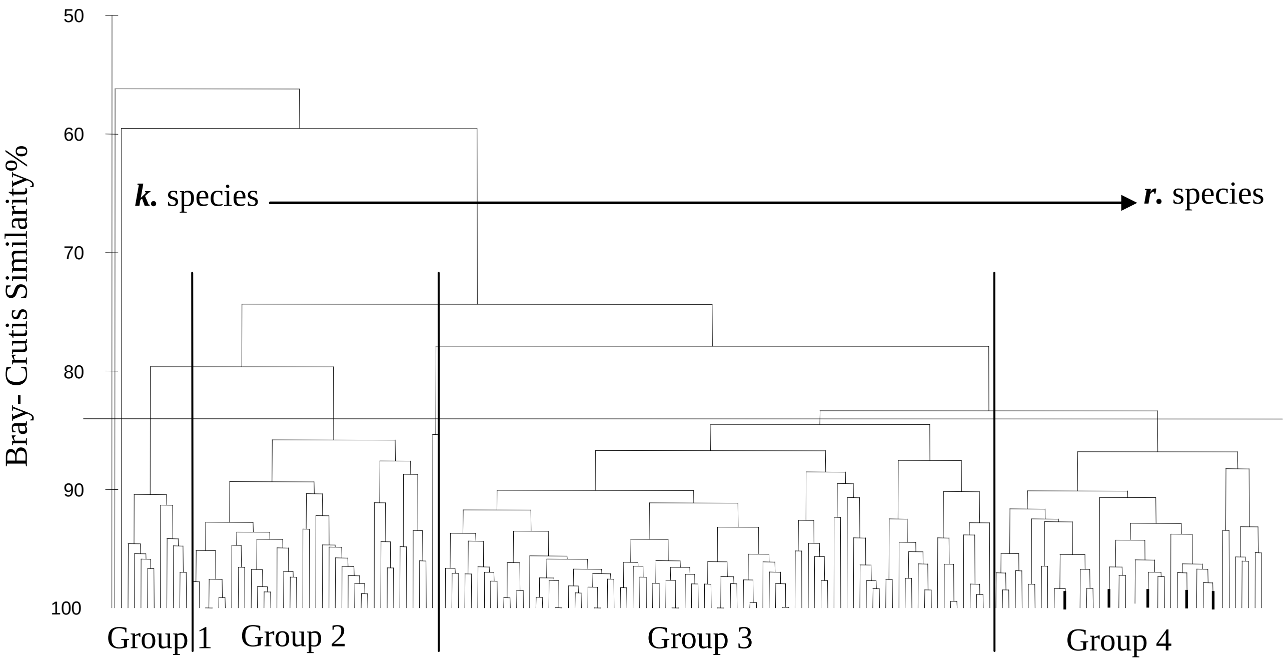


Figure 3. Dendrogram of Tonle Sap ecosystem fish species grouped by nine biological attributes

Fish species compositions were similar in both TS river and lake environments. Of which, the major number of species belonged to group 3 (45% and 51%), the least number of species belonged to group 1 (5% and 7%), while the group 2 and 4 were about 22-28%. However, the fish species diversity analysis could not be done because of different record systems for TS river "dai" fish catch "before" and "after" 2001 during 1995-2003 (before: only 40 major species were recorded by names, after: all species were recorded by names). But there were quite different fish catch proportions (weight) between TS Rive and Lake, the first major contribution in river was group 4, the second was group 3, while the major contribution in lake were groups 2 and 3. Group 1 was the least proportion in both river and lake (Fig 5).

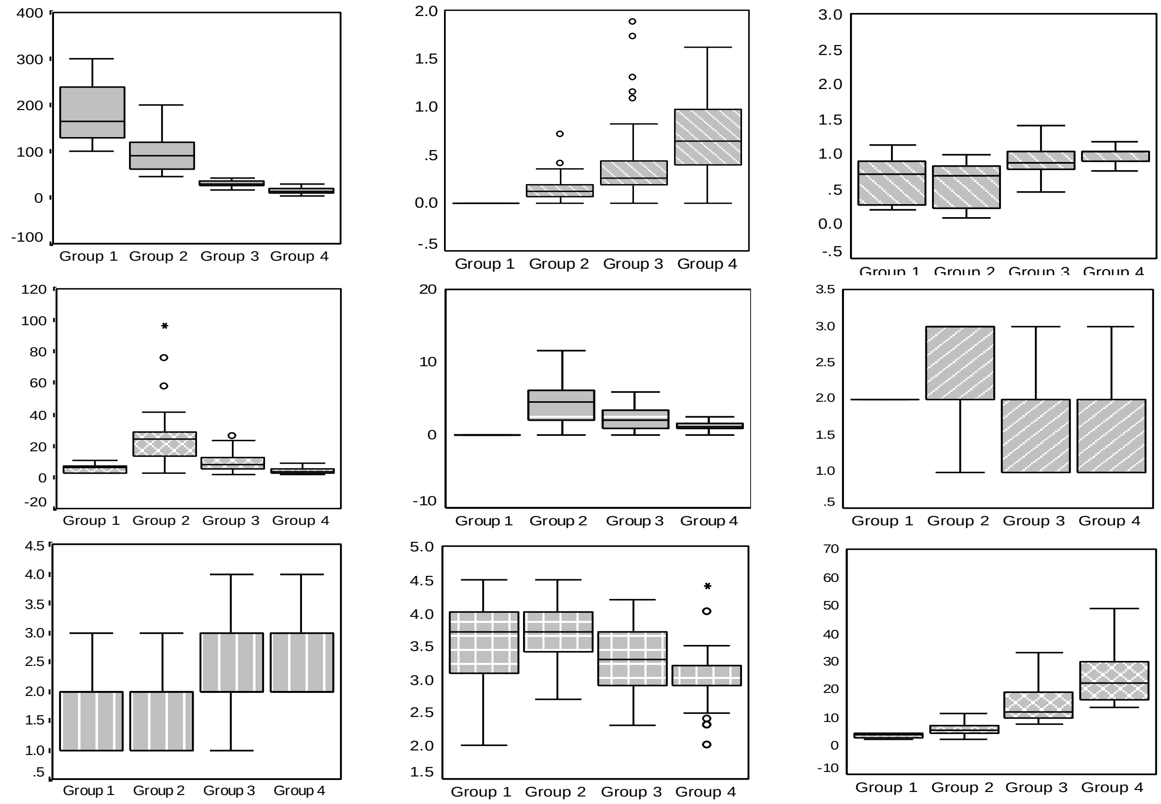


Figure 4. Tonle Sap ecosystem fish species groups and their nine biological attributes

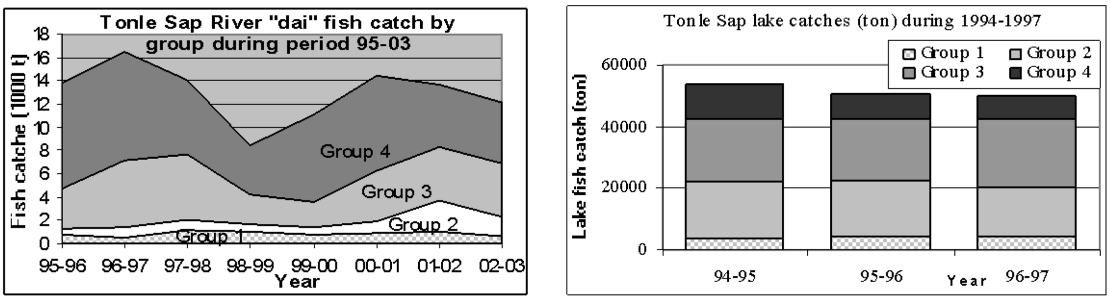


Figure 5. Tonle Sap river "dai" and lake fish catch proportions by four fish biological groups

Tonle Sap River "Dai" Fish Catches and Multi-Relationships among Fish Families

Results of clustering analysis showed that one fish family was ably representative for more than one biological group such as: the *Pangasiidae* represented at group 1 and 3; *Siluridae* represented at group 1 and 4, while *Cyprinidae* represented at group 2, 3 and 4 (Fig 6-left). Among 10 dominant fish families (of total 37 recorded families) contributed 84.5-99.8% of yearly "dai" catch. Of which, the most and the second contributions in yearly catches were *Cyprinidae* of group 4 and 3 respectively, the third was *Ambasiidae* of group 3 (Fig 6-left). In general, the "dai" fish catch proportions of each group 1 or 2 (*k* species) seemed stably between 4 to 7% of total catch, exception 12-20% of group 2 in 2001 and 2002, while the group 3 and 4 catches (*r* species) tended decreasingly. Fish catches of group 3 and 4 were lowest in the year between 1998 and 1999 (Fig 5), the most drought year. The catch proportion ratio between group 3 and 4 (more *r* species) and group 1 and 2 (more *k* species) from 1995 to 2003, in order, were 9.4; 11.2; 5.6; 4.2; 6.9; 6.3; 2.6; and 4.4. Fish catches at *k* and *r* group-family level were up and down by years, exception *Ambisiidae* and *Cobitidae* families' catches were gradually declining from 1962.4 to 52.2 tons and from 851.1 to 102.3 tons in years 1995 and 2003 for each family respectively (Fig 5).

Interestingly, on PCA those *k* and *r* group-families were opposite direction distributing in three different areas (Fig 6-right), almost families belonging to group 3 and 4 located in the area of dotted circle, while the families belonging to group 1 and 2 located in two areas of solid circles (Fig 6-right). Additionally, there was negative correlation (r= – 0.715, *P= 0.046*) between *Pangasiidae* and *Siluridae* families in group 1.

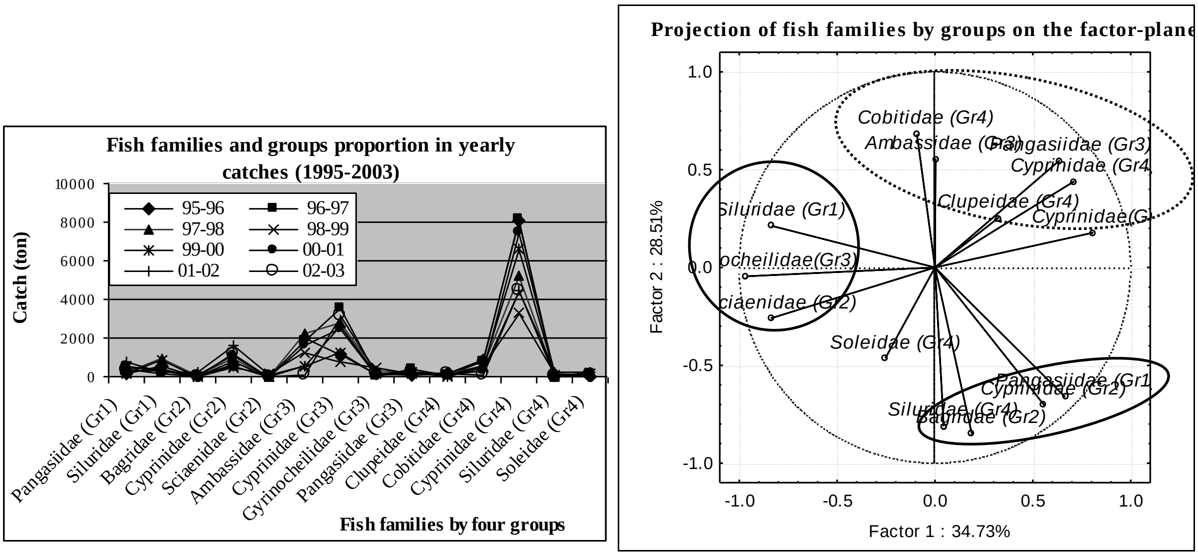


Figure 6. PCA of Tonle Sap river fish family proportions in yearly catch (left) and their multi-relationships (right).

Tonle Sap Ecosystem Hydrological Regimes and Hydro-Ecological Index Development

As the determination, the TS Lake bankfull was blocked at 2 m deep. Then 1) the drought inundated duration was determined as the number of days the water level lower 2 m deep; 2) the flood timing was determined the dayth when the water starting rising from 2 m up; 3) flood duration was determined as the number of days since the water starting rising from 2 m up to the maximal peak; 4) inversely, the receding duration was determined as the number of days when the water starting receding from the maximal peak down to 2 m bankfull; 5) the receding duration was determined as the ratio between number of receding days and the water level from 2 m bankfull up (Fig. 7). The overview of Kampong Luong station hydrological parameters showed: in 2000, The shortest drought duration and the highest water level, while in 1998, the longest drought duration and the shallowest water level (Fig 8-left); The earliest flood timing and the highest water level in 2000 and the latest flood timing and the lowest water level in 1998 (Fig 8-middle); and the longest receding duration in 2002 and the shortest receding duration in 1998 (Fig 8-right). Finally, eight potential hydrological parameters were identified and the parameters' values were showed in Table 1. Among these parameters, five parameters having correlation over (+ or -) 0.738 on factor 1 of PCA, were selected to synthesize the HE index, that were "drought duration"; "drought inundated area"; "flood timing"; "maximal flood inundated area"; and "receding duration". Acceptably, the parameter of "water level" was not selected. Among those parameters, "drought duration" and "flood timing" parameters were strongly negative correlations with other parameters and total fish catch (Fig 9- left). Temporally, the year 2000 was closer to the parameters having positive correlation with total fish catch, while the year 1998 was closer to the parameters having negative correlation with total fish catch (Fig 9-right).

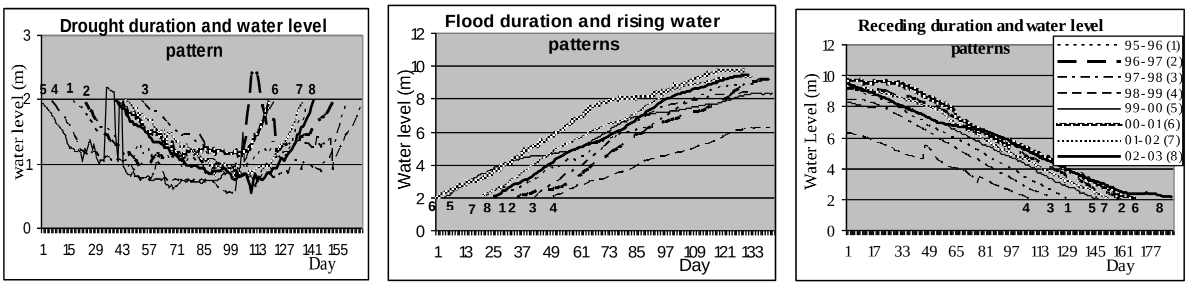


Figure 8. Kampong Luong station hydrological parameters (water level and drought, flood and receding duration)

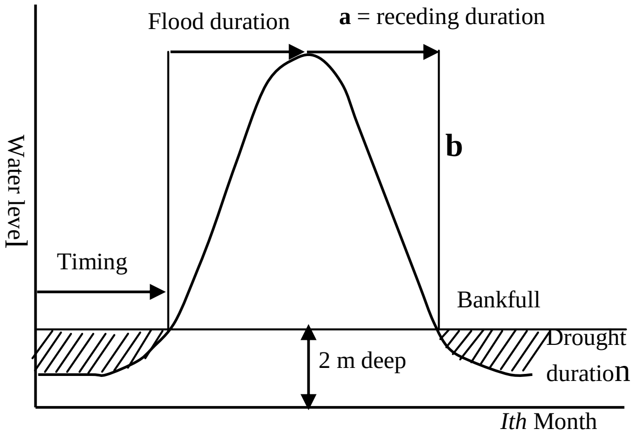
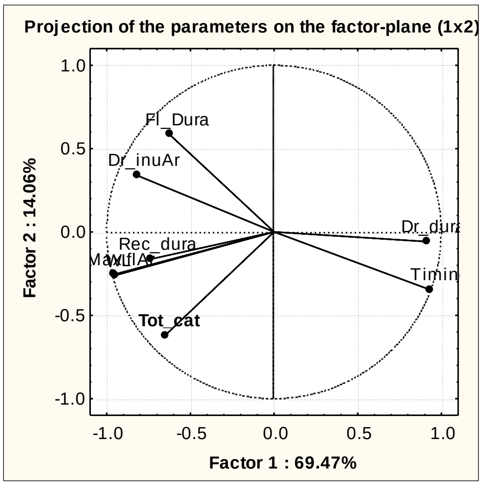


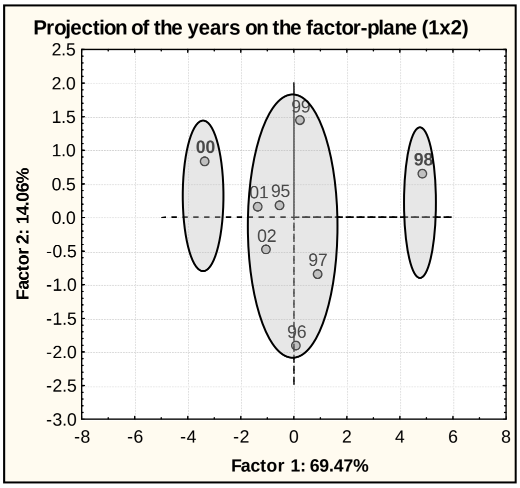
Figure 7. Hydrological parameter

Table 1. Eight potential hydrological parameters in Tonle Sap ecosystem and their expected responses to fish catches

Year	Max. water level (m)	Drought duration (day)	Average drought inundated area (km2)	Flood timing (day*th)*	Flood duration (day)	Max. flood inundated area (km2)	Receding duration (day)	Receding slope (a/b)	Total catch (ton)
	WL	Dr_dura	Dr_InuAr	Timing	Fl_Dura	Fl_InuAr	Rec_dura	Rec_slp	Tot_cat
95-96	9.13	123	2,611	170	121	12,450	129	14.1	14,428
96-97	9.17	130	2,518	184	106	12,564	160	17.1	16,834
97-98	8.4	107	2,580	184	93	11,095	119	14.2	14,604
98-99	6.22	162	2,507	198	92	7,665	107	17.2	8,894
99-00	8.33	121	2,561	172	139	11,007	147	17.6	11,485
00-01	9.72	77	2,688	149	130	13,554	168	17.3	14,974
01-02	9.25	94	2,635	168	114	12,678	153	16.5	13,738
02-03	9.46	104	2,575	173	108	13,122	194	20.5	12,427
Exp. Res	*Positive*	*Negative*	*Positive*	*Negative*	*Positive*	*Positive*	*Positive*	*Positive*	

Note: Exp.Res = Expected Responses to fish catch





Note: (HEI was hydro-ecological index, see the Table 1 for parameters' abbreviations)

Figure 9. Hydrological parameters, total "dai" fish catch and years on PCA

Individual parameter thresholds a_i and b_i were identified by accumulation analysis and reported in Table 2. The index score was maximal 5 in year 2000, while the lowest index score was the year 1998. The Pearson correlation test between HE index and total "dai" fish catch and *k* and *r* fish groups were as followed: total "dai" fish catch, $r = 0.644$, $P = 0.042$; group 1, $r = -0.288$, $P = 0.244$; group 2, $r = 0.513$, $P = 0.097$; group 3, $r = 0.445$,

Table 2. Yearly parameter and index scores and parameter value thresholds

	Parameter and index scores by year								**Parameter threshold values**		
Parameter	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	**1** $\leq a_i$ or $\geq b_i$	**3** (bet. a_i and b_i)	**5** $\geq b_i$ or $a_i \leq$
Drought duration (day)	3	3	5	1	3	5	5	5	≥ 162	107 - 162	≤ 107
Average drought inundated area (km2)	5	1	3	1	3	5	5	3	≤ 2,518	2,518 – 2,611	≥ 2,611
Max. flood inundated area (km2)	5	5	3	1	3	5	5	5	≤ 7,665	7,665 – 12,487	≥ 12,487
Receding duration (day)	1	5	1	1	3	5	3	5	≤ 129	129 – 160	≥ 160
Timing (day*th)*	3	3	3	1	3	5	3	3	≥198	149 – 198	≤ 149
Total score	17	17	15	5	15	25	21	21			
Index score	**3.4**	**3.4**	**3**	**1**	**3**	**5**	**4.2**	**4.2**			
Ratting narration	Good	Good	Fair	Very poor	Fair	Very good	Very good	Very good			

The index scores were narrated as following: 1-2 = poor; 2-3 = fair; 3-4 = good and 4-5 = very good

P = 0.135, and group 4, r = 0.379, P = 0.177 (1-tailed). At the fish family level, five fish families of *Pangasiidae* and *Siluridae* (group 1), *Cyprinidae* and *Sciaenidae* (group 2) and *Gyrinocheiidae* (group 3) were significant correlation (p<0.05, 1-tailed) with HE index as the followed 0.650, -0.688, 0.703, -0.681 and -0.829 (r-value). The correlation between HE index and total "dai" fish catch were showed in Fig 10. The gradient change of HE scores from highest in 2000 to lowest in 1998 as showed in Fig 9-right. The individual parameter threshold values (Table 2) were used as the criteria of hydrological condition for fish production assessments.

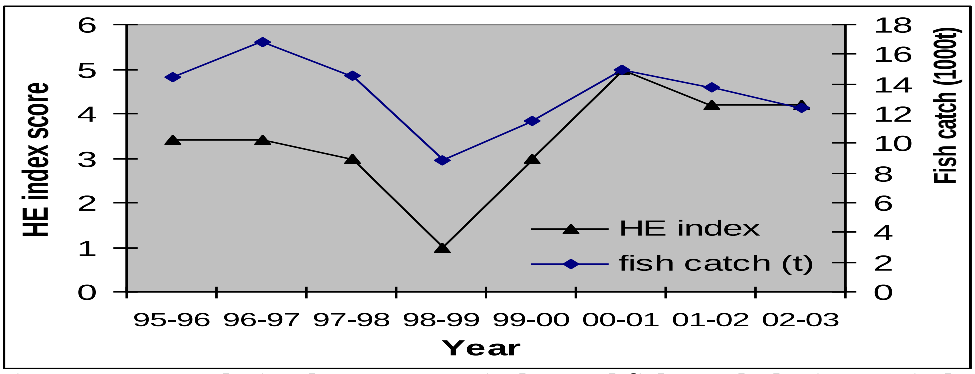


Figure 10. Correlation between HE index and fish catch during period 1995-2003

DISCUSSION

Nine biological attributes of Tonle Sap ecosystem fish species are used instead of using the terms of “black”, “white” and “opportunities” in the previous researches or just focusing on trophic creation (Lim et al 1999) to analyze and illustrate the TS ecosystem fish communities and their structural relationships. Four biological fish groups are clearly classified in the rank of *k* and *r* species (as showed in result section above). The similarity of *k* and *r* species compositions and domination of *r* species in both TS lake and river, and their different proportions in catches (groups 4 and 3, dominate in TS River, while species groups 2 and 3 dominate in TS Lake) are somehow indicates the important functions of TS Lake as the spawning and nursing grounds (Lambert 2001), especially for *k*-species, while TS River functions as the transition habitat, this is similar with Lim et al’s results (Lim et al 1999). For the TS river “dai” fish, the inverse direction correlations among groups 3 and 4 and groups 1 and 2 on PCA somehow indicate the TS ecosystem fish community structure relationships in the senses of predator-prey and or habitat competition. However, this conclusion should be studied more and better examined together with TS Lake fish community structures. The “dai” *k* fish species (groups 1 and 2) catches are stable and the *r* fish species (groups 3 and 4) catches are decreasing, perhaps because of “fishing down” practice because of small mesh size fishing gear uses nowadays, especially “dai” fish net with 0.5 cm mesh size. Seemingly, there is limitation of food for predator *k*-species because the increases of catch ratio between *k* and *r* species (predator and prey) quantitatively from 1995 to 2003. Supposedly, all species of group 1 and 2 are directly predator of all species of groups 3 and 4 and 10% of food chain energy efficiency. However, this should be confirmed by researches and or experiments of life cycle and history at species level. The negative correlation ($r = -0.715$, $P = 0.046$) between *Pangasiidae* and *Siluridae* families in group 1 should be studied more in the questions about food and or habitat competitions. Similarly, the gradual decrease of *Ambasiidae* family should be studied more too. Excellently, the multi-relationships among hydrological parameters and fish catches are clearly projected on PCA, these results are similar as Baran and Welcomme’s hypotheses mentioned in introduction section and Olden and Poff framework (Olden and Proff 2003). Parameter of “Flood duration” is reduced because of low correlation (-0.624 on factor 1) with other parameters and fish catch (Fig 9- left). Parameter of “receding slope” is reduced because of negative correlation with total fish catch, this seems to be used as the indication for relationship between fish catch and discharge more than fish production. Especially, to avoid the overweight of the “water level” parameter, it is not selected to combine into the index, because it was used to calculate the parameter of “maximum flooded area”. In New Zealand stream hydro-ecological indices and benthic biota, research results shows that the strongest correlation between “flood variation” and Chl-a, species richness, number of species and diversity index (Clause and Biggs 1997). However, the hydrological regimes of New Zealand streams are one-way flow direction, while TS ecosystem is two-way flow directions. Although the HE index is not satisfied to statistical significant test in responding to fish catches at fish biological groups. However, importantly, the positive correlation between HE index with total “dai” fish catches indicates the sensitive response of total fish catch to HE index. Then, the HE index promises to be used as the hydro-ecological monitoring tool to assess fish catch or production as well as to support for hydro-policy scenarios and decisions. Five families of *Pangasiidae* and *Siluridae* (group1), *Cyprinidae* and *Sciaenidae* (group2) and *Gyrinocheiidae* (group3) should be considered as the TS ecosystem hydro-ecological bioindicators.

The yearly hydrological conditions are classified by the hydro-ecological index, of which, three years 2000 to 2002 are evaluated in the very good hydrological regimes, the year 1995 and 1996 are evaluated in good condition, the year 1997 and 1999 before and after the year 1998 are evaluated just in fair condition, while the hydrological regime in 1998 is evaluated in very poor condition.

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WATER RESOURCE AND THEIR PROTECTION IN SLOVAK REPUBLIC

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Water supply resources are groundwater and surface water bodies currently used or intended for prospective use. Water used from identified water bodies shall meet relevant qualitative objectives and resulting requirements on water quality and quantity according to its purpose of use. Water resources protection should be viewed as a integrated protection of quality and quantity of sustace and ground water, including natural curative springs and minerals waters. For water resources protection the protection zones with limited agricultural use and other activities are designated according to the valid legislation. The paper deals with issues relating to water quality and quantity protection.
Keywords: *water sources; surface water; groundwater; protection of water sources, protection of water quality, vulnerable areas*

Surface water quality

Surface water quality assessment is based on the Summarization of the classification results under the Slovak Technical Standard (STS) 75 7221 - As the Slovak Hydrometeorological Institute(SHMI) have not submitted the results of analyses for 2004 due to unallocated funds of the Ministry of Environment for this works, the Slovak Water Management Enterprise has conducted the review of surface water quality assessment for 2004 using own result of physical, chemical, biological and microbiological analyses carried out for the purpose of surface watercourses and reservoirs quality monitoring. This assessment was performed within the operational monitoring of the administrator of important water management watercourses. In 2004 the water quality monitoring was carried out in 182 profiles of the national surface water monitoring network including 20 profiles of transboundary rivers, 8 water supply reservoirs and other 309 monitoring sites at streams and 73 water reservoirs that are monitored within the operational monitoring performed by the administrator of important watercourses. The network of basic and additional profiles is located at important water management watercourses and reservoirs throughout Slovakia.

Surface water quality monitoring and assessment have been conducted under the Slovak Technical Standard No. 75 7221 “Surface Water Quality, which recognize 8 groups (A to H) of important water management watercourses monitored surface water quality 12 times in 300 quality of 214 streams in Slovakia with length about 3,695 river kilometers. A number of regime, basic physical-chemical parameters, nutrients and microbiological parameters) were monitored at 464 sampling sites and biological parameters (group D) at 146 sampling sites, micro-pollutants (group E) at 96 sites and radioactivity (group H) at 108 sampling sites.

A general assessment points out negative classification of surface water caused mostly by microbiological parameters of group E, in which 326 sites are classified into the quality categories IV and V. In groups A, B, C, and D the most of sampling sites is classified into the category III. In selected sites of the Danube river basin the toxicity (group H) tests were carried out proving the quality category I.

Surface water quality in the Slovak streams is primarily affected by wastewater discharged from the point sources of pollution. The 2003 and 2004 data proved slight downward trend in pollution production. Despite the increase in identified pollution source amount of wastewater discharged into surface water has decreased in a range from 4 to 8% and thus the recompenses for wastewater discharge has been decreased.

The general assessment points out a negative classification of surface water mainly due to microbiological parameters of group E in which 326 sampling sites are classified into the quality categories 4 and 5 for 2004. The most of sampling sites from the A, B, C and D quality groups are classified into the quality category 3. In selected areas of the Danube River Basin the toxicity tests have been performed (group G) and proved the 1st quality category.

Groundwater quality

In 2004, groundwater quality was monitored in 26 important water management regions (especially in alluvial deposits, mezozoic and neovolcanic complexes) at objects of the Slovak Hydrometeorlogical Institute’s network added by wells and used or unused springs. The monitoring network consists of 333 points with monitoring frequency of two times a year.

The groundwater of the “Žitný ostrov” region forms separate part of groundwater quality monitoring in four regions with frequency of 2 up to 12 times a year.

Previous monitoring has proved that there is a problem with unfavorable oxidation-reduction network in Slovakia. In 2004, the groundwater quality was monitored at 46 monitoring objects conditions indicated by frequently present higher concentrations of Fe, Mn and NH_4. The pollution caused by organic substances indicated by frequent exceeding of limit values for concentrations of nonpolar extractable substances (NELuv) and phenols remains the same as in previous years.

The dominant character of land use in monitored areas results in relatively frequent higher concentrations of oxidized and reduced forms of nitrogen in waters.

From the trace elements, higher concentrations were mostly observed in the aluminium concentrations, but together with other parameters they have only local character.

The following groundwater quality parameters measured in situ in the region of "Žitný ostrov" almost at all measuring objects did not meet limit concentrations: dissolved oxygen, in some objects also water temperature (33 measurements), conductivity (9 measurements) and pH (3 measurements). From the group of basic physical-chemical analysis the following parameters had higher concentrations: iron, manganese, ammonium ions, nitrides, nitrates, chlorides, chemical consumption of oxygen with permanganate and fluoranthene as well as phenols and NELuv.

Natural groundwaters are the most important resources of drinking water on the Slovak territory. They represent one of the basic elements of ecosystems. They are used in industry and agriculture. Therefore, it is very important to know their quality within the monitoring of groundwater regime.

In addition to quantitative characteristics, the objective of groundwater monitoring is also focused on:

- assessment of the current state of groundwater quality
- description of ground water quality trends
- providing water management authorities and other entities with basic data
- for decision making process
- application of results to research and expertise activities

Systematic groundwater monitoring within the frame of the National monitoring programme runs since 1982. At the present time, 26 significant water management regions are monitored (alluvial deposits, mezozoic and neovolcanic complexes). For fulfilment of requirements on gathered information about water quality development in regions without considerable anthropogenic effects also pre-quaternary structures were included in monitoring programme.

In 2004, 333 objects were monitored - 208 wells of the SHMI basic network, 36 used and 19 unused wells (exploration wells), 47 used and 23 unused springs. In 2004, the groundwater samples were taken only one time in the autumn.

The results of laboratory analyses were evaluated according to the Decree of the Ministry of Health of the Slovak Republic No. 126/2006 Coll. on requirements on drinking water and control of drinking water quality by comparing the measured and limit values for all analysed parameters. The results are annually published in the "Groundwater quality in Slovakia" Yearbook. In 2004, the values of acceptable concentration (the highest acceptable concentration) were more often exceeded by the following parameters: Mn (144 times), total Fe (148 times) and NEL_{uv} (63 times) from the total number of 333 measurements.

The unfavorable oxidation-reduction conditions indicated by frequently present higher concentrations of Fe, Mn and NH_4^+ pose currently the most significant problem within the groundwater quality assessment process.

As in previous years, the pollution by organic substances indicated by frequent exceeding of the nonpolar extractable substance limit concentrations (NEL_{uv} and chemical consumption of oxygen with permanganate) still prevails. In some monitored regions the number of exceeded NEL_{uv} concentrations has increased compared to previous periods.

The dominant character of land use in monitored areas results in relatively frequent higher concentrations of oxidized and reduced forms of nitrogen in water (nitrides - 35 times, nitrates – 9 times).

As far as trace elements are considered, the most frequent higher concentrations were observed for As (19 times), Al (13 times), Ni (1 times), Pb (1 time) and Hg (1 time). The pollution by specific organic substance has only local character.

Water Resources Protection

Protection of water quantity

The major objective of water utilities is to maximize usage of the stored water resource. In the period between 1989 and 1991, the impact of environmentally uncontrolled exploitation of water-deficit regions was highly adverse, ultimately resulting in the depletion of ground water resources by using the accumulated reserves. As a consequence, water managers, in addition to qualitative water resource protection, began to pay closer attention to quantitative protection, i.e. protection of the volume of water reserves.

The water resources protection in Slovakia is considered as an integrated protection of groundwater and surface water quality and quantity, including springs and mineral waters. Quantitative protection is based on accumulation ability and management of particular region with respect to abstracted or pumped water. This is the reason why the limit for surface water use is determined by so-called ecological limit (MW_{eko}), which has no effect on a habitat in river basin.

The quantitative protection of the yield of ground water was introduced in 1993. At the same time, the Methodology of Establishing Ecological Limits of Ground Water Resource Utilization was developed and applied in the General Protection and Rational Water Utilization. The methodology defines how to establish usable volumes of ground water resources while ensuring sustainable development of the land by defining general ecological limits for the entire watershed – a hydrogeological zone or hydrogeological structure, as well as local ecological limits for particular sources that are being used (springs and wells). Previous experience shows a decrease in the volume of continuously used springs Q_{min} and wells Q_{rec} of 15-20% and 20-30%, respectively.

Qualitative protection plays significant role in water resource quality protection. The pollution comes from population, industry and agriculture through various types of contamination. Legislation determines obligations and responsibilities for wastewater discharge and manipulation with chemicals in order to avoid deterioration of surface and ground water resources.

Protection of water quality

One of the key roles of water protection in terms of water quality is to resolve the problems relating to sources of pollution. Pollution sources, which have a negative impact on water quality, are broken down into two categories based on the type and severity of their impact: point sources of pollution and non-point sources of pollution.

The most significant point sources of pollution are wastewater discharges from industrial and agricultural facilities and from residences. Even though the volume of discharged wastewater has been declining since 1990, in order to ensure active water quality protection, the portion of population connected to the sewage system has to be increased and measures relating to wastewater treatment have to be taken.

Legally, the polluter is in charge of drainage water and sewerage treatment and obliged to monitor the quantity and quality of discharged wastewater. The validity of monitoring results depends on the precision of the sampling procedure and the level of expertise of laboratories providing wastewater analyses.

The currently operated wastewater treatment plants represent a specific problem, because they are overloaded (both hydraulically and from a load point of view) and the wastewater treatment technology does not comply with legal regulation standards any more.
Protected areas are determined according to the Act No. 184/2002 Coll.:

1. Protected water management areas (PA)
2. Protection zones of water supply resources (PZ)
3. Sensitive areas (SA)
4. Vulnerable areas (VA)
5. Areas containing surface water intended for drinking water abstraction
6. Bathing water areas
7. Areas with water suitable for life and reproduction of indigenous fish species
8. Protected areas and their protection zones under the article 17, Act. No. 543/2002 Coll on Nature and Landscape Protection

Protected water management areas

The protected water management areas are defined as areas where, due to favorable natural conditions, surface and ground water are accumulated. This is why the Government may declare them as the protected water management areas.

All activities in protected water management areas can be planned and performed only if a broad protection of surface and ground water will be assured. The protection of water production, occurrence as well as transport and other interests shall be in accordance with requirements set for protected water management areas within the processing of development conceptions and regional planning documentation.

Today, there are ten designated protected water management areas in Slovakia covering area of 6942 sq km that represents 14, 16 % of the entire Slovak territory.
Basic characterization of designated protected water management areas are listed in table 1.

TABLE 1.: Protected Water Management Areas in Slovakia

No.	Name	Area	Available water resources		
			surface	ground	total
		sq.km	$m^3.s^{-1}$	$m^3.s^{-1}$	$m^3.s^{-1}$
1.	Beskydy – Javorníky	1 856	1,84	0,69	2,53
2.	Žitný ostrov	1 400	-	18,00	18,00
3.	Nízke Tatry	1 290			
	a) western part	358	-	2,50	2,50
	b) eastern part	805	2,33	2,43	4,76
4.	Strážovské vrchy	757	-	2,33	2,33
5.	Veľká Fatra	644	0,97	2,98	3,95
6.	Upper river basin of Ipeľ, Rimavica and Slatina	375	1,09	0,11	1,20
7.	Vihorlat	225	0,08	0,43	0,51
8.	Slovak karst	209			
	a) Plešivská planina	57	-	0,55	0,55
	b) Horný vrch	152	-	1,97	1,9
9.	Muránska planina	205	-	1,40	1,40
10.	Upper river basin of Hnilec	108	0,16	1,10	0,26
Total:		**6 942**	**6,47**	**33,49**	**39,96**

Protection zones of water supply resources

Protection zones of water supply resources are designated by the state water authorities with aim to protect their yield, quality and safety.

Protection zones of water supply resources are divided into the protected zone of the 1st degree serving for its protection in direct vicinity of water abstraction points or capture devices and the 2nd degree protection zone serves for protection of water supply resource against risks coming from more distant sites. For enhanced protection the water authority is allowed to establish also the 3rd degree protection zone.

Protection Zone 1 serves to protect water supply resource in the immediate vicinity of the water intake or water collector.

Protection Zone 2 serves to protect water supply resource against contamination from farther resources.

Protection Zone 3 can be established to improve the overall protection of water supply resource.

If conditions in the locality of the 1st degree protection zone provide sufficient protection of water resource yield, quality and safety, further degrees of protection zones will not be designated.

Designated protected zones serve simultaneously specific regulations.

According to 2002 data there are about 1138 PZ groundwater resources in Slovakia. A single PZ, especially the 2nd degree PZ, may comprise several water resources, e.g. the entire spring line or group of wells, etc.

TABLE 2.: Number and Areas of Protection Zones in Slovakia

No.	River Basin District	Sub-basin	Sub-basin areas (sq. km)	Number		Area of Protection Zones (ha)		Total area (km2)	% of river basin area
				ground water	surface water	ground water	surface water		
International Danube River Basin									
1.	Danube	Morava	2282	39	0	13901	0	139,0	6,1
			1138	31	0	7375	0	73,8	6,5
2.	Váh	Váh incl. Nitra	18769	396	6	205101	44,038	2491,4	13,3
3.	Hron	Hron	5465	124	7	55123	9316	644,4	11,8
		Ipeľ	3649	49	1	8360	7872	162,3	4,4
		Slaná	3217	71	5	16371	17703	340,7	10,6
4.	Bodrog	Bodrog	7272	207	15	6760	335272	3420,3	47,0
5.	Hornád	Hornád	4414	140	1	19865	67890	877,6	19,9
			858	31	7	7818	9024	168,4	18,6
International Virtual River Basin									
1.	Dunajec a Poprad	Dunajec a Poprad	1950	50	13	15606	14023	296,3	15,2
Total (Slovakia):			**49014**	**1138**	**73**	**356,280**	**505,139**	**8614,2**	**17,6**

In Slovakia there are 73 protection zones designated for the need of surface water abstraction for drinking purposes, 8 of which are designated for the abstraction from water supply reservoirs and 65 for the direct water abstraction from surface streams that are mostly situated in the East Slovakia Region.

TABLE 3.: The Water Supply Protection Zones in Slovakia for Water Reservoirs

No.	Name of Water Reservoir	(sq km)		
		Total	Agricultural Land	Forest Area
1.	Bukovec	52,9	5,12	45,91
2.	Hriňová	71,04	9,61	60,97
3.	Klenovec	92,12	26,9	65,22
4.	Málinec	78,72	33,46	44,17
5.	Nová Bystrica	59,32	5,39	53,13
6.	Rozhund	3,42	0,47	2,89
7.	Starina	120,45	4,99	115,46
8.	Turček	28,96	-	28,96
Total:		**506,93**	**85,94**	**416,71**

In Slovakia there are 73 PZ intended for surface drinking water abstraction, of which 8 are related to abstraction from water supply reservoirs and 65 PZ are designated to direct abstraction from surface streams that are situated mostly in the East Slovakia Region.

The above-mentioned data indicate high percentage of the area covered by protection zones in Slovakia – 17,56 %. It is important to note that the areas of protection zones of some water supply resources arte often overlapping. Therefore, the area of 17,75 % does not represent the total area of protection zones in Slovakia, but it is a sum of all individual protection zone areas without mutual overlapping. After consideration of the zone overlapping, the area of all protection zones covers 3 113 sq km in total, i. E. 6,36 % of the Slovak territory.

Sensitive areas

Sensitive areas are surface water bodies, water quality of which is or can be threatened by increased nutrient concentrations; which are or can be used as water supply resources as well as water bodies requiring a higher level of discharged wastewater treatment with regard to advanced water protection interests.

From 2003, the Governmental Regulation specifying designation of sensitive and vulnerable areas came into force. All surface water bodies in Slovakia. It means that all area of Slovakia have been declared as sensitive areas.

Vulnerable areas

Vulnerable zones under the Water Act are agriculturally used areas where rainfall water flows into a surface water or infiltrates to groundwater resources in which the nitrate concentration is higher that 50 mg.l-1 or can be exceeded in the near future. Plots agriculturally used in particular cadastral territories listed in the Governmental Regulation have been designated as vulnerable zones. In particular, it relates to all lowland areas of Slovakia, alluvial plains of larger rivers as well as lower situated valleys with agriculturally used land.

Sensitive and vulnerable area identification is being re-evaluated every four years under the coordination of the Ministry of Environment of the Slovak Republic.

The Regulation accepts the possibility to not declare the 3rd or even 2nd degree PZ of water supply resource, if there exist other type of area protection, e.g. vulnerable area. In practice it means that such protection can substitute the function of the 3rd degree PZ and in specific cases even the 2nd degree PZ.

surface water resources intended for drinking water abstraction

Water supply streams and their river basins can be considered as protected areas with surface water intended for drinking water abstraction under the Decree No. 211/2005 Coll. Setting the list of important water management rivers and water supply streams. There are 102 identified water supply streams in Slovakia. According to Article 7 of the Water Act water supply streams are water supply resources of surface water. Ground water supply resources are groundwater bodies used for drinking water abstraction or groundwater bodies supplying more than 50 person or allowing water abstraction in average of more than 10m3 a day in natural status or after treatment.

Bathing Water

In 2004 Water Administration Authority of the Ministry of Environment together with the Public Health Office identified 39 nature localities with water suitable for bathing in Slovakia. The listed localities are situated mostly in proximity of water reservoir and gravel pits.

water suitable for life and reproduction of indigenous fish species

Protected areas with water suitable for life and reproduction of indigenous fish species have not been designated by 2004.

Implementation of Protected Areas in Slovak Republic

The European System of Protected Areas – NATURA 2000 is applied for protection of animal and plant species of Slovakia. It is confirmed in the Act. No. 543/2002 Coll. on Nature and Landscape Protection.

NATURA 2000 us a system of the EU member states protected the most rare and endangered plant and animal species as well as natural habitants and through this preserve biological diversity throughout the European Union.

The system of NATURA 2000 consists of the two types of protected areas:

- Special Protection Areas
- Special Areas of Conservation

The national system of protected areas is created in conformity with the Act No. 543/2002 Coll. on Nature and Landscape Protection. It divides the Slovak territory in to five levels of protection. The higher level of protection is established the wider range of measures is applied. The areas not included in any protection category are classified into the first level of protection under the act mentioned above.

In particular, it concerns the following categories of protection areas and protection levels:

- Protected Landscape Area (2nd protection level)
- National Park (3rd protection level) and its protection zone (2nd protection level)
- Protected Range (3rd to 5th protection level)
- Narute Monument and National Nature Monument (4th to 5th protection level)
- Protected Landscape Element (2nd to 5th protection level)

At the present time there is designated 23 large protected areas in Slovakia comprising 9 National Parks and 14 Protected Landscape Areas covering an area of 1113,565 ha including protection zones. The number of small protected areas is 1101 inclusive of 385 Natural Reserves, 239 Nature Monuments, 60 National Nature Monuments and 189 protected Ranges covering the total area of 111,062 ha including their protection zones.

Special type of protection areas – wetlands

Wetlands are areas of marshes, fens, peat lands or water, whether natural or artificial, including habitats dependent on aquatic environment.

Wetland protection is provided at national and international levels. International wetland protection is included in the Convention on Wetlands, signed in Ramsar, Iran in 1971 and known as the Ramsar Convention. The Convention provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.

The Slovak Republic signed the Ramsar Convention in 1990, which obliged Slovakia to meet requirements on wetland protection in its territory. The fulfilment of obligations resulting from the Ramsar Convention are managed and coordinated through the Slovak Ramsar Committee.

Wetland mapping in Slovakia is coordinated by the Wetland Mapping Centre, headquartered in Prievidza. The Centre keeps records of the following categories and numbers of wetlands:

- 13 wetlands of international importance included in the List of Wetlands of International Importance, i.e. Ramsar sites with area of 39337 ha. (Another four sites with area of 1007 ha are proposed for the List of Wetlands of International Importance.)
- 72 wetlands of national importance
- 179 wetlands of regional importance
- 1050 wetlands of local importance
-

Pecuniary damages/Loss

In connection with pecuniary damages compensation in protected areas due to limited economic activities it is important to distinguish between protected areas designated under the Act No. 543/2002 Coll. on Nature and Landscape Protection and protected areas designated under the Act No. 364/2004 Coll.

Conclusion

Monitoring of water resources qualitative parameters has a long-standing tradition in Slovakia. Issued legislative regulations define parameters and character of quality monitoring as well as number of analyses in relevant monitoring periods. The above results indicate that quality of our water resources becomes slightly better. However, there exist some water resources with water unsuitable for long-term drinking water abstraction. Protected areas it is important to note that individual components of landscape protection shall be integrated within the frame of integrated approach to the institutes of landscape protection as a whole.

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Decree no. 211/2005 of the Ministry of Environment of the Slovak Republic establishing the list of significant water management rivers and water supply streams

Decree no. 221/2005 of the Ministry of Environment of the Slovak Republic determining the details on identification, assessment and monitoring of surface water and groundwater, on water resources inventory and water balance

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SITNICA RIVER FLOOD PROTECTION

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Kosova, with an area of 10907km^2, is characterized with a non-uniform distribution of surface water-flow in space and a time period.

In the past, flood damages in the Kosova territory were considerably evident, which had their impact in the overall economical development of Kosova.

Acording to the Kosova master-plan has been predicted that from the flood occurrences with a return time period of 100 years, would be endangered 34000Ha. This endangered area is consisted of 51% area of the “Sitnica” watershed, 38% area of the “Drini i bardhë” watershed, 10% area of the “Morava e Binçës” watershed and with 1% area of the “Lepenc” watershed.

According to the above stated fact, our flood protection analysis will be dealing with the “Sitnica” watershed.

In this paper will be treated the flood problems occurring in the Sitnica river and it will be given a real representation of the present situation of the riverbed (in the aspect of incomplete riverbed regulation, and of the lack of maintenance as well). It will also be given suggestions and comments as a function of eliminating the negative phenomena, i.e. river floods, which recent years occur twice a year.

Introduction

Natural conditions of Kosova are such that the flat regions of the territory are appropriate and potential for housings, industry placing, infrastructure development, whereas the mountaneous and hilly terrain in the surrounding determine the speedy flowings and with big water dicharges. Utilization and fulfilment of these spaces, their exploitation and value increases, for what cause also increases the flood protection need, while the existing construction need to be reconstructed and retrofited.

Taken in general, the present situation of the water-beds, and flood protection in the overall region of Kosova is not satisfactorilly nevertheless the fact that in the past have been taken considerable construction works for river-bed regulation. This is due to the time effect to which there have been incur considerable damages with various intensities and they have not been maintained afterwards.

The water sector development in Kosova started by the end of sixties, but more intensive was after the year of 1974 when in Kosova were eshtablished the basis for its economical strategy development and then started the construction of infrastructural hidrotechnical works as well as works for protection due to water damage effects.

In the period before 1990 were realised numerous projects for the Kosova rivers and also were analised, with technical and biological principles, a considerable number of streams. Up to the year of 1990 were built around 150km legth of embankments, several tenths of kilometers of walls parallell to the city zones, many streams were regulated and also the draining from sufficitary waters with above 10000ha..

If we analyse the damages from the river discharges with probability of occurence of 100 years return period, for the development stage of the watersheds in the year of 1980, was noticed that the most severe damages are expected in the watershed of "Drini i Bardhë" river (about 50% of the overall river damages in Kosova), afterwards in the rivershed of "Ibër" and "Sitnicë" (around 24%), "Lepenci" river (20%), while in the watershed of "Morava e Binçës" the damages would be minimal (around 6%).

Considering the below given table (Table 1) about the maessurements taken for the damages due to river flood, it is represented for the total length of overall rivers of 491km, while the regulated length of all the rivers is around 140km, which is approximately around 28%.

Table 1.

Nr.	River	Length of the river (non regulated)	Regulated length of river	Percantage of regulated river
1	Morava e Binçës	30.35	22.15	73
	Branches of M.Binçës	56.45	24.1	42.7
	Total	86.8	46.25	53.3
2	Sitnicë	62.37	43	70.1
	Branches of Sitnica	141.73	26.7	11.8
	Total	203.1	59.7	29.4
3	Ibri	7.7	4.5	58.4
	Branches (Lushta)	2.6	0.85	32.7
	Total	10.3	5.35	51.9
4	Drini i Bardhë	76.56	13.4	17.5
	Branches of Drini i Bardhë	92.07	12.92	14
	Total	168.63	26.32	16.6
5	Lepenci river	5	-	0
	Branches	17.5	2.8	15
	Total	22.5	2.8	12
	Overall Total	**491.3**	**140.92**	**28.6**

Damages or river floods in the Kosova territory were with considerable amount and significantly have hardened and slowed down the development of all the economical branches, and along with that the overall development of Kosova.

Floods, despite that they made direct damages to rivers beds, they also inflicted indirect damages, mainly as a result of the interruption of the production activities, occurrence of disease , blocking of communication, etc.

The 1979 floods surely were one of the most severe ones. Due to these floods were flooded 50000Ha area and above 11000 residential houses, 5km of railway damaged, 3.7km road, 35.2km water-supply pipes an 6.5km canalization network. Also there have been damaged and devastated many bridges, power transmission network, and numerous individual and social buildings. In the overall tragic-balance due to flood were registered 6 people dead and above 100 hurt.

Considering the damages occurred in the earlier periods, it is not possible to be given real damage evaluation because the evidences for damage evaluation were not recorded in systematic procedures.

From the questionnaires elaborated for formulation of the "Hidroeconomy Basis", completed by the year of 1981, show that a small number of municipalities possess global recorded data about the damages in their territory.

Up till the year of 1965, the damage evaluation were not done by the same methodology, therefore the measurements that can be compared to each other, considering the period up till 1965, are very insignificant. Contrary to aforementioned, damage evaluation due to floods in the earliest periods were not observed with adequate specification for documentation of the real evaluation, and very often the damages due to floods were given together with the damages made due to other environmental factors (lightning, hailing, soil sliding, etc.)

Eventually, for the cases when damage documentation is obtainable, their data are difficult to be used because they are not correlated with the data for hydraulic and hydrologic parameters as well as technical and economical parameters, which are necessary for analysing of the correlation of the amount of damage, condition of the infrastructure of the region at risk and for the probability of occurrence of floods.

During the elaboration of the "Water Master-plan of Kosova" for the present condition for the year of 1981 was evaluated that from the flooding of surface waters, (with probability of occurrence of 100 years), is endangered a surface area of 34000ha along the rivers and from this part, 51% of the area is a part of the "Sitnica" watershed.

From the results of the completed observations results that the teritorial allocation of the expected potential damages would be like the following:

- 50%, in the "Drini i Bardhë" watershed
- 24% in the "Ibër" and "Sitnica" watershed
- 20% is part of the "Lepenci" watershed
- 6% is part of the "Moravës e Binçës" watershed

Sitnica river, general characteristics

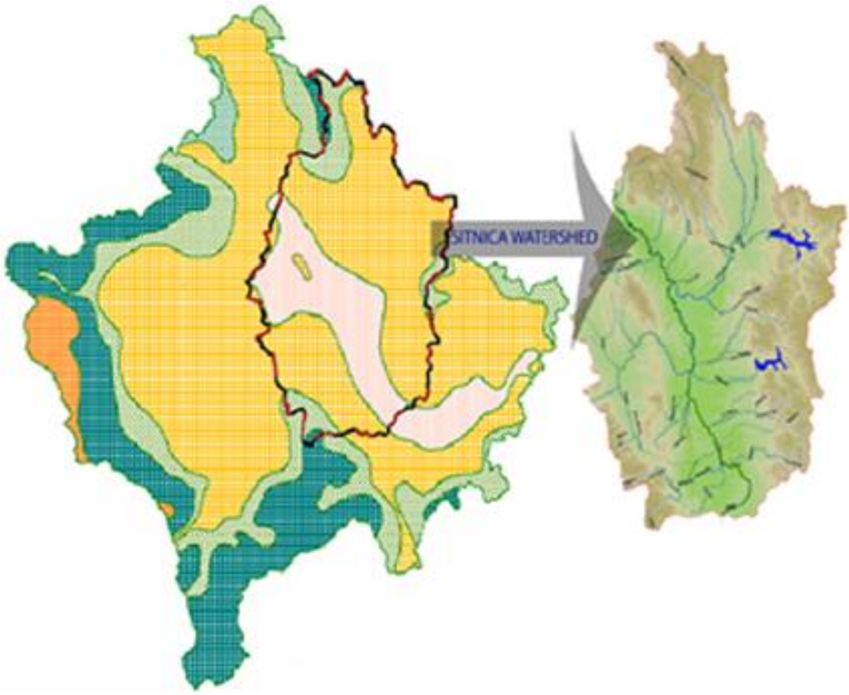

Figure 1. Sitnica watershed and Kosova territory

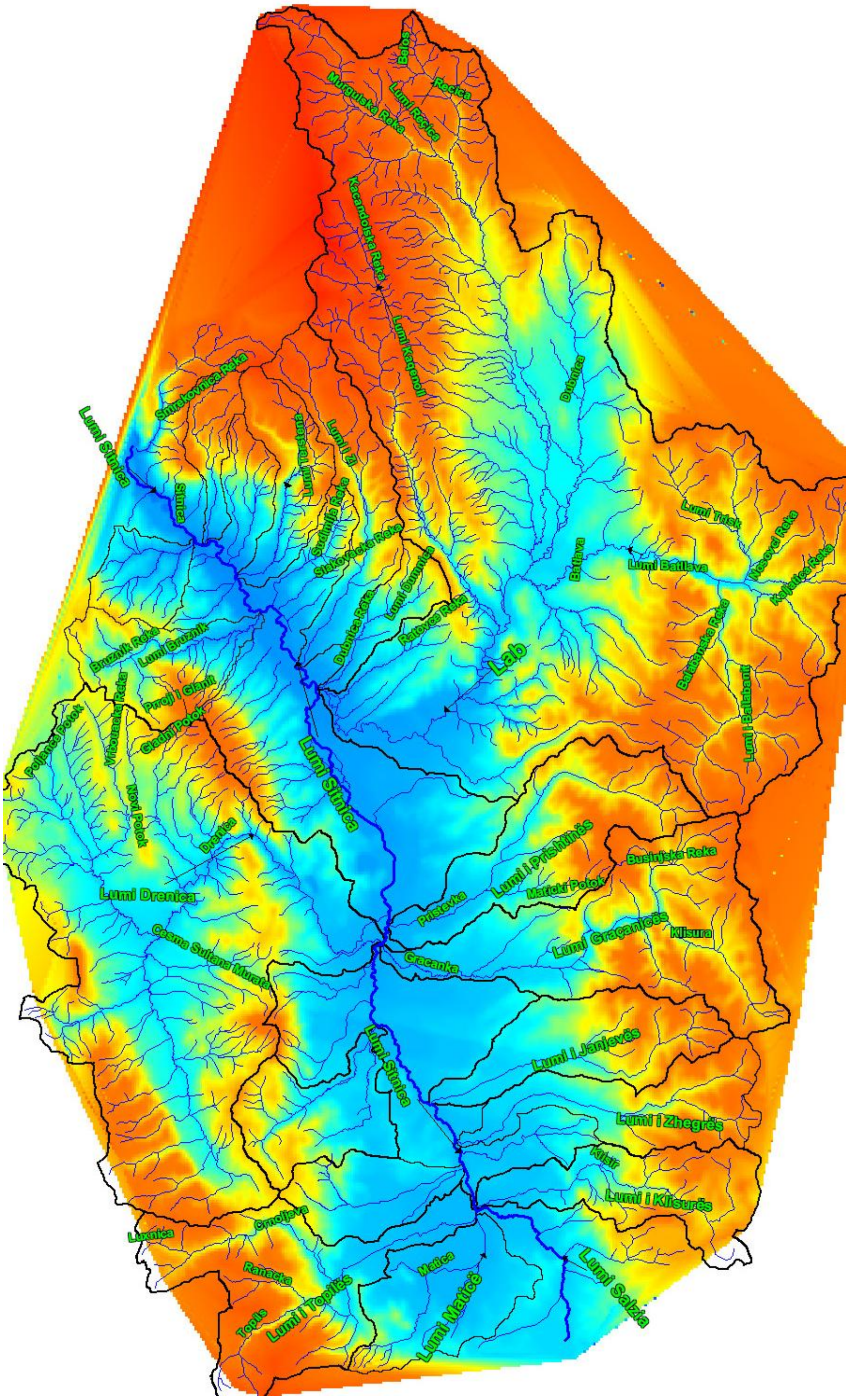

Figure 2. Sitnica watershed

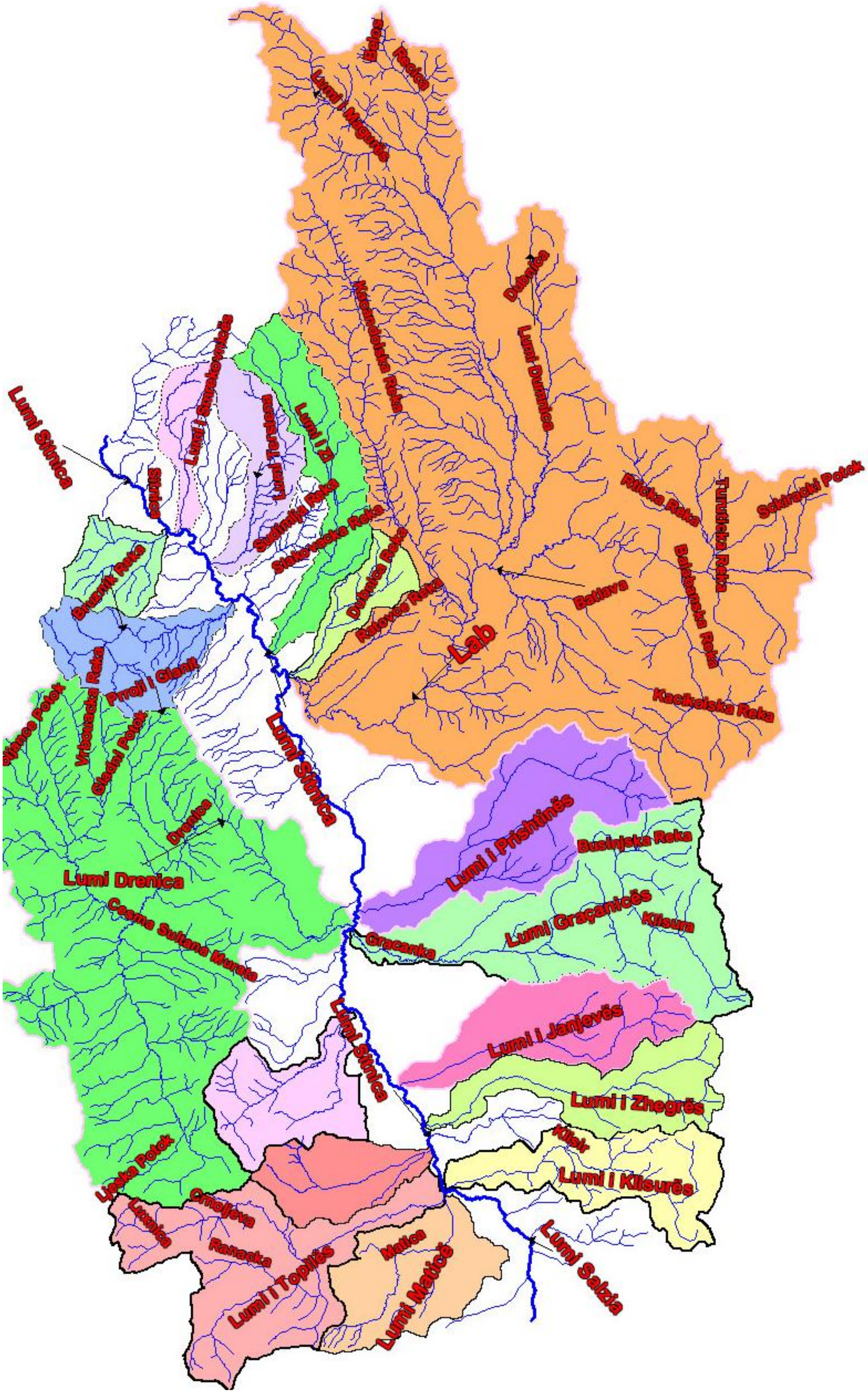

Figure 3. Sitnica river and its branches

Sitnica river takes part in the central part of Kosova and flows through the regions of Ferizaj, Lipjan, Fushë Kosovë, Vushtrri and pours our in the “Ibër” river in Mitrovicë. Along its river bed, this river has a very soft longitudinal slope and it is a typical flat terrain. This is the main reason that this river has ability to often escape from its river bed. i.e. during high river discharge.

Sitnica is the main branch of the Ibër river. It is distinguished not only by its watershed size ($2861 km^2$), but also with its mean water annual discharge ($16{,}6\, m^3/s$). Near the Rabovë village coincide the river Maticë and Shtime, thus forming the Sitnica river flow, which from Rabovcë until its pouring in the Ibër river, passes a distance of $92{,}3 km$. With a mean longitudinal slope od 0,054% is characterized as a valley river, flowing in the alluvial valley. The highest parts of the river have altitude of 1750m, while near the Ibër river, the Sitnica river has altitude of 520m.

The south boundary of the watershed is consisted of the Sharr mountains, while the west boundary consists of the mountains of Nerodime and Drenicë. The north boundary of the watershed is consisted of the Kopauniku mountains while the east boundary is consisted of the Gollak mountains.

The terrain topography where the Sitnica river is present, does not enable any surface water accumulation (construction of dams) that would eventually collect the flooding (the high river discharge). Therefore the single possibility for flood protection along the Sitnica river is the construction of protective structures from floodings along the Sitnica river (embankments).

The majority of the existing embankments are damaged and in certain parts are completely demolished. The main reason for this is the human factor itself. They either contributed in the demolishing process or did not take account for the maintenance of the embankments. From the beginning of 90s and up till today, there has been no governmental investments for maintenance activity of the embankments. The nature itself, slowly impose the degradation of these structures up till their total demolishing, and consequently the river flooding phenomena with different intensities occurs.

From their lack of maintenance occurs the up-growth of woods which slowly change the river bed. Consequently, the river erodes the shores and thus coming even close to the embankment bodies up till their damaging and demolition. A certain obstacle, in the free water flow of the rivers, would be the presence of the garbage materials in the river bed.

Therefore, the flooding events of the Sitnica river and its main braches (streams), these recent years are classified as a customary natural phenomena occurring mainly in the spring and autumn seasons.

Figure 4. Flooding of Sitnica river in 23 February, 2006. Damage of embankments

Floods, and river flood protection of the Sitnica rivershed

Taken in general, the present situation of the riverbeds and river flood protection in the Sitnica watershed as well as in all the other watershed within the Kosova region are in a very poor condition.

This condition is as a result of insufficient maintenance and rehabilitation works. Also, many rehabilitation works done up till now have been of a local character and have been executed for solving of the local problems due to floods. At this point can be emphasised also the fact that in some parts of the river, rehabilitation works did not achieve the desired and expected effects, while in some other parts these rehabilitation works were a complete failure.

The rainfalls distributed in a non-equall way (in time and space) combined with the unpleasant natural conditions, impose accelerated river flows in the direction of the flat regions. The majority of the rivers have flat riverbeds, and do not have the ability to withstand the high river discharges and as a result there are many occurrences of large-scale river floods. The time duration of floods is different in different areas. Hence, it is necessary for various strategies and criteria for river flood protection in different parts of Kosova region. Despite the technical solution for flood protection, there are several different methods such as: flooded region identification, restriction of construction activities in the regions evaluated as frequently flooded regions, alarming systems along with system for forecasting of maximal river discharges, etc.

In the flooding phenomena of the Sitnica river in particular, in a considerable amount influence the below-mentioned factors:

- natural, unprotected and relatively shallow river beds
- uncontrolled influx of garbage in the river beds
- uncontrolled application of inert materials from the river beds.

All the rivers and streams in the Sitnica watershed, depending on the activities undertaken in the river beds, the rivers can be clasfied in three groups:

- River flows which up till present day have not been regulated for protection from floodings
- River flows to which have been realized partial works which have reported positive efects, and
- River flows to which have been realized rehabilitation works which have not reported positive efects (due to different reasons)

Considering the present situation of the river-flows in the Sitnica watershed, as a result of not regulating and maintaining of the river beds, for the recent years, floods are geting to be more and more common, while only their intensity remains variable.

The recent rainfalls have affected the major parts of all the regions in Kosova. Rainfall amounts in February were 48.4mm(Prishtina), 87.3mm (Pejë) and 45mm (Ferizaj), while for March there is still not known the evaluated amount. All of these values are in the normal range, but in combination with the snow melting and non-maintenance of the river-beds the probability for flood occurences increase.

As a consequence of recent floodings, above 600 households have been damaged, and above 3000 habitants evacuated. There have been damages also in the rural infrastructure, mainly in roads and bridges. Above 4700ha of land have been flooded, thus putting the agriculture economy in considerable losses.

In the Ibër and Sitnica watershed, the greatest damages could be inflicted by Sitnica river from the pouring of Lab stream in the Sitnica river down untill the pouring of the Sitnica river in the river Ibër. Afterwards, the Lusha river can inflict considerable flood damages in the city of Mitrovica.

Embankment construction design for the Sitnica river is not fully completed, and also the existing ones are partially damaged in certain sectors. During the season of high rainfalls (spring and autumn), Sitnica river and its streams flood the surrounding areas of their river bed, and thus flooding and damaging the households, water and road infrastructure and the agricultural lads as well.

In the following, in a tabular format are shown the damages inflicted during rainfalls in the period of February of 2006, in the watershed of Sitnica, specifically n the region of Mitrovicë and Prishtinë.

Mitrovica region
As a consequence of intensive rainfalls, from their riverbeds have flooded the following rivers: Ibër, Sitnica and Lushta. The damages inflicted due to their flooding are shown in the following given table.

Table 1. Mitrovica region damages due to flood

Damages	Mitrovicë	Vushtrri	Skenderaj	Total
Nr. of flooded households	76	9	23	108
Evacuated habitants	471	44	137	652
Agricultural land (ha)				209.03
Infrastructure	4 damaged bridges (3 Orasje, 1 Rudnik)			

Prishtina region
As a consequence of intensive rainfalls, from their riverbeds have flooded the following rivers: Sitnica, Drenica, Graçanka and Prishtevka. The damages inflicted due to their flooding are shown in the following given table.

Table 2. Prishtina region damages due to flood

Damages	Drenas	Obiliq	F. Kosovë	Lipjan	Podujeva	Total
Nr. of flooded households	142	14	235	1	2	394
Evacuated habitants	830	32	1159	10	8	2007
Agricultural land (ha)						1.297
Infrastructure	4 roads (2Nekoc, 1K.Rekë, 1 Dobroshevc) 2 bridges					

Reasons for flood occurrences

The majority of the rivers in the Kosova region, as mentioned earliers, are natural and with shallow river bed, i.e. are not able to accept the high water levels and as a consequence the flooding with various sizes occurs (river flows out of its bed). The reason of flooding is that the biggest part of the river coasts is without embankments (protective structures against floods), while the extisting ones are already damaged.

Uncontrolled exploatation of inert particles (sand, gravel), espetially after 1999 have seriously damaged the river beds and coasts of almost all the segments of the rivers in Kosova.

Lack of maintenance of the river flows enables the occurrence of floodings ever for the minimal quantities of rainfalls.

There is a lack of finantial support in the related projects. The government has not planed any financial budget from the year of 1999 with the exeption of finantial investemnt of "Fushë Kosova" municipality for rehabilitation of the Sitnica river in Vragoli – Fushë Kosovë. Financial investments has not been given from donators as well, since the water resources are not seen as governmental priority for the moment.

It has been observed that in many cities, flooding phenomena (accumulation of rainfalls) has been the reason that the canalization network (atmospheric or mixed, depending from the city) has been jammed.

Recommendations

- It needs to be made the regulation of the Drenica river bed which pours out in Sitnica, and the Sitnica river itself (partitions which are not adjusted or that are damaged).
- Reconstruction of the existing structures (embankments), in what way it is increased the safety due to flooding
- The emergent cessation of the aggregate exploitation from all of the river beds and coasts
- The municipalities need to present their strategies and plans for river filtration and rehabilitation in address of the "Water department" and to plan the financial investments and technical equipments for the initiation of river filtration and rehabilitation.
- The Goverment need to determine water resources in their priority list, since all of the Kosova rivers have international character. This will impose also for the increasing of investments from the side of donators as well.
- All of the projects concerning or related with the water resources needs to be checked fron from the relevant institution, Water department, Ministry of environment and spatial planing, MESP.
- To be established a special fond in the govermental level, for coping with the emergent situations.
- A similar font needs to be established by the municipal assemblies in order that similar situations to be confronted with ease.

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MODELING GROUNDWATER FLOW IN A RAW MATERIAL SITE OF A CEMENT FACTORY, KOCAELI-DARICA, TURKEY

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An areal numerical simulation has been carried out to investigate effects of below-sea-level (BSL) excavation in the raw material site of a cement factory in Turkey. A finite element model (585 nodes and 534 elements) is formed to solve for the head distribution in the quarry site upon quarry operation planned to be implemented in the near future. The model has been successfully calibrated to the field using appropriate physical parameters and boundary conditions. After the calibration, the model has been run to estimate water levels and discharge rates during a probable below sea level quarry operations.

Above sea level (ASL) and below sea level (BSL) operations have been simulated and water level contour maps are obtained both for the ASL production period (for 2000-2030 period) and for each BSL production periods (for -10, -20, and –30 m below sea levels) which would take 13 years.

Transient simulation has shown that the proposed model runs properly and estimates the water levels and discharge rates accurately for probable future quarry operations.

Keywords: *Groundwater flow modeling, BSL mining simulation*

Introduction

Main objective of this research is to formulate an areal (2D) finite element model to simulate groundwater flow in the raw material site of a cement factory upon below sea level (BSL) quarry operations. Proposed model has been developed to estimate water levels over the quarry area upon ASL and BSL quarry operations, as a continuation of the Karahanoglu and Doyuran's (2003) 2D-cross sectional model. In this way it is expected to evaluate the variations in the water levels in the quarry site along profiles other than the one used for the cross sectional model.Quarry site is located at the south of Kocaeli Peninsula, 5 km southwest of Gebze and 2.5 km west of Darıca (Fig.1) in Turkey. The factory has been in operation since 1970s and it is now planned to be excavated below sea levels. The quarry has been investigated for the possibility of below sea level excavations, to estimate the amount of discharge from the pit, and to determine the rate of advance of salt water front during quarrying operations (Doyuran and others, 2001). A 2D cross sectional model was developed and the hydrogeological and hydrochemical conditions in the aquifer has been extensively studied along a sea to land profile (Karahanoglu and Doyuran, 2003).

Previous geological studies related with the raw material area were given in Erguvanlı and others (1972) and MTA (1991). Gültekin (1983) also performed investigation studies related to the raw material in the area. MTA (1991) conducted investigations in the area to study hydrogeology of the quarry site. Several boreholes were drilled and pumping tests were performed to determine physical parameters of the region. Geophysical investigations were conducted by Yeraltı Aramacılık (1994) to locate saltwater/fresh water interface and to assess excavatability of the rocks.

Hydrogeology

Carbonate type of rocks, limestones, dolomites and marls with occasional alternations of conglomerates, sandstones and claystones, dominate the lithology in the area. Primary porosity of the lithological unit is very low. Joints, fractures and shear zones provide a certain degree of porosity (Karahanoglu and Doyuran, 2003). Due to small primary and secondary porosities, no significant amount of water storage is expected. The permeability of the sequence is very low. The discontinuities, which provide secondary permeability to the rocks, may permit groundwater circulation. During field investigations systematic joint measurements and field observations of shear zones and fault planes were performed. It was found that the joints did not contribute significantly to groundwater circulation. Rather than that the shear zones were claimed to be considered significant for groundwater movement throughout the area. Groundwater level measurements were taken periodically from some of the existing wells and the BH wells drilled during the research project (Table 1).

Numerical modeling

There are two simulation studies performed in the study area.
Gemmes (1997) performed a study to predict groundwater flow and the migration of the saltwater front. During this research 6 pumping wells and 4 boreholes were drilled and a trench was excavated. A numerical flow and transport model was applied in the west part of the quarry along 2 E-W profiles. The results showed that the estimated values were greater than the observed ones.

Karahanoglu and Doyuran (2003) developed a 2D cross sectional model to define the intrusion mechanism into the aquifer. The model was located along a sea to land profile, being 1000 m long and 100 m deep, with 3633 nodes and 3440 rectangular elements. It was successfully calibrated to the field conditions, and it was applied to the field to estimate the effects of future BSL and ASL excavations. These operations were simulated using two scenarios and the behaviour of the aquifer upon ASL and BSL operations was successfully simulated along the cross section. The model estimated probable distributions of the head and concentrations along the cross sectional model for the future operations.

Present research is introduced in order to study areal distribution of the water levels along the entire aquifer upon BSL operations. The quarry site has been discretized into 534 rectangular elements with 585 nodal points (Fig. 2). The finite element model is then supported by appropriate boundary conditions (Fig.3), such that the area is recharged from the eastern boundary; discharged from a part of the southern boundary and having constant heads with the sea boundary.

The areal model is calibrated to the field conditions using different physical parameters (Table 2) and boundary conditions. During calibration studies steady state conditions are assumed and the observed groundwater levels of July 2001 of the cross sectional model are used (Table 1). Table 3 lists deviations between the observed and the estimated water levels and the average error associated to the calibration runs. A regression analysis is made between the observed and the estimated values and a regression constant of 0.9977 is obtained which indicates a very succesful calibration (Table 4, Fig.4). Figure 5 shows the distribution of water level contours over the aquifer area as computed as a result of the calibration.

Areal Simulation Studies

The calibrated model has been run to simulate the flow dynamics in the aquifer by following the same Scenarios of the previous cross sectional model. In the first Scenario ASL would operate for the next 30 years and then BSL would continue for the last 13 years. Both ASL and BSL would operate together in the second scenario for 43 years.

During the first scenario the whole quarry is expected to be flattened and transformed into a a platform having elevations of about 2-3 m in the next 30 years. This operation is simulated by running the model for six consequtive 5-year simulation intervals (Fig. 6) assuming water loss from the aquifer due to evaporation during quarry operations. At the end of each simulation period the estimations have been compared with the results of the cross sectional model (Table 5). Figures 7, 8, 9, 10,and 11, show the water level contours drawn from estimated water levels over the entire area for each of the simulation intervals. After completion of the ASL simulation BSL simulation is started which would take 13 years. During this process BSL operation is assumed to start at 170 m distance from the shore with a 30 m bench width. Fig.12 shows the expected boundaries of the –10 m, -20m and –30m excavations. During simulation of BSL operation it is aimed at estimating – 10 m water level in the –10 m BSL boundary. During the simulation runs this is achieved by adjusting appropriate discharge rates from the interior nodes corresponding to required pumpage rates from the aquifer (Fig. 13). Figure14 and Figure 15 show the water level contours estimated at BSL levels of –20 m and –30 m levels respectively. Table 6 lists the amount of water discharge to be made during BSL quarry operations for different BSL levels.

Conclusions

An areal, two-dimensional groundwater flow model has been developed to study spatial change of water levels upon BSL excavation in the quarry site of the Lafarge Kocaeli-Darıca Cement factory. The studied model has been successfully calibrated to the field conditions and a correlation analysis yielded very high correlation coefficients between the observed and the computed values.

During simulation studies the quarry site has been flattened for the next 30 years and then the BSL excavation was started at a distance of 170 m from the shoreline. For each of the BSL levels areal distribution of the water levels has been obtained. The amounts of water discharge required for BSL operations were also determined in the simulation runs. It is found that the amount of water discharge would be very low and would not create a serious problem during future excavations. This conclusion is in a very good agreement with the previous cross sectional model.

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SUSTAINABLE USE OF WATER RESOURCES AND RURAL DEVELOPMENT IN DROUGHT AFFECTED AREAS

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Existing and planned EU policies have identified links through common environmental issues, however in their formulation and assessment strategies they still focus substantially on single thematic issue. As a result, the implementation at local level is rather unconnected and local policies and management measures confirm this approach both at institutional level and in practical terms.

For the water resources, an example of an integrated approach is the Water Framework EU Directive which indicates the Water District as the elementary territorial reference unit on which environmental management decision policies should be defined. The delayed implementation of that Directive in the EU countries highlights the difficulties to translate the integrated approach at local level.

The paper is dealing with a pilot project finalized to set up an integrated approach in water resources management, involving water districts belonging to the Mediterranean Regions and relay on a case study, based on the preliminary results of a current research activities carried out in Basilicata (Southern Italy) and in Crete. The participatory watershed management is the base for predicting the social, economical and environmental implications of the selected integrated management of conservation measures, recognizing the crucial role played by people participation and collaboration among different institutional and social actors.

A web-based tool for assessing social and economic impacts of integrated policies/measures at territorial level has been developed and validated both under the methodological and empirical profile.

The first simulation results obtained in Basilicata pilot area seem to be very helpful showing its potentialities for other areas with analogous characteristics. The tool, that is going to be tested also in Crete pilot Basin, is intended to support the decision making processes on sustainable use of natural resources and it is designed to be useful in assessing the effects (ex-ante and in-itinere) of implementing the 2007/2013 rural development and environmental policies in different contexts.

Key words: *Water Framework Directive; Integrated natural resources management; Participatory approach; Policy evaluation*

1. INTRODUCTION

At EU level the importance of environmental integration is progressively increasing. It is recognised, in fact, in the Article 6 of the EC Treaty, which stipulates: "*environmental protection requirements must be integrated into the definition and implementation of the Community policies […] in particular with a view to promoting sustainable development*". In 1998, when the so-called Cardiff process started, the environmental integration process received an institutional impulsion, recognising that environmental policy alone can not achieve the environmental improvements needed as part of sustainable development. It is only integrating environmental concerns into other sectors, such as agriculture, fisheries, transport, energy etc. and reducing environmental pressures coming from them, that sustainable development can be achieved. Afterwards, in 2001, during the Gothenburg Summit, has been adopted the EU Sustainable Development Strategy (EU SDS), with the main aim of pursuing both priority environmental goals and the integration of economic and social objectives with environmental matters. In other words, the Strategy tries to combine a dynamic economy with social cohesion and high environmental standards. It, in fact, underlines the need "*to finalise and further develop sector strategies for integrating environment into all relevant Community policy areas with a view to implementing them as soon as possible*".

The EU Water Framework Directive (WFD) derives from this approach and it aims to develop an integrated water resources management. In short, it mainly attempts to achieve a «good status» of water bodies. Among all the European legislative instrument implemented, the WFD represents the finest example proficient in addressing both European and global concerns about environmental problems. Despite political, organisational and investment efforts, the quality and quantity of water resources is inadequate in many European countries. This appears clear comparing them to the standards underpinned by the Water Framework Directive (WFD). The motivations behind this situation are different: from the fast urbanisation and industrialisation processes to the intensive land use. To tackle these pressures, the EU has implemented several legislative documents. However, the numerous gaps between WFD requirements and existing legislation and policies alongside its scarce implementation by the Member States, still represent a source of several pressures.

Starting from these considerations, the focus here is on the European Common Agricultural Policy (CAP) and the Rural Development Policy in the context of the WFD.
Taken for granted that agriculture and forestry, which cover more than three quarters of the European Union's land, play a key role in determining rural economies as well as rural landscape, it is necessary to develop synergies between policy sectors and instruments, both addressed at agricultural activities and water protection efforts, whereby to reach the WFD objectives and to undertake the pressures resulting from certain agricultural practices.

The European agriculture is extremely diverse, ranging from large and specialised commercial production based on intensive farming practices to subsistence and semi-subsistence farming using mainly traditional practices. Its impacts on the environment vary both in scale and intensity. On one hand, modern farming methods, despite its benefits for the whole society, exert considerable pressures on the environment, including on water resources. On the other hand, agriculture plays an important role in maintaining the countryside and its biodiversity, providing undoubted benefits for the environment, particularly in those European regions where the environmental risk associated with agricultural change is that of abandonment. In light of this, the European Common Agricultural Policy (CAP) has been progressively reformed, trying to reduce pressures from agriculture on the environment. For instance, the most recent reform of the CAP (in 2003) reduced incentives to produce intensively, by decoupling payments from production and linking them to the respect of environmental standards (cross-compliance), and increased opportunities to support farmers in addressing environmental issues through Rural Development (RD) payments. However, the possibilities to improve the environmental situation by using only the existing CAP measures are rather limited by competing demands on RD and a limited overall budget. Despite the existing RD measures supporting the environment, different Member States are missing the opportunity for using them to reduce the negative impact of agriculture on the environment. This depend on both administration and farmers weakness. In some cases, for example, there is a lack of information. A further effort, thus, is needed in promoting projects aimed at improving the education of farmers about the importance of protecting the environment, in particular water resources.

Bearing this in mid, this paper shows the integrated water resources management approach already set up, utilising the partial results of an ongoing pilot project run in two water districts belonging to the Mediterranean Regions. In particular the paper, focuses on a specific web-based tool for assessing social and economic impacts of integrated rural policies/measures at territorial level, underlining the crucial role played by the adopted participatory approach. After a brief description of the WFD and its relationship with EU rural development policies (first and second pillar), the objective is to describe the methodological approach utilised to build the tool. The first results obtained are then discussed, drawing preliminary conclusions.

2. EU Water Framework Directive and EU Rural Policies

As stated, the agricultural sector has a twofold role in the water management. On one hand, it represents one of the main causes of water degradation. On the other hand, it strongly depends on the availability of sufficient qualitative water. It appears clear, then, the need to establish a common approach and to develop a common language between the two policy sectors.

The Water Framework Directive entered into force in December 2000. It operates on a larger scale than in the past, involving all aquatic systems, surface waters (rivers and lakes), groundwater and coastal waters. Its main goal is to achieve a "good status" of all waters through the implementation of river basin management plans, including summaries of programmes of measures, in accordance with its eight main objectives[7]. The programmes of measures, in fact, can be considered as the principal mechanism for the implementation of the environmental objectives of the WFD and they have to be developed for each river basin district (Hansen et al., 2004). Furthermore, these programmes have to be established by 2009 and made operational by 2012 (Art. 11 WFD) and they should be based on a risk assessment (Art. 5 WFD).

The WFD distinguishes between '*basic measures*' (minimum requirements) and '*supplementary measures*'. Basic measures include, according to Annex VI (Part A), the implementation of a number of environmental directives (e.g. Nitrates Directive (91/676/EEC)) that are directly or indirectly involved in the water protection. When the basic measures are not adequate for achieving the environmental objectives, supplementary measures can be taken into account (Annex VI Part B WFD). The Directive, in fact, provides a non-exclusive list of such measures, which are aimed at either reinforcing the provisions or setting up new ones. Programmes of measures can also include not exclusively water-based activities, such as measures regarding land use activities, putting further pressure on the agricultural sector, especially with regards to income development, and requiring further discussions on the necessity to compensate farmers. As a matter of the fact, in accordance with the Annex III, the WFD necessitates the identification of the most cost-effective combination of measures to be included in the programme of measures based on the information provided by the status report and the monitoring.

[7] The WFD has the following main objectives:
- Expanding the scope of water protection to all waters;
- To achieve the "good status" of all waters in the Community by 2015 and ensure that there is no deterioration in the status (Art. 4);
- Water management based on river basins across national boundaries, choosing an integrated approach within river catchment areas;
- "Combined approach" of emission limit values and quality standards, plus the phasing out of priority hazardous substances;
- Introduction of incentive water pricing policies to help achieve objectives and the polluter pays principle;
- Getting the public more closely involved in water issues, which means interested parties must have opportunities to participate;
- Streamlining water legislation;
- Establishing a coherent managerial framework for all water-related legislation (e.g. energy, transport, agriculture, fisheries, regional policy, tourism), thus allowing for consistency in planning and measures at the same time.

Among the EU policies, the CAP, established in 1962, represents one of the EU central policy areas and one of the most developed forms of EU supranational decision-making and it involves a larger share of the EC budget than any other policy. The latest CAP reform took place into a context of various internal developments and external pressures, such as the WTO negotiations, the EU enlargement process, the increased awareness concerning environmental protection and nature conservation and so far. In sum, the key elements of this reform are four. First, the introduction of *decoupled payments*. From 2005 onwards, the majority of direct payments are paid to farmers independently of their production volume and together with the farmers' respect of environment, animal and plant health, animal welfare standards as well as the requirement of keeping all farmland in good agricultural and environmental condition, (*cross compliance*).Second, the reduction in direct payments for bigger farms. The funds raised are used to fund rural development measures, *modulation*. In other words, these modulated funds are added to the rural development budget and redistributed for rural development purposes across the Community, in particular those Member States with greater rural development needs. Fourth a mechanism for *financial discipline* to ensure that the farm budget fixed until 2013 is not overshot. Finally, the revisions of the *market policy* of the CAP, focusing especially on the asymmetric price cuts in the milk sector, a reduction of the monthly increments in the cereals sector by half and reforms in the rice, durum wheat, nuts, starch potatoes and dried fodder sectors.

The EU rural development policy, on the contrary, historically developed within the CAP in response to the geographical and landscape difference among European rural areas as well as to the challenges they have to face. These challenges range from the restructuring of the agricultural sector, isolation, poor service provision and depopulation to population influx and pressure on the natural environment, particularly in the rural areas near urban centres, (Bendz, 2004). Over the years, rural development has increased its importance within EU agricultural policy. In 1999, in fact, the introduction of the RD Regulation 1257/1999 (RDR) marked an important step in the strengthening of this policy. The RDR gathered up numerous policy measures in a single instrument, forming the 'second pillar' of the CAP concerned with rural development. Broadly speaking, the EU RD policy is designed to connect agriculture with the protection of the rural environment, the quality of produced food and the attractiveness of rural areas to young farmers and new residents, highlighting its multifunctionality. The new Council Regulation on Support for Rural Development by the European Agricultural Fund for Rural Development (EAFRD) has been adopted on 20 September 2005. The reform is based on four major policy objectives (Axes). Axis 1 aiming at improving competitiveness of farming and forestry. Axis 2 concerning with the environment and land management. Axis 3 to improve quality of life and diversification. Finally, Axis 4 (LEADER) that streamlines the local development strategies adopting a bottom-up approach. In sum, the three Axis consist of many different measures, with a variety of objectives: specifically, potentially and implicitly environmental. Obviously, Axis 2 offers much more opportunities for a direct contribution to the delivery of WFD objectives, in particular in relation to payments linked to the WFD (Art. 38). However RD programmes should not just involve directly targeted measures but should also consider how other measures might be tailored so as to give added value by contributing to the WFD delivery. Improving competitiveness of farming and forestry (Axis 1) and improving quality of life and diversification (Axis 3) offer opportunities to contribute indirectly to WFD delivery.

Care needs to be taken to assure the sustainability of land management practices in order to continue both to preserve water resources and to draw upon the benefits that soil provides: clean water, flood control, food and timber, wildlife habitat and a pleasant place to live. Most analyses have treated water and land issues separately. Yet the quality and flow of water resources is determined mostly by the management of land resources. By the same token, the productivity and sustainability of land resources are critically associated with water resources. Thus, the best results are to be obtained by managing both resources simultaneously within a landscape framework.

Soil issues are, in fact, often linked to water and air, as well as land use, which adds a socio-economic dimension to managing environmental impact. Problem issues with soil and water impact on both rural and urban communities - but with agriculture managing three-quarters of the EU land surface, this industry has a key contribution to make in resolving the problem.
The interactions between land and water are attracting increasing interest from the perspectives of science, policy and practice. The water and land sectors have also been brought closer together through the links increasingly being made between the Water Framework Directive and the reform of the Common Agricultural Policy.

However, the developing focus on the relationship between **land** and **water** at a catchment scale has often tended to overlook the critical role of **soil** at the interface. In reality the structure, properties, and management of soil are all key elements in meeting emerging EU policy objectives.

A failure to understand the role of soils and their interactions with water in the environment means that society is missing opportunities to find cost-effective ways of mitigating problems and delivering benefits[8]. Government policy makers have responded by delivering policy statements, action plans, manipulating subsidy and support schemes, amending legislation and urging other policy makers and society to move forward. There is broad agreement that soil and water is important and that considering the scale of the problem its' resolution cannot be left to individual land managers/farmers or agencies acting alone, concerted and co-ordinated action will be needed. The key task ahead is to deliver the necessary changes in farm practice at a regional and local level. Critical to success is the active engagement and support of all stakeholders and land managers/farmers.

[8] **Soil and Diffuse Pollution:** Better soil management in water gathering grounds would reduce the costs of treating water to remove nitrate, pathogens and pesticides from drinking water.
Soil and flooding: Managing soils to capture hold water upstream would reduce the impact of fluvial flooding on settlements downstream, reducing the need for investment in flood defences.
Soil, organic matter and fertilisers: Making greater use of organic composts would enhance soil productivity and structure and sequester carbon that would otherwise contribute to climate change.
Soil, siltation and aquatic biodiversity: By tackling soil erosion, better soil management would reduce the impact on game fisheries of siltation of spawning gravels.

3. The integrated approach proposed

The equilibrium regulating the relationship between economics activities and environment is quite delicate. It depends particularly on the utilisation of resources which should always be suited to the environmental conditions. Sustainable evaluation of this relationship it is not so easy, because it involves environmental aspects and also social and economic dimensions, both at the economic unit and a wider scale. With this in mind, there is a need for a tool that easily supplies, in an immediate and simple way, a synthetic judgment on natural resources management, considering reciprocal relationships that exist between management options, climate, physical-chemical-biological soil characteristics and water quality and quality. In this way all the people using resources or planning development strategies, can simulate the effects of different technical solutions, evaluating all the generated impacts. Such a tool can support a substantial distribution of sustainable techniques and technologies, appearing as a valid aid for policies implementation, as well as acting as a useful tool to support development programmes at the wider scale. Research has highlighted that available methods used to evaluate sustainable economic practices are extremely complex, and often not practical. It is to answer this implicit need of simplification that the proposed operational tool offers an easy and immediate answers to everyone involved in natural resources management. The method may not consider the complexity of all existing interconnections among different variables that influence sustainable processes according to indexes/indicators available for stakeholders, but it tries to keep the essence of the linkages associated with degradation. ManPrAs is a tool for Management Practices Assessment[9].

The tool already developed has the objective to suggest a method to assess the sustainability of agricultural practices and other rural land use through its soil conservation index (SCI) and economic results (Gross Margin-GM), and to simulate the impact on soil degradation, farm profitability and socio-economic features of alternative crops in a specific context. The tool is strongly user-orientated, and allows assessment of the environmental and economic aspects of rural management practice, giving a powerful simulation tool to farmers and stakeholders involved in land management.

[9] An agricultural version of ManPrAs was set up within DESERTLINKS project and it is going to be further developed in the IMAGE – Archimed Project.

The tool is composed of two different but integrated parts:

- The first part allows the calculation of a soil and water conservation index (SCI), a "dynamic" indicator of soil and water quality combining the interaction among the physical-chemical and climatic site characteristics and the single management operations. SCI considers the effects of both physical-chemical-climatic characteristics and the management operations on the principal threats to soil (erosion, decline in organic matter, soil contamination (local and diffuse soil contamination), soil compaction, decline in soil biodiversity, salinisation). Each interaction among the three classes of parameters (physical-chemical-climatic; management operations; soil threats) has been established taking into consideration both the literature review and stakeholder consultations. For each parameter value classes have been derived taking account of the same information. There are essentially two starting points: a) Each single soil operation (technique) influences soil conservation. Every single agricultural operation can influence, to a greater or lesser extent, soil and its capability to maintain its intrinsic characteristics. b) The final effect (direction and intensity) depends both on the modality (management) and the context characteristics (climate, physical and chemical properties, site specific). The final effect of every agricultural practice, in terms of both direction and intensity of the process, strongly depends on how this practice is carried out (i.e. on the management) and on the context in which it is adopted (climate, physical and chemical characteristics, site specific).The SCI calculation procedure requires that all the three interacting dimensions have to be specified: soil threats, climate, physical and chemical soil characteristics, agricultural practices.

The second part of the tool is designed for the economic evaluation of management practices. Through an algorithm it is possible to obtain the gross margin (GM) for each practice. Most farmers, including those involved in sustainable agriculture, carry out a number of different enterprises (e.g. different crops and livestock) with a wide range of technologies (agricultural techniques) and often need to address one of the following questions.

- How would the returns over variable costs of my enterprises be affected by changing production practices having different effects on soil/water conservation - soil/water degradation?
- How would the returns over variable costs of an enterprise change, if the product price and/or subsidies structure and/or input costs changed?

Gross margin analysis (GMA) provides a convenient and simple way to summarize information required to address such questions and, as a result, can provide a useful tool in planning changes, also with respect to soil threats. Gross margin is the difference between gross income[10] and variable costs[11]. It is convenient, because it provides a measure of returns over variable costs and is a step in the direction of measuring profit. It is simple, because it does not consider fixed costs[12], which can often be difficult to allocate to individual enterprises. Users of GMA need to be aware that the simplification gained by not considering fixed costs gives rise to some limitations. Profit is often defined as returns over total costs. Therefore, one must account for both fixed and variable costs when measuring the profit of farm enterprises, even though this latter term is useless with family farms (the most common type of farm all around the world).

Together, SCI and GM, provide the possibility of checking the degree of soil conservation on a farm, the tradeoff options to switch towards more or less sustainable practices, and the economic impact.

4. ManPrAs validation: some remarks

In order to validate the tool, simulations, with the agricultural version of ManPrAs, were performed in a Basilicata pilot area. ManPrAs has been used to calculate the SCI index related to different agricultural techniques in similar environmental contexts, to both verify the impact of the management variables on the index value and to compare similar agricultural techniques in different physical contexts. The validation has been made at a qualitative level, comparing the results both with the farmers judgement and by direct field observations. All the results obtained are in line with the ManPrAs conclusions both in terms of soil conservation and economic results and they will represent a first stage within an ongoing EU Archimed project named IMAGE. The aims of the project is to set up a Water and Rural Development Support System (WARDSS) intended as a computer based open-source tool for predicting the social, economical and environmental implications of an integrated management of conservation measures. In both the pilot areas (Agri Basin in Italy and Crete in Greece) the WARDSS, based on an inter-institutional and a participatory approach, will be used as a support tool for decision making processes on sustainable use of natural resources and rural development and as such it will be useful in assessing the effects (ex-ante and in-itinere) of implementing the 2007/2013 rural development policies in different contexts and the implementation of WFD.

[10] Value of production of the enterprise. It takes into account not only what is sold but also an estimated value of what as been produced but not sold during the period under consideration. The latter is in essence income, although this is not realized in cash terms until all the product is sold. Sometimes the combination of sold and unsold products is called gross product. Gross income also may be called gross revenue or gross receipts.

[11] Costs that vary according to the level of production (e.g., more wheat leads to higher fertilizer costs). Variable costs are the costs of inputs, such as seed or fertilizer, that are normally used up in a short-run production period. In many cases, variable costs are associated with specific enterprises and thus are sometimes called direct costs.

[12] Costs that have to be paid whether or not production takes place (e.g., interest payments on land). Fixed costs are the costs of inputs that are normally not used up in a short-run production period. Therefore, they are sometimes called overhead costs or common costs, because in many cases, they cannot be allocated easily to a specific enterprise. This means that expenses that do not change, no matter what enterprise(s) you implement or at what level, are fixed costs.

The ManPrAs tool represents a fundamental part of the WARDSS. The participatory approach utilised in the IMAGE project is relies on the consideration that any policy can be implemented successfully if it does not have public acceptance, and success is extremely unlikely without the acceptance of relevant natural resources (water and soil) users. Thus, public participation plays a key factor to develop a common approach between farmers and authorities responsible for water management at all levels. The involvement of relevant stakeholders, such as farmers, water suppliers and nature conservation groups, can give the possibility to identify measures that result in benefits for each of the parties (for example, farmers can reduce the costs of mineral fertilisers and pesticides thanks to a better application of these substances; water suppliers can abandon responses to increasing water pollution, such as the closure of wells).

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MULTI DISCIPLINARY MODELING, IN STRATIGRAPHY AND GROUNDWATER STRATIGRAPHY OF THE JORDAN RIVER BASIN.

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The study area is known in several names all following eminent morphological features, the Jordan River flows along the center of the Jordan Valley, and the Dead Sea which is the lowest water reservoir found on the globe (412 m B.S.L.), had granted its name to this exceptional region of the Dead Sea Rift. This uniqueness is as well by geological means since series of intense tectonic offsets had created the Dead Sea rift valley. The study area is considered arid in its southern border, to semiarid in its north. Along the last few decades water budget became depleted, restraining the natural development of the prevailing agricultural settlements scattered in the study area. Preliminary groundwater flow model suggested that large amount of freshwater is lost as consequence of salinization processes that occur as groundwater of the mountain aquifers penetrates the saline clastic Neogene aquifer complex. Delineation of the local hydrogeological system is essential in order to approve the regional water management policy. Since the Rift valley is lacking outcrops or boreholes penetrating the aquiferic rock sequence, an interpolation of models from several fields of geosciences was applied. The methods conducted during this research included: geological survey, geophysical modeling based of interpretation of seismic profiles and geochemical modeling based on chemical and isotopic analysis of runoff, sediments and groundwater.

From the results of the research several important conclusions are emerging: groundwater are becoming saline as it flows from the Rift margins to its center, utilization of these groundwater on the hillsides is recommended, nevertheless, the margins of the Rift are penetrating the valley exhibiting in places relatively high cretaceous aquifer sequence fit for utilization (up to 20 mm^3/A). The input of deep-seated saline sources to the aquifers, found in the geochemical model, is making zones with dense vertical faulting systems found in the geophysical research as suspected conduits for these saline sources. Fresh groundwater in the clastic aquifer complex is rare, furthermore, two evaporates bodies were encountered (Auja and Zaharat el Qurein), probably acting as the source for fresh water salinization. While, runoff recharge quantity to the Jordan Valley aquifer complex is negligible, the unique increase in runoff and runin TDS, is transforming this negligible freshwater recharge to a significant salts contributor.

Introduction:

The study area is located along the Lower Jordan Valley (Figure 1), though during the last decade the natural development in the region is some what restricted due to the roll of sustainable water supply as natural resource, the unique climatic and socioeconomic setting is making the potential for development to be very high. The northern part of the study area is considered semiarid with precipitation of about 200 mm/Y whereas in the south, it is arid with less then 100 mm/Y. Groundwater recharge by runoff and runin is significant during winter and is characterized by a regime of random floods. Runoff is draining mainly to the Jordan River system flowing southward, to the Dead Sea (Ferber et al., 2004).

Drawing the overall picture of the Jordan Valley hydrogeologic system must be based upon the geological history, of the Dead Sea Rift Valley. Tectonic processes forging the hydrogeologic system of the study area can be the keys for the reconstruction of major events in the basin history. Thus, phases such as: seawater penetrations which occurred three times since the regression of the Eocene sea. And mainly since the Miocene, fast subsidence of the basin floor, compression and decompression resulting folding and faulting during the uplift of the eastern and western borders of the Dead Sea basin, should be placed in their right space and time location. Another Important aspect concerning the Salinization process mechanism might give a hint about the force that in both saline end members is either forcing groundwater to dissolve salts on their path or, pressurizing salts in to the fresh groundwater reservoirs.

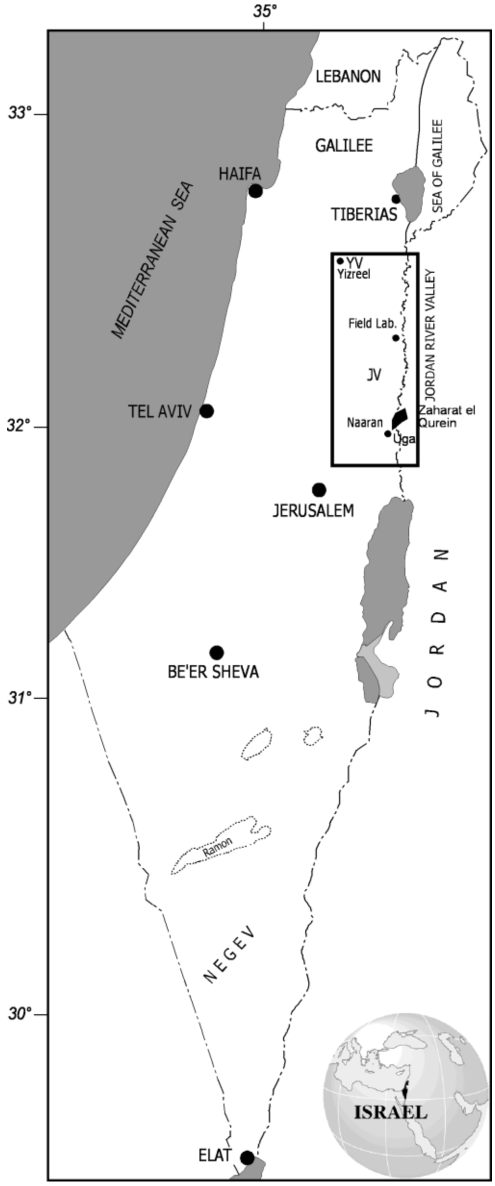

Figure 1: location map

The Dead Sea Rift Valley (Figures 1) was formed along the intra - continental Dead Sea Transform. The transform is some 1000 Km. Long, forming the boundary between the Arabian plate and the Sinai sub – plate, which is an appendage of the African plate (Garfunkel and Ben Avraham, 1996).

The pre transform continental Pan African orogen was consolidated during the Late Proterozoic, and during most of the Phanerozoic it behaved as a rather stable platform, which was covered by few kilometers of mostly marine sediments. Few tectonic and magmatic activity phases had punctuated the platformal history, when the most important were during the Permian, Triassic and Early Jurassic. These phases are related to the formation of the Eastern Mediterranean branch of the Neo – Tethys and had shaped its passive margins. Mild compressional deformation (Syrian arc phase) had started during Late Cretaceous beginning the closure of the Neo – Tethys neighboring part, ending some time along the Miocene. While producing bundle of NNE – SSW to ENE – SSW trending folds, and a group of East – West trending lineaments undergoing right – lateral shearing of up to few kilometers (central Negev shear belts) (Garfunkel and Ben Avraham, 1996).

The detachment of Arabia from Africa (Young continental breakup phase) had started in Late Oligocene, creating the Red Sea where incipient sea floor spreading took place. Initial stage with mostly western movement yielded the opening of the Suez Rift followed by more northern component yielding the Red Sea the Dead Sea Transform; hence the combination of these two features covered the largest part of the Arabian – African plate motion. Young sediments faulting and on going present-day seismic activity indicate that this phase has not ended yet. Left lateral movement of about 105 kilometers was measured based on matching of the platformal sedimentary cover (older then 20 Ma.) and some units of the basement crystalline complex across the transform. Refined movement estimate was obtained from displacement of major lineaments such as the Sinai – Negev shearing belts and old (about 20 Ma.) dikes crossing the transform. There is a large angel between the axis of the transform and of the Dead Sea; hence, the link between the opening of the Red Sea and the movement on the transform provides an additional constraint.

Methods:

The study of groundwater transport and interactions required use of several methods out of different geosciences fields. Preliminary survey yielded reasonable illustration of the study area margins geology and stratigraphy, wide database was established consisting of hydrological, geophysical, geological and hydrochemical parameters. In addition, a comprehensive study of the regional sub-surface three-dimensional geological and geophysical setting was delineated, in order to define the regional anatomy of aquifer structures, and of morphotectonic elements that influence the hydrological setting. The subsurface stratigraphy void along most of the central part of the valley was accomplished out of seismic interpretation of about 20 seismic profiles spread all around the study area and number of key–seismic profiles out were interpreted were also selected for geological modeling. Five seismic reflectors interpreted as stratigraphic layers with hydrogeological significance extrapolated as structural depth converted layers.

Finally in order to give quantities estimation of recharge and Salinization processes occurring during the infiltration of fresh water into the multiaquifer system. Several models were applied based up on the reconstruction of hydrogeochemical paths. Since the different water solutions – rock interaction reconstruction, is essential, two hydrogeochemical regression models were applied, and preliminary thermodynamic salts dissolution model (SNORM). The first regression model was VBA salts reconstruction model, which came to refine the results of the SNORM model, and to indicate the potential salts dissolved or precipitated in each solution. Following by applying the results of the initial modeling and field research to classification of the various groundwater bodies and salinization sources that formed the data set for the USGS PhreeqC regression modeling which produced probable pathways for formation of the different freshwater type out of the sources of salts and fluids.

Results and discussion:

As mentioned the geochemical modeling had been preformed in order to localize the water groups and saline sources in the geochemical expanse in order to interpolate it in the geological expanse a geophysical conceptual modeling was accomplished.

Geophysics

Geophysical data such as seismic reflection and gravity surveys were used to reveal and delineate major subsurface structural elements that control the geohydrological setting and enable its reconstruction and evaluation. Compilation of this data yielded sufficient framework for construction of conceptual hydrogeological model for the region. Several important implications were learned about the structure and tectonic setting of the subsurface. The interpreted time sections were converted to depth as part of the geological modeling and several geological cross sections were produced. Five reflectors were delineated as key horizons, Top Neogene indicate the transition from the Tiberias group to the Dead Sea group, Top Eocene underlying it, Top Cretaceous, LC3 indicate the transition from Lower to Upper Cretaceous and finally Top Jurassic, in addition in some profiles the Top Triassic reflector was also delineated.

Subsurface structure is naturally a major factor in the reconstruction and evaluation of the geohydrological setting. The mountainous margins of the area were studied by Mimran (1969), Shaliv (1972), Benjamini (1973) and Begin (1975) in the west, and by Muneizel and Khalil (1993) and Shawabakeh (2001) in the east. Shaliv (1972) and Guttman (1997) studied also the hydrological network both indicating that there is a southern groundwater flow component except for the Faria area where it seems to be due to the local structure of the Faria graben (Shaliv, 1972).

A broad observation of the entire region suggested that this southern component is consistent along the margins, increasing southwards as the Dead Sea basin is predominant. The eastern margins hydrological setting is some what different; it seems that the flow pattern is mainly westward nevertheless it is shifted in places due to local structural elements (Salameh et al., 2003). While in its western flank the inclination to the rift is characterized by several normal step-blocks, the inclination of the eastern flank is more rapid along several increments of one major normal fault (Salameh et al., 2003). However, several relatively east-west directed faulting system are crossing the rift causing discontinuance in the eastern border fault system and as such acts as conduits for groundwater. Two distinctive such systems are the Wadi Shu'ieb (Shawabakeh, 2001) and Wadi Zarqa (Muneizel and Khalil, 1993) systems. In the same way the western step-blocks margin of the rift are interrupted by the structural basins found in its center. The faulting systems of the basins Dead Sea, Faria, and Argman regions differ from one another (Figure 2). The main runoff and groundwater drainage basin in the region is the Dead Sea; Malaha basin is an intermediate basin draining after cetin threshold to the Dead Sea. The Argaman - Fari'a groundwater basin is unique since under the current hydrological setting it is terminal and not a part of larger basin hence, Bet Sean basin on its north and the Dead Sea at the south. The hydrological impact is well noticed from the flow lines in the geohydrological map of Shaliv in IGS, (1983), diverting the groundwater northwards north to the Fari'a structure.

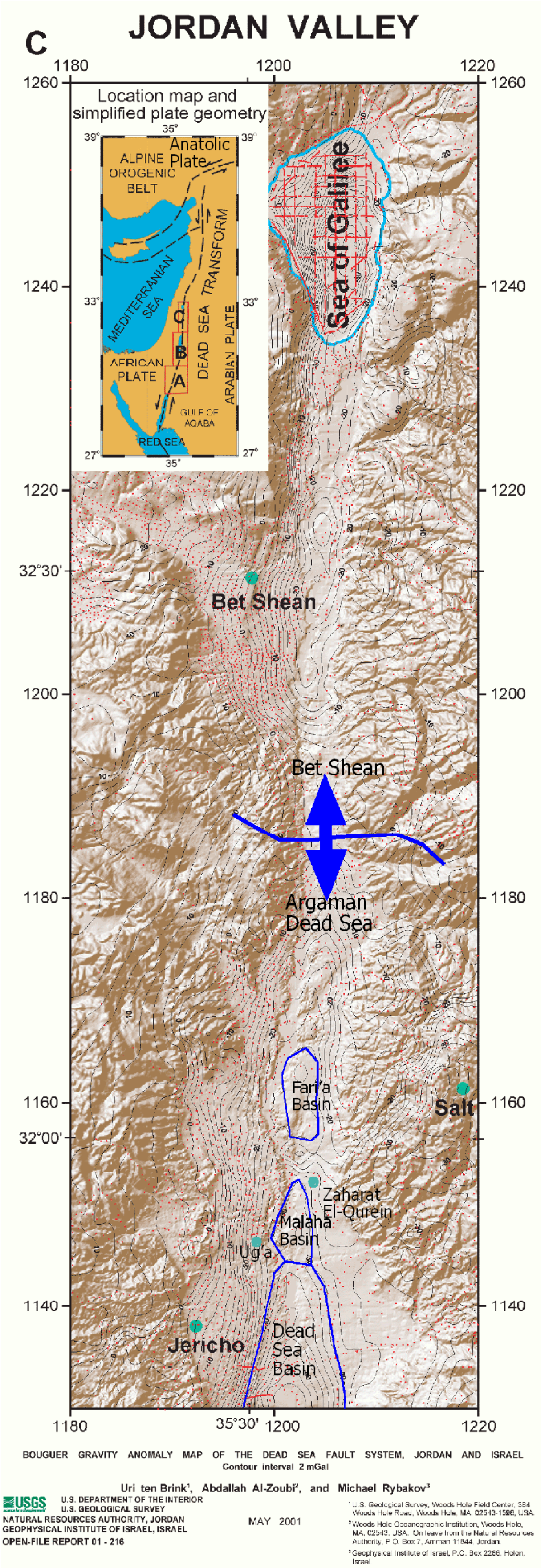

Figure 3: Bougur gravity anomaly map after Ten Brink et al., (2001), showing a chain of basins suppurated by structural saddles

Furthermore, the juxta position of the Eocene sequence with the Cretaceous aquifer is serving for groundwater production in the Argaman wells which are located on Eocene outcrops along hydrological divide line between the Fari'a basin and the Argaman basin that is located north to it. Shaliv in IGS, (1983) also implied that the study area can be divided into three basins, the Dead Sea basin, The Intermediate Fari'a basin, and the Argaman basin. This assumption can be farther concluded from the Bougur gravity anomaly map **(Figure 2, Ten Brink et al., 2001).** These three basins are located along the rift, while the southern basin is the northern extent of the Dead Sea basin. In this southern region that reaches the current shore of the

Dead Sea Lazar (2004) defined two sub-basins filled with sediments, accumulated during the time when the Dead Sea and its progenitor lakes were covering that area.

The Dead Sea transform major faulting system which, as in the work of Lazar (2004), was not definitely encountered in any of the seismic section interpreted, nonetheless, it is probably emerge north to the northern Dead Sea province (Lazar, 2004), running east to Jordan River gorge to the north (Salameh et al, 2003). The last major faulting element noticeable along the study area is the Jericho fault (Begin, 1975, Reches and Hoexter, 1981, Gardosh et al., 1990) which can also be seen as linear feature in aerial photos. The Jericho fault starts where the rhombic feature of the Dead Sea basin ends (Lazar, 2004) pushing northwards and sub-parallel to the Jordan River. The appearance of a flower structure in seismic line might indicate some lateral movement on the Jericho fault. Interesting findings emerged from the interpretation of five seismic lines in which a lenticular body was observed (Flexer et al., 2004). In addition Halokinetic phenomena such as up-swelling of the strata were encountered at its margin (Figure 3). The overall structure of the body, as well as its almost transparency appearance which is in contrast to the coherent events surrounding it might imply that this lenticular body is made of halite – rich evaporites with inter bedded clays, marls and aragonite. Further reinforcement to the assumption is being extrapolated from trenches study made by Lazar (2004) and from methodological study of soils, soil crusts and seasonal lake, which were made during this study. Lazar (2004) described the sediments of the trenches as “salt saturated”, and also in the current study the bed of the Malaha seasonal lake were found to be “salt saturated”. These observations are strengthening by the findings of high concentrations of halite gypsum and other evaporates in soil samples from all around the study area.

From correlating this finding with the works of Lazar (2004) and Ten Brink et al. (2001) it can be implied that the evaporitic body is located at the northern point of the Dead Sea Northern Province that, can be noticed on the Bougur gravity anomaly map as a local low (Figure 2). About 10Km to its north Belitzky and Mimran (1996) interpreted a gravimetric anomaly at Zaarat el Qurein as being the result of halokintic movement in a local evaporitic system. As implied from the geological interpretation of the area, branching of the Malaha evaporitic body to the nearby Zaarat el Qurein system can not be ruled-out. Although west to the Jordan River it is delimited by local hydrological divide line from the intermediate Faria basin (Shaliv, 1983 and Ten Brink et al., 2001), sleight correction in the path of the Jericho fault can locate a strike slip fault between these two evaporitic provinces (Figure 2), even dough estimation of the horizontal movement is not yet possible this connection can not be out ruled.

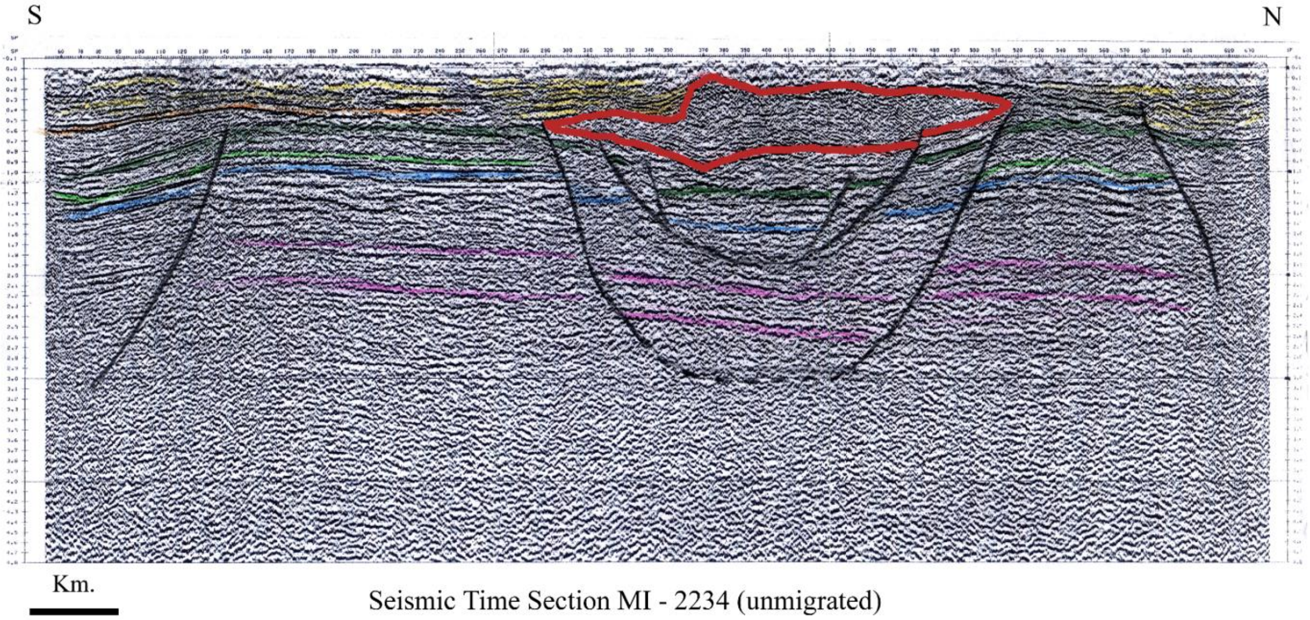

Figure 3: Geological interpretation of seismic line MI-2234 indicating for possible existence of evaporated minerals accumulation

Geochemistry

After reviewing different methods for water classification, the classification that was found most suitable is the one which was used by Taussig (1961), with some enhancements according to Starinsky (1974) and Vengosh and Rosenthal (1994) and Möller et al (2006). Taussig (1961) defined several representative water groups which, differ by chemical parameters, and represents most of the natural water groups in the region. Further more, some propositions for the morphosis of these waters were suggested. In the following decades many researches were made in these fields of sciences while, Starinsky (1974) and Vengosh and Rosenthal (1994) were found to add important knowledge, required in the current research. Möller et al (2006) had dealt with definition of regional saline end members, and their relations with the local aquiferic units, they are deciphering the end member into preliminary, secondary and tertiary brine or salts types.

Table 1: Data set for the PreeqC modeling

Phreeq #	Temp	pH	Density	Ca	Mg	Na	K	Cl	S(6)	Alkalinity as HCO_3	Br	Name	Ref.
1	20	7	1.000	4262	2682	9955	592	25261	4276	87.9	1595	# Runoff - Kfr5	Current study
2	20	6	1.220	16700	43800	35600	7410	220000	450	220	5500	# Dead-Sea	Stein et al. 97
3	20	8	1.023	410	1290	10800	400	19500	2690	140	67	# Ocean Water	Broecker and pang 82
4	20	7	1.000	3067	861	6851	338	18053	751	171	246	# Kineret 2	Starinsky 74
5	20	7	1.000	1530	24	1525	14	4370	1140	12	34	# Timna (D-683)	Starinsky 74
6	20	7	1.243	50600	12000	50500	1030	202000	122	61	3670	# Arava-1	Bentor 69
7	20	7	1.000	410	783	1230	155	4840	103	320	98.6	# Yam-7C	Moise 96
8	20	7	1.000	3330	651	6800	316	18000	788	140	230	# Tiberias-main	klein et al. 04
9	20	7	1.000	501	146	1420	51.8	3200	259	304	304	# Sartan-Iver	klein et al. 05
10	20	7	1.000	43.9	81.3	100	0	212	46	306	0	#Anton Nazzal 2 10	Geohydrological
11	20	7	1.000	35.0	26	37.0	0	71.0	12.7	215	0.2	# Sa'id Abu Mansour A-6	Information
12	20	7	1.000	126	56	260	0.08	577	92	199	5.9	# P_MHAOULAH_2	Center
13	20	7	1.000	70.0	46.1	70.0	0	187	24	273	2.1	# Gitit 3	Tel Aviv
14	20	7	1.000	111	76.3	167	1.47	475	41	328	6	# Jericho 1	University
15	20	7	1.000	237	208	610	0.00	1798	53	282	26	# MK_PTSAL_11	

After interpolating the groundwater of the study area in to chemically representative groups, six major groups which represent chemical parameters of several reservoirs, were defined and evaluated using the different models for the sources of salinity dictating their chemistry (Table 1).

The first geochemical group is similar to the first water group at Taussig (1961), according to that work this water had undergone dissolution of carbonates or sandstone with calcitic cement and input of soluble carbonate salts. This group is including much of the water of the Quaternary and Neogene aquifer complexes on the western Jordan valley, and is typical to the low salinity groundwater. The sources of salinity to water of group 1 are combination of Dead Sea type brines, runoff, Seawater residue, Kinneret 2 type brine and Arava 1 type brines (Table 1). In addition there is significant contribution of dolomite Halite and Gypsum dissolution and calcite precipitation. The Dead Sea type brines were regarded by Möller et al (2006) as a complex mixture Lisan or proto – Dead Sea brines from different sources.

The second water group is similar to group five in Taussig (1961), which represent water that have Ca – Chloride association. This water group was studied by Starinsky, (1974) and is common in the Jordan Rift Valley Water of this group can be found in the Quaternary western complex. In the deep aquifers it is found in groundwater of the Upper Cretaceous in the west, and in mixtures of Lower and Upper Cretaceous groundwater in the eastern side of the Jordan Valley, in both cases these groundwater has saline input from Ca – Chloride end member. The salts dissolution model indicates that the first and second groups are consisted by Ca-Cl saline source which contribute about 50% of the salts, in addition to contribution of halite, dolomite, anhydrite and Mg-Cl type sources. Moreover, this model indicated on precipitation of aragonite and anhydrite. Water of this type was found at all of the aquifers except for the Eocene. The sources of salinity to water of group 2 are combination of Kinneret 2 type brines, Seawater residue in form of Yam 7 type brines, Tiberias type brines and print of Timna D 683 type brine (Table 1). In addition there is significant contribution of dolomite calcite and anhydrite and other soluble salts such as Halite sylvite and others.
As suggested by Möller et al (2006) this Seawater residue might be a synonym of Tiberias type brine which was regarded to dilution of evaporitic residue of Mediterranean Sea water that had transgressed in into the Jordan Valley during the Pliocene.

The third water group is similar to group six in Taussig (1961), and consist of waters in association with water of the first water group undergone additional stage of Mg^{2+} – Na^{+} exchange. Water of this group is common all over the hydrostratigraphic units except of the Eocene aquifers. From the salts dissolution model its arrears that this group consist of groundwater which dissolved dolomite, halite and print of Ca,Mg-Cl type source is also evident, and precipitation of aragonite was also occurred during their formation. This water type is also found at al aquifers except the Eocene. The sources of salinity to water of group 3 are combination of Seawater residue in form of Yam 7 type brines, runoff, Kineret 2 type brines and print of Arava type brines (Table 1). In addition there is significant contribution of dolomite calcite and anhydrite dissolution, and calcite precipitation.

The forth water group consists of water that has Na – Chloride trend, and according to Vengosh and Rosenthal (1994) it is in association with the second water group. It is common in all of the hydrostratigraphic when in the Eocene aquifers it is representing the high salinity end member. The salts dissolution model indicates that this water group consists of groundwater that had dissolved mainly halite and dolomite. This water type is found in all aquifers when as mentioned in the Eocene is considered as saline end member. The sources of salinity to water of group 4 are combination of runoff, Seawater residue in form of Yam 7 type brines and Tiberias type brines. In addition there is significant contribution of dolomite halite and soluble salts. This model seems to apply to the model suggested by Klein-Ben David at al. (2004) this work regarded the mixing process of several seawater related brines under different stages of evaporation to be major source of salinity.

The fifth water group consist of waters of the seventh group of Taussig (1961) which their chemical composition were modified by dissolution of Mg – Chloride salts, were, in later stage had undergone Mg^{2+} – Na^{+} exchange. Water of this group can be found in the Neogene complex and in the Upper and Lower Cretaceous aquifers. This group is found mostly in the Tiberias group aquifer and in some cases in the Judea aquifer; it is consist of sodium reach water that had probably dissolved halite and mineral from the Trona and Na-SO_4 type minerals. The sources of salinity to water of group 5 are combination of runoff, Seawater residue in form of Yam 7 type brines and Dead Sea type brines **or** Kinneret 2 type brines (Table 1). In addition there is significant contribution of anhydrite, sylvite and dolomite.

The sixth group is similar to the seventh group of Taussig (1961), and according to that research the water of this group is associated with groundwater of the first group, but, with Ca – Carbonate dominance, and as water the former group had additional, less significant stage of Mg^{2+} – Na^{+} exchange. This group represents groundwater of the Neogene aquifer complex and of the Quaternary complex on the eastern Jordan Valley. In addition, it can be found in the other aquifers while, in the Eocene aquifer it is representing the low salinity end member. The sources of salinity to water of group 6 are combination of Seawater residue in form of Yam 7 type brines, runoff, and Dead Sea type brines **or** Kinneret 2 type brines (Table 1). In addition there is significant contribution anhydrite, sylvite and other soluble salts and dolomite. The salinity source of group 6 can be related to a complex saline end member regarded by Möller et al (2006) as chemical evolution of the late brines of the Sdom Lake comprises evaporation of seawater loaded with dissolved Massinian salts, total evaporation of the solution had yielded evaporitic bodies as demonstrated in this work at the Ug'a evaporitic body. By Belitzky and Mimran (1996) for the Zaarat el Qurein system and by Zak (1967) for the Sdom diaper. On the other hand, dilution with drainage water had created the Dead Sea brine.

Modelling Conclusions:

Combination of the chemical grouping and processes, with the regional subsurface morphology yielded some important suggestion for the regional water management plan:

The runoff TDS increase in comparison to rain is up to second order of magnitude in certain cases. This process is probably due to dissolution of salts from soil crusts. The same trend might be intensified as runin (the fraction of runoff that is recharging the aquifer) is recharging the shallow aquifers after it had dissolved additional salts in the unsaturated zone. Though quantity of runin based recharge is small (up to 100,000 CM/Y) groundwater recharge by water with TDS values with up to several thousands mg. per liter might be important salts source

generating groundwater deterioration. In addition, the geochemical modeling is suggesting that an evaporitic sequence such as the one found by geophysical and geochemical modeling, might also exist in the North West part of the study area near Wadi Bezeq and Wadi Milha.
Classification of the groundwater in the region to six groups seems to give good approximation of the geochemical members of the Jordan Valley hydrogeochemical system. Nine saline end members, in addition to water – rock interactions were classified as major sources of salts to the groundwater. Good comprehension of the geochemical processes and saline sources chemical and physical origins was achieved by interpolating the structural modeling with the salts dissolution and the PreeqC regression modeling. Several insights from this part of the study are also relevant for the regional water mengment plan:
In general concentrated runoff type saline source is leeched to the groundwater as it penetrating the Jordan Valley fill sedimentary sequence, in addition, several types of Rift type brines are mixing with the groundwater as it flow through the Rift faulting zones. It is important to note that after the occurrence of this deterioration the utilization of these waters is hardly economical.

Two saddles like structures in the regions of Ug'a and Argaman were decipher during the geophysical modeling, in addition the level of the aquiferic strata is rather sallow underneath the young sediments cover, making the utilization of these aquifers feasible. The geochemical modeling is indicating that the groundwater of the Cretaceous (Naaran) and Eocene (Argaman) aquifers are fresh group 1 type water turning as they replenish the Neogene a Quaternary aquifers to more saline type 6 water. As so utilization of the aquifers at the structural saddles is recommended.

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INDIGENOUS WATER MANAGEMENT SYSTEMS IN ARID AREAS OF SOUTH AFRICA: THE CASE OF THE BATSWANA PEOPLE IN THE NORTH WEST PROVINCE (SOUTH AFRICA)

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Various studies indicate that water scarcity will be one of the major threats to humankind during the 21st Century. This is due to the fact that the available water resources taken from streams, rivers and ground water will not be sufficient to cover the increasing needs of both rural and urban areas, especially in the arid and semi-arid areas (with <600 mm of rainfall per annum). For instance, water scarcity in the arid and semi-arid regions of South Africa such as the North-West Province, poses a grave threat to the well-being of the people, especially those in the rural areas who depend on subsistence agriculture for survival. The conventional approach to this problem has been to emphasize western technologies over African indigenous forms of water management, without seriously considering the potential benefits of the latter, which have evolved with the local environment and are specifically adapted to local conditions. Since the Rio Earth Summit in 1992, environmental and water-related conferences have often highlighted the role of indigenous knowledge systems in sustainable environmental and natural resource management including water.

The North-West Province is one of the semi-arid provinces of South Africa (<500 mm of rainfall per annum). The province is predominantly rural (>65%). The indigenous African people in this Province are the Batswana people. They depend on subsistence farming (both crop and animal production) for survival. In response to these arid and semi-arid conditions, the Batswana people have over the years developed an intricate web of strategies for managing their scarce water resources. They devised ways to access water, without depleting its scarce reserves. One of the indigenous methods developed and used by the Batswana, especially in areas without permanent rivers, where people rely on rainfall, is water harvesting for agriculture, i.e. rainwater harvesting, floodwater harvesting, dew and fog harvesting. However, when European settler farmers came to South Africa with their livestock and introduction of commercial farming, the fragile balance which the African indigenous people including the Batswana, had established with their environment over the years was destroyed and their indigenous knowledge systems were marginalized. The European settlers introduced new water technology systems such as boreholes, pumping masses of water from deep within the ground; the ever-increasing livestock herds depleted water and other natural resources.

Furthermore, with increasing pressure on natural resources as a result of population growth, climate change, geopolitical and other forces, there is a growing need for sustainable rural development and water management policies for the Batswana and other people in the area. The main challenge for the subsistence farmers and the post-apartheid government in South Africa is how to improve agricultural production and the well-being of local inhabitants without further degrading the fragile environment and scarce water resources. This calls for the reassessment of the value of the African indigenous water management systems. If these community based- small-scale water management systems could be revived and improved, they will contribute greatly to easing future water scarcity in the arid and semi-arid areas of the Province and South Africa at large. These methods coupled with indigenous water saving techniques, modern hydrological tools and remote sensing, could supplement other sources of water supply and help communities to secure sustainable water supply.

Introduction

Various studies indicate that water scarcity will be one of the major threats to humankind during the 21st Century. This is due to the fact that the available water resources taken from streams, rivers and ground water will not be sufficient to cover the increasing needs of both rural and urban areas, especially in the arid and semi-arid areas) of the world with less than 600 mm of rainfall per annum (FAO, 1995).

For instance, the Southern African countries with predominantly rural economies and high dependence on dryland agriculture are at risk because they are highly vulnerable to shifts in seasonal climatic patterns. Over 75% of available water in these areas is used for agriculture, but competition for the limited water resources in the dry areas is increasing with domestic and commercial demand reinforced by high population growth rates, and improvements in living conditions, depriving agriculture of substantial amounts. Renewable water resources are limited and rainfall is highly variable and unpredictable, both spatially and temporally, increasing the risks and uncertainty involved in agricultural production. This short-term climatic variability is likely to be exacerbated by longer-term climate change (Elwell, 1993).

Nowhere is this challenge as awesome as in the drylands South Africa such as the North-West province. The province is 65% rural. The majority of the population make their living from rainfed agriculture, and depend to a large extent on small-holder, subsistence agriculture for their livelihood security.

The drylands of the province are characterised by a low annual rainfall concentrated to one or two short rainy seasons. Rainfall varies from 400 - 600 mm in the semi-arid areas such as Ganyesa and Kuruman. The length of growing period (LGP) ranges from 75-120 days in the semi-arid zone, and 121 – 179 days in the dry sub-humid areas with 1000 mm of rainfall per annum. The daily potential evapotranspiration (PET) levels are high, ranging from 5 - 8 mm day (Allen, 1990).

The rainfall in summer is highly erratic, and most rain falls as intensive, often convective storms, with very high rainfall intensity and extreme spatial and temporal rainfall variability. The result is a very high risk for annual droughts and intra-seasonal dry spells. This means that the poor distribution of rainfall over time often constitutes a more common cause for crop failure than absolute water scarcity due to low cumulative annual rainfall. This is why it is important to distinguish between droughts and dry spells.

An agricultural drought occurs when the cumulative plant available soil water is significantly lower than cumulative crop water requirements, i.e., there is absolute water scarcity. A dry spell occurs as short periods of water stress, often only a couple of weeks long, during crop growth. Such short periods of water stress can have a serious effect on crop yields if occurring during water sensitive development stages like, e.g., during flowering (Veenhuizen, 1998).

The paper argues that the conventional approach to the water shortage problem in most of the arid and semi-arid areas of South Africa including the North-West Province has been to emphasize western technologies over indigenous forms of water management, without seriously considering the potential benefits of the latter, which have evolved with the local environment and are specifically adapted to local conditions.

The Batswana people possess accumulated practical knowledge of their arid environment through experience and productive activity. They have therefore, developed complex systems of agriculture, water, vegetation and wildlife management that have survived the test of time and the vagaries of an arid environment. They have used various sustainable water management systems and methods which enabled them to secure food, income, employment, and social welfare, diversification of crops and preservation of animals and crops species over the years.

Since the Rio Earth Summit in 1992 and World Summit for Sustainable Development (WSSD) in Johannesburg in 2002, environmental and water-related conferences have often highlighted the role of indigenous knowledge systems in sustainable environmental and natural resource management including water.

On the basis of the survey conducted among the Batswana people in the North-West Province (South Africa), the main focus of this paper is on Batswana indigenous management systems of using low-tech practices, both for domestic purposes and for agricultural production. The term Indigenous Knowledge Systems (IKS) refers to a distinctive body of knowledge, innovations and practices that have been developed over many generations outside the formal educational system, and that enable communities in their specific natural and cultural environments to survive (Mascarenhas, 2004). The most important form of Batswana indigenous water management in the arid areas of the North-West province is water harvesting. The paper argues that there has been a tendency among development agencies including government in the Province of neglecting possible indigenous water management systems of increasing the efficient use of rainfall, where and when it falls. Instead support has focused on costly systems of providing water through conventional irrigation schemes (FAO, 1995).

The paper looks at the opportunities of increasing the efficiency of Batswana indigenous water harvesting techniques in rainfed, smallholder agriculture in drylands of the North-West Province. The paper provides some field experiences of Batswana indigenous water harvesting techniques for agricultural production.

Methodology

The knowledge and techniques related to indigenous water management systems among the Batswana of the North-West Province (South Africa) was elicited through participatory techniques such as interviews and meetings with local experts in the study areas, as well as examination of secondary sources such as past research documents, internet sources, etc. Workshops were organized to bring together local innovators and outside experts to investigate promising indigenous water management technologies.

Batswana Indigenous Water Harvesting Systems and Strategies for Drought Mitigation

Indigenous rainwater and floodwater harvesting as a water management technique has been practised in many dry regions of the world since millennia (Agromisa, 1997). Water harvesting in the context of this paper is a broad umbrella definition including all methods for concentrating, storing and collecting surface runoff water in different mediums, for domestic or agricultural uses. A common definition of water harvesting is the collection of runoff for productive use (Siegert, 1994).

Traditionally, among the Batsawna people, runoff water can be collected from roofs or ground surfaces (rainwater harvesting) as well as from seasonal streams (flood water harvesting). The harvested runoff can involve different forms of surface runoff (sheet, rill, and gully and stream flow) and the storage is either done above ground, in different systems of tanks, reservoirs or dams, or below ground in the soil. The methods for harvesting runoff water and managing it can be distinguished after: the source of the surface water (external or within-field catchments from sheet, rill, gully or stream flow), (ii) the method of managing the water (maximising infiltration in the soil, storing water in tanks/dams, inundating crop fields with storm floods) and (iii) the use of water (livestock, households, crop production and erosion management).

Water harvesting systems among the Batswana operate at different scales (household, field, catchment), and can affect water availability at downstream locations and activities. The shifts in water flows as a result of water harvesting impacts on agricultural and domestic water use in these locations. This is due to the fact that natural ecosystems in a landscape, like wetlands and swamps, depend on a certain inflow of surface overland flow, and can therefore be affected by water harvesting interventions upstream. At the same time wetlands are in themselves thereby a form of water harvesting that can be used for water treatment and as a source of domestic and agricultural water (Auerbach, 1998).

The following are the various Batswana indigenous water management techniques identified from the study. However, examination of secondary sources indicates that these water management techniques are practised by other ethnic groups in the Southern Africa region living in similar arid and semi-arid conditions.

Runoff farming

Among the Batswana people and other ethnic groups of the dryland areas of Southern Africa, in-situ water conservation systems are by far the most common. It is also within this category that most of the indigenous systems can be found (Reij et al., 1996). From a development perspective the argument for the promotion of water conservation systems - generally referred to as soil and water conservation measures - have been to control soil erosion, i.e., to manage the negative side-effects of rain water. The survey showed that a number of indigenous water nanagement techniques have been used by the Batswana people over the years:

(I) Pitting techniques, where shallow planting holes (< 25 cm deep) are dug for concentration of surface runoff and crop residue/manure. The pitting technique has proven to improve millet yields, especially during low rainfall years.

(ii) Construction of moisture retention terraces and ditches is another common indigenous water management technique among the Batswana and in the Southern African region at large. The terraces are made by digging a trench, normally along the contour, and throwing the soil upslope to form an embankment This has had a very significant effect on reducing soil erosion in areas with relatively steep slopes
(< 20 %). Tiffen et al. (1994) present evidence from other communities in Southern Africa suggesting that the adoption of terrace system played an important role in reducing land degradation in the period population growth in these communities.

The study found that in some areas of the North-West Province, where the Batswana people live such as Kuruman, mobilisation campaigns are used to rehabilitate degraded lands by constructing retention ditches and stone terraces (Lundgren, 1993). In other areas of the Province such as Ganyesa, micro-basins (roughly 1 m long and < 50 cm deep) are often constructed along the retention ditches for tree planting. These retention ditches, which prevent large volumes of surface runoff from flowing down the steep escarpments, have contributed to the revival of natural springs which according to the local communities had dried out (probably due to severe upstream deforestation.

(iii) In low rainfall areas of the Province, Batswana small-scale farmers have developed a highly specialised water harvesting system. The cropland is prepared in multitudes of circular depressions (3 - 4 m in diameter and < 1 m deep) where a variety of crops were inter-cropped. There is literally no run-off from the fields. In good years, all crops are harvested. However, the kind and amount of crop yield decreases with the reduction of the seasonal rainfall depths. The decline/loss of yield followed a pattern or sequences like maize, then sorghum followed and pigeon pea.

Flood irrigation

The survey found that in some areas of the Province, flood irrigation was used in alley cropping systems with sorghum and *Acacia saligna*. The basic rationale is the capturing of storm-floods from rainfall-rich highland areas, which were than diverted into levelled basins in the arid lowlands. The following techniques were used in harvesting floodwater for agriculture and other uses:

(i) Construction of embankments for conveying the storm-water. These were built by shovelling the sandy soils using animal traction. The maintenance of these embankments is very labour intensive, and hence is done communally.

(ii) Gully reclamation for productive purposes has been practised among the Batswana with favourable agronomic results including the growing of various crops, but with complex socioeconomic implications. The objective has been to privatise sections of gullies, where the households involved in gully reclamation could also have exclusive rights to cultivation in the reclaimed sections. However, due to unclear land tenure, the reclaimed gully could not be privatised because it brought conflicts between different farmers over the land use rights, and hence it remained under communal ownership.

Storage irrigation

Indigenous water harvesting systems with storage for supplemental irrigation are common in most Southern African communities. It is common to find micro-dams and farm ponds for storing water, usually located downstream in watersheds. The water is predominantly used for livestock and to cover household needs. This study and previous studies done by Farmesa, (1997) have shown that farmers use earth dams for irrigation (with buckets) of small vegetable gardens (< 0.25 ha). This indicates a very essential character of storage water harvesting structures; namely that they generally serve multipurpose uses. The survey indicated that farmers first of all prioritise domestic water uses before considering supplemental irrigation. Their choice of small vegetable gardens when considering irrigation is also logic, as the water generally has to be lifted from the earth dam/farm pond to the crop field, which is very labour intensive.

Utilising Fog and Dew

Harvesting dew is defined as the deposit of water droplets on objects the surface of which is sufficiently cool, generally by nocturnal radiation, to bring about the direct condensation of water vapour from the surrounding air. Dew formation is favoured by: a relative humidity at sunset of at least 75 %. Wind speed less than 3 m/s and clear skies. The effect of dew formation is strongest in valleys, as in mountainous areas where the cooling air masses become heavier, flowing to the valley floors, where they continue to cool down, eventually leading to dew formation (Cooper, et. al, 1986).

The survey showed that under specific environmental conditions fog and dew can be captured and can yield substantial amounts of water which can be used for domestic purposes, livestock, growing of trees, and of crops. In order to supplement the moisture collected by plants themselves, artificial surfaces can be exposed such as netting-surfaced traps.

Benefits and limitations Indigenous Rainwater and Floodwater Harvesting

The survey and other studies (Falkenmark, 1995; Hagmann and Murwirwa, 1996) show that indigenous rainwater and floodwater harvesting have the potential to increase the productivity of arable and grazing land by increasing the yields and by reducing the risk of crop failure. They also facilitate re- or afforestation, fruit tree planting or agroforestry. With regard to tree establishment, water harvesting can contribute to the fight against desertification. Rainwater harvesting techniques are relatively cheap to implement and can therefore be a viable alternative where irrigation water from other sources is not readily available or too costly for poor communities. Unlike pumping water, water harvesting saves energy and maintenance costs. Using harvested rainwater helps in decreasing the use of other valuable water sources like groundwater.

As pat of interfacing modern and indigenous technologies, modern technologies such as Remote Sensing and Geographical Information Systems can help in the determination of areas suitable for water harvesting. Nissen-Petersen and Lee (1990), however, indicate that although these indigenous methods and techniques of water management can increase water availability, the climatic risks still exists and in years with extremely low rainfall, it can not compensate for the shortage. Successful water harvesting projects are often based on farmers' experience and trial and error rather than on scientifically well established techniques, and can therefore not be reproduced easily. Most agricultural extension services have often limited experience with it. Further disadvantages are the possible conflicts between upstream and downstream users, and a possible harm to fauna and flora adapted to running waters and wetlands.

Conclusion and Recommendations

Indigenous water harvesting systems for domestic and agricultural production have a large potential in semi-arid regions of South Africa including the North-West Province, which remains untapped.

The development focus when it comes to water resources management within South Africa and the Southern African region at large has to a large extent focused on large scale, downstream located systems, like irrigation schemes. There is a substantial opportunity to shift attention upstream, to indigenous small-scale water harvesting systems taking advantage of gravity already at the farmer’s field. The challenge, however, is to find ways of anchoring innovative water harvesting systems in the present rural communities by moulding them within the site-specific bio-physical and socio-economic contexts.

The predominant scale of water harvesting development at present among the Batswana people is on household scale. There are limited efforts to design management water harvesting systems on a sub-catchment or catchment scale. Small-scale farmers will always need support from extension services to design earth dams and gravity fed micro-irrigation schemes. This means that the development challenge involves both bottom-up approaches to ensure ownership by these farmers, and training of capable engineers, surveyors, etc.

Experience in other parts of the world (FAO, 1995) show that indigenous water harvesting for agricultural production, if successfully implemented within a social and hydrological catchment, have many interacting implications on biophysical, economic, and ecological systems. This implies that a systems approach is advisable when developing rural water management approaches. A systems approach would involve different biophysical disciplines within a watershed (e.g., upstream/downstream hydrological impacts; land/water linkages; linkages between e.g., livestock, crop production, and forestry) and linkages between the agroecological system and the rural society, and between production and markets, as a few examples.

There are scattered development efforts in the Southern African region and South Africa in particular, on indigenous water harvesting, but seemingly little research on the viability of these systems within the context of farming systems. Research has to be conducted on-farm, addressing different scales (field, hill slope, community, and watershed).

The paper suggests that indigenous water harvesting systems cannot be an isolated effort within a farming system. It should be seen as a catalyst to improve indigenous production systems. A major challenge, however, in promoting water harvesting systems for agriculture, is the critical issues of land tenure on a watershed scale when introducing gravity-fed water harvesting systems. Policies are lacking to properly address the complex upstream and downstream conflicts that can evolve from intensified tapping of surface waters produced upstream.

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ROOF TOP RAIN WATER HARVESTING IN INDUSTRIAL SECTOR

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The "survival of fittest" is the slogan, now the company will have to follow to stay in business. Top management is concerned with profitability, growth, resource generation and management proper, middle management is on control of operations, resource utilization, earning, productivity and cost reduction.

INTRODUCTION

The progress of industrialization, development of new techniques has led to the development of large industrial organizations with multilane and multilevel operations. Today, the business has to face many challenges due to:

* Increase in product complexity and size of operations.
* Stiff competition at national and international levels.

Strict enforcement of quality control measures through sound quality management alone can help the company to withstand the fierce competition in the national and international market. The "survival of fittest" is the slogan now the company will have to follow to stay in business.

* Consumer awareness.
* National and international legislation etc.
* To face these challenges, to strive for excellence and grow in business the responsibility for product quality has gradually shifted from operator to foreman to inspector to quality control department and later to quality management. Productivity and quality. Create and innovative approaches by management have a good potential in quality improvement. The quality revolution therefore assumes a tremendous importance in this highly competitive world.

The company can survive the fierce competition if it paid attention to plan, achieve, maintain and improve quality constantly to meet the challenges.

Proper understanding of cost of rejection, scrap, rework and warranty claims can lead to identification of problems and quality improvement projects and substantial benefits due to improved productivity and profitability.

Management role and functions have become more defined. While, top management is concerned with profitability, growth, resource generation and management proper, middle management is on control of operations, resource utilization, earnings, productivity and cost reduction.

OBJECTIVE

The project aims to design and introduce low cost integrated rainwater harvesting systems in newly and existing urban and industrial sector.

SUB OBJECTIVES ARE

- **To** assess the economic viability/ environmental impacts of using rainwater harvesting in urban sector.
- To create awareness on rain water harvesting among the urban community.
- To carry out research and development on new technology for urban households/ buildings.
- To set up a pool of trained masons on constructing rainwater harvesting systems for urban areas.
- To create awareness among architects in order to design low cost tanks.
- To recommend a suitable policy for implementation.

DEFINITION OF RWH

Rain Water Harvesting is a way to capture the rain water when it rains, store that water above ground or change the underground and use it later. This happens naturally in open rural areas. But in congested, over-paved metropolitan cities, we need to create methods to capture the rain water.

BENEFITS OF RWH

- Saves Money.
- Saves Energy.
- Provides control over water source.
- Protects from rate hikes.
- Can be kept free from contamination.
- Minimizes urban flooding.
- Contributes to ecological cause.

OUR CAPABILITIES

- Hydro geological mapping.
- Ground water quality analysis and interpretation.
- Water audit.
- Rainfall pattern and distribution analysis.
- Strategies for rainwater harvesting including storage/ recharge optimization.
- Catchment management plan.

METHODOLOGY FOR RWH

Preliminary Feasibility Study:

The first step in designing a rain water harvesting scheme is a preliminary feasibility study which involves site visit and inspiration.

The study includes

- site condition
- rainwater incident on site
- quantum of harvesting rainwater
- consumption pattern
- evaluate existing water supply assets
- best means to conserve water

Detailed Assessment:

Subsequently a detailed assessment is carried out which involves

- Hydro geological investigation
- Groundwater quality analysis
- Rainfall pattern analysis
- Catchment management plan
- Design of rainwater harvesting scheme

SOME SUCCESSFUL INSTALLATIONS

Industries

- Denso Kirloskar, Peenya, Tumkur Road, Bangalore, Karnataka.
- Escorts, Yelahanka, Bangalore, Karnataka.
- E & C, Peenya, Bangalore, Karnataka.
- Ingersoll-Rand, Peenya, Bangalore, Karnataka.

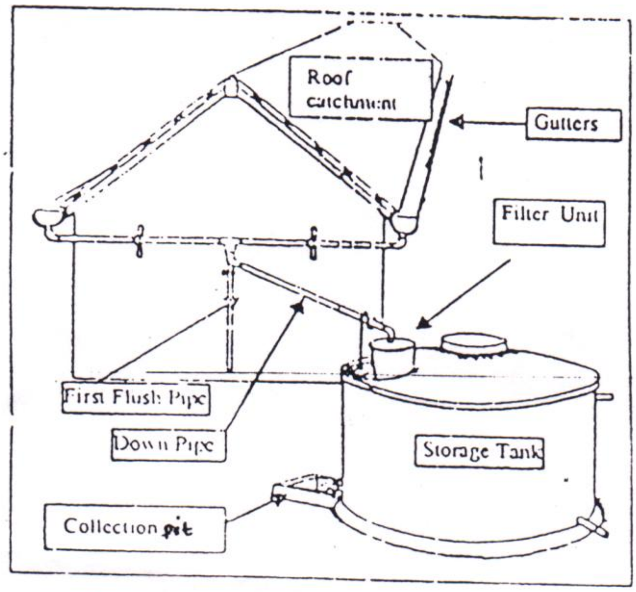
Institutions

- Chemical Engineering Department, Indian Institute of Science, Bangalore, Karnataka.
- Bishop Cotton's Girls High School, Bangalore, Karnataka.
- AISIN NTTF, Bangalore, Karnataka.
- Jawaharlal Nehru Planetarium, Bangalore, Karnataka.

HOW DOES A ROOF TOP RAIN WATER SYSTEM WORK

All rain water harvesting systems whether large or small are composed of six components.

a) Catchment area / Roof, the surface upon which the rain falls.
b) Gutter and down pipe, the transport channels from catchment surface to filter bed.
c) Roof washers, the system that remove contaminants and debris.
d) Filter unit and Water treatment, the system that removes the suspended silt and dust particles and disinfect.
e) Storage tanks, collection pit.
f) Ground water recharges structure.



CATCHMENT AREA

The Catchment area is the surface on which the rainwater that will be collected falls. Rainwater yield varies with the size and texture of the catchment area. The style, construction and material of the roof affect the suitability as a catchment. Roofs made up of corrugated iron sheet, asbestos sheet, tiles or concrete can be utilized as such for harvesting of rain water (fig – 2 & 3). A smoother, cleaner and more impervious roofing material contributes to better water quality and greater quantity. While loss is negligible for pitched metal roofs, concrete or asphalt roofs average just less than 10% loss and built up tar and gravel roofs average a maximum of 15% loss. Losses can also occur in gutters and in storage. Regardless of roofing material, many designers assume up to a 25% loss on annual rainfall. These losses are due to several factors: the roofing material texture, which shows down the flow, evaporation and inefficiencies in the collection process. Catchment area size: The size of a roof catchment area is the building's footprint under the roof. The catchment surface is limited to the area, which is guttered. To calculate the roof catchment area length is to be multiplied with width of the guttered area (Fig – 4). The catchment area (roof) should not be shaded by trees, as it will create obstruction to rain fall.

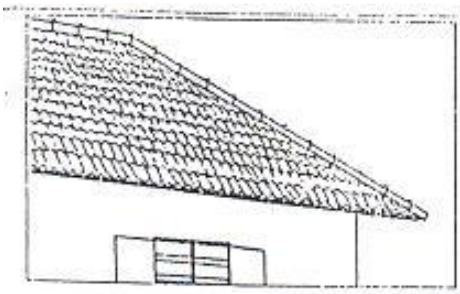


Fig. 2 : Tiled Roof

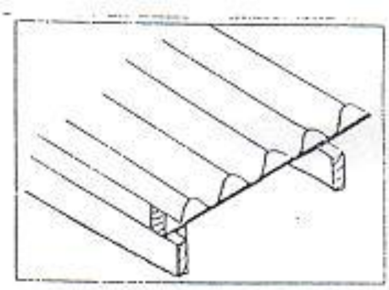
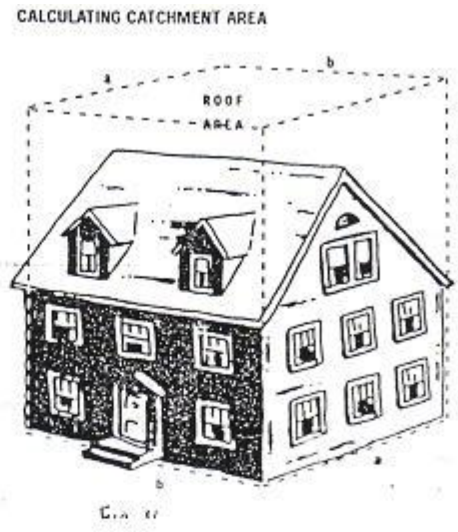


Fig. 3 : Corrugated GI sheet roof



GUTTER & DOWN PIPES

Gutters are the components, which catch the rainwater from the roof catchments surface and down pipes transport it to the filter media and treatment plant. These are channels fixed to edge of roof all around to collect and transport rainwater from roof to the filter media and treatment plant. Gutters can be prepared semi-circular and rectangular shapes. (Fig – 5&6). Locally available material such as plain galvanized iron sheet can be easily folded to required shapes to prepare semi-circular and rectangular gutters. Semi circular gutters of PVC material can be readily prepared by cutting the PVC pipes into two equal semi-circular channels. Standard shapes and sizes are easily obtained and maintained, although customs fabricated profiles are available to maximize the total amount of harvested rainfall. Gutters and down pipes must be properly sized, sloped and installed in order to maximize the quantity of harvested rain fall. Gutter hangers are generally placed at every 3 feet. The outside face of the gutter should be lower than the inside face to encourage draining away from the building wall. The most common material for off the shelf gutters is seamless aluminum. A 3 inch down pipe is used with 5 inch gutter and a 4 inch down pipe with a 6 inch gutter (Fig-7). Galvanized steel is another common material, which can be bent to section more than 6 inches. Copper and stainless steel are also used for gutters and down pipe but are costlier.
In case of RCC building arrangements for gutters are not required instead the outlets of the roof may be connected with the help of PVC pipes which will drain the rain water from the roof catchments surface to the filter bed through delivery pipes.

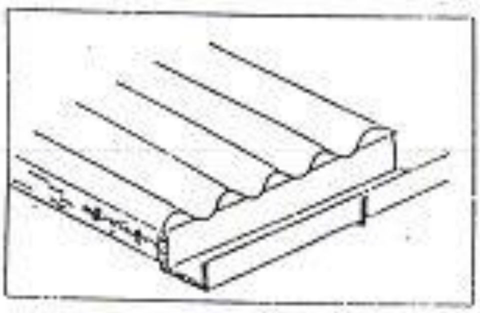


Fig. 5: Rectangular Gutter

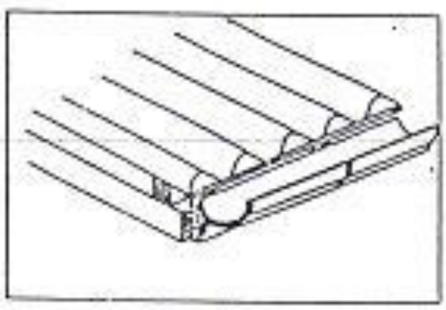


Fig. 6: Semi-circular Gutter

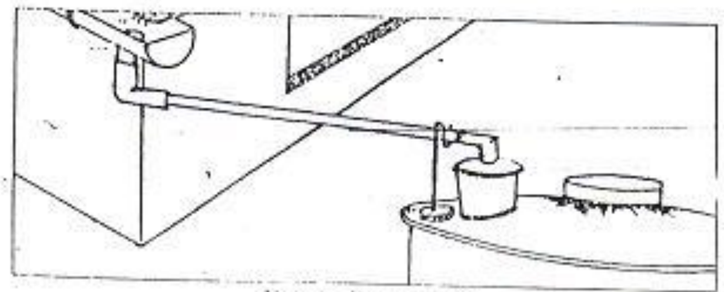


Fig. 7 Down Pipe

ROOF WASHER

Roof washing and collection and disposal of the first flush of water from a roof, is of particular concern if the rainwater is to be used for human consumption, since the first flush picks up most of the dirt, debris and contaminants such as bird droppings that have collected on the roof and in the gutters during dry periods. The most simple of these systems is to provide a separate vertical pipe fixed to the down pipe with a valve below the “T” junction so that the first flush can be drained out through the vertical pipe. After the first flush the valve is closed to allow the water to enter the down pipe and reach the treatment plant via filter media (Fig – 8)

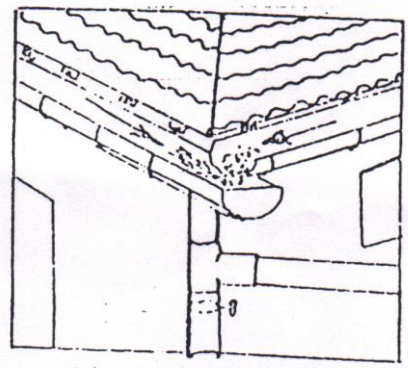


Fig. 8 First Flush Pipe

FILTER UNIT AND WATER TREATMENT

The rainwater which carries finer particles, dirt needs to be filtered and treated before collection in the storage tank or recharge to ground floor.

Filter Unit: The filter unit is a container or chamber filled with filter media such as pebbles, gravels and coarse sand arranged successively from bottom upward (Fig-9). The container is provided with perforated bottom to allow the passage of water. The filter unit is either placed over the storage tank or before it depending upon size. In case of larger roof catchments area where more than one storage tank is required the filter unit is to be placed before the storage tank. In case recharge to ground water filter unit is to be placed before the recharge structure. In case of concrete roof provision for settling pit is to be provided to arrest the silt and dine sand washed out by the rainwater. Commonly used filters are of two types. One is a ferro cement filter unit, which is comparatively heavy and the other is made of either aluminum or plastic bucket. The later is readily available in the market and has advantage of ease in removing, cleaning and replacing.

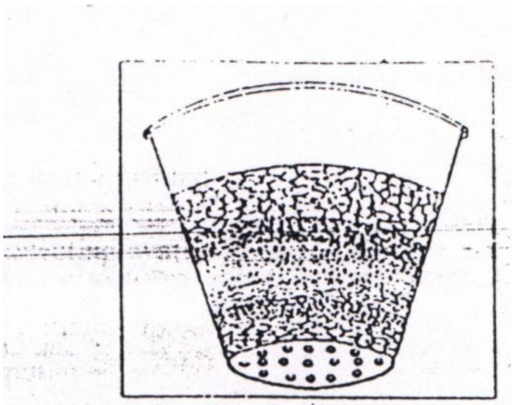


Fig. 9 Filter Unit

WATER TREATMENT:

Even after roof washing and filtration bird and rodent feces, airborne bacteria and cysts find their way into the storage tank. Some form of disinfection is the minimum treatment recommended if the water is to be used for human consumption. Most commonly used treatments are ultraviolet light and chemical treatment the most common method is chlorination. Chlorine is the most common disinfectant because of its dependability, water solubility and availability. Household bleach contains a 5% solution of sodium hypochlorite and is proven to be reliable, inexpensive and easily obtained. A dose is one liquid ounce of bleach for 100 gallons (one and a quarter cups of bleach per 1000 gallons) of rainwater collected will most likely be sufficient to disinfect the collected rainwater. A level between 0.2 mg/lit and 1.5 mg/lit is recommended for chlorine concentration.

STORAGE TANK

Storage tank is used to store the filtered and disinfected water (Fig-10). Common vessels such as plastic bowels, buckets, jerry cans, clay or ceramic jars, old oil drums etc. are used for small scale water storage. For storing larger quantities of water, the system will require bigger tank with sufficient strength and durability. There are unlimited options for the construction of these tanks with respect to shape (cylindrical, rectangular and square) and size (capacity from 1000 lit to 15000 lit or even higher) and the material of construction (brick work, concrete, Ferro cement, stonework, fiberglass, polythene, galvanized steel). A tight fitting cover is essential to prevent evaporation, mosquito breeding, and to keep insects, birds, lizards, frogs and rodents from entering into the tank. The maximize the efficiency storage tank should be located as close to both the supply and demand points as possible. And to facilitate the use of gravity or lower stress on a pump, the tank should be placed on the highest level that is workable. The storage tank should be shaded since direct sunlight can heat the stored rainwater in the tank and thereby encourage algae and bacterial growth, which can lower the quality.

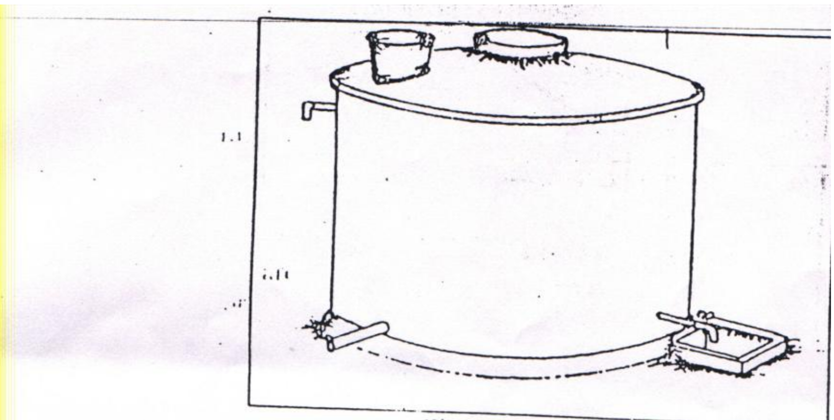


Fig.10: Storage Tank

COLLECTION PIT

A small pit is dug in the ground beneath the tap of the storage tank and constructed on brick masonry to make a chamber, so that a vessel could be conveniently placed beneath the tap for collecting water from the storage tank. A small hole is left at the bottom of the chamber to allow the excess water to drain out stagnation. Size of collection pit shall be 60 cm x 60 cm.

GROUND WATER RECHARGE STRUCTURE

The rainwater collected from the roof catchments area could be recharged to ground water reservoir through

a) Abandoned dug well, b) Abandoned / running hand pump, c) Recharge pit, d) Recharge trench. e) Gravity head recharge tube well. f) Recharge shaft

Abandoned dug well, recharge shaft and recharge trench are used for recharging the water table aquifer where as abandoned / running hand pump and gravity head recharge tube well are used for recharging the shallow and deep confined aquifers respectively. The post monsoon ground water level is to be considered before formulating the scheme for artificial recharge to ground water. Deep post monsoon ground water level will provide a substantial zone in the aquifer to accommodate the rainwater. Shallow post monsoon water level will refuse recharge and reject a substantial amount of rainwater. Shallow post monsoon water level will create adverse effect like water logging and soil salinity in course of time. The nature and design of recharge structure will depend on the hydrogeology of the area concerned, amount of rainfall available, area of the catchments (roof) and water requirement.

ROOF TOP RAINWATER CONSERVATION

Darjeeling town is facing acute scarcity of domestic water supply in dry period. The existing water supply can not meet the daily requirements particularly in lean period. To overcome this problem and to augment the supply, conservation oil rainwater and its subsequent use in lean period is the only solution. Considering the high normal rainfall, high surface run off due to steep surface gradient and availability of a large no. of roofs as catchments area, conservation of roof top rainwater in this hilly terrain is the best mode of rainwater harvesting.

Roof top rainwater conservation structure has been constructed in the campus of Louis Juilee Complex at Darjeeling town, West Bengal to conserve rainwater particularly during monsoon period and to use it in the subsequent lean period. The details of the structures are as follows:

Roof area	: 690 Sq. M	
Normal rainfall	: 2500 mm	
Total amount of rainwater available	: 690m^2 x 2500 mm x 80%	= 1380 m^3
		= 13, 80,000 liters.
Storage tanks	: 10,000 liters x 12 nos	= 12,000 liters.

ARTIFICIAL RECHARGE OF ROOF TOP RAINWATER TO GROUND WATER

Kolkata is underlain by unconsolidated Quaternary sediments with a thick blanket of surface clay at the top. Ground water occurs under confined condition. Heavy withdrawal of groundwater in excess of replenishment has caused lowering of piezometric head from 5 to 9 m during the last 40 years in KMC area.

To study the effect of artificial recharge of rainwater to groundwater occurring at deeper level a scheme of roof top rainwater harvesting has been taken in the campus of All India Soil and Land Use Survey at Baishnabghata Patuli, Kolkata.

ROOF TOP RAIN WATER HARVESTING

SITE: AISLUS Campus, Baishnbghata Patuli, Kolkata

Aquifer : Fine to medium grained, yellowish to grayish, quartzose & micaceous sand,
More than 134 m thick from 48.70 to 182.90 m
Bgl Aquifer below 125 m bgl is saline / Brakish

Roof Area : 676 m^2

RECHARGE STRUCTURE

No. of Recharge Well: 2

	Recharge well – 1	Recharge well – 2
Housing pipe (150 mm dia)	0 – 0.77 m agl	0 – 0.77 m agl
Housing pipe (150 mm dia)	0 – 102.6 m bgl	0 – 102.6 m bgl
Slotted Pipe (150 mm dia)	102.61 – 114.77 m bgl (12.16 m)	102.61-114.77 m bgl
Bail Plug	114.77-119.30 m bgl	114.77-119.30 m bgl
Clay Packing	0.0-85.0 m bgl	
Gravel packing	85.0 – 121.0 m bgl	

Distance between two Recharge Wells – 9.50 m

Filter Pit:

Dimension	Material	Thickness (m)
Length: 12 m	Sand (1.5-2 mm)	1.00
Width: 1.7 m	Gravel (5-10 mm)	0.50
Height: 2.84 m	Boulder (10-20 mm)	0.50

Water level: 14.19 m bgl (Pre-monsoon)

RAIN WATER AVAILABLE

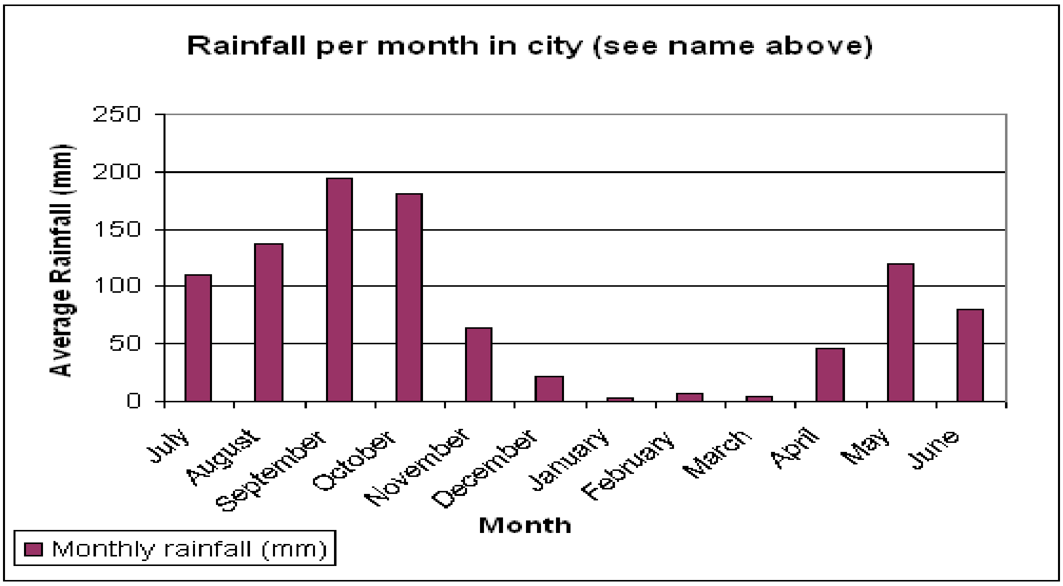
Normal Rainfall: 1500 mm
Normal Monsoon Rainfall: 1050 mm
Volume of Rain water available
Annual: 676 m^2 x 1500 mm x 80% = 811 m^3
Monsoon: 676 m^2 x 1050 mm x 80% = 568 m^3

HALDIA INDUSTRIAL COMPLEX AREA

The Haldia Industrial Complex area falls in the coastal plains of Sutahata I & II blocks of East Medinipur District, West Bengal. The area is bounded by two rivers namely Hugli & Haldi. The rivers of the area are influence by tidal effects due to close vicinity of coastal tracts. As a result, river water in Haldia Industrial area is brackish to saline in nature. During last three decades, there has been tremendous growth of Industrial development in Haldia Industrial Complex area and ground water use in this area has increased many folds.

HYDROGEOLOGICAL SET UP

The area is underlain by Quaternary to Tertiary sediments consisting of clay, slit, sand of various grades and gravels. The litho logical log of boreholes indicates rhythmic pattern of sedimentation represented by alternate deposition of clays and sands. The sediments down to 120 m are generally argillaceous in nature with a few sand horizons occurring at different depths. Between 120 – 300 mbgl depth, the sediments are generally erinaceous. Aquifers in this part of the coastal tract are saline to brackish down to the depth of 120 mbgl with a blanket of 6 to 50 m thick clay from the surface. Below the saline to brackish water bearing aquifers, fresh water bearing aquifers occurs in the depth range of 120 m and 300 mbgl. These two aquifers are separated by 12 to 24 m thick clay layer. The aquifers below are again brackish in nature.
Ground water occurs under confined condition. The piezometric level of the fresh ground water in the area lies within 7 – 15 m bgl. Study indicate that there is a distinct lowering of piezometric level of the fresh ground water to the tune of 5 – 7 m during last three decades due to heavy withdrawal of ground water from large no of heavy duty tube wells constructed by several organizations (Annual withdrawal of fresh ground water in the area is 24.63 MCM and the annual ground water flow through the confined aquifer is 5.348 MCM leaving an annual deficit of 18.282 MCM). As a result of this heavy withdrawal of fresh ground water, a ground through has been formed in the area close to the river Hughli. Long term analysis of piezometric level data show a distinct falling trend of piezometric level in both pre and post monsoon period. The situation is very much alarming as there is every possibility of deterioration of quality of ground water by mixing of saline water from the overlying aquifers and intrusion of saline water rom sea and hence needs special attention Quality of ground water of the aquifers in the depth range of 120 – 300 mbgl is in general good and is potable. However, in some parts iron is present in little excess of permissible limit and needs treatment before use



SCOPE FOR ROOF TOP RAIN WATER HARVESTING
HDA (HALDIA DEVELOPMENT AUTHORITY) AREA: 326 SQ. KM.
NOTIFIED AREA (HALDIA NOTIFIED AREA MUNICIPALITY AREA): 130 SQ. KM
AVERAGE ANNUAL RAINFALL: 1568 MM
TOTAL RAINWATER AVAILABLE IN THE NOTIFIED AREA: 154.5 MCM
NET RAINWATER AVAILABLE FOR THE AREA (CONSIDERING 20% AS EVAPORATION LOSS): 123.6 MCM

This clearly indicates that the rain water available in a year in the area is 5 times more than the annual withdrawal of ground water and this natural resource is practically goes to the sea unused. There is a bright scope of rainwater including roof top rainwater harvesting in the area.

WET MEADOW MANAGEMENT IN ZAMANTI RIVER CROSSING OF BTC CRUDE OIL PIPELINE PROJECT

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This paper is concentrated on Zamantı River crossing of the Baku-Tbilisi-Ceyhan (BTC) Crude Oil Pipeline Project and its wet meadow management activities for the protection of sensitive river landscape. The BTC Project comprises a pipeline to transport crude oil from the oil fields of the Caspian Sea region via the Republics of Azerbaijan, Georgia and Turkey to a crude oil storage and export terminal constructed at Ceyhan on the Mediterranean coast of Turkey. The BTC Project has 1,076 km of pipeline (and associated facilities) in Turkish Section and passing through many ecologically sensitive areas such as Zamantı River wet meadow.

Zamantı River crossing is located on Ecologically Sensitive Area (ESA 36), stretch located between KP 796.360 and 797.020 of the BTC Project Right of Way near Kayseri City. The river itself and its wet meadow host important animal and plant species. Also wet meadows are special landscapes with their particular wetland characteristics. For these reasons, Zamantı River and wet meadow crossing of the Project required to develop a particular methodology for the landscape protection and management considering inherent ecological constraints. Apart from high level of generic environmental standards of the BTC project; turf stripping, stockpiling and re-spreading activities were implemented by the Contractor. This methodology was suggested and monitored by a landscape architect (first author of this paper, with close collaboration with other two authors) who was one of the Third Party's experts on ecology of the Project. By this paper, the mentioned methodology was explained and as a result possible improvement was discussed.

Key words: *Turfing, wet meadow, restoration, landscape*

1. INTRODUCTION

1.1. BTC Crude Oil Pipeline Project

The proposed Baku-Tbilisi-Ceyhan Crude Oil Pipeline (BTC P/L) Project comprises a pipeline to transport crude oil from the oil fields of the Caspian Sea region via the Republics of Azerbaijan, Georgia and Turkey to a crude oil storage and export terminal constructed at Ceyhan on the Mediterranean coast of Turkey. In Turkey, the BTC P/L Project comprises 1,076 km of pipeline (and associated facilities) from the Georgian border to the Mediterranean coast and a marine terminal at Ceyhan (BTC P/L Project EIA, 2002). At present situation, the pipeline construction was completed. The monitoring phase for post-reinstatement and project operation phase for all activities is ongoing. The proposed BTC P/L Project was developed by a group of petroleum companies, herein after referred to as BTC Pipeline Company (BTC Co) formed in July 2002 (BTC P/L Project EIA, 2002).

1.2. Roles and Responsibilities

BTC Company: BTC Co maintained monitoring, auditing and reviewing role to ensure that the Project was undertaken in compliance with the Project Agreements and applicable health, safety, quality, social and environmental standards (ÇINAR 2003).

BOTAŞ: The Government of Turkey (Ministry of Energy and Natural Resources) has appointed BOTAŞ, the state owned Turkish Petroleum Pipeline Corporation, to operate the facilities that comprise the Turkish section of the BTC P/L Project. As the Turnkey Contractor and (subsequently) Designated Operator, BOTAŞ is defined as responsible party for delivery of all commitments made in EIA Report and for the development and implementation of the various outline Management and Monitoring Plans of EIA report to the satisfaction of BTC Co and the Turkish regulators (BTC P/L Project EIA, 2002).

Engineering, Procurement and Construction (EPC) Contractors: BOTAŞ management is responsible for ensuring that all BOTAŞ commitments in the EIA and Environmental Management and Monitoring Plans (EMMP) are translated into EPC Contractors requirements and these requirements are implemented to the full intent and extent of BOTAŞ original commitment. BOTAŞ EPC Contractors is responsible for implementation of all the mitigation measures outlined in the EIA and EMMP (ÇINAR, 2003).

ÇINAR- Third Party: In addition to the management structure established for day-to-day overseeing of the EPC Contractor’s environmental performance, independent construction environmental monitoring activities was conducted by a third party consulting firm, ÇINAR.

2. PURPOSE AND SCOPE: Third Party Ecological Monitoring

The purpose of this paper is to explain wet meadow management activities during Zamantı River crossing of BTC P/L Project. Zamantı River which is among the most important rivers along the route is a wide floodplain of orchid-covered wet meadows and marshes important for birds including threatened species. Also the Zamantı River itself provides important habitats for fish species. Additionally, wet meadows have particular wetland characteristics. For these reasons, a particular river-crossing methodology was required during the implementation of BTC P/L Project comprising both the river itself and its wide floodplain.

The ecological monitoring that built up the scope of that paper is a part of the Reinstatement Plan (RP) of EMMP within the content of EIA. This plan specifies the minimum technical requirements for reinstatement and restoration of areas affected by construction activities. The primary aim of the RP is that all such areas shall be returned to their pre-construction state (BTC P/L Project EIA, 2002). The reinstatement methodology for Zamantı River and wet meadow river crossing was suggested and monitored by Third Party's experts on ecology of the Project. Third Party ecological responsibilities were clearly described in an official document prepared by ÇINAR and approved by BOTAŞ as follow (ÇINAR, 2003):

- ✓ Check the methodologies of the EPC Contractors for pre-construction vegetation mapping surveys, verify survey techniques being carried out by EPC Contractors, check reports, site specific plans and method statements and monitor the EPC Contractors' activities against the requirements of the EIA,
- ✓ Monitor reinstatement of Ecologically Sensitive Areas (ESAs) on a daily basis and document their situations regarding compliance with the EIA, the site-specific plans and method statements,
- ✓ Ensure that all environmental non-compliance situations at site are documented and reported,
- ✓ Provide advice to BOTAŞ' Lead Environmental Monitor and his/her staff regarding environmental matters,
- ✓ Assist BOTAŞ's and EPC Contractor's construction staff in resolving non-compliance situations in the field,
- ✓ Monitor the performance of the EPC Contractors at site with respect to their arrangements and performance related to the Environment, and
- ✓ To participate in interface meetings at construction site as required.

All above activities were realised in different stages of BTC P/L Project construction phases being before construction, during construction and after construction. Figure 1 illustrates main components of Reinstatement Plan according to which all ecological monitoring activities were executed.

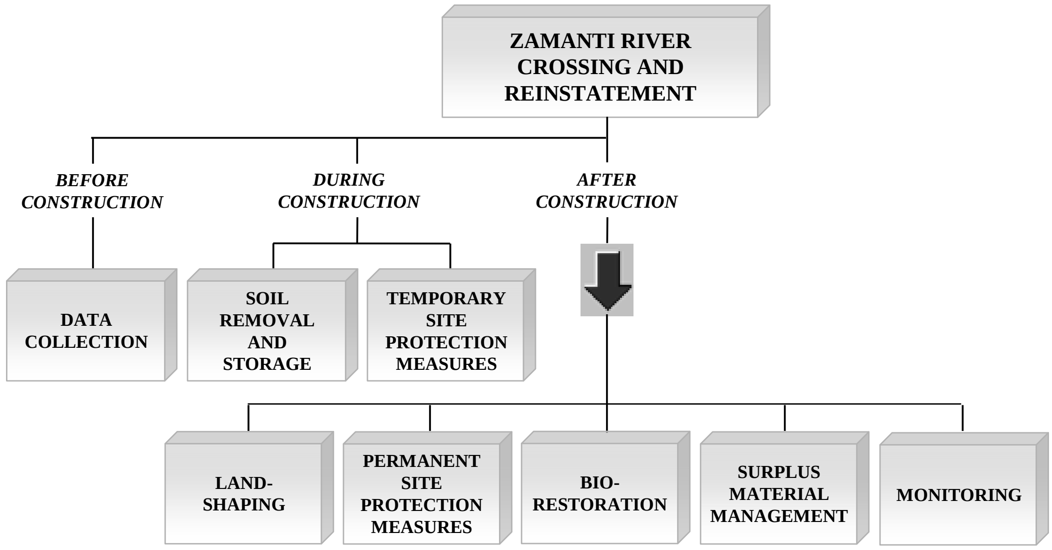


Figure 1: The components of reinstatement plan, accordingly ecological monitoring activities regarding different implementation phases of the project

3. ZAMANTI RIVER WET MEADOW

Zamantı River meadow which occurs between KP (kilometre point) 796.36 and 797.02 was defined as special area (Ecologically Sensitive Area - ESA 36) by EIA of BTC P/L Project. This ESA 36 stretch is located on Uzun Plateau at Kayseri Province (Figure 2) (PLL MST ENS PLC 020, 2004). The alignment traverses through a broad, orchid-rich, marshy grass floodplain, the terrain of which is flat (Figure 3). No trees and shrub cover present at the meadow crossing.

The river channel is irregular and meandering with a rectangular cross-section at the meander inflection point. Width of crossing is 25m and the bank-full width is between 15 and 21 m, although the floodplain (wet meadow) is about 750 m wide. The Zamantı riverbed consists of silt and river flow is perennial of a uniform and tranquil. The soil type of the wet meadow is sandy silty clay. Bank side vegetation comprises reeds and sedges, land cover is hay and land use is grazing (PLL MST ENS PLC 020, 2004a). Zamantı River forms upstream part of the Seyhan River.

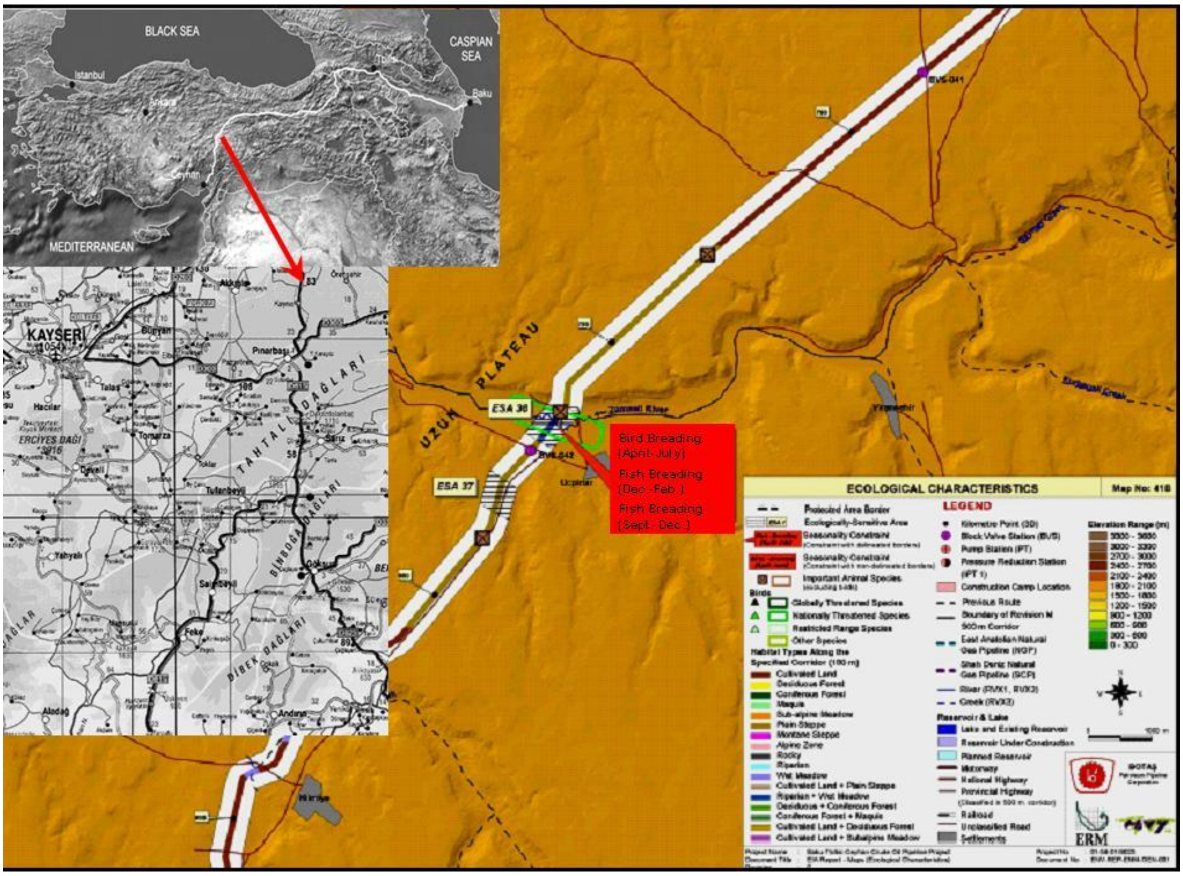


Figure 2: Location of Zamantı River wet meadow (Adapted from BTC P/L Project EIA, 2002)

Zamantı River supports breeding of migratory fish species of high commercial value - brown trout (*Salmo trutta magrosligma*), breeding between December to February, and European eel (*Anguilla anguilla*), breeding from April to August and migrating between September and March. Zamantı River wet meadow is important for birds including three nationally-threatened species (i.e.: Common Crane (*Grus grus*), Whinchat (*Saxicola rubetra*) and Icterine Warbler (*Hippolais icteriana*) (PLL MST ENS PLC 020, 2004a).Table 1 shows the seasonal sensitivity and constraints for working in Zamantı River, which has led to considering March and/or August as the suitable time for construction.

Table 1: Seasonal constraints regarding flora and wild life (BTC P/L Project EIA, 2002)

	J	F	M	A	M	J	J	A	S	O	N	D
Important Flora (ESA 37, KP 797.84 – 798.38)												
Breeding birds (Zamantı Floodplain ESA 36, KP 796.36 – 797.02)												
Breeding fish (Zamantı River)												
Migrating fish – eel (Zamantı River crossing)												

Construction and Reinstatement Target – 3 weeks

Absolute Seasonal Constraint

Extent of Constraint and required response subject to findings of preconstruction survey

Seasonal Constraint but amenable to mitigation

Figure 3: Zamantı River landscape

The plants shown in Table 2 were defined by EPC Contractor with the field survey of the area in 2003. *Dactylorhiza osmanica var. osmanica* is under conservation concern by CITES.

Table 2: Dominant Plants and Abundance Scale in ESA 36 (PLL MST ENS PLC 020, 2004a)

Taxon	Endemism	Abundance (Braun - Blanquet)	English name	Risk Category (IUCN)
Ranunculaceae				
Ranunculus constantinopolitanus (DC.) Urv.	__	+	Crow-Foot	LR(lc)
Poaceae				
Alopecurus arundinacea Poiret	__	+	Foxtail grass	LR(lc)
Poa trivialis L.	__	+	Meadow grass	LR(lc)
Plantaginaceae				
Plantago major L.	__	+	Wegerich	LR(lc)
Scrophulariaceae				
Pedicularis comosa L.	__	+	__	LR(lc)
Asteraceae				
Cirsium alatum (Gmelin) Bobrov	__	+	Thistle	LR(lc)
Juncaginaceae				
Triglochin palustris L.	__	+	__	LR(lc)
Juncaceae				
Eleocharis palustris (L.) Roemer & Schultes	__	+	__	LR(lc)
Cyperaceae				
Carex divisa Hudson	__	+	Blue-grass, sedge	LR(lc)
Orchidaceae				
Dactlorhiza osmanica (Kl.) Soo var. *osmanica*	__	+	__	LR(lc)

4. WET MEADOW LANDSCAPE MANAGEMENT AND MONITORING

The reinstatement of ESA 36 consists of Reinstatement of the wet meadow together with Reinstatement of Zamantı River. In that scope the ecological monitoring for ESA 36 was covered the following issues.

4.1 Document Reviewing: *Reinstatement Method Statement for Zamantı River Crossing*

The special area method statement for ESA 36 was reviewed by landscape architects together with a soil scientist considering a checklist that was recommended by Third Party and approved by BOTAŞ for all special areas reviewing (Table 3). All items with respect to reference in document were evaluated with comments about its deficiencies, non-compliance status and suggestions for revision.

Table 3: Special Areas Method statements reviewing checklist

Check List For Reviewing
General
A. Introduction 1. SARMS definition and locations
2. References from EIA and other related documents prepared by contractor and approved by BOTAŞ
3. Definitions and abbreviations
B. Purpose 4. Target plants and animals' identification, their threatened status, and their location in area
5. Population abundance of these target species
6. Mitigation measures to restore the habitat and the population of these plants following construction
7. Habitats in the vicinity of RoW, which could be impacted by the project, and possible mitigation measures
8. Erosion control practices
9. Land recountouring for the reconstruction of landscape and original drainage basin topography, and visual impact mitigation

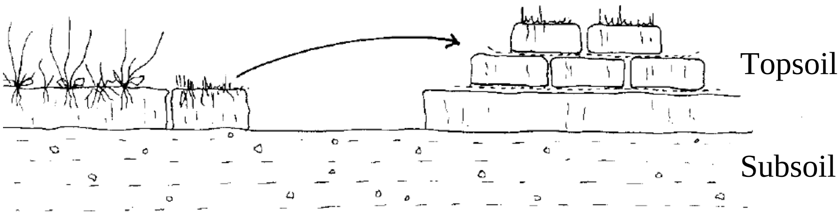
Table 3: Cont.

C. Scope ***Scope means whether these titles between 11-15 were covered in any section of the Document WITHOUT giving attention to the quality and quantity of the information.*** 10. Protection of target species and bio-restoration of the area after construction
11. Erosion control (temporary and permanent) in the ESA
12. Soil management (soil removal, stockpiling and re-spreading)
13. Landscape restoration (surface manipulation, re-contouring, revegetation)
14. Schedule for Mitigation and Reinstatement Activities
15. Follow-up monitoring program
D. Baseline Conditions and Constraints 16. Landscape description technique and results (the altitude (ASL), land use &vegetation cover and quality, existing problems, etc.)
17. Target plant species (characteristics, definition technique and results)
18. Target animal species (characteristics, definition technique and results)
19. Soil sampling (technique characteristics, erosion class, and assessment*
20. Constraints for reinstatement (seasonal constraints for fauna, climate for topsoil striping, constructional etc.)
21. 21 days limitation between RoW clearance and topsoil respreading. Exceptional acceptable conditions.
E. Mitigation Measures and Reinstatement Activities 22. Topsoil and overburden stripping and stockpiling*
23. Soil erosion control (temporary and permanent)*
24. Reinstatement of Landscape (Landscaping, re-contouring)
25. Redistribution of topsoil (where available) and surface manipulation*
26. Bio-restoration of the target species - Fauna protection - Revegetation (seeding, translocation, maintenance of translocated plants, seed storage, planting, etc
27. Aftercare (fertilizing, watering etc)
28. Schedule for mitigation and reinstatement activities
29. Follow-up monitoring

Revegetation Strategy:

Wet meadows commonly occur in poorly drained areas such as shallow lake basins, low-lying depressions, and the land between shallow marshes and upland areas. Precipitation serves as their primary water supply, so they are often dry in the summer (EPA 2001). With regard to Zamantı River wet meadow, the climate of the area is characterised by dry summers, cold winters and low rainfall. This means, although the existing vegetation cover is at steady state, revegetation with seeding is of concern under existing condition after construction. Sandy silty clay characteristic of the soil causes the revegetation with seeding more difficult. The best management technique for those kinds of area is be turf stripping and replacing work, wherein the topsoil with grass will be stripped in layers and laid onto a storage area. Turf can be stripped and stored on porous geotextile sheets for up to three months (up to 5 months in winter). Turfs should be stored with vegetation facing vegetation, and shaded or watered at intervals to prevent drying out. It is important to replace turf level, as protruding edges will dry out and die. Gaps between turfs should be packed with subsoil and seeded with an appropriate grass mixture (Figure 3) (Anonymous 2007).

1. Trim vegetation to 5-10 cm
2. Slice surface with disc harrow at about 0,3 m centres
3. Stack on porous geotextile sheet. Keep moist. Cut turves 20 cm deep, up to 5 m long, with excavator, or smaller lenghts by hand



4. Re-lay level, without protruding edges. Fill the gaps with topsoil. Water well.

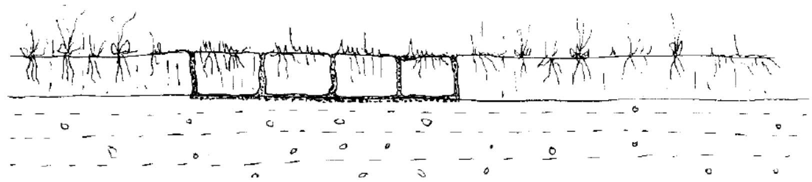


Figure 3: A sequence for stripping and replacing turf (Anonymous 2007).

The general procedures of wet meadow management at Zamantı River Crossing are as follow:

- ✓ Turf stripping at meadow crossing was done using excavator. Since ESA 36 consists of orchids, the topsoil up to a depth of 30 cm was suggested to strip considering the tuber depth.
- ✓ Subsoil taken from the trench was put over the grassland aside after underlying spreading geotextile with suitable thickness quality.
- ✓ The heavy machines that excavated trench, laid down the pipe, and backfilled subsoil were provided to move over the settled wooden platform up to open trench on the grass.
- ✓ River was protected from sedimentation using silt fences
- ✓ River banks were stabilized by installing gabions.
- ✓ Turf was replaced by man-power.
- ✓ Subsoil stocking area that was protected from subsoil by spreading geotextile over grassland before stocking were maintained by cleaning from surplus clay, and improved by additional seeding.

4.2. Periodic monitoring at field and reporting

The monitoring activities cover daily base field inspections and daily reporting with regard to the compliance with the environmental conditions and requirements of the EIA. According to seasonal sensitivity constraint (Table 1), the construction at river crossing was started in March and completed in one month. Figure 4 shows some pictures from monitoring activities during Zamantı River wet meadow crossing.

4.3. Variance Request Program

Such variance request program also was required for the impacts occurred at site specific circumstances which were not predicted during the preparation EIA report and Reinstatement Method Statement for Zamantı River Crossing, but affected construction in a daily basis and required applying an alternative management method integrated with alternative mitigation measures. Third party monitoring minimized the time required for review and approval of variance requests while providing high level of environmental quality.

Turf protection: Wooden platform installation

Turf protection during subsoil stocking

Turf replacement

Turf replacement

Soil improvement by organic manure spreading

Turf replacement:

Zamantı River meadow during construction

Zamantı River meadow after reinstatement

Figure 4 (Cont.): Some samples from monitoring activities at field

4.4. Training

Trainings about ecological reinstatement were given to the personnel at field or through an organized training seminar as EIA requirement and EMMP of it. The target groups were range from lay person to the construction staff that is not sufficiently aware of environmental responsibilities of the project.

5. DISCUSSION

Landscape restoration methods are site specific. Each landscape has its own structure and function changing temporally and spatially. Success on any restoration activity depends upon the success of landscape analysis considering the project specific requirements. Diving forces-pressure-state-impact analysis is the best way to understand the relationship between project and landscape.

Wet meadow management was succeeded in BTC P/L Project Zamantı River crossing by the implementation of turfing technique with additional protection efforts such as wooden platform implementation, geotextile spreading over grassland before subsoil stocking, etc. The environmental management activities included wet meadow protection should be systematically constructed for each project phases as; 1. Pre-Construction, 2. During Construction, 3. Post-Construction, and 4. Operation. The success at each step is crucially depends on the preparatory works at earlier stages. The landscape restoration works after construction, for instance, can be implemented in due time only if all required plant material/seeds in expected standards was planned to provide starting from pre-construction stage. If plants are intended to provide after construction, the commercial stocks might be limited or unavailable. Moreover, as ecological reinstatement means to restore back the ecological conditions as it was before construction, and the native plants do not have commercial values in general, it is difficult to find them out from commercial suppliers. Experiences showed that construction engineers are not very much aware of this condition, so that do not have enough willingness to undertake preparatory works for landscaping. The suggestion is to strengthen the monitoring for the implementations of necessary preliminary actions for further landscape restoration activities

ACKNOWLEGMENT

The success on Zamantı River wet meadow management of BTC P/L Project was strongly depend upon the enormous contribution of deceased **Mr. Mustafa Çelikel** as dear colleague and soil science expert of ÇINAR. This paper is dedicated to his memory. No doubt, the wet meadow protection became a real story with serious efforts of Mr A. Venkataramana as Environmental Manager and Mr. Cengiz Demirhan as landscape architect of EPC Contractor during method statement preparation and implementation.

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ECOLOGICAL-BASED WATER RESOURCE PLANNING AND MANAGEMENT.

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Over the last 30 years, Danish water planning has changed focus for several reasons. The aims of this article are threefold, firstly to identify and present the major changes emphasising the ecological methods used in planning and management, secondly to discuss advantages and shortages in the abatement of pollution and, finally, to analyse the effects on the quality of water ecosystems.
The overall perspective of the article is to identify Danish experiences that can inspire other countries, here as an example Malaysia, in their water resource management. For this reason, some of the methods are described in greater detail.

Keywords: *Water pollution, water regulation, Danish water resource management 1974-2005, biological indicators, mass balances, and the water circle.*

Introduction.

Denmark has regulated the use of water resources for many years. Every spring farmers want to drain water from the fields and others actors want to store water for hydropower or other purposes. The conflicts that arise from conflicting demands have been regulated through watercourse acts since 1880 (Arffmann 1980). In the 1950s and 1960s water pollution grew and the need for further regulation was intensified.

An environmental protection act was prepared at the end of the 1960s, the inspiration for which was found in California where the authorities relenquished the idea of maintaining water resources in their natural state, instead a river's useful applications were identified and thereafter the relevant water quality was defined. Furthermore, for some pollutants, self-purification was introduced and the recipient could receive some polluting substances without harming a useful application. The accepted planning principle was to ensure that the discharge was treated sufficiently, so that the water could be used, and so that it was possible for both the cities and industries to expand. (Harremoës 1969)

The present paper will start with the first Danish act, passed in the seventies, dealing with pollution and chart the developments until the present day. Water pollution problems and changes in legislation will be identified and periodized. The main ecological methods used in water resource management will be presented and discussed.

Methods.

A public discussion of an environmental issue is used as an indicator of major environmental problems related to water resources. In order to identify the pollution problems I have collected information from newspapers, journal articles, books and legislation over many years The basic idea was that there is a positive relationship between the environmental problems discussed in the newspapers and other mass media and the future environmental regulation. Certain regulations were enacted without much public debate, often a result of the implementation of an EEC environmental directive. (Andersson 1992)

The public environmental debate started in the sixties and the first Danish environmental protection act was launched in 1973. Around 3,000 articles from two to four of the leading newspapers placed in a database have been scrutinized and major water pollution problems were identified. With regard to the legal and regulatory aspects acts, hearings and regulations were analysed, and major changes within the scope of water pollution problems were included in the study as well as the ecological knowledge used for the specific regulation. The debate, the legislation and the ecological background were the indicators used to periodize the years 1973 to 2005. I divided them four periods and reasons for doing so will be presented (see Figure 1a & 1b). Full documentation has not been presented here because the focus for this paper is the natural scientific strategy of the water management. In this way, I followed a historical process where the pollution of water resources was the main issue. The regulation started with rivers and lakes, thereafter the sea was included as was groundwater. Legislation not dealing with pollution was not assessed and some laws with a narrow purpose, such as oil spills from ships, were left out. Since water resource regulation has been decentralized, I have chosen to present part of management of water resources through a case of the city Horsens, but the principles were the same for the whole country.

The use of the concept of environmental regulation refers to both the legal background and the different administrative practises. Since the Danish Environmental Protection Act was a frame act, the environmental authorities will in many cases have to fill out the frame with guidelines of a different kind.

1973-1979. The dilution of organic pollution and heavy metals.

The 1974 Environmental Protection Act was comprised of a chapter 3 for the protection of groundwater, a chapter 4 dealing with the protection of surface water, a chapter 5 including an approval system for new plants and major enlargements, and a chapter 9 describing monitoring and planning. It was the obligation of the local councils to prepare the plans that would include the location of industries and other polluting activities, the plans were to be based on the vulnerability of the surroundings to pollution. (Environmental Protection Act 1973)

Rivers in Denmark were in poor condition because of organic pollutants from domestic sewerage systems and food processing industries. The act explicitly mentioned that the regional councils should monitor water ecosystems and develop planning systems. One of the ecological systems used was based on a biological assessment where quantitative monitoring of the aquatic invertebrate communities is made at a number of stations along a watercourse. In a river, the aquatic macro invertebrates decompose organic matter as part of the food chain. An assessment of the integrity of the invertebrate community is an early indicator of the integrity of the river ecosystem's health. The system is called saprobic because a decomposition of organic matter takes place. When a river is exposed to increased amounts of organic matter the number of species and animals present can characterize the quality of the system. As long as the pollution is organic (not toxic) and the water is not running too fast, the saprobic system can be used in river planning. Different kinds of index can describe the actual situation. One system has four categories where I refers to no pollution, II is moderately polluted, III rather strongly polluted and IV is very strongly polluted. (Iversen 1976)

Many Danish watercourses will have good water quality up stream, but as pollution is discharged down stream the water quality deteriorates. Such information can be used in plans for improving water quality. In the late seventies, the EU established water quality targets which would ensure that specific fish like Salmon and Carp would be able to live and breed (Directive 1978).

In the same period, there was a great deal of focus on water pollution due to heavy metals discharged from industrial production including the fertilizer, chemical, galvanic, plating industries, but also many more. Consequently pollution was monitored in many areas. Heavy metals could be diluted and the impact minimised for some time. So the local councils used different emission standards for the same heavy metal depending on the ability of the recipient to dilute the discharge. This was legal because the central environmental authorities had published a guide concerning emission standards relating to watercourses, lakes and the sea (Vejledning 1974). If the local authorities found that the industry should have higher standards because of technical or economic difficulties to observe the guidance standard it was possible for the local authorities to do that. Many industrial approvals included a maximum concentration but there were no restrictions on quantity, so the industries could dilute the processed water and observe the standards. The strategy of using guiding standards of emission created a scientific boom in experimental doses response tests with different test organisms and different concentrations and combinations of heavy metals. Furthermore there was an increased monitoring of heavy metals from industrial sources. The decentralised management of toxic pollution with heavy metals lacked specific knowledge and the result was not environmentally acceptable.

1980-1986. Dynamic surface water planning.

In 1982, the planning procedures concerning surface water resources were made more transparent and an amendment to the act described a recipient quality plan (RQP). The RQP was introduced by the 14 regional councils and 275 local councils. The regional councils were responsible for the planning, but were required to negotiate with the local councils. A RQP should include:

1. Objectives concerning water quality in watercourses, lakes or coastal zones.
2. A study of the existing and planned wastewater discharges that were related to the objectives.
3. Timing when the objectives and the related quality standards should be observed
4. The regional councils' assessment of the economic consequences.

(Environmental Protection Act 1982)

RQP is a sector plan that is summarised in the physical planning at the regional council level. In the physical planning, the regional authorities balance stakeholder interests and the public is consulted about all physical plans. The state authorities (central level) only have power to withhold approvals of sector plans not to change them directly.

The regional councils prepared a plan for the use of water ecosystems within its borders. The RQP was based on scientific data and on an analysis of the interests involved such as commercial fisheries, recreation, scientific interests and interests in discharging wastewater. The regional councils were responsible for preparing a RQP for the coastal area and the plan should contain objectives for the quality of the water's ecosystem in respect to the existing conditions and the use of the water.

The distinction of objectives was based on the philosophy that a number of discharged substances, such as organic matter, nutrients, and some heavy metals are naturally present in ecosystems, and therefore they can be part of the natural metabolism. Since the ecosystems' ability to "digest" these substances was different, the discharged load could also be different. Consequently, the local authorities' decisions might diverge from other local authorities if they discharged to larger (more diluting) ecosystems, and if the flow of water was faster. So it was part of the RQP that maximum emission standards and loads were different for different water ecosystems and similar industries were allowed different conditions for discharges depending on location.

A main problem with Danish water regulation was co-ordinating the water-planning system with the approval system for industries especially in relation to water pollution. The regional councils and the local councils were both responsible for the water management system RQP, and now also for the co-ordination with environmental approvals of industrial plants. The following case illustrates how sector planning and environmental approval of industries was arranged in Denmark.

Horsens is an old town with approximately 50,000 inhabitants and many different manufacturing plants situated near the shallow Horsens fjord (see Figure 2). The relevant authorities are Horsens Kommune (the local council) and Vejle Amt (the regional council.

The RQP for Horsens fjord was decided in 1985. Some areas of the water ecosystem were given a so-called lenient objective - meaning that some impacts from wastewater treatment plants and fish farms were accepted. Most of the fjord was covered by the general objective implying that there must be no or only weak influence on flora and fauna. (Vejle Amt 1985)

The fjord's environmental problems had been obvious for many years and the pollution of the fjord increased before 1971 when the first measurements of the water quality were made. A number of different methods have been applied to describe the ecological situation in the fjord. A low transparency (a result of eutrophication) of the water and bad quality of bathing water characterized the fjord. Eutrophication resulted in an extreme growth of plankton algae preventing higher plants and bottom animals from surviving. Eutrophication was caused by nutrients like nitrogen and phosphorus. The transparency of the water was a simple method that measured the penetration of light into the water indicating the degree of eutrophication. This parameter was used to form a standard for a general objective, the satisfactory transparency of the water in the summer period should not be less then two metres. (Vejle Amt 1985)

The regional council estimated how much impact Horsens Fjord could accept when other defined social purposes were feasible. The regional council provided the objectives as well as the list of allowed discharges from the wastewater treatment plant in Horsens for different substances per year.

In 1972/73 a mechanical wastewater treatment plant was built near the harbor. A few years after all the sewers were centralized and the wastewater treatment plant effluent constituted the main point source to the fjord. All industrial plants were discharging to the municipal sewerage system. Given the permission to discharge, the local council had the responsibility to distribute discharge permits to all water polluting industries. Each factory was given permission by the authorities to discharge wastewater and impact the water ecosystems to a certain extent. These permits were given allowing a concentration and a yearly amount of kg for each discharged substance. The local council also had to monitor whether given standards were observed by industries, while the regional council controlled the sewerage outlet. The RQP was dynamic in the sense that if the regional council discovered an unacceptable situation in the fjord, it could alter the permission from the local council and reduce the permitted discharge from the sewerage system. The local council would then have to reduce the individual industrial contributions of wastewater to the sewerage system.

An advantage of the RQP system was that the Danish authorities were obliged to survey the ecological situation in the water ecosystems. For a specific marine area it proved to be a time and resource consuming activity to establish adequate scientific documentation, this was a weakness of the system as it was very difficult to establish sufficient knowledge of the discharges and their consequences for the water ecosystems, especially in the coastal areas.

The maximum standards of emissions made by the local or central authorities provided an operative instrument for controlling the water pollution. An effective enforcement of maximum parameter limits of emissions was necessary before the heavy metal polluting industries took active steps to reduce the their loads.

The RQP system covered all the Danish freshwater ecosystems and coastal zones, but not the open sea. In autumn 1986, oxygen depletion was documented in large areas of the open sea, Kattegat, and this phenomenon raised a public debate that the politicians reacted to. The oxygen depletion was caused by many nutrients (nitrogen and phosphorous) in the water and a correspondent growth of algae. Dead algae drop to the sea bottom and the decomposition of organic matter causes oxygen depletion. Kattegat was supposed to be the optimal recipient of wastewater, so the oxygen depletion was a major failure of the RQP.

1987 – 2000. Source orientated management.

The Danish Parliament approved a water action plan with the objectives of ensuring that the discharge of nitrogen to the sea should be reduced by 50% and the discharge of phosphorous by 80% within three years. (Schroll 1987).

The political plan was not mandatory for the authorities that should act based on legislation. It was suspected that the nutrients were coming from the cities' sewerage systems and from agriculture. An executive order stated that wastewater treatment plants larger then 15,000 persons equivalent should observe an emission standard of less then eight mg total N per liter, and less then 1.5 mg total P per liter (Miljøministeriets bekendtgørelse 1987).

The objectives of the action plan were not scientifically based because nobody knew the mass balances in the huge and complex ecosystem of Denmark and Kattegat. This political objective demanded a new type of ecological knowledge in environmental management. The flow of matter and mass balances should be a priority before the quality of ecosystems. The flow of matter was based on the constancy of elements and such studies were made for nutrients and heavy metals. Mass balances can provide important information concerning the flows and storages of specific substances and be valuable in identifying important consumption and potential impacts. Another consequence of the regulation with uniform standards of emission for discharges of certain substances undermined the RQP because independently of the location (good recipient or not), the same wastewater treatment result should be observed. In that way, the use of mass balances was contradictory to a recipient orientated regulation where individual aspects of the ecosystem could be taken into account. Instead of dynamic regulation, the regulation was directed at reducing the discharge of a substance as much as possible without taking care of location and/or biological quality.

Another part of the water action plan was that agriculture should halve its nitrogen discharge to the sea. Agriculture was not regulated directly for its use of fertilizers and manure, but specific rules on the storage of manure, wintergreen fields and the handling of manure were established.

Returning to the case of Horsens, oxygen depletion had a remarkable effect on wastewater from cites and industries. In 1989 the wastewater treatment plant removed phosphorus, and in 1991 the biological part of the wastewater treatment for removal of nitrogen was built, which constituted an important step on the way to improving the ecological situation in the fjord. One can say that the treatment of wastewater was a plain "end of pipe" solution where a complicated mixture of industrial and domestic wastewater and surface water was treated, whilst, evidently, a direct regulation of the sources would make more sense. But considerable investments made in the sewerage system over many years had narrowed the possibilities and determined the background from which improvements had to be seen.

One very expensive activity had been going on for many years. The sewerage system was continuously separated into two, one for sewerage and one for rainwater. This paired system was necessary to avoid rainwater being treated in the wastewater treatment plant. Based on the Recipient Quality Plan, the regional council (Vejle amt) imposed a set of maximum standards of emissions and maximum loads to Horsens Central Waste Water Treatment Plant for implementation not later than 1992 (Figure 3).

The wastewater discharge of phosphorus into Horsens fjord was halved between 1987 to 1991 and this was important for eutrophication. Phosphorus was the potential limiting nutrient for alga production in the spring (Marts-May/June) while nitrogen is the potential limiting factor in the autumn (May-September/October). Compared to the mid- eighties an improvement was seen in the transparency of the water in the summertime because the concentration of plankton algae in the water was lowered. Latest reports showed a reduction in transparency and the objectives for the environmental quality in Horsens Fjord were not met (Vejle Amt 1991, Vejle Amt 2002)

The mass balance principle was also used on the heavy metal copper. The regional council Vejle had assessed how much copper the fjord could absorb and from that assessment a set of maximum limits of parameters of emission were given to the wastewater treatment plant for discharges (Figure 3). As the next step, the local council distributed the amount of copper among the water polluting industries in Horsens. So the regional council had the overall planning responsibility while the local council carried out the details about the allowed amounts. If copper created environmental problems, the regional council could, if necessary, reduce the amount of copper allowed to enter the fjord and then the local council had to reduce the wastewater contributions of copper from the industries.

Improved wastewater treatments lead to increased amount of sludge and problems with the sludge disposal. An ecological way of handling the sludge was to bring nutrients back to the agricultural fields but because of a high load of heavy metals it was, in many cases, impossible. The local council then had to trace the heavy metal sources and reduce them. On several occasions copper had created problems in Horsens and maximum emission standards were used to limit this toxic compound. A maximum copper emission standard was given to industries so they had to observe the limit of 1 mg copper per liter in their wastewater discharged to the sewerage system. Copper effluents were common wastes from electroplating industries, metal surface treatment, cooler industries and others.

The trend concerning copper discharge is presented in Figure 4. It appears that the copper discharge from industries in Horsens has been reduced from 313 kg in 1990 to 135 in 1992 and then the load has risen to 334 kg in 2000.

Some uncertainties were related to these figures. Depending on the range of copper concentrations in the industrial wastewater, the local council increased the number of samples and consequently some of the figures were based on more samples from one industry than others. Where it was necessary to make estimations, conservative ones were made in order not to underestimate the copper load. Over the years, there had not been a reduction of the industrial copper load to the sewerage system. Other copper sources then industrial ones were present in the city. In the end of the eighties, less than one third of the copper in the sludge could be correlated to known industrial effluents. In particular, copper might come from products used in households or from copper roofs in the city. (Schroll 1995)

In the case of Horsens, the regional council, Vejle, had assessed that it would be sustainable to allow an impact to the fjord of 720 kg copper per year. This was more than the actual industrial load of 334 kg copper per year and consequently the industrial contributions of copper were not expected to violate this part of the RQP. But the discharge of copper might create problems due to lack of knowledge. For many years, the ecological situation in the fjord of Horsens had been unacceptable and there was very little information about the former unpolluted fjord. The lack of base line data make it difficult to establish acceptable effluents and the permission for the wastewater treatment plant to discharge 720 kg copper per year to the fjord had a very weak scientific background.

The scientific knowledge was not sufficient to make a sophisticated plan so ecologically based mass balances were used to find important sources of pollution and not least identify where it was economically cheapest to reduce the problematic substances. The politicians decided the objectives and it was their responsibility to decide the means used to reach the objectives. The objective of reduced outflow of nutrients from agriculture was not supported by efficient regulation. The Danish RQP system, several water actions plans and the industrial approvals had an influence on the Danish water management system, but it was difficult to see any substantial improvements in the quality of water ecosystems. This rather sad development has now gained a new dimension, because the EU has forced Denmark to implement a water frame directive.

2001 –2005. Water cycle management.

In 2000, a European Community directive established a framework for Community action in the field of water policy (Directive 2000). A directive must be implemented in a member state within three years. After this period, national legislation covering the issues of the directive shall be in force.

River basins are core units. Administratively, they can be united but not divided and each country has to form river basin districts and appropriate administrative arrangements. In this way, surface water run off decides the area but groundwater and water supply will also be the responsibility of the new water administrations, so the same authority will administrate the water circle.

The new water policy focuses on the natural water flow through rivers to the sea and on surface water and groundwater interaction in terms of ecological status, quality and quantity. An ambitious policy combines protection of ecological status with the long-term sustainable use of water for human purposes to ensure the quantities and qualities required for sustainable development.

Ambitious environmental objectives must be met by 2015. 1) The protection of high ecological status and good surface water status of all other waters; 2) good groundwater status; and 3) compliance with objectives for protected nature areas and drinking water abstraction areas. 4) "No-deterioration" of present status is required from the date of entry into force.
(Directive 2000)

The definition of good water status combines social needs with protection of the water ecology by allowing for a certain human impact. Good surface water status requires a rich, balanced and sustainable ecosystem and respect of environmental quality standards. Good groundwater status requires that abstraction and alteration to natural recharge are sustainable in the long run without loss of ecological quality in associated surface waters or damage to terrestrial ecosystems. Conformity with standards for pollutants is required, e.g. nitrate and pesticides. High water status requires negligible human disturbance.

There is an emphasis on river basin management with co-operation between all parties sharing the same waters, be it regions, EC Member States or non-Member States. One river basin district, one management plan is the idea. Measurement programmes cover the entire river basin district with co-ordination of other EC policy areas, in particular with agricultural and regional policies. Monitoring programmes must be established with economic and environmental impact indicators. Consultation is required at all stages in the development of river basin management plans in order to ensure that all parties, including the general public, are properly involved and informed. (Directive 2000)

The water framework directive requires that existing waters of a high ecological status (i.e. essentially undisturbed) must not deteriorate. However, for most waters, the main purpose is a combination of sustainable use of water and protection of the aquatic environment. This is reflected in the general objective of achieving a "good ecological status", defined as an aquatic ecosystem, which is in ecological balance. The directive operates with five different objectives for surface water of which the first two indicate good ecological status (Figure 5). Water must be abstracted, and discharges into water are allowed, provided this will not harm the long-term sustainability and use of such waters. The inclusion of a possibility of using derogation (deviation) reflects that space is given for further human development, whereas strict criteria for the use of derogation reflects the importance of protecting the essential functions of waters i.e. to strike a balance between these two needs. (Directive 2000)

The good ecological status of aquatic ecosystems is defined in a way that takes into account the natural climatic and ecological conditions as these vary across the Community. If a river dries out in parts of its course during the summer as a natural part of its annual ecological cycle, this will be reflected in the definitions of what constitute good ecological status and consequently also good water status. Good ecological status also allows for some degree of disturbance due to human activity by specifying good status as slightly disturbed compared to its natural ecological state. The directive does not distinguish between different uses of waters for different purposes. Good status is required for all waters. The basic assumption is that surface water of a good ecological status will inherently be of good quality and in sufficient quantity and as such amenable for the specific uses required, otherwise good status will not have been achieved. Good status therefore becomes the fundamental yardstick safeguarding all other uses.

Moreover, the proposal introduces a requirement for recovering the cost for water services provided for water uses and, on a longer-term basis, prepares for the recovery of environmental and resource costs. This element of the directive deserves special attention. Securing adequate supplies of a resource for which demand is continuously increasing is one of the drivers behind the introduction of an economic analysis of water use within river basins and an obligation to charge for recovery of costs for water services. Water must be priced and users must make adequate contributions to the costs of using water, divided at least into industrial, agricultural and household users. This requirement also implements the polluter pays principle of the Treaty. (Directive 2000)

Six year management plans covering each entire river basin district are required with co-ordinated programmes of measures to ensure the good status of waters by 2015. Programmes of measures must take into account all sources of impact on the aquatic ecosystems including impacts from agriculture, energy production, transport, and area planning. Systematic monitoring of achievements is required. The directive contains a strong component of public participation with the requirement that all river basin management plans must undergo a public consultation process involving the public in general as well as all interested actors. This open participatory process shall also be seen as an important element of control and quality insurance.

The water framework directive will have a major influence on environmental management in Denmark. A coherent legal and administrative framework facilitates implementation of objectives through co-ordinated measures within an overall planning process. The policy moves from protection of particular waters of special interest (a nature area, specific aquatic organisms, raw water for drinking water) to protection and use based on an overall understanding of the hydrology and ecology of the entire natural cycle of each river basin. Focus will be moved to a combination of the natural, social and economic possibilities and limitations, which must be respected in a long-term sustainable use of water. The new EC policy rests on principles where the river basin is the only sensible geographical basis upon which planning may achieve its objectives to avoid a patchy, non-co-ordinated approach.
The water frame directive policy started to be implemented in Denmark and the government's intension was to establish four river basin districts and to make the environmental ministry responsible for the management. This centralisation is connected to the Government's plan for a local structure without regional councils and around 100 local councils. (Miljøstyrelsen 2004)

Conclusions.

Water resource planning in Denmark has seen rather different strategies.
In the seventies, water pollution was managed by the principle of dilution and a use of emission standards for water polluting industries. The planning was coherent and most developed for watercourses. The scientists did not believe that the open sea would be harmed by pollution because of the huge dilution effect. On the contrary, more nutrients were believed to increase the harvest of fish. It was important in general to reduce the impacts of heavy metals like mercury and cadmium but this was a problem with certain types of industrial production. In the beginning of the eighties, a dynamic water planning system was launched. The coastal zone was now included and objectives become established against the background of the ecosystem's quality and social use of water ecosystems. The biological background played a role for the objectives, but water should also be used for social purposes like fishing, diluting wastewater, bathing etc. It was the duty of the regional councils to find a balanced way of defining quality of ecosystems and benefits of society. Then the local councils had to give permission to pollute to discharging industries. The administrative system consisted of two levels of authorities, regional and local, which were involved in water pollution planning, and approval of industries, this created an independent control and often a public debate between the authorities. The system was dynamic in that if the regional council monitored inappropriate changes in the water ecosystem, a stricter discharge of pollution should be introduced. The crucial point of this type of planning was the lack of sufficient knowledge about the ecosystems. It took a long time to get a sequence of data that could significantly correlate water quality and the discharges. Other obstacles were the diffuse pollution and the accumulation of polluting substances in the ecosystems in unexpected areas and organisms.

In 1987, oxygen depletion in the open sea caused the politicians to change water regulation. The recipient quality planning system was obviously insufficient in protecting the sea and a strategy with political objectives was formulated as a certain reduction of nutrients polluting the sea. The scientific focus changed from the biological situation in many ecosystems to a reduction of the different sources to the pollution. Maximum standards of emission for certain discharges were introduced for large wastewater treatment plants. Political reasons meant that agriculture was submitted to ineffective regulation with the result that the Danish surface waters deteriorated further. Instead of good water quality, the regulation became directed against reductions with least costs. A scientific implication is that there is need of knowledge of activities and quantitative flow of matters and it is difficult scientifically to correlate reductions to the ecological situation in waters.

The last experiment with water management was initiated by the EU and was called the water frame directive. The full implementation of the directive would be expected in 2015 so I had to do more theoretical assessments of this development. The water frame directive implied that water regulation in Denmark would be legal described and even the status of water quality will be included in details in the law. Such a legally based water planning was an advantage because Danish water planning had been based on voluntary procedures and guidelines and so it had been relatively easy for environmental authorities to reduce the cost of environmental protection.

One reasonable assumption was that in the future when one authority administered water supply and surface water, the management would be more efficient. Impacts from pesticides or soil pollution were threatening the water cycle and the holistic management approach could create a more efficient intervention. On the other hand, some public control and visibility might be lost with one authority. The approval and control of industries that have been divided between the regional and local authorities following the principle that one had the jurisdiction to approve and the other was responsible for the control and reverse. In Denmark there had been very little public participation involved in water sector planning, and the public was only invited to hearings when regional plans were published. In that context, public participation in the water frame directive would be a clear improvement for the Danish water planning system.
The scientific problems of the water sector planning system were the lack of knowledge of natural ecosystems and the need to determine background figures, which was often very difficult to measure because many ecosystem had been impacted by anthropogenic activities. Lack of environmental knowledge would become a delaying factor especially when all surface water ecosystems should be ranked according to the five different ecological statuses (objectives).

So what has been learned from this long water resource planning history if for example Malaysia should develop her water management? It was a good idea to manage the entire river basin area and include the water cycle, ground water and coastal areas within one unit but also to secure independent control. Polluting sources should be known and quantified and mitigated starting with the hazardous and quantitative important substances. The legal background should be rather precise. The water quality should be based on biological and chemical criteria and objectives. And most important of all, Malaysia should avoid the diluting strategy for the ecosystems and manage the water resources in order to avoid all pollution impacts.

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ASSESSMENT OF USLE NOMOGRAPH FOR ESTIMATING ERODIBILITY OF CALCAREOUS SOILS IN NORTHWESTERN IRAN

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Soil erodibility defines the resistance of the soil to both detachment and transport. Erodibility varies with soil physicochemical characteristics that affect on aggregate stability and permeability of soil. In Universal Soil Loss Equation (USLE), soil erodibility (K) is estimated by the nomograph. The nomograph was presented based on factors influencing soil loss at unit plots in uncalcareous soils. In calcareous soils, calcium is an important factor in soil structure and hence may affect on soil erodibility. Therefore application of nomograph in calcareous soils may lead to inaccurate assessment of K-factor. The study was conducted in the Hashtrood, located in northwestern Iran from March 2005 to March 2006. The study soils had almost 13% lime and 1% organic matter that mainly are used for wheat dry farming. In order to investigate, the square network of agricultural soils with 900 km^2 in area was selected and divided into 36 regular grids 5 × 5 km. In each grid, the erosion plots designed agreement to unit plot at 3 replicates with 1.5 m intervals. The soil loss (sediment) at the unit plots was affected by 23 natural rainfall events during the study period. The K-factor was estimated by the nomograph and measured as soil loss amount per unit rainfall erosivity index for a year. The results indicated that measured-K was significantly smaller than the estimated-K by a factor of 10.47. The correlation coefficient between measured and estimated-K factor was very low (r^2=0.16). Results indicated that measured-K significantly correlated (r^2=0.85, $p<0.001$) with some physicochemical soil properties (sand, silt, clay, gravel, organic matter and lime). The lime, sand, organic matter and gravel significantly decreased soil erodibility but silt and clay significantly increased it. The effect of lime in decreasing erodibility was due to its remarkable role in increasing the aggregate stability and permeability. In the USLE nomograph this factor is not studied and therefore, it can not accurately estimate the erodibility of calcareous soils under study. In this soils, the K-factor can be estimated by a regression equation with easily-measurable soil properties.

Keywords: *USLE nomograph; Calcareous soil; erodibility; Iran*

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1. Introduction

Soil erosion by water is a continuing problem in many parts of Iran particularly in the semi-arid regions where farming is carried out on slopes. Proper evaluation of the main erosional factors in area of interest is the first step in the choice of a strategy to reduce soil erosion. The Universal Soil Loss Equation technology (USLE, Wischmeier and Smith, 1978) and its versions are widely used to predict soil loss and to plan soil conservation (Renard et al., 1991).

Soil erodibility is one of six factors in the USLE that is thought of as the ease with which soil is detached by splash during rainfall or by surface flow or both (Renard et al., 1997). This factor reflects the fact that different soils erode at different rate when the other factors that affect erosion are the same (Kirkby and Morgan, 1980). It is generally considered as an inherent soil property with a constant value. For the USLE, the concept of soil erodibility was introduced as the K factor, which was defined as the mean rate of soil loss per unit of rainfall erosivity index (EI_{30}) from a cultivated contininuous fallow plot on a 9 % slope and 22.1 m long (unit plot). Thus, the K factor for a specific soil can only be determined from long-term observation of rainfall erosivity and soil loss from a unit plot. For an erosion risk assessment, the use of the erodibility factor K in the USLE is desirable because it makes the erodibility assessment comparable with other assessment in the region.

To allow estimation of soil erodibility from measurable soil properties, the soil erodibility nomograph was developed in the early 1970s (Wischmeier et al., 1971). For areas where there is no field experimental data, the K factor is predicted from a multi-regression equation or from the nomograph, being a graphical interpretation of the equation. Main factors considered in the soil erodibility calculation in the USLE include soil particles (% sand, % silt, % very fine sand and silt, and % clay), % organic matter, soil structure code and soil permeability class (Wischmeier and Mannering, 1969; Wischmeier et al., 1971; Wischmeier and Smith, 1978). The K-value represents the soil loss per unit of EI_{30}, as measured in the field on a unit plot (Wischmeier and Smith, 1978). The K factor for the USLE was calculated according to Wischmeier and Smith (1978) as follows:

$$K = 2.8 \times 10^{-7} M^{1.14} (12\text{-}a) + 4.3 \times 10^{-3} (b\text{-}2) + 3.3 \times 10^{-3} (c\text{-}3) \quad (1)$$

where K is expressed in units of $Mg.ha.h.MJ^{-1}.ha^{-1}.mm^{-1}$, a is % soil organic matter, M is (% silt + % very fine sand) □ (100- % clay), b is soil structure code and c is permeability class.
The USLE nomograph, where is applied to soil with similar characteristics to those in the USA, a close correlation exists between predicted and measured, but poorer predictions may be obtained where the other soil properties affect on the soil erodibility. Soil properties that affect infiltration rate and permeability to water also affect on the amount of erodibility. Texture and structure are two soil properties that affect on permeability and soil erodibility (Troeh et al., 1980). The soil properties influencing the infiltration rate and permeability, total water capacity, dispersion, splash, abrasion, and transporting forces also affect on the erodibility (Kirkby and Morgan, 1980). Soil organic matter content affects soil aggregation, soil particle size distribution and soil infiltration capacity (Stevenson, 1985).

Erodibility depends on the primary particle, distribution, how strongly these primary particles are aggregated together, and whether runoff occurs during a rain. In erosion models, these parameters need to be related to easily measured soil properties (Duiker et al., 2001). The concept of erodibility and how to assess it is complicated since the susceptibility of the soil to erosion is influenced by a large number of properties such as physical, mechanical, hydrologic, chemical, rheological, mineralogical and biological, not to mention the soil profile characteristics such as the depth of the soil and its influence on vegetative growth (Veihe, 2002).

Soil properties influencing soil erodibility are grouped into two categories: (1) those that affect infiltration rate, movement of water through the soil, and water storage capacity; and (2) those that affect dispersion, detachability, abrasion and mobility of soil particles by rainfall and runoff (Renard et al., 1997 and Soil Survey Staff, 1997). Therefore different soil properties influencing detachability and transportability of particles are important in erodibility of soil. In the soils of semi arid regions, calcium is main factor in flocculation of particles and increasing aggregate stability. Thus, in these soils, lime effect on aggregate stability and detachability of particles. This nomograph was presented based on field measurement of erosion in relatively uncalcareous soils in semi-humid regions of USA (Rafahi, 1996). In calcareous soils, calcium is an important factor in aggregate stability and hence can affect erodibility of soil. Therefore application of nomograph for estimating erodibility of calcareous soils from semi-arid regions may lead to inaccurate assessment of K factor.

Several attempts have been made to devise a simple index of erodibility based on the properties of the soil determined either in the laboratory or in the field. Some researches showed that other soil properties, which may influence erodibility, include finely divided calcium carbonate, iron and aluminum oxides, and parent materials (Trott and Singer, 1983; Cerda, 1996). The results of field measurement clearly showed that the soil erodibility factor K in the USLE better represents the effect of soil properties on soil loss than the index K_{zw} proposed by Zhou and Wu (1993) (Zhang et al., 2004). Clay usually decreases erodibility, as observed in studies in different parts of the world (Imeson and Verstraten, 1989; Dimoyiannis et al., 1998). The large surface aggregates can reduce erodibility because their greater mass increases resistance to raindrop detachment. They can also reduce runoff velocity by increasing surface roughness and reduce runoff by delaying surface sealing under rainfall (Charman and Murphy, 2000).

It was found that the important soil properties influencing soil erodibility are texture, organic matter content, size and stability of structural aggregates in the exposed layer, permeability of the subsoil, and depth to a slowly permeable layer (Wang et al., 2001). In an investigation, soil loss of the Alfisol was significantly correlated (r^2=0.96) with silt + very fine sand content, indicating that erodibility of these soils is determined by similar properties as soils in these soil orders in the USA. It was suggested that limited runoff generation is a primary reason for low erodibility of these soils (Duiker et al., 2001).

For tropical soils, unstable soil aggregates, modified silt, sand, and the corresponding base saturation were used to determine K-factor of USLE (Angima et al., 2003). Investigating erodibility of agricultural soils on the Loess Plateau of China indicated that nomograph values for the four sites are higher by a factor 3.3-8.4 than measured values. On average, using nomograph-based estimates of the K factor would lead an over-prediction of the rate of soil loss by a factor of 4.9 for the four sites. It was found that the measured K is considerably lower than the nomograph K and the relation between the two is rather poor with r^2=0.19 (Zhang et al., 2004). Study of relationship between organic carbon stocks and soil erodibility (USLE-K) showed that soil organic carbon plays a key role in the structural stability of soils in their resistance against erosion. The findings of this study suggested that the high stability to both slaking and water drop impact is due to occurrence of allophone-Fe-Organic carbon complexes, rather than to the total organic carbon, and the active the Fe and Al. (Rodríguez et al., 2006). Results of measuring soil erodibility in northern Iraq using natural runoff plot data showed that storm-to-storm variation in soil erodibility is high. It revealed the importance of long-term measurement in establishing an average seasonal soil erodibility value for a particular soil in the region. Estimated average seasonal values of soil erodibility in study site were lower than the ones predicted by using soil erodibility nomograph (Hussein et al., 2006).

A brief review of researches on soil erodibility in Iran shows that researchs in to the effect of soil properties on erodibility and assessment of USLE for soil erosion prediction have been begun in early 2000. Karimzadeh et al., (1996) indicated that land use and soil management affect soil properties and so affect erodibility of soil. Rohipoor (2001) and Khajei (2001) found that soil erodibility estimated in the Modified Universal Soil Loss Equation (MUSLE) is more than the measured soil erodibility. Ghasemi and Mohammadi (2003) showed that clay and organic matter in contrary to silt decreases the erodibility of soil. Ghorbani and Bahrami (2005) indicated that the soil erodibility was strongly correlated with particle size distribution. Bahrami et al., (2005) related soil erodibility to kind of land use. The soil erodibility increases in soils under irrigated farming rather than cultivated soils due to decreasing organic matter and porosity of soil. Ghaderi and Ghoddosi (2005) found that the soil erodibility correlated (r^2=0.95) with % (silt + sand) divided to % clay in different lands units. Javadi et al., (2005) measured soil erodibility in the USLE at plots under simulated rainfall and indicated that USLE nomograph without calibration could not correctly estimate the erodibility of soils. Agharazi (2005) indicated that the estimated erosion is 8.5 times more than the measured erosion in unit runoff plots on slope 9 %. It is quite remarkable that rare systematic attempt has been made to develop soil erodibility index for different soils and hasn’t investigated to validate USLE nomograph for erstimating erodibility of calcareous soils in Iran.

The objectives of this study were: (1) to determine the K factor in calcareous soils of semi-arid regions using measured soil loss rate from natural runoff plots (2) a comparison of estimated K factor and measured K factor, (3) to evaluate the applicability of nomograph USLE to estimate the K factor in calcareous soils, (4) characterize the soil properties influencing soil erodibility and (5) presentation an equation to estimate erodibility in these soils.

2. Materials and Methods

2.1. Study area

The study site was with an area of 900 km^2 as an square and located in Hashtrood city (36□ 47□ 24□ to 37□ 37□ 33□ N lat. and 46□ 29□ 8□ to 47□ 41□ 13□ E long), located in the south of East Azarbyjan Province in Iran (Fig. 1). The Climate is semi-arid with a mean annual temperature ranges from 13□ C and an average annual precipitation of 322 mm. The range of slopes in the study site was 5-15%. Soils are generally deep to moderately deep and clayey, underlain by calcic horizon. The soils have about 10% $CaCO_3$ and 1% organic matter with moderate permeability that are usually used for wheat dry farming (Hakimi, 1986).

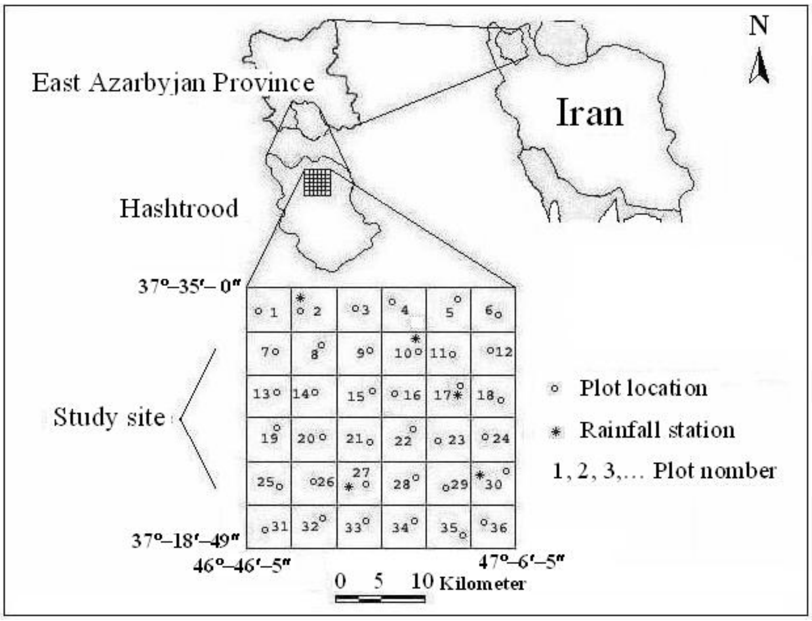

Fig. 1. Geographical location of the study site in Hashtrood, located in northwestern Iran

2.2. Study method

In order to investigate erodibility, the square grid with 900 km^2 in area of calcareous soils was selected and divided into 36 regular grids 5 × 5 km. In each grid, the erosion plots were installed on 9% uniform slops with dimension of 22.1 × 1.83 m and area of 40.47m^2 at 3 replicates with 1.5 m intervals. The entire 108 plots were cultivated at March 2005 and their borders surrounded with earthen ridge with about 30 cm in height. The plots were maintained in a bare condition by herbicide treatment. At the lower parts of the plots, runoff collecting installations were established. The installation consisted of gutter pipes, pipes and 70-l barrels. After each period of rainfall, the amount of runoff and soil loss in plots was measured.

2.3. Soil properties measurement

Soil properties consisted of physical and chemical characteristics were measured in soil samples. This properties were grouped into two categories: (1) independent physicochemical that were % sand, % coarse sand (2-0.1mm), % very fine sand or VFS (0.1-0.05mm), % silt, % clay, % organic matter (O.M.), % lime (the calcium carbonate equivalent known as the Total Neutralizing Volume or T.N.V.), % gravel and potassium content ; and (2) dependent characteristics i. e. aggregate stability and permeability. To characterize independent physicochemical properties, soil samples were taken from 0 to 30 cm depth in each plot of grids. There were 108 sampling sites on an area of 900 km^2. Laboratory analyses were also conducted for the evaluation of: particle size distribution, organic matter, lime, potassium and aggregate stability. The particle size distribution was determined by hydrometer method, and the organic matter content was analyzed with the walkley-Black procedure (Nelson and Sommers, 1982), the lime content was determined with titrimetric method, potassium content was determined by atomic absorption set. The aggregate stability was determined with wet-sieving method based on Mean Weight Diameter (MWD) using a method proposed by Angers and Mehuys (1993). The modification meant that sieves with diameters of 8, 6, 4, 2, 1, 0.5 and 0.25 mm were used rather than 4.75, 2, 1, 0.5 and 0.25 mm and because of the weak aggregate structure, shacked for 1 minute. Water-stable aggregates were determined by placing 100 g aggregates with diameter larger than 8 mm on top of a set of sieves and raising and lowering into water. The soil permeability was measured by double rings in the plots based on final infiltration rate.

2.4. Rainfall properties measurement

Rainfall amount was measured at five locations on the experimental site (Fig. 1). Four standard rainfall gauges were used to measure manually the volume of rain after each event located on the grids 2, 10, 27 and 30 on study area, and an automatic rain gauge belonging to Irrigation Office of Hashtrood located on the grid 17, allowed to determine rainfall intensities.

2.5. Runoff and soil loss measurement

Runoff volume was measured after each rainfall event, through collecting the entire runoff at the bottom of each plot using install barrel. To measure of soil loss, uniform samples were taken from sediment and runoff mixture of tank and analyzed in laboratory through weighing method. Amount of soil loss for each rainfall event, was obtained based on concentration of samples and total volume of tank contents. The annual amount of runoff and sediment in $Mg.ha^{-1}$ were separately calculated by summation of the runoff amounts and sediment amounts for 23 storms, when soil loss occurred during March 2005 to March 2006.

2.6. Calculating rainfall erosivity index

On the basis of recording rain gauge data of the meteorological station in plot 17, kinetic energy was computed using the following equation (Wischmeier and Smith, 1978):

$$KE = 11.87 + 8.73 \log_{10} I \quad (2)$$

where I is the rainfall intensity (mm h^{-1}) and E is the kinetic energy (J m^2 mm^{-1}). The rainfall erosivity factor (EI_{30}) for each storm was obtained by multiplying E into I_{30} (the maximum 30-minute intensity in mm.h^{-1}). This index was calculated only for the rainfalls, that had a duration time greater than 30 minutes during the study period. The annual rainfall erosivity index or R (MJ.mm.ha^{-1}.h^{-1}) was calculated through summation of EI_{30} in one year.

2.7. Determining soil erodibility

The soil erodibility K was estimated using the regression equation (1). The estimated K values ($K_{estimated}$) were used as a basis for comparison with actual amount of soil erodibility. The actual soil erodibility factor K for the USLE in each unit plot also was calculated according to Wischmeier and Smith (1978) as follows:

$$K = \frac{A}{RLSCP} = \frac{A}{R \times 1 \times 1 \times 1 \times 1} = \frac{A}{R} \quad (3)$$

where A is the mean annual soil loss measured at unit plot in Mg.ha^{-1}, R is annual rainfall erosivity index in MJ.mm.ha^{-1}.h^{-1} and K is measured soil erodibility ($K_{measured}$) in Mg.ha.h.MJ^{-1}.ha^{-1}.h^{-1}. The measured soil erodibility of unit plots was calculated of annual soil loss measured divided to annual rainfall erosivity index. The annual soil erodibility K factor for each grid was obtained from the mean of K factors in 3 plots during the study period.

2.8. Statistical method

Statistical analyses were carried out with SPSS 13 for windows. Factors under study were tested for normality using the Kolmogorov-Smirnov test. Analysis of variances (ANOVAs) was determined following the General Linear Model (GLM) procedure at a probability level of P□ 0.05. Significant correlations of data were tested with unstandardized coefficient procedure. Levels of significance derived from paired t-test.

3. Results and Discussion

3.1. Soil properties

The results of soil analyses showed that they had low organic matter content, moderate lime (T.N.V.), high potassium, low aggregate stability and moderate permeability. The soils texture was mainly clay loam and loam. The physical and chemical properties of the soils sampled from the study site were given in Table 1.

Table1: Descriptive statistics of physical and chemical soil properties of soils in the study area

[a] M: Arithmetic mean; Min: Minimum; Max: Maximum; SD: Standard deviation
[b] VFS: Very fine sand; CS: Coarse sand; O.M: Organic matter; T.N.V: lime; K: Potassium; MWD; Aggregate stability; Ks: Final infiltration rate

Descriptive statistics[a]	Soil properties										
	Independent									Dependent	
	Sand (%)	Clay (%)	Silt (%)	VFS[b] (%)	CS (%)	Gravel (%)	O.M (%)	T.N.V (%)	K (ppm)	MWD (mm)	Ks (cm/h)
M	36.7	31.8	31.8	16.8	19.9	9.9	1.08	12.7	391.5	1.13	3.5
Min	24.8	20.8	20.2	8.9	13.3	5.3	0.74	7.2	265.9	0.27	1.4
Max	48.3	42.2	46.4	24.8	27.7	17.5	2.13	18.4	637.8	1.91	5.8
SD	6.7	5.7	7.5	3.8	3.5	3.1	0.26	4.3	89.0	0.44	1.3

3.2. Rainfall characteristics

The annual precipitation in study site was 322 mm in the period of research and the rainfall intensity varied from 0.1 to 13.8 mm/h with an average of 2.8 mm/h with duration time of 3.9 h. The maximum amount of rainfall was during May 2005 (105 mm) and minimum amount (0.0 mm) was on July. The soil loss (sediment) at the unit plots was affected by 23 natural rainfall events during the study period. The annual rainfall erosivity index (R) based on rain station data was 438.9378 $MJ.mm.ha^{-1}.h^{-1}$ in the study site during the study period.

3.3. Soil erodibility K factor

Table 2 shows descriptive statistics of soil erodibility at plots in the study area. Values of the measured erodibility ($K_{measured}$) varied from 0.000830 to 0.007494 $Mg.ha.h.MJ^{-1}.ha^{-1}.mm^{-1}$and the estimated erodibility ($K_{estimated}$) varied from 0.025371 to 0.049233 $Mg.ha.h.MJ^{-1}.ha^{-1}.mm^{-1}$. The mean values of the measured and the estimated erodibility were 0.004258 and 0.035988 $Mg.ha.h.MJ^{-1}.ha^{-1}.mm^{-1}$ respectively.

Table 2: Descriptive statistics of soil erodibility at plots in the study site

Descriptive statistics*	Soil erodibility K factor ($Mg.ha.h.MJ^{-1}.ha^{-1}.mm^{-1}$)	
	Measured	Estimated
M	0.004258	0.035988
Min	0.000830	0.025371
Max	0.007494	0.049233
SD	0.001805	0.006812

*

M: Arithmetic mean; Min: Minimum; Max: Maximum; SD: Standard deviation;

A comparison of $K_{estimated}$ and $K_{measured}$ for soils of study site indicated that estimated values of K-factor are higher by a factor of 10.47 than measured values. Fig. 2 shows the relationship between $K_{measured}$ and $K_{measured}$ in study site. The soil erodibility values obtained from the field experiments was significantly correlated with estimated soil erodibility (r^2=0.16, p<0.05).

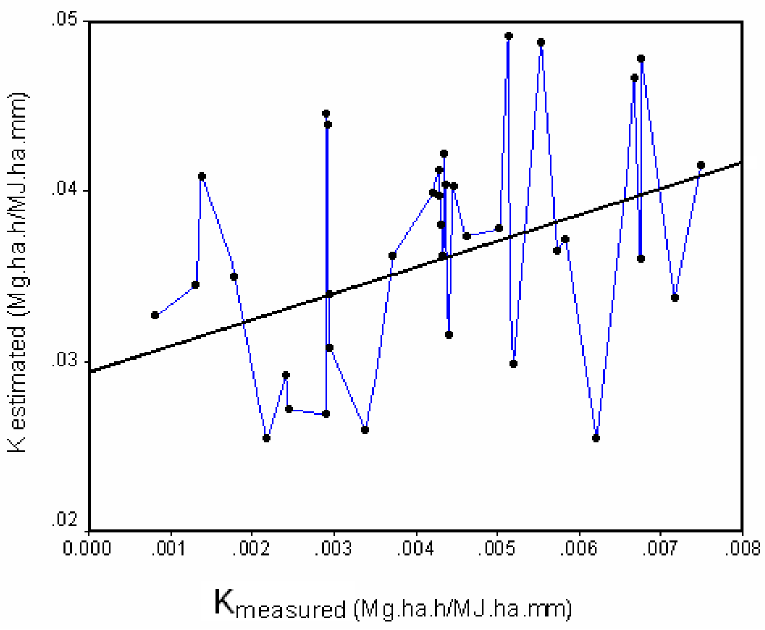

Fig. 2. Relationship between K $_{measured}$ and $K_{estimated}$ in study site

The equation of fitted line for $K_{measured}$ and $K_{estimated}$ relationship was:

$$K_{estimated} = 0.029 + 1.533\, K_{measured}\,, \qquad r^2 = 0.16 \qquad (4)$$

where $K_{estimated}$ and $K_{measured}$ are estimated and measured soil erodibility K factor in $Mg.ha.h.MJ^{-1}.ha^{-1}.mm^{-1}$ respectively in the study site.

3.4. Effect of soil properties on erodibility K factor

Before to determining of relationship between measured soil erodibiliy and independent properties, initially bivariate correlation of independent properties was studied (Table 5). As the Table 3 shows there are significant correlation between sand and silt, sand and clay, and silt and clay.

Table 3: Results of bivariate correlation of independent soil properties in study site

		Sand	Silt	Clay	O.M	T.N.V	Gravel	K
Sand	Pearson Correlation	1	- 0.682**	- 0.390*	- 0.145	- 0.131	0.039	- 0.264
	Sig. (2-tailed)		0.000	0.019	0.400	0.119	0.820	0.119
Silt	Pearson Correlation	- 0.682**	1	- 0.337*	- 0.095	0.271	- 0.290	0.220
	Sig. (2-tailed)	0.000		0.045	0.582	0.109	0.086	0.101
Clay	Pearson Correlation	- 0.390*	- 0.337*	1	0.299	0.146	0.256	- 0.235
	Sig. (2-tailed)	0.019	0.045		0.076	0.397	0.131	0.167
O.M	Pearson Correlation	- 0.145	- 0.095	0.299	1	- 0.219	0.216	0.224
	Sig. (2-tailed)	0.400	0.582	0.076		0.199	0.205	0.189
T.N.V	Pearson Correlation	-0.431	0.271	0.146	- 0.219	1	0.076	0.053
	Sig. (2-tailed)	0.009	0.109	0.397	0.199		0.661	0.758
Gravel	Pearson Correlation	0.039	- 0.290	0.256	0.216	0.076	1	0.078
	Sig. (2-tailed)	0.820	0.086	0.131	0.205	0.661		0.652
K	Pearson Correlation	- 0.264	0.220	- 0.235	0.224	0.053	0.078	1
	Sig. (2-tailed)	0.119	0.101	0.167	0.189	0.758	0.652	

To remove of the correlation between soil mineral particles was used from Principal Components Analysis (PCA) method. The appropriate equation from PCA for relationship among sand, silt and clay was described as fallow:

$$PCA1= 0.725\ Sand - 0.684\ Silt - 0.077\ Clay \qquad (5)$$

where PCA1 is the linear relationship among sand, silt and clay and sand, silt, clay are in per cent. Therefore effect of independent soil properties inside PCA1 on $K_{measured}$ was determined (Table 4). The measured soil erodibility in the plots was significantly correlated ($r^2 = 0.86$, $P<0.001$) with independent soil properties.

Table 4: Regression coefficients, standard errors and significant levels of relationship between $K_{measured}$ and independent soil properties

Model	**Unstandardized coefficients**		**Standardized coefficients**	**t**	**Sig.**
	B	Std. error	Beta		
Constant	0.01071	0.000865		12.386	0.000
PCA1*	-0.00123	0.000120	-0.888	-10.332	0.000
O.M	-0.00168	0.000515	-0.245	-3.268	0.003
T.N.V	-0.00029	0.000033	-0.687	-8.614	0.000
K	-2.3×10^{-6}	0.000002	-0.111	-1.423	0.165
Gravel	-0.00013	0.000043	-0.219	-2.955	0.006

* : PCA1: linear relationship; O.M: Organic matter; T.N.V: lime; K: Potassium

The relationship between measured soil erodibility and independent soil properties based on the results of Tble 4 and the equation (5) was as follows:

$$K_{measured} = 0.01071 - 8.91\times 10^{4}\ Sand + 8.41\times 10^{4}\ Silt + 0.95\times 10^{4}\ Clay - 0.00168\ \%O.M - 0.00029\%T.N.V - 2.3\times 10^{6}\ K - 0.00013\%Gravel \quad (6)$$

where Sand, Silt, Clay, OM, T.N.V and Gravel are in per cent, K is mg/kg and $K_{measured}$ is in $Mg.ha.h.MJ^{-1}.ha^{-1}.h^{-1}$.

The results of Table 4 also indicates that sand, organic matter, Lime and gravel significantly ($P<0.001$) decreased soil erodibility but silt and clay significantly increased it. Effect of potassium in decreasing soil erodibility was not significant. Also the effect of aggregate stability and soil permeability on measured soil erodibility were studied (Table 5). These two indexes significantly ($P<0.001$) decreased measured soil erodibility and correlation coefficient (r^2) was 0.83.

Table 5: Regression coefficients, standard errors and significant levels of relationship between $K_{measured}$ anddependent soil properties

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.
	B	Std. error	Beta		
Constant	0.00990	0.00050		19.869	0.000
MWD*	- 0.00131	0.00029	- 0.322	- 4.446	0.000
Ks	- 0.00116	0.00010	- 0.840	- 11.612	0.000

* : MWD: Water-aggregate stability; Ks: Final infiltration rate

The relationship between the indexes MWD and Ks and the measured soil erodibility based on the data of Table 5 was as fallows:

$$K_{measured} = \frac{990 - 131MWD - 116Ks}{100000} \tag{7}$$

where MWD is water-stable aggregate in mm and Ks is soil permeability in cm/h and $K_{measured}$ is the measured soil erodibility based on USLE in $Mg.ha.h.MJ^{-1}.ha^{-1}.mm^{-1}$.

3.5. Relationship between the dependent and the independent soil properties
Aggregate stability (MWD) was significantly (r^2=0.85, P<0.001) affected by independent soil properties. The results of regression coefficient indicated that clay, organic matter and lime significantly (P<0.001) and potassium nonsignificantly increased aggregate stability and sand and silt significantly (P<0.001) and gravel nonsignificantly decreased it. Table 7 presents correlation coefficients (r^2) between the independent soil properties and aggregate stability.
The correlation coefficient between soil permeability and the independent soil properties was % 74 (r^2=0.74). The results of regression coefficient indicated that sand, organic matter, lime, potassium and gravel had positively correlated with permeability and clay and silt had negatively correlated with it (Table 7). The effects of sand, silt, clay and lime were significant in P<0.01, the effect of organic matter was significant in P<0.05 and potassium and gravel effects were not significant.

Table 7: Correlation coefficient between the independent soil properties and aggregate stability and permeability

Soil properties	Aggregate stability	Permeability
Sand	-0.058**	0.662**
Silt	-0.082**	-0.624**
Clay	0.183**	-.070**
O.M	0.603**	1.109*
T.N.V	0.061**	0.105**
K	n.s.	n.s.
Gravel	n.s.	n.s.

n.s.: Not significant, * P<0. 05, ** P<0. 01

4. Conclusions

Many studies have examined the effect of soil properties on erosion and erodibility, but with a wide range of methodologies, soil types, soil management histories, different properties have proven effective in different situations. Almost any soil property may influence erodibility, but, measurable soil properties were objective of this study. Independent and dependent properties of soil significantly affected on erodibility of calcareous soil with high correlation coefficients. Dependent soil properties that determine erodibility, consisted of aggregate stability and permeability, are strongly affected by the independent soil properties (sand, silt, clay, organic matter, lime, potassium and gravel). In fact the independent soil properties indirectly influence on erodibility, but aggregate stability and permeability directly affect on erodibility.

Soil permeability is a particular factor in resistance to erosion due to its major role in generating runoff. In this study, soil permeability considerably increased with content of sand, organic matter, potassium and lime in soils. Aggregate stability also is a main factor in resistance of particles to splash and so decreases detachability of particles. This property significantly increased with content of clay, organic matter and lime in soils. Therefore, lime has very important role on increasing aggregate stability and soil permeability, and hence is an important factor in decreasing susceptibility of soils to erosion.
A comparison of estimated K factor and measured K factor for soils on study site indicated that estimated values are higher by a factor 10.47 than measured values. It was found that correlation between the estimated K and the measured K is very low. On average using nomograph-based estimates of the K factor would lead to an over-prediction of the rate of soil loss by a factor of 10.47 in the study site.

The result clearly shows that factors affecting soil erodibility in nomograph can not correctly state the effect of soil properties on actual erodibility in calcareous soils of the study site. Therefore, it is not the appropriate method to estimate of calcareous soil erodibility in the study site. In these soils, the soil erodibility could be properly estimated by a regression function with determining of soil easily-measurable properties. With the performance of this research in others calcareous soils of semi-arid regions can present an accurate alternative method to estimate erodibility in calcareous soils of Iran.

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THE SYSTEMS APPROACH TO DESIGN OF OPTIMAL WATER USAGE AND WASTEWATER TREATMENT NETWORKS

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The paper focuses on investigating the systems approach of analysis and design of wastewater reuse network (WWRN) and wastewater treatment network (WWTN). Water subsystem of chemical-engineering system may be considered as system of interactive elements: water intake and purification network, water usage network, and wastewater treatment network. It stands to reason that “water usage – wastewater treatment” system needs to be analyzed as a whole. The technique of WWRN/WWTN analysis and synthesis is proposed. The technique is based on integration of conceptual approach and mathematical programming (MP) methods. Both WWRN design and WWTN design consist of insight-based network analysis and network synthesis based on mathematical programming.

The method of industrial water usage networks retrofit design by a MP problem solution is considered. Linear programming model with provision for costs of fresh and reused water, possibilities of wastewater reuse is proposed.

Water pinch analysis and wastewater degradation concept are employed to develop an initial structure at the first step of WWTN design. The obtained superstructure is a good starting point for nonlinear optimization at the second step. Application of mathematical models of treatment processes allows taking into account relation between removal ratio of treatment process and treatment flowrate and/or contaminant concentration.

Key Words: *water subsystem, water usage, wastewater minimization, wastewater treatment, pinch analysis, mathematical programming, mathematical model*

1. Introduction

Energy- and resource saving is a current issue in many countries. Though water is one of the prevalent natural resources, the requirement for it has greatly increased through fast development of world industry. This gives rise to application of process integration methodologies aimed at water consumption reduction in existing process systems. As both water preparation and treatment systems operation costs can be considerably decreased by optimization of industrial water usage and treatment networks, it stands to reason that "water usage – wastewater treatment" system needs to be analyzed as a whole. The problem has been decomposed into the design of two subsystems as presented in fig. 1.

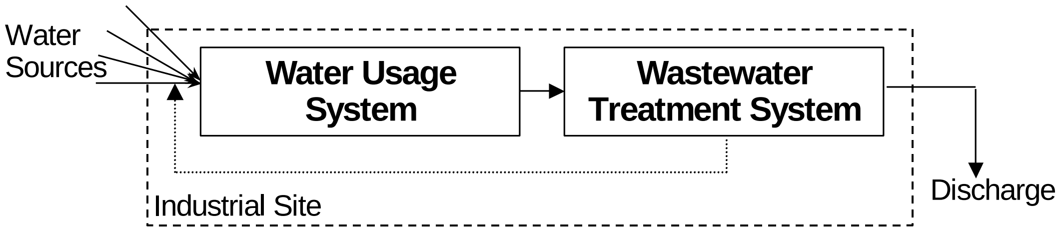

Fig. 1. Water subsystems of chemical-engineering system

One problem is the water reuse allocation. The other is the wastewater treatment problem. This paper presents a solution strategy of both problems that consists of two stages, namely preliminary analysis (conceptual stage) and optimization stage. It is shown that such two-stage approach has advantages over both separate conceptual and separate mathematical programming methods [12].

2. Water Usage Network Design

The industrial water usage system optimization can be performed by wastewater re-use, by re-allocation of water streams and by recycling without process changes. The water pinch methodology results were used to reduce the number of water re-allocation opportunities and to network optimization routine simplification. The systematic approach to industrial water usage network retrofit design is rests on the general model of WWRN, which is based on superstructure principle. The scheme of the superstructure is shown in fig. 2. The superstructure consists of water using processes, mixers and splitters. All possible WWRN structures are embedded in this superstructure.

We require that for each water using process input concentration of contaminants and flowrate of water stream be given. Notice, that since mass loads of contaminant are given, the outlet concentrations from operations are fixed and known for retrofit case. To present the optimization model of the superstructure some necessary definitions and symbols are presented below. Let No be the number of water usage operations; Ns be the number of freshwater sources; Nc be the number of contaminants. Let X_{ij} [kg/h] be the flowrate of water stream from source #i to operation #j; Y_{ij} [kg/h] is the flowrate of stream from output of operation #i to input of operation #j (see the superstructure in fig. 2)

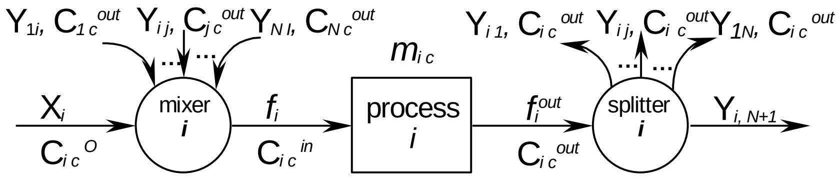

Fig. 2. The superstructure for water usage network retrofit design

The superstructure model of WWRN consists of the system of equations, which are mainly mass balances of units in the superstructure. Notice that the model presented in the following is general and does not make use of data specific for retrofit case.

The model of WWRN as a whole includes mass balances of freshwater sources, water mixers and splitters, balances for the sequence "mixer-water user-splitter"; the countercurrent mass exchanger model was taken for the general model of water using process.

On the basis of WWRN general model the linear programming model WWRN-LP (1) can be formulated for retrofit design case [2, 3].

Linear model WWRN-LP for the retrofit design of WWRN is as follows:

$$\min \qquad Z = \sum_{l=1}^{Ns}\left(\varpi_l \sum_{i=1}^{No} X_{li}\right) - \left(\sum_{i=1}^{No}\sum_{j=1}^{No} v_{ij} Y_{ji}\right) \tag{1}$$

s.t.

$$\sum_{i=1}^{No} X_{ij} \le F^s_{\max_j}, \quad j = \overline{1, Ns}$$

$$\sum_{s=1}^{Ns} X_{si} + \sum_{j=1}^{No} Y_{ij} = f_i, \quad i = \overline{1, No}$$

$$\sum_{l=1}^{Ns} C^0_{lc} X_{li} + \sum_{j=1}^{No} C^{out}_{jc} Y_{ij} \le C^{in}_{ic}\left(\sum_{l=1}^{Ns} X_{li} + \sum_{j=1}^{No} Y_{ij}\right),$$

$$i = \overline{1, No}, \quad c = \overline{1, Nc}$$

$$f_i^{OUT} = f_i - f_i^{LOSS} + f_i^{GAINS}, \qquad i = \overline{1, No}$$

$$\sum_{j=1}^{No} Y_{ij} \le f_i^{OUT}, \qquad i = \overline{1, No}$$

$$\forall i, j, l: \quad X_{li} \ge 0, \quad Y_{ij} \ge 0$$

where $F^s_{\max_j}$ is water supply ability of freshwater source #j, C^0_{lc} denotes the concentration of contaminant c in water of freshwater source # l, ϖ_l is relative unit cost of freshwater from source #*l*, v_{ij} is relative water reusing cost factors.

Notice, that in order to ensure that the global minimum usage of fresh water will be met one can add to (1) the additional constraint:

$$\sum_{i=1}^{n}\sum_{l=1}^{k} X_{li} \leq f_{MIN}^{PINCH} \tag{2}$$

Parameter f_{MIN}^{PINCH} denotes the minimum usage of freshwater. The value of this parameter can be calculated beforehand by some methods available in the literature, e.g. water pinch approach from [11].

The optimisation of WWRN-LT model (1) gives us the optimal structure of WWRN.

3. Wastewater Treatment Network Design

An application of a distributed WWTN is the key way for reducing cost of treatment stations. The investment expenses and treatment plant's operating costs depend on a proper choice of system structure and parameters (flowrates) of wastewater streams treated in various processes. Hence, an optimal design should determine the structure of network as well as key parameters of processes.

We propose to design distributed WWTN by hybrid approach with mathematical models of treatment processes. It is a sequential method applying insight-based techniques followed by mathematical programming. First, water pinch analysis and wastewater degradation concept from [1, 11] are employed to develop an initial structure. Then, a superstructure is created for WWTN. The solution from the first step is the good starting point for nonlinear optimization. This allows eliminating local optima traps. Nonlinear programming (NLP) problem is formulated on the basis of WWTN superstructure that is represented by stream split coefficients.

The general optimization model is as follows [9].

$$\min_{X}\left\{\phi(X) = \sum_{k=1}^{N_T} \upsilon^k (F^k(X))\right\} \tag{3}$$

s.t.

(i) $C_{out,j}(X) \leq C_{e,j}$; $j \in P = \{j | j = 1, 2, ..., N_P\}$

(ii) $C_{in,j}^{k}(X) \leq C_{in,j}^{k,up}$; $j \in P = \{j | j = 1, 2, ..., N_P\}$; $k \in T = \{k | k = 1, 2, ..., N_T\}$

(iii) $\chi^k(X) \geq 0$, $\chi^k(X) = 0{,}1$; $k \in T = \{k | k = 1, 2, ..., N_T\}$

(iv) $0 \leq x_g \leq 1$, g=1, 2, …,N; $N = N_S \cdot N_T + \sum_{g=2}^{N_T}(N_T - g + 1) + N_T!$

X denotes the matrix of split coefficients. ϕ denotes the cost of WWTN. F^k is treatment flowrate in TP k. $C_{out,j}$ is total outlet concentration of contaminant j from the WWTN and $C_{e,j}$ is environmental limit for contaminant j. $C_{in,j}^{k,up}$ denotes upper limit on contaminant j concentration at inlet of process k. χ^k are the case specific constraints, such as e.g. must-be or forbidden connections. Also, the user can insert other conditions, e.g. upper and/or lower limits on flowrate through TPk. Constraints and objective function, $\phi(X)$, are nonlinear. The problem is always nonlinear. To solve this NLP problem we applied adaptive cluster covering from Solomatine [4]. The technique was modified in order to account for additional inequality constraints. The investigations on developing good global optimizer for the NLP carried on.

It should be noted that in some cases obtaining removal ratios of treatment processes as functions of treatment flowrate and contaminant concentration is complicated for different reasons, mainly due to difficulties with measurements at operating industrial plant. To circumvent the problem mathematical models of treatment processes have been applied in this work. The models account for influence of wastewater flowrate and contaminant concentration on removal ratio. It is worth noting that application of mathematical models is novel feature of the approach.

One can expect that the application of rigorous mathematical model of treatment processes will increase the power, rigorousness and industrial applicability of design approach. Majority of works published to date on WWTN design applied only removal ratio as treatment process mathematical model. The values of removal ratio have to be given in the data. Additionally, the methods developed to date assumed that this ratio does not depend on contaminant concentration and treatment flowrate, i.e. it is fixed for a process independent on process conditions. Another, often found assumption is the constant total flowrate via processes and, thus, within total WWTN. We apply mathematical models of treatment processes at the optimisation stage to take into account a relation between the removal ratio of a treatment process and treatment flowrate and/or contaminant concentration. Also it allows considering material losses and gains in a particular treatment process and, as a result, changes of total flowrate in WWTN within design procedure [8].

Steady-state models of treatment processes have been developed to take into account possible changes of treatment process removal ratio caused by flowrate and contaminant concentration variations while designing a distributed WWTN. The mathematical models are based on the revised and/or new design procedures of treatment units. These models allow to consider not only removal ratio changes but also to reckon specific parameters of treatment process in, e.g. water loss in the network with sediment from settler, with froth from flotation or coagulation unit, additional constraints at the units inlet etc.

The application of mathematical models of treatment processes for WWTN design allows taking into consideration specific features of treatment methods. Changes in wastewater treatment flowrate can result in shift of settling conditions or violation of boundary rate of filtration etc. In addition, the application of mathematical models allows making recommendations on adjustment of process parameters that need no major constructional modifications of treatment unit, e.g. treatment cycle time. The models of treatment processes require treatment flowrate, contaminant concentration and properties, apparatus and process parameters of the particular treatment unit as the data. For these parameter the treatment process removal ratio of the given contaminant and the outlet flowrate from treatment process are determined.

4. Summary and conclusions

The systems approach for finding the minimum freshwater consumption rate and wastewater treatment capacity in water usage and treatment systems is proposed.
Mathematical models of water usage and water treatment networks components and models of networks as a whole have been worked out. The hybrid approach for designing optimal WWRN/WWTN has been developed.
The systems approach has been supported by case studies of retrofitting water usage and wastewater treatment systems of industrial plants. The investigation has shown that reduction of water usage and effluent production up to 60% could be achieved [5, 6]. Also the treatment flowrate decrease of order 20 – 40% on the average can be obtained for different treatment processes over existing wastewater treatment systems [7, 10]. Resulting from the case studies as well as our past experience we can state that the combined approach is a useful technique for retrofitting water usage and wastewater treatment facilities.

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MANAGEMENT OF WATER RESOURCES AND SUSTAINABLE REGIONAL DEVELOPMENT

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Water is one of the most important, on the other hand, the most limiting environmental resource in developing arid and semi-arid regions.Khorassan province in the east part of Iran faces with deficit of rainfall and draught because of locating on arid belt as well as being far away from humid centers. Increasing growth of population, need for agricultural and animal products, increasing need for water supply in the industry sector, mean while, and the limitation of water resources, on the other hand, bears severe problems for the development of province. On the other hand, inadaptability of potentials and capacities and the restriction of water resources as well as the exploitation procedure have increased the development challenges of the province due to inappropriate settlement of the population and activities.

Severe shortage of water resources resulted from unauthorized and excessive exploitations, population growth, and increase of demand in different sectors have made the role of this vital material in regional development more significant. Therefore, establishing a balance in rate of water consumption and revived water in the region in tandem with the land use(land preparation) policies is one of the most important measures which are necessary to be taken in the later phases of optimal exploitation of water resources(increase of the irrigation yield). In other words, paying no attention to the present situation of exploiting water resources, removing existing bottlenecks, not applying land preparation policies in settlement of population and activities, will confront the region with essential challenges.

Key world : resource management , sustainable development , ecological limitations , environmental challenges , regional development

1 Introduction

Khorassan province with a population more than 6 million, large area, inharmonious dispersion of habitats, situating in an arid and semi-arid region, neighboring salt and central deserts in the west and regions with low altitude of Afghanistan as well as exposing to 120-day blowing winds of Sistan in the south and south-east part, neighboring Ghareh Ghoroum desert in the north and the north-east, enjoys specefic characteristics. These specifications have caused severe shortage of water resources (15 plains with critical conditions, and 44 prohibited ones from among the total 78 plains). The low rate of rainfall and inappropriate time and place of rainfall , high rate of evaporation and transpiration , natural isolation and severe dispersion of habitats have resulted in spatial disorder followed by spatial inequality in the province. Spatial inequality includes inequality between cities and villages, cities and towns, deprived and developed regions, etc..[Chalbi,1996, P 201].

Spatial inequalities in the province causes in unemployment, migration, poverty, and population structural changes. Migration is continuously underway from villages towards the towns, from towns to cities or from the deprived regions to the developed ones. The immigrants form special culture and customs in the city or the new region. Ecologic isolation in cities is one of the other social issues resulted from migration. The immigrants mainly settle on the margins of the cities and bring about suburbanization. As an example, we may see more than 650,000 suburbanite around Mashhad City. [Javan, 2004,p 46]

Poverty, lack of appropriate social status, not being accepted by people of region, etc… prepare the ground for social deviations. Since these people reside illegally on the suburb of the cities, they are deprived of welfare services, the feeling of being a stranger is reinforced in them, and the social problems in the cities become intensified. All the abovementioned factors indicate that most of the problems are rooted in spatial inequality and injustice existing among the regions. The effective factors of spatial isolation in the field of economical, political, and bio-social orders may result in concentration of poverty in districts and in special cases ghetto and shanty dwellings in the cities[Afroogh,1998,p 239].

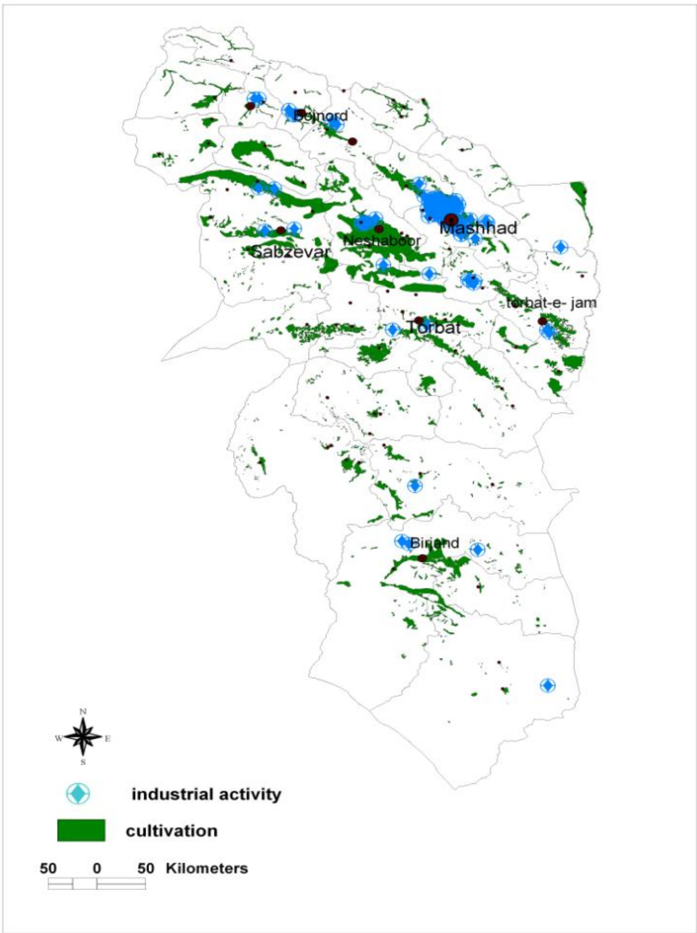
Water plays a significant role in continuation of life and various measures taken for living especially in agriculture sector in Iran and the under-study region. In the past, the power of government in the country was associated with reliable and regular water resources, therefore, the initial condition for economical development in the region is having sufficient and regular water resources(Mojtahedi,1994,p.26). In the current situation, the basis of the regional economy depends on agriculture and small cultivation units. The shortage or excess of water may result in economic recession or flourishing.

The objective of surveying water situation in the region is campaigning against water overflow, soil erosion, and supplying water needed for agriculture, industry and drinking. The development measures for achieving this objective include erecting dams for reserving water, brooks for transferring water and irrigation as well as improving exploitation methods.[Dereo, 1992, p.957]. Since water transfer faces with limitations, therefore, spatial organization for appropriate settlement of the population and activities is a suitable approach.
The present study is the result of surveying the capacities and shortages of water resources in Khorassan province and exploiting them as well as presenting regional development approaches with …….(preparation) objective. For achieving this goal, the settlement of population and activities and water exploitation status have been studied in addition to surveying the situation of water resources.

From the total area of the region which is 240,000SqKm., the total area of cultivated land by various agricultural products is 8% .A large area of the land includes desert and arid regions with saline, low depth of soil, and rock protrusion, in brief, these regions are inappropriate for agricultural and industrial activities. The main part of the agricultural lands and industrial activities (industrial estates and regions) of the province have been formed as patches on the vicinity of Mashhad, Torbat Heidarieh, Torbat Jam, Ghoochan, and some other cities and towns [Yasoori, 2004].

Map No.1

Disterbution of industral activity and cultivatin in Khorassan Region



In fact, agricultural usage of land in different regions of the province has been dependent on the soil capacities and more important than this, on the access to water resources including the subsurface, surface,and reserved ones. In the same line, the main part of lands under aquaculture has been formed in the central regions of the province. This is because of severe ecological limitations including rate of rainfall and high temperature the result of which is the high rate of evaporation and perspiration.

The northern regions of the province are faced with shortage of suitable soil in spite of relative balance of ecological situation. Most of the lands in the region have changed into small farms and orchards and in highlands dry farming is prevalent. In the central regions and Mashhad a pressure has been applied to agricultural lands due to settlement of the main part of the population and lack of equilibrium between population and resources. Unlicensed wells have been dug for more exploitation of lands and water has been transferred from the deep depths to the surface without paying any attention to the fact that the capacity of the subsurface basins are limited. During the recent years, the most part of plains of Khorassan province have been declared critical and supra-critical. (from among 78 plains existing in Khorassan province, 65 ones have been declared prohibited).[Khorassan Regional Water Organization, 1990,p.17].

Irregular discharge of subsurface water resources has caused severe fall of water level which has doubled the farmers' problems. The charges for drainage, using more powerful motor pumps and fossil fuels have increased more and more. In addition to the increase in production costs and decrease in farmers' revenues, it has caused environment problems. Lack of suitable lands for cultivation, shortage of water resources, lack of proper policies in using lands, lack of necessary infrastructures such as installations for preserving and reserving surface waters, legal and ownership restrictions for lands and production resources, etc. have been effective in inappropriate exploitation and environmental instability in the agricultural sector of the region.[Ministry of Agriculture,1993, p.38].

Considering the decisions made in the past and the planning policies of the previous decades about the industrial uses of lands, there are imbalances that originated from environmental, economical, and political issues. Providing facilities for living and activity as well as the concentration of population in the central regions of the province, mainly the suburb of Mashhad city, have caused the formation of infrastructures for settlement of industrial units. Such land use has formed industrial regions and estates and in some cases the individual factories and industrial units have been erected.

Such activities have been operated in 20 industrial estates and 16 industrial regions.
About 63% of the industrial workshops of the province are located in Mashhad city. Ghoochan, Neishabour, Bojnord, Torbat Heidarieh, Sabzevar, and Birjand with 5.8%,5%.,3.8%,3.5%, 2.4%, and 2.3% of the industrial units respectively stand in the next standings after Mashhad. 14.7% of the industrial units are situated in other towns of the province (19 towns).[Khorassan Management & Planning Organization,2001, p.14]

Concerning other land uses, we may refer to the residential one and urban and rural habitats. In 90 urban and 7700 rural districts, a vast area of the lands with the highest quality has been allocated to residential infrastructures and structures. One of main challenges for developing the province is destroying agricultural lands located on the suburbs of cities and towns, imbalance in water resource capacities and different water consumptions. This is observable especially in the suburb of Mashhad,Neishabour, Torbat Heidarieh, Sabzevar, Ghoochan, etc..[yasoori, 2004, p.245]

The per capita rate of water available in this province incessantly reduces. During the recent 40 years, the per capita rate of water has decreased from 7000 to about 2000 cubic meters. If such a process continues, the per capita rate of water in province will reach to less than 1000 cubic meters per year. In order words, the region will quickly face crisis in water resources.[Khorassan Planning & Management Organization, 2004, p.65].

The volume and percentage of various types of water consumption in the province:
With regard to the volume of exploitation of the subsurface and surface water resources in all the sectors, the last status of the exploitation and the share of water in any of different sectors are as follows: The total volume of water consumption in the province (including the surface and subsurface water) is 12.4 billion cubic meters from which the rates in agriculture, urban and rural drinking water, and industry and service sectors are 11.5 billion,578 million, and 330 million cubic meters respectively. The percentage of water consumption in agriculture, urban and rural drinking, and industry and service sectors are 92.4%,4.8% and 2.8% respectively. Considering the need for supplying urban and rural drinking water and the increasing demand of water consumption in the industry and service sector as well as the necessity for supplying a part of the shortage of subsurface water basins of the province through economizing in exploitation of the subterranean water resources, it seems that if we assume the potential of water supplied from water resources of the province is constant, the only reasonable way will be optimal consumption of water among all the sectors especially in agriculture.

During the recent 30 years, in most plains of the province the number of wells and the rate of discharged water have increased more than double times. On the basis of the studies done on the suburb of Torbat Heidarieh town, especially, on Rokh Plain, the number of deep wells from 85 in the year 1975 increased to 295 in the year 2002 and the rate of water discharge during the same period increased from 115 to about 245 million cubic meters.[Yasoori , 2000, p. 68]. It should be noted that, during this period, a large area of the cultivated land of the region was allocated to cultivation of sugar beet which needs plenty of water.

2 The general water balance in the province

On the basis of the available data, the average of rainfall in the province is 205mm.Consiedring the area of the region (237,000 SqKm.) the volume of annual average rainfall is 48.5 billion cubic meters from which about 74% is lost due to evaporation and perspiration because of the regional dry climate; only 11.9 billion cubic meters are used in the hydrology cycle . In fact, this volume of water may be considered as the long-term average of water of the province. From 11.9 billion cubic meters of available water in the province, about 8 billion cubic meters are used for feeding subsurface water tables and 3.9 billion cubic meters flow in the province as the surface flowing waters. With regard to exploiting 9.7 billion cubic meters water from the subsurface resources, it seems that the subsurface water resources of the province are confronted with a shortage of 1.7 billion cubic meters of water per year. The total volume of water exploited of the water resources increased from 10 billion cubic meters in the year 1980 to 12 billion cubic meters in the year 2001.

Through controlling the surface waters during the following years (2011), the volume of exploiting water resources of the province will reach 12.53 billion cubic meters. Then, due to excess increase in exploiting the subsurface water resources because of social and economical necessities, the volume of the usable water will decrease. It is predicted that the volume of the usable water will decrease from 11.66 to 11.1 billion cubic meters per year during the years 2011 to 2021.

Table 1, changes in exploiting water resources of the province (in billion cubic meters)

year	total volume of surface water exploitation	Total volume of subsurface water exploitation	total number of resources water exploitation	subterranean canal discharge	fountains Discharge	wells	
						discharge	number
1980	2.15	7.88	10.03	2.8	0.98	4.1	6720
1991	2.3	8.67	10.97	2.1	0.97	5.6	14437
2001	2.7	9.7	12.4	1.99	0.96	6.74	21896
Prediction 2011	3.2	8.46	11.66	1.45	0.91	6.1	22700

Reference :Khorassan Regional Water Organization,2002.

3 The situation of subsurface water resources of the province

There are 76 plains in Khorassan province. The volume of exploiting subsurface water is 9.7 billion cubic meters at present which is 1.7 billion cubic meters more than the capacity of feeding subsurface water in the province per year. The excessive exploitation of water resources has caused the annual fall in a large number of plains of the province in such a way that in 59 plains of the province, the rate of exploitation has been more than the feeding rate and they are entitled as the prohibited plains.

From among these, 15 plains have a critical and dangerous situation. The other 17 plains have no problem due to exploiting subsurface water resources. They are mainly located on the regions where their exploitation development are confronted with problems qualitatively and quantitatively and at the early stages it is not considered economical. The most recent situation of exploiting subtsurface water resources is as follows:

The total number of subsurface water resources(wells, fountains, and subterranean canals) is 35269- The volume of potential subsurface water resources of the province: 8 billion cubic meters- the total volume of exploiting and discharging subsurface water resources:9.7 billion cubic meters- Shortage of plain reservoirs in the province:1.7 billion cubic meters- Number of wells in the province:21814- The wells bearing the exploitation permit:9431- Unlicensed wells:1127- Under-study and operation wells:1256- The volume of exploiting water of wells:6.74 cubic meters- Number of fountains:3812- The volume of discharge through fountains:0.96 billion cubic meters- Number of subterranean canals:9643- The volume of water exploitation of subterranean canals:1.99 billion cubic meters [Khorassan Regional Water Organization, 2004,p .17].

The situation of surface water resources in the province: The volume of surface river flows in the province is 3.9 billion cubic meters. Exploiting surface waters is mainly done in traditional method through using the base running rate of rivers.

Moreover, a part of surface waters related to storm flow are controlled by earth dams, dams, and installations. At present, the dams existing in the province are able to regulate the flow of 255 million cubic meters per year in average. The most recent situation of exploiting surface water resources of the province is as follows:

The total volume of the surface water resources in the province: 3.9 billion cubic meters- The rate of exploiting base flows of rivers in traditional method:about 2.2 billion cubic meters- the rate of exploiting by the modern installations(dams, diversion dam, other installations for controlling water):About 505 million cubic meters- The total rate of water outflow to the borders of the province:about 1.2 billion cubic meters- The volume of water outflow to Turkmenistan(the quota of Iran):50 million cubic meters- The volume of water outflow to Golestan province:237 million cubic meters- The volume of water outflow to the desert regions of the country:213 million cubic meters

4 Main challenges in water sector of the region and the perspective of the present process

The main challenges in water sector of the region include the intervention of external factors and conditions on the reasonable management of water resources in the watershed and unlicensed and irregular exploitation of subsurface basins. The population increase, promotion of life standards, and increase in water demand in various sectors, supplying, reserving and distribution of drinking water of Mashhad city and implementation of sewerage collection system project, unlicensed occupation of river beds and borders which results in increasing potential to be susceptible to floods and incurring damage, the inconformity of water capacity with the population settlement and activities, and low rate of irrigation yield in agriculture sector are among the other grounds for challenge in water resources of the province.

The perspective of the continuation of the current process is becoming a large number of water resources(subterranean canals and fountains) dry, falling a large number of villages into desuetude due to becoming their water resources dry, occurring social and political crises resulted from the shortage of drinking water in cities especially in Mashhad and due to shortage of water resources in agriculture and industry sectors- land subsidence and increase of pipe laying in prohibited and critical plains the result of which is decrease in reservation capacity of subsurface basins and crisis in management of border and common waters with the neighboring countries.

In spite of the limitation in water resources, the agricultural activity dominates in this province. Especially, a large area of the cultivated lands is allocated to the products which need a lot of water such as sugar beet and the ……….products. These products need water more than double of the average rate of the other products. Low rate of per capita of land, low rate of production, low price of agricultural products due to improper policies of cultivation and market, have obliged the farmers to exploit water resources of the region irregularly. Irregular exploitation, have changed the water balance of regional plains .Therefore, reasonable management on exploitation procedure deems it advisable that the annual output should not exceed the annual feeding rate of subsurface water, otherwise, the plain will face shortage of water supply. If such a process continues, once the region will lost its water reserves and will become dry. [Velayati, 1995, p.78].

Table 2, The situation of water resources of the province and Iran

situation	Khorassan Region	Iran
Area (sq km)	236513	1648000
rainfall in 1994	6050000	60000000
precipitation(mm)	205	251
total revived water resources	11/9	130
The rate of exploiting the subsurface water resources	9/7	50/6
rate of subsurface water reservoirs shortage	1/7	3/27
total number of plains	76	631
total number of prohibited plains	59	183
number of critical plains	15	41
rate of subsurface water reservoirs shortage (in billion cubic meters)	0/255	32/9
per capita of revived water -1994	2360	---
per capita of revived water 2004	2066	----
prediction per capita of revived water 2010	1485	---

Reference :Khorassan Regional Water Organization,2002.

5 The executive policies for development in the water sector

The executive policies for development in the water sector include:
-Giving a definition about the cultivation pattern in different plains and directing the farmers towards respecting cultivation pattern- Changing the irrigation system and equipping farms with modern irrigation networks- Controlling surface waters with giving priority to common border rivers- Using saline and ……..waters- recycling waste waters and exploiting them as substitute for agricultural water-Purchasing agricultural wells and changing their usage to drinking water and water used in industry.-Electrifying wells for establishing facilities for exploitation- Implementing projects for flood dispersion and artificial feeding in susceptible regions –Specifying river borders and preventing from any invasion to them- Reinforcing water packing industry and consumption of its products- Erecting appropriate networks for sewerage disposal and management in cities- Controlling and preventing water resources from contamination by industrial and home waste waters- Making water tariffs reasonable- Doing research on cloud insemination for increasing the potential of water resources.

Taking measures such as propagating the culture of proper exploitation of water with the help of mass media and the irrigation and technicians of irrigation, reinforcing the potential of subsurface water basins through artificial feeding by using the dispersed floods of southern and northern mountains, developing traditional dam structures for exploiting floods, studying the cultivation of the plants resistant to salinity in agriculture in the southern regions, and etc. for developing the exploitation of agricultural water resources may be effective in improving exploitation from regional water resource [Anaabestani , 2004,37]

In addition to executive policies of development, it deems necessary that the management policies for developing in the water sector should be taken. Some the policies are as follows:
-Applying the general land management for appropriate distribution of population and activities in the region- decentralization of population and activities from Mashhad city and some of the cities and regions of the province- Uniform management on water resources and establishing water exploitation organization in line with optimal usage of water resources-Providing facilities and grounds for consumers of optimal exploitation of water resources and user of the waste waters and ……….waters- Assigning the irrigation installations and networks to the exploiters for optimal exploitation of the installations- allocating water with the priority to drinking, industry and agriculture consumptions and paying serious attention to the environmental issues- Amending laws, integrating lands and paving the ground for executing the existing laws- Paying attention to the applied researches in the field of water and establishing modern and update data banks for water- Diversification in supplying financial resources for executing development plans- Investing in water sector and benefiting from international loans.

6 Conclusion

The present status of exploiting water resources is severely influenced by the spatial organization of the province and the improper policies of development planners in the east part of the country. Severe centralization of population(%34) and activities(%67) in Mashhad and the suburbs caused the severe destruction of environmental resources including the soil and water resources and severe air pollution, deprivation of other regions from development and formation of critical centers, severe displacement of population especially the skilled and specialist workforce, capital etc.

For decreasing the imbalance and providing the grounds for stable regional growth and development and preserving the basic resources of development, the environment should be reconstructed and the spatial structures and population and activity settlement to be reviewed. Reviewing the spatial, economical and residential structures - Amending the regional policies and planning - Applying proper methods for environmental resources management - optimal exploitation of basic resources of development,- Exploiting the regional situation and opportunities such as developing regional communications are some the measures that should be taken for achieving regional stable development. On the other hand, with regard to the severe shortage of water resources, stable regional development may rely merely on activities of the first sector (agriculture). Emphasis on transit situation, tourism attractions, partnership planning and expansion of infra-regional political, economical, and commercial relations are considered as the basic priorities.

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ANCIENT ECO-TECHNOLOGY OF QANATS FOR ENGINEERING A SUSTAINABLE WATER SUPPLY IN THE MEDITERRANEAN ISLAND OF CYPRUS

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The qanat water supply technology, which gravity drains mountain aquifers into valleys, is considered as a culturally appropriate and ecological sustainable design to meet northern Cyprus' drinking water development needs. The proposed qanat recharge area of 370 km2 is in the upper elevations of the limestone dominated Five Finger Mountain Range, analyzed using global elevation data from the Shuttle Ranging Topography Mission (SRTM). Field visits, SRTM analysis, and river and meteorological data records, ranging from 8 to 30 years length, were used to demarcate the recharge area, establish no channel discharge from the area, as well as quantify precipitation inputs and evapotranspiration outputs. Accuracy of +/- 50° Latitude satellite based Tropical Rainfall Measuring Mission (TRMM) annual rainfall totals at a 0.25° grid was found inadequate for narrow mountain peaks, and gage records were instead used to set inputs at 530 mm yr-1. A calibrated complementary relationship areal evapotranspiration (CRAE) model established atmospheric outputs at 221 mm yr-1. Recharge to the qanat aquifer was determined by subtracting evaporation from precipitation, and then 50% of the remainder was allocated to environmental services. The estimated 57 Mm3 yr-1 of water fills the annual northern Cyprus drinking water deficit of 13 Mm3, and is nearly half of the total water demand, and provides more for the growing urban areas.

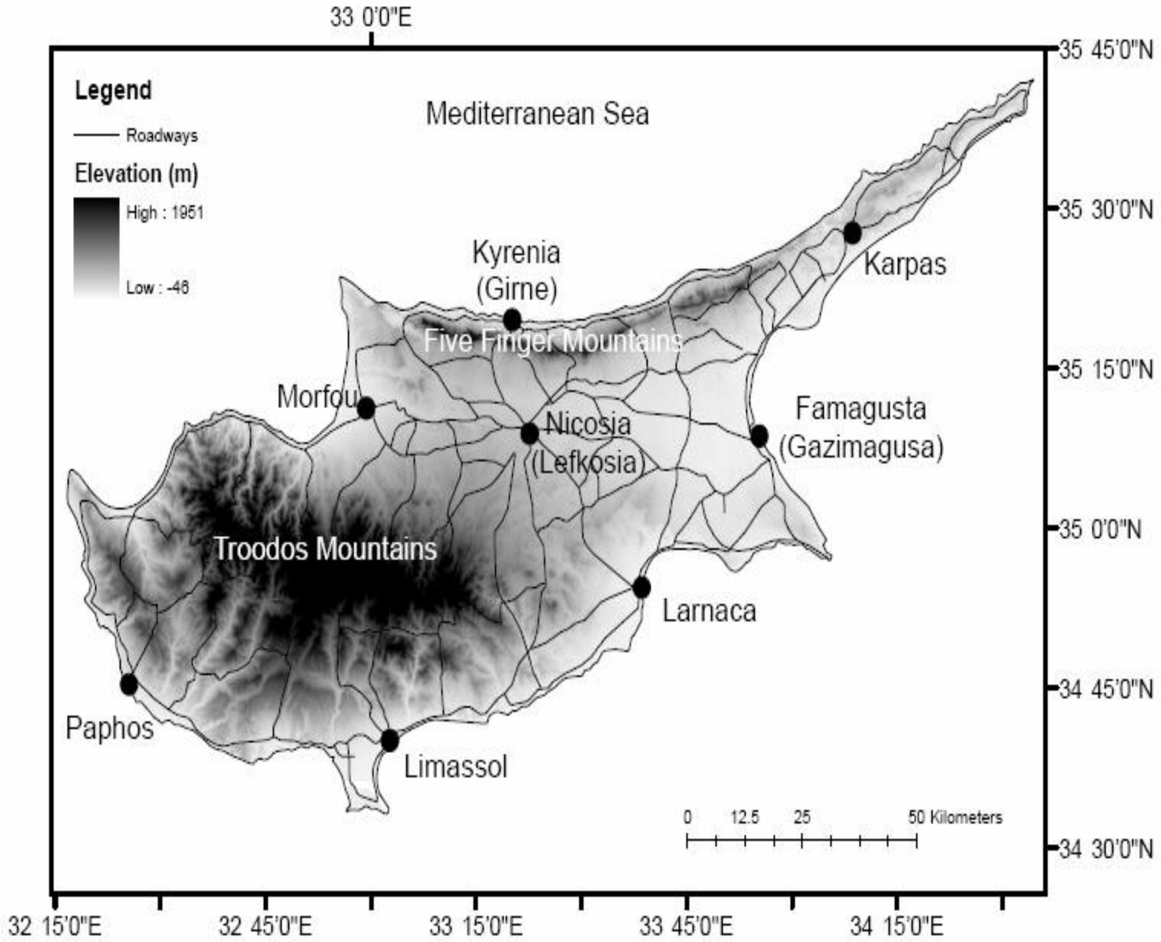
Keywords: *Water Scarcity; Remotely Sensed Data; Complementary Relationship Areal Evaporation; Environment; Ecological Engineering.*

Introduction:

The island of Cyprus, 9240 km2 in area, is located in the semi-arid eastern Mediterranean Sea and like many neighboring countries water scarcity problems. The island is shown in **Figure 1**, and is situated 75 km south of Turkey and 95 km west of Syria. Fresh water supply on Cyprus is limited to 1210 m3 person-1 yr-1, below the 1700 m3 person-1 yr-1 threshold indicating intermittent water scarcity, but above the 1000 m3 person-1 yr-1 indicating water poverty, values reported by the Population and Environment Program (Gardner-Outlaw and Engelman, 1997). Despite water shortages, the supply is expected to meet rapidly advancing commercial, residential, and tourist development, as well as existing agricultural withdrawals.As demand exceeds supply, water has been obtained through over pumping of aquifers,particularly in northern Cyprus. Over-pumping of the island's thin freshwater aquifershas resulted in salt water intrusion (Gokcekus et al., 2005), spoiling major groundwateraquifers such as Gazimagusa and Gecitkale (Bicak and Jenkins, 2000).

In addition to saltwater intrusion, pumping has desiccated historic human-engineered springs, called qanats. Qanats are gravity drained horizontal wells running from mountain to valley, as a sustainable source for domestic, commercial, and agricultural water delivery.

Figure 1



In this paper, qanats are promoted as an ecologically sustainable alternative to pumping, and research is presented that establishes recharge rates for a qanat-based drinking water supply to the urban areas in northern Cyprus. Qanats in Cyprus have been identified in many ancient village and urban sites around Cyprus. Lightfoot (2000), in mapping the diffusion of qanats throughout the Arabian

Peninsula, identifies potential routes the technology may have first entered Cyprus, as early as the 6th Century. Many of these qanats are thought to have been refurbished beginning in 1571 (Goblot, 1979), when the island came under Turkish rule. Cypriot qanats were dug using the shaft technique, which is a vertical opening at the surface used to access the horizontal tunnel. The shafts let in fresh air to workers, and let out buckets hauling excavated soil and rock. Some shafts in Cyprus were dug to 35 m depths, and horizontal tunnels would run lengths between 6 and 8 km to reach urban settlements. One qanat serving 20,000 inhabitants in Larnaca was reported to discharge 6000 to 8200 m3 day-1 (Goblot, 1979). Cressy (1958) reports dry season discharges of 1500 m3 day-1, wet season discharges at 11,400 m3 day-1, and an annual supply from all Cypriot qanats in 1950 estimated at 35 Mm3. Presently, there are no substantial supplies from qanats in Cyprus, but this paper identifies potential recharge rates for abandoned and new qanats, and then suggests permissible discharges. Given that qanats are gravity drained, when they are designed with proper discharge rates and location they protect against aquifer over-extraction.

In this paper the following sections follow. First, we provide a brief description of the water scarcity problem faced by the urban expansion and development in Cyprus. Second, we describe the geography, climate, and vegetation of the potential qanat recharge areas that could supply this urban growth. Third, we present the first use of satellite derived precipitation data to estimate aerial water inputs to the surface and compare with recorded climatic averages. Fourth, we present the first use of a parameterized complementary evapotranspiration model in northern Cyprus, and with meteorological data estimate aerial water losses to the atmosphere. Finally, a summary is presented to estimate the annual recharge of water for qanats, along with a discussion to present project insights.

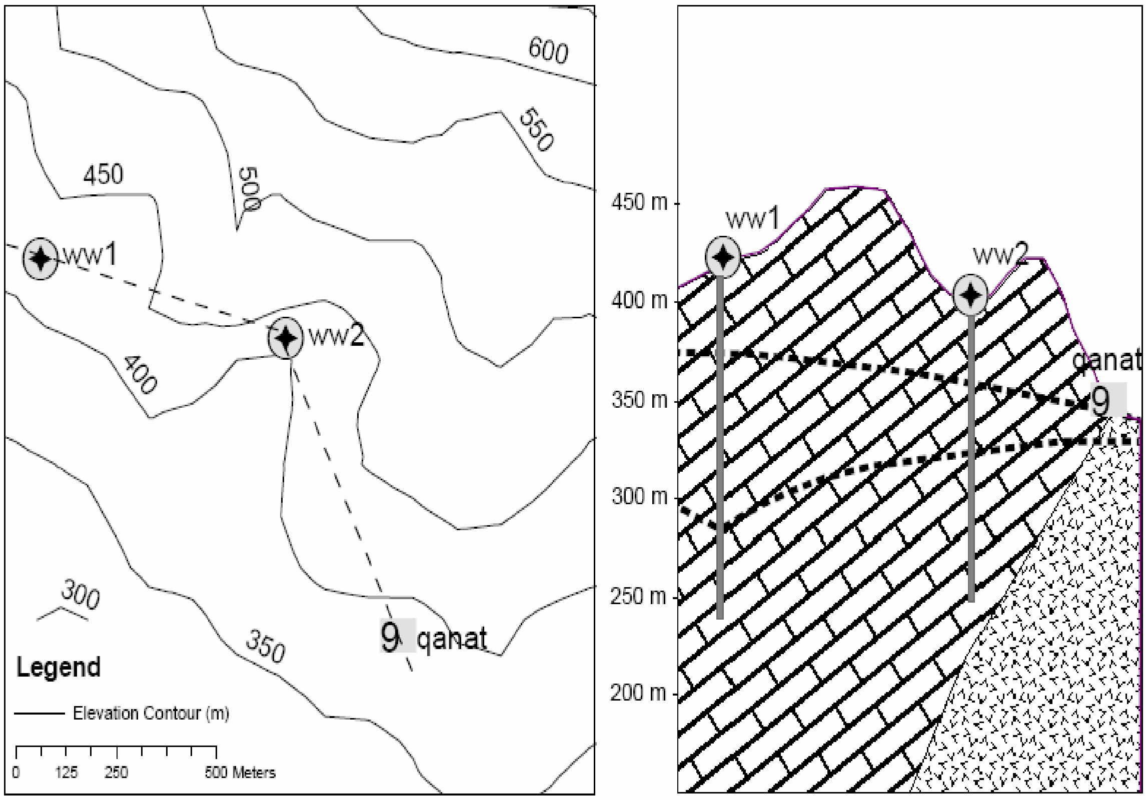
Water Scarcity in Northern Cyprus

Water shortages on the island of Cyprus are directly linked to population pressure, and have been predicted to reach crisis levels at 996 m3 person-1 yr-1 by 2025, with a population of 904,000 given United Nations projected growth rates (Gardner-Outlaw and Engelman, 1997). While there has been no island-wide census since the 1960s, the island population was estimated at 780,000 in 2005 (CIA, 2005), with 200,000 living in northern Cyprus, 55% of these northerners having emigrated from Turkey since the 1974 crisis.

Water shortages are not evenly divided between the north and south side of the island. The Population and Environment Program (Gardner-Outlaw and Engelman, 1997) estimated the entire island provides 900 Mm3 annually to supply fresh-water needs. Research by Bicak and Jenkins (2000) estimated a sustainable freshwater supply to the north at 94 Mm3 annually, only 10.5% of the island total despite its land area representing 38% of the island. Of this 94 Mm3 of sustainable annual water supply in northern Cyprus, 79% is delivered as safe yield from aquifers, 14% from intermittent flowing rivers, and 7% from dams (Bicak and Jenkins, 2000).

Northern Cyprus has not limited itself to this sustainable supply, and freshwater demand is estimated at 107 Mm3 annually, with agriculture for crops and animals taking 83%, sector wide drinking water consuming 16%, and commercial / industrial using 1% (Bicak and Jenkins, 2000). **Figure 2** shows a plan view and cross-section of two government water wells, situated near an old qanat. Prior to pumping the qanat was flowing, but pumping of the first well lowered the groundwater surface and dried the qanat. The second well will exacerbate the problem. Motorized pumps have dried gravity fed qanats elsewhere, and Lightfoot (1996) reports on desiccation and abandonment of Syrian qanats as modern wells pump the aquifer water from deeper levels. While northern Cyprus is over-pumping groundwater in many aquifers, there are coastal sub-marine springs paralleling the north coast Five Finger (Pentadaktylos) Mountain range that indicate un-tapped freshwater supplies. This suggests that beyond the influence of the government wells, water is freely discharging, and need only be tapped by qanats. In establishing a water surface balance for the area, we can more accurately establish the qanat placement, sizing and flow rates such that this water source is optimally used.

Figure 2



Site Description:
Geographic Setting
Qanat development is proposed to access water sources within the Five Finger Mountain Range, formed during the Permian (250 mya) to Middle Miocene (15 mya). The Five Finger range is generally characterized as karst topography (Necdet, 2003), and its geologic history has involved episodic rift, passive-margin, active-margin, strike-slip and uplift phases (Robertson and Woodcock, 1996). The range is ideal for qanats, comprised of calcareous limestone and chalk sedimentary rock formations which are considered pervious to highly pervious to percolating rainfall. The calcareous formation tilts to the north, and directs the majority of drainage to the coast. Interestingly, the range is considered part of Alpine belt connecting the Pyrenees to Himalayan ranges (FAO,1995).

Geographic boundaries of the Five Finger Mountains were explored with Shuttle Ranging Topography Mission (SRTM) data, a relatively new product derived from an international, 11-day, interferometer mission in early 2000 (Rabus et al., 2003). SRTM data, processed in ArcGIS (ESRI, 2005), identified the ground-observed multiple ridges along the East to West extent, and estimated the highest peak at 1013 m, 7 m below 1:25,000 map estimates. Based on field visits, two potential qanat recharge regions within the Mountain Range were selected for further SRTM analysis. The recharge regions provide the specific aerial extent for the surface water budget analysis performed in this research. Rainfall, evapotranspiration, and net recharge will be estimated within these regional boundaries.

The first qanat region, referred to as the Kyrenia region, was demarcated at the 250 m elevation contour within the center section of the Mountain Range. This elevation is the approximate boundary where the geology changes from calcareous rocks to impervious clays. Ephemeral runoff is observed below this boundary, and above the boundary most water either evapotranspires or recharges. The second region, referred to as the Karpas region, was demarcated at the 150 m elevation contour on the eastern edge, within the Karpas Peninsula. There are no significant surface water flows from this region, and the 150 m elevation creates an area of adequate size for qanat development. **Figure 1** shows the approximate location for each region, denoted by the words Kyrenia and Karpas. The Kyrenia region is approximately 8 km in length, has a median width of 4.km, and a total area of 310 km2. The Karpas region is approximately 3 km in length, has a median width of 0.75 km, and a total area of 60 km2. The Five Finger Mountain Range forms the northern boundary of the Mesaoria plain, which during the Tertiary period was the Athalas Sea and accumulated clayey impervious to slightly pervious deposits. The region was formed by a succession of Upper Cretaceous (70 mya) to Pleistocene (c 1 mya) sedimentation (FAO, 1995) and has many schist formed hills bounding the plain. The Yialias and Pedhieos Rivers flow ephemerally east into Famagusta Bay and the Serraghis River flows ephemerally west into Morphou. South of the Mesaoria is the Troodos Mountain Massif, occupying the southern third of the island. It was formed in the Triassic period from volcanic activity and subsequent upthrusting of oceanic crust when Africa and Europe converged. These igneous rocks consist of ophiolite, pillow lavas, diabase, gabro, peridotite, dunite, and serptentine (FAO, 1995), and while they are rich in copper, they make for a poor drinking water supply. Rocks of the Troodos are mostly impervious to slightly pervious, and water that does infiltrate provides down gradient communities with relatively soft, spring fed, drinking water. Surface waters from the Troodos are vulnerable to pollution originating from the outcrops of copper sulfate mines (FAO, 1995).

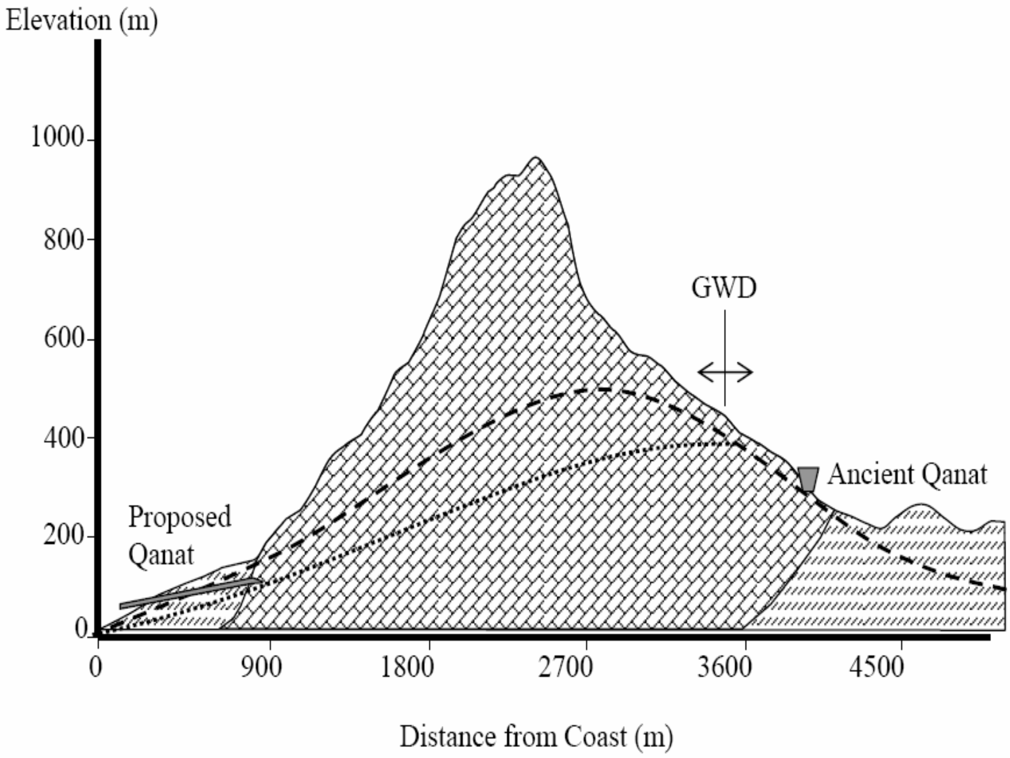
Vegetation and Climate

Ground cover above the 250 m contour varies with the aspect of the Five Finger Mountain range, where the northern face is more verdant, and with the degree of exposed rock surfaces. Based on site samples, nearly 15% of the projected surface area of the range is un-vegetated soil and exposed rock. Cyprus' climate is intense Mediterranean with a cool wet winter extending from November to mid-March and hot dry summers from May to mid-September separated by rapid seasonal change in Spring and Autumn. Five Finger Mountain range mean daily temperature for the high peaks is 7º C in January and 25º C in July, respectively, and by comparison January and July temperatures along the north coast are 13º C and 28º C, and on the Mesaoria plain are 10º C and 29º C. Analysis of temperature at gages in the Mesaoria plane and south coast revealed a 1º C rise the past 100 years (Price et al., 1999), based largely due to the increase in daily minimum values at both gages.

Climate extremes and isolation from larger land masses have created a wide range and large number of Cypriot indigenous plant taxa (species, subspecies, varieties, hybrids and forms), with 52 trees, 131 shrubs, 88 sub-shrubs and 1637 herbs recorded in 2005 (MOA, 2005).Vegetation surveys along the Five Finger Mountains clearly distinguish the moister north side and the rain shadow south side. Mediterranean cypress (Cupressus sempervirens), which prefers the limestone substrate of the region, grows with Calabrian pine (Pinus brutia) on the lower elevations and less steeply sloped north side.

Cupressus sempervirens occur as single stands on the high peaks and steep slopes were adequate soil has accumulated. Down slope of the southern Mountain peaks, these woodland stands and their accompanying moist environment plant community grade into dry tolerant flora. Dry tolerant forests species (xerophilous, sclerophyllous, evergreen, and thorny) include Garigue, which are low- and sub-shrubs, and Phrygana, which are more sub-shrubs and herbs, which occupy recently burnt and over-grazed areas. Magui forests evolve from the Garigue and Phrygana cover, and are noted for average heights between 2 and 3 meters. Growing in the in small cracks of rock surfaces are isolated chasmophytic flora, with specific species more tolerant of the limestone rocks, aspect, and elevation of the Five Finger range (MOA, 2005). This vegetative-soil complex and surrounding rocks and barren soil provide the surface cover for intercepting precipitation in the two regions. In establishing a surface water budget for the regions, the goal is to use annual recharge rates to set qanat withdrawal rates. The balance of recharge and withdrawal should keep the aquifer's watertable at an elevation that prevents salt-water intrusion and keeps historic qanats from desiccating. A cross-section of the SRTM data for the Five Finger Mountains in the Kyrenia region is Nshown in **Figure 3**, illustrating how the watertable will lower after development of new qanats. It is important to note that the new watertable level is still adequate for maintaining the old qanat.

Figure 3.

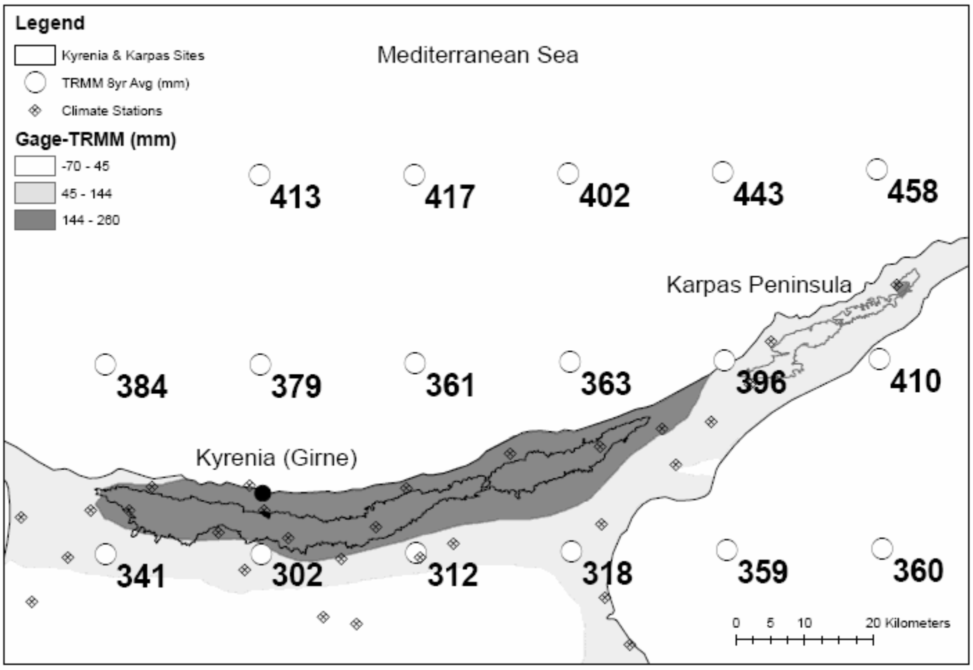


Water Balance Study

Precipitation Analysis with TRMM and Station Data

Five Finger Mountain range may include snow during the winter at higher altitudes, and cloud deposition, stratiform drizzle and intense cumuliform rain. The coastal proximity of the range creates an orographic convective precipitation cycle, where the relatively warm and moist on-shore winds are lifted up the Mountain to cool, condense, and precipitate. According to FAO reports (1995), rainfall on the coast is 450 mm and increases to 550 mm in the Five Finger ridges at about 1000 m elevation, and then decreases to between 300 and 350 in the Mesaoria Plain. Research summarized by Biyikoglu (1995) reports that average northern Cyprus annual rainfall depths have declined from an average of 402 mm during 1941 to 1972 to an average of 382 mm during 1975 to 1993, which is in agreement with research in southern Cyprus that reports an 8% decrease in annual precipitation since 1970 (Cyprus WDD, 2002). These values are rough averages for the region, and more spatially detailed values were wanted for the qanat recharge analysis. Spatially detailed precipitation data were available from two sources for estimating inputs Mto the proposed qanat regions. The first source was government run meteorological stations, using a combination of 1) a 30-yr climatic annual average, ending in 1972 and reported in the Hydrological Year-Book (MOANR, 1975), and 2) 1985 to 2005 annual depths, provided by the Northern Cyprus Ministry of Works and Transports Meteorological Office. The stations used for these values are shown in **Figure 4**, along with the boundaries of the Kyrenia and Karpas qanat regions. The precipitation second source was the rainfall product 3B42 from the +/- 50° Latitude coverage Tropical Rainfall Measuring Mission (TRMM) satellite. The 3B42 data were downloaded in ASCII format from the online V6 archives as 3-hr accumulated rainfall for the period 1998 to 2005. TRMM 3B42 data are a combination of TRMM precipitation estimates, referred to as HQ, and geostationary infrared rainfall estimates, and are scaled to match monthly gage analyses (Huffman et al., 2005). The 3B42 estimates for the period are shown in **Figure 4** at the center point of the 0.25º x 0.25º area grid that each center point represents. TRMM measurements integrate across the sample area, and provide spatial continuity compared with the gage data.

Figure 4.



However, the TRMM grid estimates are averages that miss sub-grid heterogeneity, such as higher accumulated rainfall depths on the 7-km wide Five Finger Mountain Range, which is relatively narrow compared with the TRMM sampling.

TRMM 3B42 data accuracy had not been tested in Cyprus, so a differencing of gage and TRMM data was performed for the period of record. TRMM data spatial coverage and 3- hr sampling interval are improvements on the gage data that would be useful if accuracy was adequate. Along the north coast and within the Mountains, TRMM annual averages underestimated gage observations by a maximum of 68%, and on average by 43%. In the Mesaoria plain, which is a rain shadow feature, receiving the least rainfall in Cyprus, TRMM data were 23% higher than gage observations. **Figure 4** shows the gage-TRMM annual average differences in terms of lengths. TRMM data represent a sampling width too large for the rainfall heterogeneity along the 15 km transect from coast through Mountain to Mesaoria plain. Given the inadequate TRMM accuracy, gage data were used to obtain average annual rainfall depths for the two qanat recharge regions. For the Kyrenia region, average annual precipitation is 531.4 mm, and for the Karpas region it is 527.7 mm.

Evapotranspiration Analysis with Complementary Relationship

Actual evaporation for the Five Finger Mountain range was estimated using the robust and globally tested complementary relationship areal evapotranspiration (CRAE) model of Morton (Morton, 1983). Unlike many models that only estimate potential evapotranspiration, CRAE focuses on establishing actual outputs to the atmosphere. Soil, plant, and meteorological data constraints in Cyprus make the monthly time-step and soil-plant independent CRAE model ideal for estimating actual areal evapotranspiration, ET. Should hourly meteorological data become available, as well as detailed physical descriptions of soil-water characteristic curves and plant rooting depths and resistances for the region, then more complex soil-vegetation-atmosphere transfer (SVAT) schemes are recommended for rigorous ET estimation (Wood et al., 1998). The CRAE model is based on theory that ET has a negative and complementary relationship with potential evapotranspiration, ETP. This relationship is conceptually explained by first considering a completely dry environment with no water, and all incoming solar radiation is converted to sensible heat, which generates maximum air temperatures. In such an environment, ET is by definition zero, and ETP, which increases with air temperature, is its maximum value. Next considering a wet environment where plants have unlimited access to water for evapotranspiration, incoming solar radiation is partly converted to latent heat, and the air is cooler than in the earlier dry condition. In such an environment, ET is at its maximum, which is equal to ETP, and defined as wet environment areal evapotranspiration, ETW.

The CRAE model arranges the terms in this complementary relationship to solve for ET as,

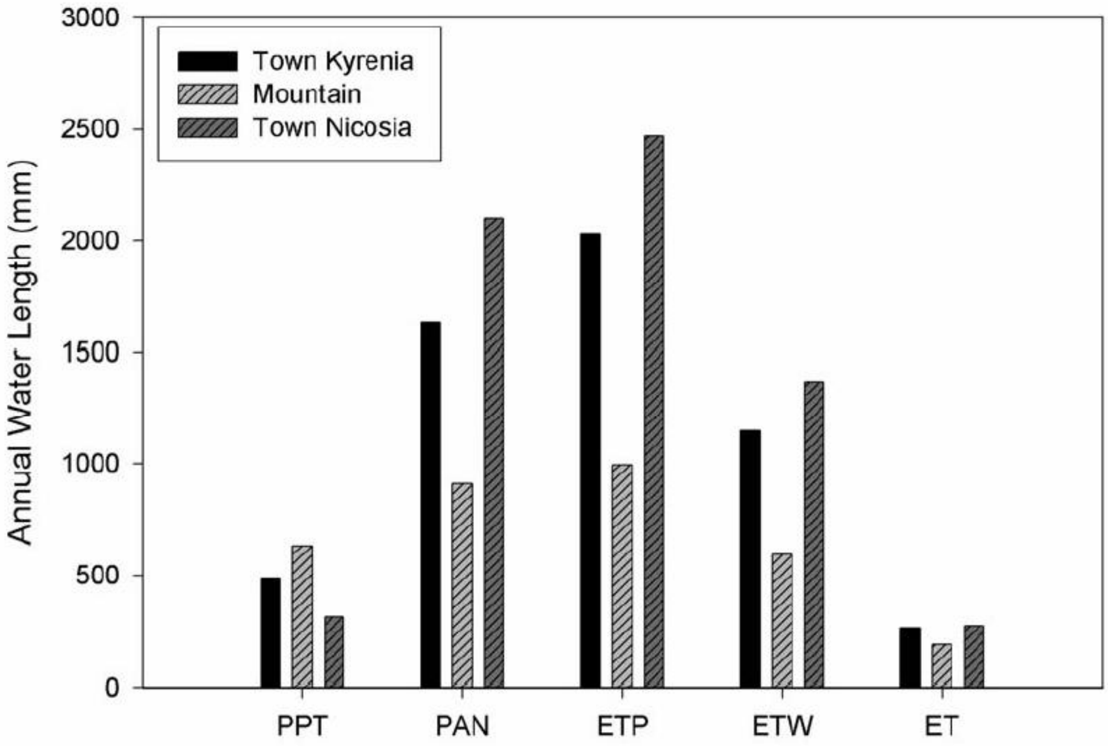
$$ET = 2ETW - ETP$$

The right hand side terms are found as follows. ETP is estimated with two equations, one a form of the energy balance equation and the other the vapor transfer equation. The energy balance uses an actual and equilibrium air temperature, TP, while the vapor transfer uses on TP. TP is iteratively adjusted until both equations give the same estimate for ETP. Once TP is found, net available energy for evapotranspiration, RTP, is adjusted by TP, and used

with two coefficients, b1 and b2, to compute ETW. The b1 and b2 terms were established by Morton when CRAE was tested against long-term water budgets on 143 river basins in North America, Africa, Ireland, Australia, and New Zealand, including several arid catchments. Coefficient b1 represents advection energy, and was set to 14 W m-2, or 0.49 mm day-1 at water temperature of 20°C. Coefficient b2 represents the factor by which energy based evaporation should be increased to account for turbulent transfer, and was set to 1.2.

The CRAE model coefficients b1 and b2 were fine tuned using a water-balance approach for the Pyrgou watershed on the north coast of Cyprus by Xu and Singh (Xu and Singh, 2005). Based on 5-yrs of calibration data, ending in 1993, the b1 term was tuned to value of 10 W m-2 and the b2 term was tuned to a value of 1.18. These tuned coefficients were then used for estimating the 1985 – 2005 average ET for the qanat recharge regions. Our implementation of the CRAE model had the additional components. First, net radiation was not recorded by meteorological stations, nor was hours of daylight, so net radiation was estimated using an inverse method with measured pan evaporation. In this inverse approach, the energy balance equation was used with water density and latent heat of vaporization derived for the average air temperature. Second, following the recommendation of Xu and Singh, net radiation was reduced by 20% to account for ground heat flux, which represents daily warming of the soil rather than all insolation being available for evapotranspiration. Results from the CRAE model are shown in **Figure 5** for three gages along a transect cutting through the Five Finger Mountain Range. The figure reports precipitation (PPT), pan evaporation (PAN), and the ETP, ETW, and ET terms. Along this transect, the town of Kyrenia station is on the north coast, and ET is 55% of PPT, the mountain station has ET at 30% of PPT, and the town of Nicosia station has ET as 88% of PPT. The average ET depth for the entire gage area was 255 mm, which compares well with the 280 mm island average ET rate estimated by the Cyprus Water Development Department (Cyprus WDD, 2002). Because the qanat recharge regions are in the Mountain Range, ET values are lower than the gage area average. For the Kyrenia region, average annual evapotranspiration is 222.6 mm, and for the Karpas region it is 221.6 mm.

Figure 5.



Recharge to Qanat Regions & Consideration of Rivers and Springs:
Annual average surface water recharge to into the Kyrenia and Karpas regions is taken as the residual of areal precipitation and evapotranspiration. For the Kyrenia region, this is 308.6 mm, and for the Karpas region this is 306.4 mm. With the 310 km2 areal extent of the Kyrenia region, annual recharge volume is computed at 95.7 Mm3, and with the 60 km2 areal extent of the Karpas region, annual recharge volume is computed at 18.4 Mm3. While there are no known surface channels draining the proposed recharge regions (MOANR, 1975), we allocate a flow-through factor of 50% which allows for possible discharge into down gradient rivers as baseflow, mountain springs, or as coastal submarine springs. In a late 1960s study of the 30 to 60 m thick coastal plain aquifer north of the Mountain Range, annual rainfall recharge was estimated at 12 Mm3, with nonextracted recharge quickly discharging as sub-marine springs (MOANR, 1971). This study suggests that water not captured by the qanats may be discharging in excess to submarine springs, and with monitoring the flow-through can be adjusted as the project develops.

Working with a 50% flow-through estimate, the Kyrenia and Karpas qanat regions provide a combined annual average water supply of 57 Mm3. This annual volume is capable of meeting the water supply deficit of 13 Mm3 at 23% of total qanat development. An incremental qanat development approach is recommended, locating and designing the first qanat on the north face of the Five Finger Mountain Range, while restoring nearby desiccated qanats.

Discussion
Qanat restoration and development in Cyprus provides a cultural significant water supply that is more ecologically sustainable than the current well-field development approaches causing over-extraction and salt water intrusion. Alternative water supply ideas for Cyprus, suggested by others, include: water banking (Hatem-Moussallem and Gaffney, 1999), reservoir films and mixing (Cox, 1999), desalinization (Mark, 1999), Turkey- Cyprus water pipeline, water bags and tanker (Bicak and Jenkins, 2000), and new reservoirs (Ozdemirag, 1998). Water banking is inherently a useful economic idea that will likely lead to water efficiencies, such as drip irrigation systems for agriculture or low-flow fixtures for residences. This innovation has the potential to fill the current water deficit if implemented properly, and should be pursued regardless of qanat restoration, but considered with any new qanat development. Reservoir films and mixing was examined for southern Cyprus and had nominal (<1Mm3) efficiencies. Given that northern Cyprus has fewer reservoirs, it is not likely this technology would fill the water deficit. Desalinization is an energy intensive and costly process that is operational in southern Cyprus, but it has the potential to meet nearly all water deficit, and therefore should be compared with qanats in a cost-benefit analysis.

Extensive economic analysis has been given to plans for a Turkey-Cyprus pipeline or shipment of 75 Mm3 of water annually (Bicak and Jenkins, 2000; Bicak and Jenkins,1999) along with development of new Cypriot reservoirs (Bicak et al., 2000) (Ozdemirag,1998) underwent extensive economic analysis. The development and supply cost for these plans ranges from \$0.56 to 0.75 per cubic meter, and when residential delivery losses of 20 to 30% are considered, the household cost increase to \$0.99 or \$1.13 (Bicak and Jenkins, 1999). The dam, which is proposed for Yesilirmak to the west of the Five Finger Mountain Range, has a project life of 50 years, has three net volume options of 6.2, 6.5 or 9.2 Mm3 per year, which is split between a nearby village and irrigating regional agriculture. Reservoir construction has some external costs including displacement of families that will see their land flooded, and possible violation of European Union environmental provisions regarding natural flows for rivers. Already, northern Cyprus extracts 14% of its supply from intermittent rivers. The qanat development project, now that recharge rates are established, should undergo economic feasibility analysis and compared with these alternatives. Qanat restoration and development in Cyprus can be designed to avoid mistakes encountered elsewhere, as well as borrow from successes. One study in Israel’s Negev desert, where water conservation is critical, suggested that ancient Byzantine developers arriving from more humid Mediterranean environments utilized inappropriate technologies such as dams and reservoirs, rather than qanats suited for the arid climate (Rubin, 1988). These concerns are present today, where the reservoirs designed by western educated engineers suffer in arid, sparsely vegetated areas from excessive water losses to evaporation as well as siltation.

Development aid agencies and non-governmental organizations (NGOs) have noted that surface water supplies in developing regions suffer not only from evaporation but from pollutants. Counter measures for pollutants include subsurface capture and delivery systems, such as qanats, which represent a technology that has been culturally important (Reimann and Banks, 2004). In Afghanistan reconstruction activities, NGOs are using a groundwater management policy that promotes groundwater as a drinking source, suggest collection methods that avoid motorized pumps, uses groundwater for irrigation to dampen the effects of surface water drought on food supply, keeps recharge zones free of pollutants, and monitors water quality (Banks and Soldal, 2002). Qanats must be placed in a regional plan to ensure that tunnels are not jeopardizing community infrastructure. For example, in Kerman City, Iran, qanat tunnels were dug in too close proximity, and ultimately accelerated natural karstification of calcareous rocks in the urban area (Atapour and Aftabi, 2002), Monitoring qanats is critical to ensure appropriate water quantity and quality. In Iran, the Shahrood Qanat delivers 30% of the municipal water, and water quality and quantity has been systematically monitored in a multiyear program since 1999. Assessment of data revealed that physical indicators remained relatively steady state except for seasonal temperature fluctuations, travel time, and mixing considerations. The quality of qanat water is low in total dissolved solids (TDS) but high calcium (Ca), magnesium (Mg), alkalinity (pH), and hardness from carbonate rocks ($CaCO_3$). The monitoring also revealed a higher than recommended Nitrate-Nitrogen (14.9 mg L^{-1}) and Phosphate (0.105 mg L^{-1}) concentration, which was traced to excessive fertilizer application in the recharge zone (Kazemi, 2004).

Water quality prospects are good for Cyprus. In the Five Finger Mountain Range, recharge areas are too rugged for agriculture, yet measures must be instituted to monitor and ensure pollutants are not introduced. While qanat technology has similarities to *ghayls* of Yemen, which are subterranean tunnels tapping multiple rain-fed springs, qanat supply areas are typically further up gradient from public use of the water. This separation of source and use can better protect qanat supplies from the wastewater recharge contaminants that have polluted water supplies in ghayls (Foppen, 2002). Regarding natural minerals in qanat supplied water, the limestone of the Five Finger Mountain Range is finely to highly crystallized, and it is not likely to release high concentrations of $CaCO_3$ or TDS.

Ensuring urban and rural community involvement with the qanats is also important. In Iran, when vertical wells with motorized pumps lowered the watertable and desiccated qanats, they became abandoned. This interruption of qanat flow, together with land reform in the 1960s that created uncertain ownership of qanats, reduced community valuation of qanats and their motivation for qanat maintenance (Bonine, 1996). Further, the urban community should be able to afford its water supply technology. For example, qanats were recommended in Syrian small communities faced with water shortages and limited capital investment or revenue for maintenance of high-tech water delivery systems (Wessels, 2003). Qanats can expand the urban water supply area, but not solve fundamental issues of water scarcity. In the water delivery for the City of Tehran, qanats became inadequate because urban population growth and water demand exceeded the water supply (Vojdani, 2004).

Conclusions:

Qanats are considered a culturally significant, ecological sustainable and practical drinking water supply for urban areas in northern Cyprus. Recently available satellite collected elevation data, referred to as SRTM, were used to delineate potential recharge areas that will restore ancient qanats and provide sites for new qanats. While satellite derived rainfall estimates from the Tropical Rainfall Measuring Mission (TRMM) may provide data needs in more homogeneous terrain, they were on average 43% below the 20 year recorded depths at meteorological gages. Actual, not potential, surface losses to the atmosphere were derived from a globally tested and locally tuned complementary relationship areal evapotranspiration model (CRAE). A conservative flow-through volume of 50% was allocated for environmental services, and the resulting annual recharge was established at 57 Mm^3, which at 23% development fills northern Cyprus' 13 Mm^3 annual water shortages.

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URGENT ARMENIAN NATIONAL PROBLEM - LAKE SEVAN

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The role of Lake Sevan was, and still is, very important in the national economy of Armenia. The use of the lake's water has highly developed the hydroelectric power generation and agricultural land irrigation.

Ecological balance were greatly disturbed and have led to degradation of the whole ecosystem and changes in various processes (biodegradation, sedimentation, etc).

Some times ago, as there were a consumer approach towards the resources of the lake and poor ecological management from an oligotrophic level, the lake collapsed into a eutrophic bio-level.

At the oligotrophic bio-level, no organic matter was accumulated and qualitatively, the water of the lake was regarded as potable. Organic toxic substances are the main sources of anthropogenic pollution: agriculture (stock-breeding, farming, mineral fertilizers, poisonous chemicals), industry and household sewage waste waters.

The communities and food, fish and other factories are situated mainly along the lake cost. Under above mentioned conditions of water supply the waste water treatment on Sevan catchment basin should be effective after a corresponding pretreatment of raw water.

Based on experimental bench studies followed by field triais using a pilot plant a treatment technology was developed, including the following processes:

- simplified aeration;
- two-stage rapid filtration without use of chemicals;
- sorption;
- oxidation;
- membrane filtration.

The increasing demand for ion-exchange materials as ecological problems simulated the intensive study of natural and modified zeolites because they are considered to be cheep modified sorbents.

For sorption process we proposed the zeolite use. The technological stability of zeolites as sorbents is determined first of all by such characteristics as mineral and chemical composition, sorption ability and then mechanical, physical and following from them filtering properties. Natural zeolites e.g. zeolite-containing tuff are considered to be a promising material for raising the quality of raw material, semi-finished and finished products in this field of drinks production.

Introduction

The role of Lake Sevan was, and still is, very important in the national economy of Armenia. The use of the lake's water has highly developed the hydroelectric power generation and agricultural land irrigation.

The republic of Armenia is located in the South Caucasus. It`s a highland country, about 90% of its territory is situated at a height of over 1000 m and 40% out it –over 2000m a.s.l. The lake Sevan is in the central part of Republic of Armenia. One of the highest among freshwater lakes in the world and the main source of freshwater of the Transcaucasian region - Lake Sevan is located at the height of 1.897 m a.s.l. in Geghama mountain-chain. Sevan plays also an important role for regulating as Armenia`s as well as the regions water balance. Common square of lake is 4.89km2 (16% of the whole territory of Armenia).

Armenian water resources are generally formed on its territory and add about 7,8km3 annually, whish includes 4,7km3 surface water 3,1km3 groundwater. There are more than 300 rivers over 10 km long and 9 500 small drains up to 10 km long. About 30 small rivers and drains pour into Sevan, bringing about 700 mln .m3 per year and there is only Razdan river origins from it.

During the period 1933-1981 water of lake intensively used for agricultural and energy sectors (cascade of six hydro power stations were constructed on Razdan river) level of lake dropped dramatically (by 19m), reducing the lake`s volume by 25 billion m3 (42%) , while to1933 Sevan contained 58,5 billion m3 i.e. 80% of Armenia`s water resources. The lowering of the lake's water level started in 1933, but intense water discharges and a drastic drop in the lake's water level has occurred since 1949 when the annual discharges reached 1.000 to 1.700 bin m3. In 1962, when the water level had dropped by 15.7 m, the "water bloom" phenomena was observed in Lake Sevan.

Ecological problems

Ecological balance were greatly disturbed and have led to degradation of the whole ecosystem and changes in various processes (biodegradation, sedimentation, etc). Some times ago, as there were a consumer approach towards the resources of the lake and poor ecological management from an oligotrophic level, the lake collapsed into a eutrophic bio-level. At the oligotrophic bio-level, no organic matter was accumulated and qualitatively, the water of the lake was regarded as potable.

At the eutrophic bio-level, which developed in 70's, equilibrium was shattered and organic matter began to accumulate, entailing a positive balance of biogeochemical circulation. All this brought enhanced autotrophic subsystem activity and a subsequent sharp decline of water quality.

So, all the above-said necessitate a sound scientific approach for tackling the issues of restoration, preservation, rehabilitation of resources and streamline measures to overcome the problems. The Sevan ecosystem is increasingly in a non-equilibrium state now, and the changes taking place within 2 to 3 year time, would have taken from 50 to 120 years before the water level of the Lake dropped by approximately 19 meters.

The main cause of the anthropogenic eutrophication of the lake is the concurrent influence of two effects, e.g. inner-lake occurs as a result of a water level drop of 19 meters, and secondly, the vast quantities of biogen and toxic substances inflow to the lake.

The catchment basin influences the lake system mainly through river flow. 28 rivers flow into Lake Sevan; of them, only 10 have permanent flow. Since 1981, the waters of the Arpa River have been flowing into the lake. Amongst large rivers, only the Gavaraget River flows into Minor Sevan. The total annual flow of tributaries to lake Sevan amounts to 1.016.5 million m3, which is 3% of the volume of the lake.

Organic toxic substances are the main sources of anthropogenic pollution: agriculture (stock-breeding, farming, mineral fertilizers, poisonous chemicals), industry and household sewage waste waters.

The intensification of economic activity in Lake Sevan catchment basin is the cause of essential changes in the hydrocarbon chemical content of the rivers. The amount of dissolved organic matter in the water has grown up to 3 mg/l; the content of chlorides and sulfates has increased several fold; the concentration of nitrogen nitrate and ammonia forms have increased ten-fold; the total mineralization has grown from 130 to 190 mg/l. Noticeable changes took place in the concentration of mineral nitrogen which is the consequence of mineral fertilizers and stock-breeding development.

The most polluted rivers are: the Gavaraget, Masrik, Makenis, Argichi, Vardenik, Tsak-kar; the Lichk river is the cleanest one. In terms of sanitation and hygiene indicators, the Gavaraget, Makenis and Masrik rivers are considered polluted, and the cleanest river is the Argichi.

Also, heavy metal concentrations have been determined for Lake Sevan trubataries (Fe, Mn, Zn, Cu, Ni, Co). The rivers Gavaraget, Vardenik and Masrik are most polluted with heavy metals; the cleanest one this respect is the river Arpa. All rivers are high in iron compounds (70-140 mkg/l) and low in manganese content (7-18 mkg/l).

The estimation of the water quality judging from average values does not reflect the alterations in the ecosystem of Sevan during the process of eutrophication.

The growth of the trophic level in many lakes of the world is dependent on the growth of the load of organic elements, particularly, nitrogen and phosphorus, from the catchment basin. The eutrophication causes of Lake Sevan differ from those of other lakes of the world.

The ecological changes in Lake Sevan in the early 1990s destablished its ecosystem and, perticularly, caused perceptible structural changes in fish symbioses (biological and population indicators have changed).

Lake Sevan eutrophication is attended with profound structural changes in phytoplankton. In response the problem of eutrophication, the decision was made to increase inflow to lake Sevan from neighboring Arpa river. Since 1982, about 250 million m3 of water each year has been carried through the 48 km long Arpa-Sevan tunnel and 1990 the lake`s level increased by 1,2m. A number of bioproduction, physical, biochemical and chemical processes had stabilized, resulting in significant decrease in the levels of eutrophication. Since establishment of National park (1981) efforts to preserve the huge water reservoir in generally addressed to proper organization of services at recreation area and minimizing of pollution resulted by agricultural activity. Tree planting was important step in that direction and number of forest areas was increasing.

Improvement of water quality

The communities and food, fish and other factories are situated mainly along the lake cost. Under above mentioned conditions of water supply the waste water treatment on Sevan catchment basin should be effective after a corresponding pretreatment of raw water.

Based on experimental bench studies followed by field triais using a pilot plant a treatment technology was developed, including the following processes:

- simplified aeration;
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Natural zeolites uses of in the following fields of waste water cleaning:

1. removal and recovery of NH4 ,
2. removal and storage of radionuclides,
3. removal and storage of heavy metals,
4. removal of organics.

The advantages of zeolites in comparison with other sorbents are their reserves in Armenia, a unique complex of technological properties / sorptional, moilecular-sieving/ as well as their natural origin, possibilities of they modification in various directions, regeneration and utilization. The application of the Armenian natural zeolites in the processes of water preparation has been scientifically approved according to the all-round evaluation ov mechanical, physical, physical-chemical, technological properties of zeolites developed. It has been established that the natural zeolites and their combination with other systems is necessary to remove metal ions from water. It have been established the regularities of extraction processes of ions of iron, magnesium, calcium, zinc, copper, nickel, cobalt, lead and ammonium from water. The dependence of efficiency and mechanism of sorption of components from water, filtering parameters, length of contact liquid and solid phases ratio and other factors are obtained.

High porosity of zeolites as compared with quartz sand provides the increased filtering capacity, the reduction of losses of head increment and therefore the increase of filtering cycle duration and increase specific load of the filter. Chemical stability and mechanical . strength of natural Armenian zeolites – Mordenite and Clinopilolite meet the requirements filtering materials.

The Using zeolites

Natural zeolite deposits of sedimentary origin are widespread in Idjevan / Clinopilolite / and Shirak / Mordenite / regions of Armenia.

Conclusion

It is advantageous to continue the research in ammonia and organic pollutant sorption using Armenian natural zeolites. This offers a convenient method for the successful sorption of ammonia and organic pollutants from water. The method can be applied to river water treatment processes.

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THE SIMULATION GEOLOGICAL FOR WATER SHORTAGE FROM JIFARA PLAIN BASIN NORTHWEST OF LIBYA

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Libya is among the countries suffering surface water supply shortage Due to scarcity of rain and snow era, and the formation mature, the vast Libyan lands (1.700.000km) of which 95% arid lands, in this study our focus will mainly be on Jifara blain basin with such a complicated geological formation higher to the south and lower to the north with extreme slop towards the sea, this area was exposed to cleave movement resulted in two fractures, the first fractures heading north-east toward Tunisia borders as for as Jabal Abu-kirsh , 100 to 200 meters , the second fracture is heading west and called , the greater Azizia elevate , such movement led to fold and slop towards the sea forming three rock units :

1- Mountain front sequence extending from homes to missiles to the west where it includes gargarish formation constituting sand lime sediments, such sediments formed water reservoirs of great subterranean water reserves.

2- Mountain front sequence extending east and west to Tunisian borders, this line of sequence includes Abu-gailan and Abu-shaiba being covered by sand and limestone soil sedimentary containing underneath lime sediments it is around 700 meters over sea level, this formation also contains deep and wide gulfs including mjineen and Essirt valleys being the main feeder to most north west area.

3- Hadba surface sequences include the 4th era formations scattered in most edges and centre of the area with rock masses in which much low water exists. It is believed that such rock units moved back to its present place by reason of different erosion factors, the basin is believed to be covered by lime and sand rock that led to the birth of lime water accumulations reaching 2.4x1610cubic km. Also the occurrence of low level water reservoirs scattered in the centre of the basin which was exposed to up and down and fracture movement contributed to the lowering of the north part of the basin most parts of this basin have been flooded by sea water during the Miocene and Oligocene resulted in the formation of rock Hollows consisting large quantities of water most of which are accumulated in the sea it is also believed that there is a large water basin branching from Jifara plain, it is also believed that the low level in the underground reservoirs is attributed to the low level of the north part of the basin where water flows from the south part towards the lower north part to flow into the sea water forming fresh water reservoirs inside the sea if we examine the way taken by water during the water cycle we find the movement indicates that it originates from sea to land , then land to sea again , once again it is believed that most countries will produce fresh water from sea in future as a result of water cycle of water returning to its original source.

The 4th era sediments are considered to have contributed to the basin surface and underground features formation during Holocene containing water carrying sediments such as quaser el-haj formation consisting of lime and grain rocks where reservoirs of al-azizia abushaibs and abughailan are located where water is being pumped from Miocene layer as well as gargarish Formation which contains ber El-ghanam and kikla reservoirs that are covered by lime sediments, water is being pumped towards south of the basin, the south area of the Jifara plain . there are also saline sediments being spread south and west of the basin such saline's were as result of dropping of Oligocene the matter which led to the salinity of the soil by effect of infiltration of salts contained in the rain water by this study we expect to find a trace of water flow from Jifara plain, towards sea, through a hollow in its north part, this matter resulted in creation of severe water shortage in the area. In this study, it is proposed that 3D three dimension surveys be carries out in the basin to find out the geological structure which led to this natural phenomena resulting in deformation to the installation of water distillation units for the purpose of refilling of such underground water reservoirs for the increase of its pressure and water reserve and increase of pressure.

INTRODUCTION

Through this study we hope to know places of fresh water Immigration of Its direction in the seawater and the exploration in of the flooded area Tripoli and Zwuarah this area has in the past been exposed to cleaving movement and Descending resulted in major fault systems of fracturesthat Contributed to the Immigration of huge Quantities of water to the Sea and vice versa saltwater to Jifara Plain basin forming large of We also believe that system faults beds to the spreadof large Quantities of water in the sea water in this form of water springs And Basins immigratedfrom Azizia and Abughelan water reservoir Through Azizia cleave and Other Small Riftsextending north east .

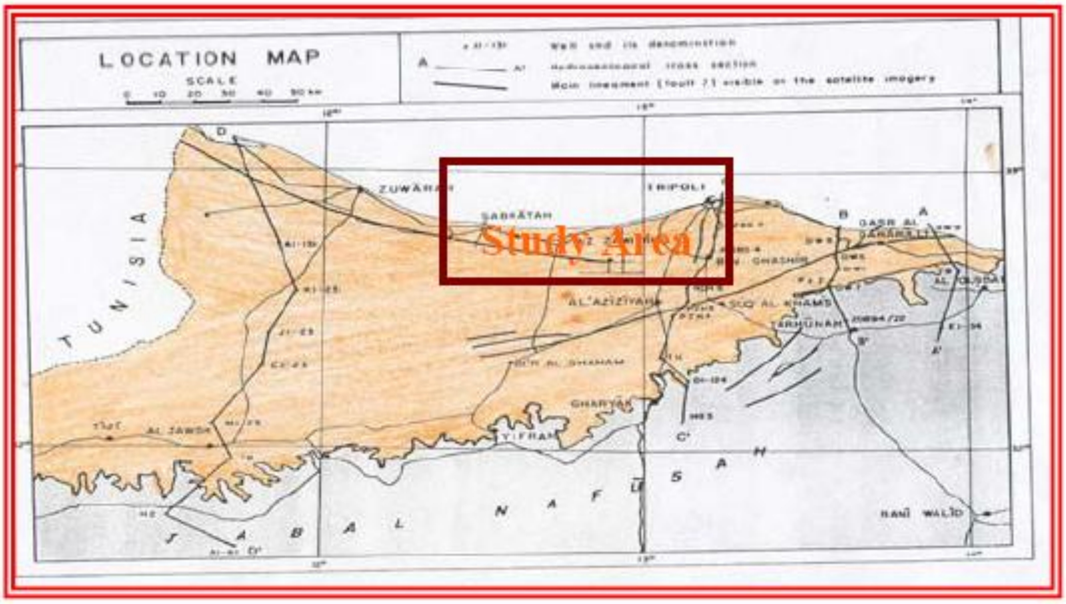
Two refract have been attributed to inclination and crack monument:

The first Refract It's in the direction of North West south east at distance of 100-200 m to knish mountain .**The second** Refract It's from El Azizia in the east to About Ghilan in the east. As a result of this movement, AI Jifara plain is inclined swords the sea and huge amounts of water gathering formed in basin extended from khoum is to Zuwarah. It's believed that ground water flowing through those cracks towards the sea may form water springs.

At the beginning of fourth era, sediments and alluvium have been formed in the area from north east to southwest during the raining era. The inclination is rated 2 –4 richer scales

LOCATION GEOGRAPHY

The Study Area is Situated in the western area of Jamahiriya. on area of 13500 km, being bordered by Mediterranean sea from the northern and hit etude 32,00 to the south and between 12,00 – 13,300 to the Mediterranean sea .



Location geography Jifara plain

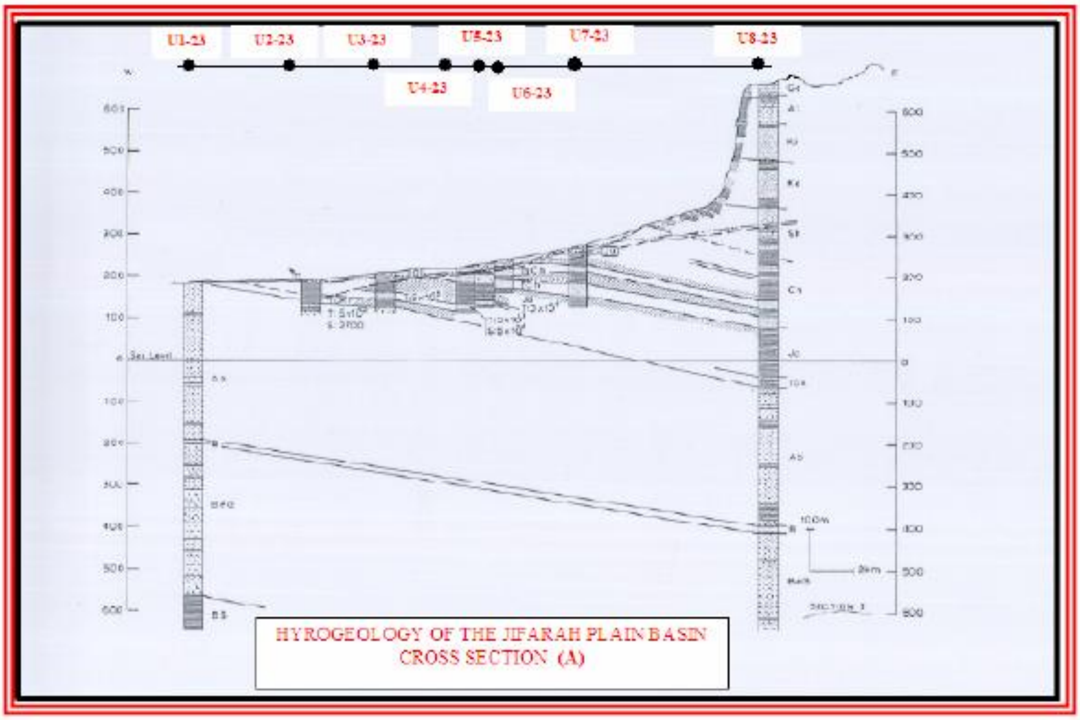
OBJECTIVE STUDY

This study aims at finding out of areas of fresh water immigration through cleaves towards the sea and Interpenetration areas threatening agricultural areas by thought and collapse.

• The study also aims at locating areas of fresh water among salt water which can be utilized in filling groundwater reservoir to increase its pressure.

•* finding out the Geological position of the area for construction of seismic observation posts along the coast line.

•* finding out the environmental position of sea bed for study of pollution problems .



SIMULATION WATER RESERVOIRS STUDY SEDIMENTATION
Study of surface Geology (geomorphology and topography), And its sediments is very important in different areas because it is provides clues about subsurface geology and structural geology that give good indication about Mineral mines (coal, iron, gold, Diamond, phosphates and radioactive elements).

We also believe that system faults beds to the spread of large Quantities of water in the sea water in this form of water springs And Basins immigrated from Azizia and Abughelan water reservoir Through Azizia cleave and other small Rifts extending north East And South-West in the area of study this area has also been .

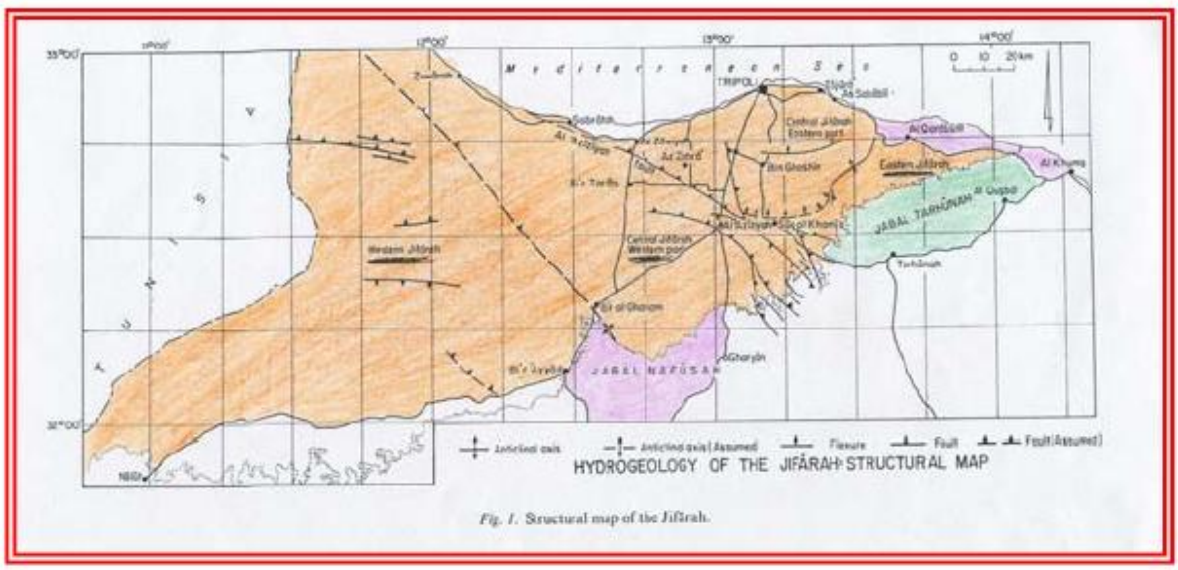


Fig. 1. Structural map of the Jifarah.

Structure Geological & simulation **Jifarah plain**

GROUND WATER SOURCES IN THE AREA

The area is covered by rocks containing mender ground water reservoir containing fresh water namely:

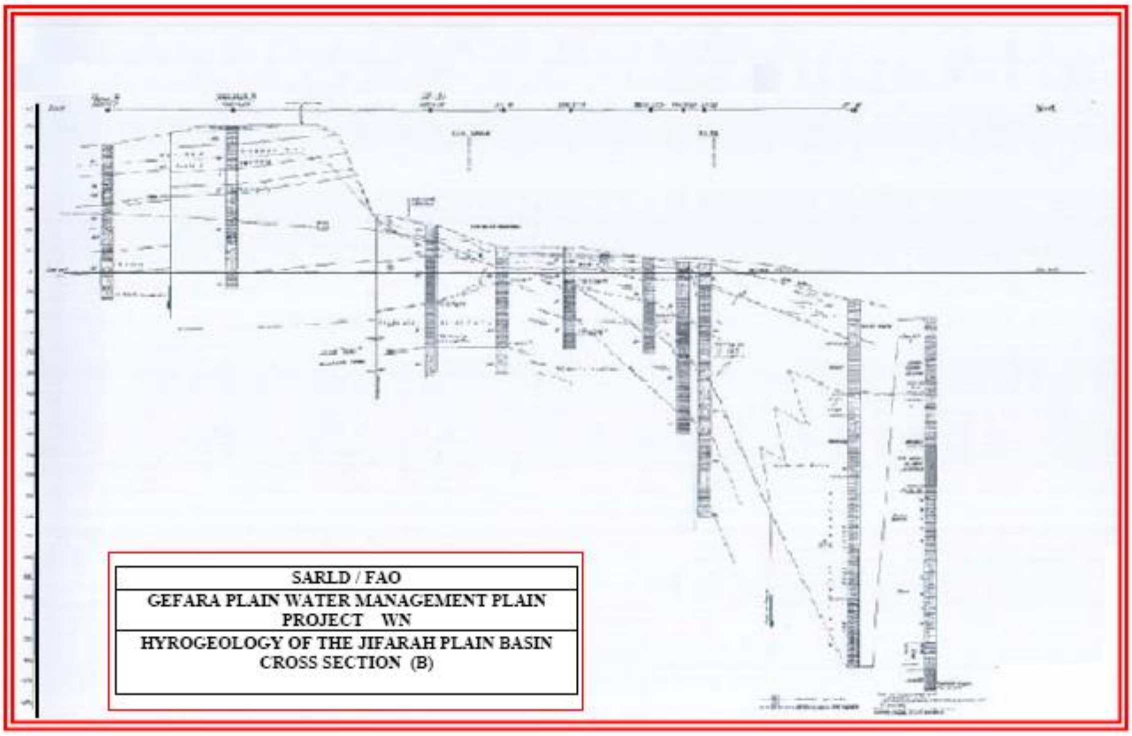
1- The north part of Jifara plain pumping water from reservoirs in the Holocene age and Miocene where water is found in sandstone and limestone which contains mud non porosity lagers.

2- The southern port pumps water from Abu-kersh formations, Azizia and Abushaiba , where depth water wells is not less that 70 meters at bier El-ghanam area and 325 meter at Azizia area.

3- The western part in this area is being pumped from kikla formation where depth of well is not less than 200 meters.

Number of water springs such as been El-haj water springs in Gharion area, and aim tuba water spring.

These resources are the main feeders to the area and most water have immigrated towards the sea through cleaves and faults forming water springs in side the sea which can be utilized



STRATIGRAPHY

@Through Azizia cleave and other small Rifts extending north -East And South-West in the area of study, this area has also been Exposed to water valley sediments during Rating seasons.

@ System Faulty of Paleozoic and Mesozoic Rocks that occur in the surrounding It consists of three rocky unit :

SARLD / FAO
GEFARA PLAIN WATER MANAGEMENT PLAIN
PROJECT WN
HYROGEOLOGY OF THE JIFARAH PLAIN BASIN
CROSS SECTION (B)

1- Al-Jifara plain :

It stretches from mountain is adjacent to the sea to Tunisian borders . its about 150 km wide . the plain costal line is covered by sediments of the fourth era carrying water including Gargarsh and Jifarah formation where AI Jifarah plain is located which includes Azizia and abou Sheiba reservoirs.

As for the middle part of the plain is covered by AI Jifara formation sediments sand hills 100m above sea level. the southern part is covered by foot of Nafousa mountain from which water flows towards the reservoirs and AI Jifara plain during rainfall season .

2- front of hill or mountain :

Its stretches from al khoumis in the east to the Tunisian borders in the west and it known as Nafousa mountain and consists of lime-silicate rocks mud and plaster , its about 400-700 m high above sea level . the front of a mountain is formed in high prominences by Elmjaneen and elusory valleys. Its believed that the southern part of this mountain has been moved to its present place due to denudation where as the northern part has been formed as are salt of sea denudation and moved to its place due to sequential denudation

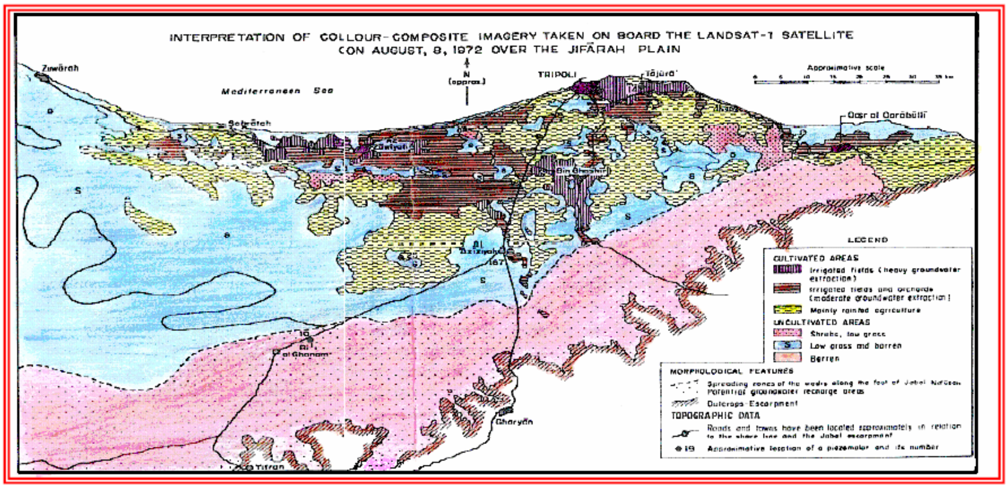
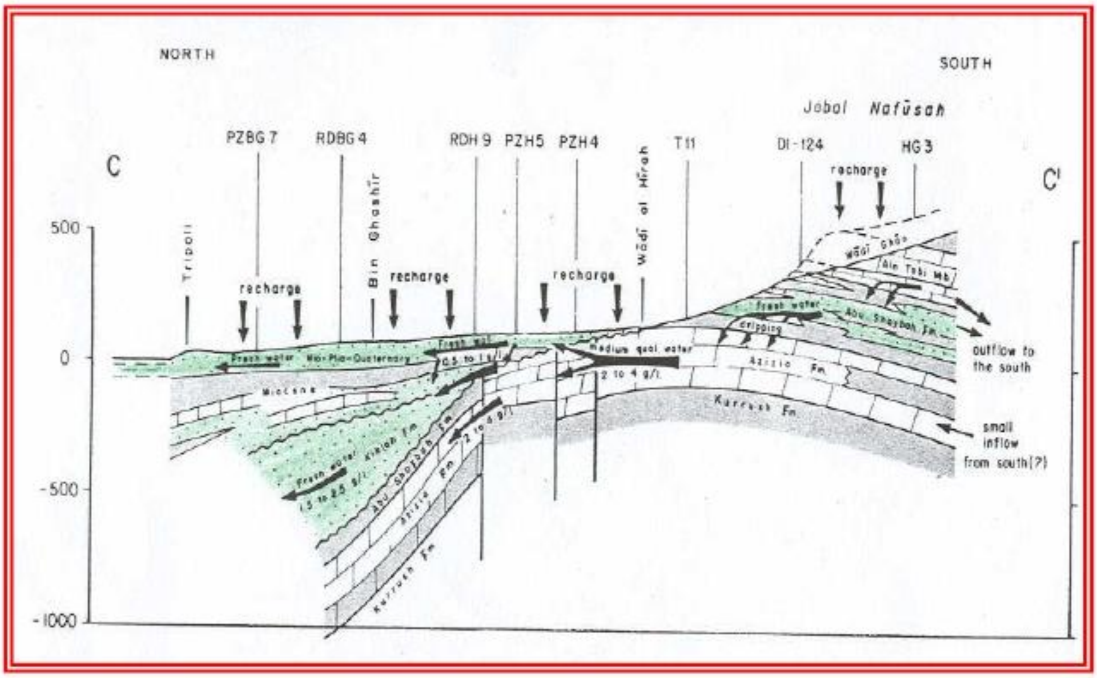


Fig.17. interrelation of colour - composite imagery taken by LANDAT on 8 August 1972 over the jifarah plain .

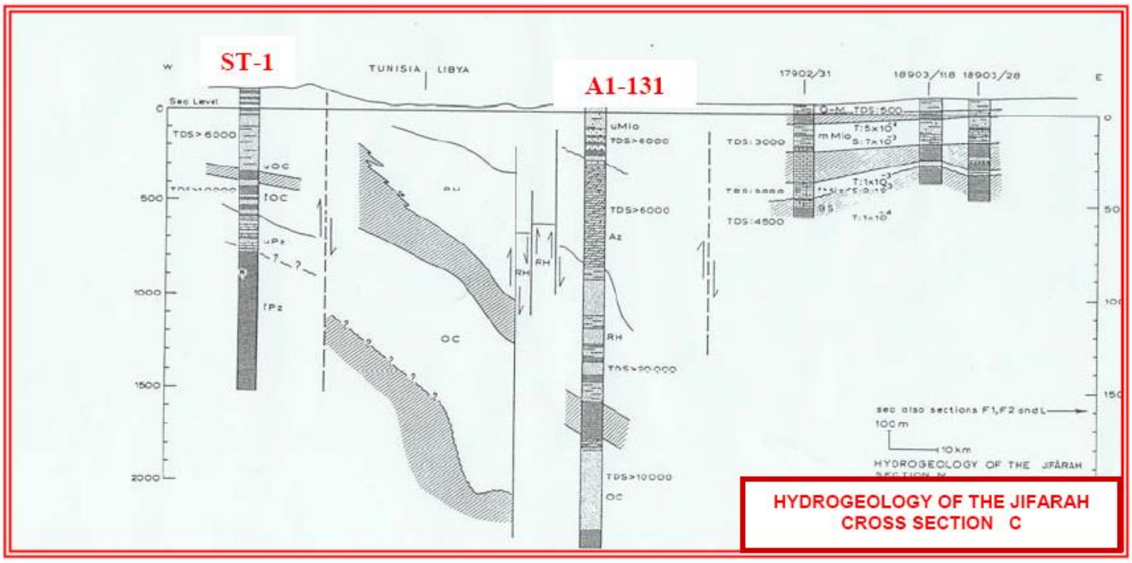
3- foot of a hill or mountain :

the hill is covered by line and dolomite rocks classified as cretaceous while the southern east part is covered by basalt rocks and its about 500-800 m above sea level



Cross section D north **Jifara plain**

SEDIMENTS OF THE FOURTH ERA CARRING WATER IN THE AREA.
The most important sediments in the area since they are the base of water basins and layers carrying water. These sediments are divided into rocky units as follows: _
1- Qasr El-haj formation;
it consists of differently consists tent pebbles along with caliche layers as well as it includes Qasr El-Haj water spring AI Jifara .
2- AI Jifara formation;
It covers AI Jifara plain and consists of sand sediments, silt and caliches rocks as well as it includes reservoir in Azizia Abou sheiba and abou ghilan .
3- karkarsh formation :
it forms littoral foots and consists of kainite used for gravel .
4- Moor sediments:
The locate in the coastal zone between Sabrata and Zuwarah. It consists of calciferous crust with sand and silt.
5- Windy and water sediments they cover low parts of hill foot and consist of silt and soft sand
6- Sediments of sand dunes the cover the mid part of Al Jifara plain and sometimes cover the beach the
consists.
7- Sediments of recent valleys they consist of pebbles, silt and soft sand.



FORMS OF AQUIFERS IN THE AREA :

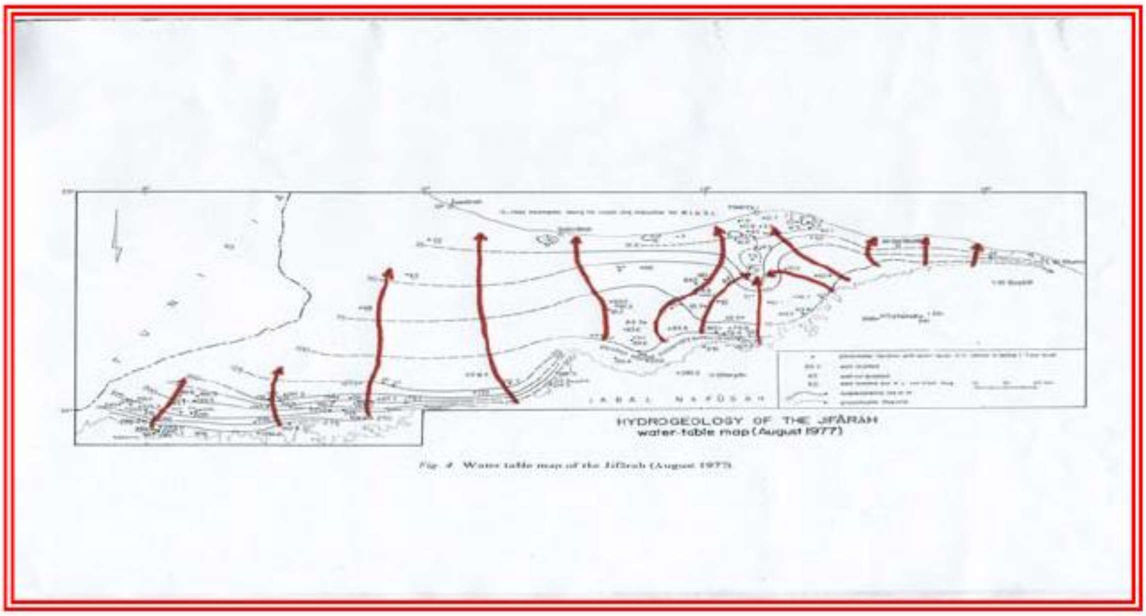
1- Non -confined aquifers

they are large mounts of water under earths surface and subsurface as well as equalize the atmospheric pressure and opened on the atmosphere .

2- confined Aquifers :

water flows out vertically to semi-confined Aquifer and they are fed by rainfalls.

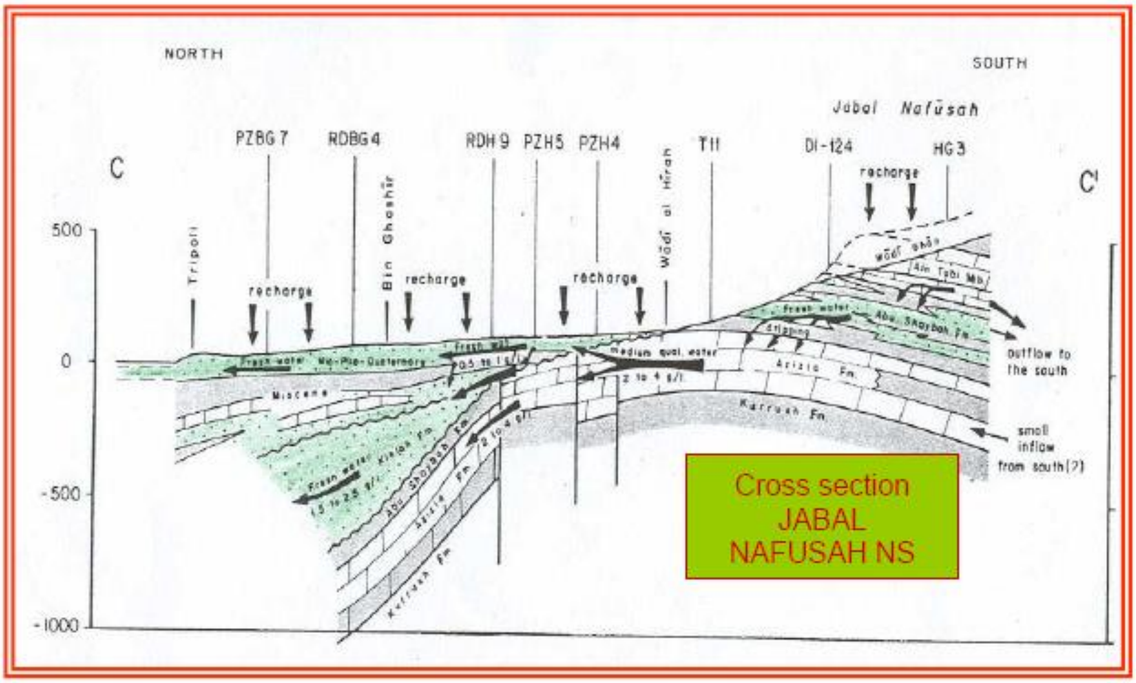
This sort of Aquifers locates in the middle area in Jamahiriya



Flower water to north Jifare Basin

PROBLEMS OF PUMPING GROUNDWATER IN THE AREA:
The pumping of ground water may cause to form crocks with sharps edge and refracts in earths surface. These crocks consist of refracts parallel generally with contour lines and they may block surface water ranging towards arable lands in AI Jifara plain.

Inundation running water is to deepen the cracks and lead to join them together. Consequently the distance for these cracks increase as well as differential subsidence due to non identical sedimentation in AI Jifara plain which leads water flow to the sea.



Simulation Reservoir Jifare plain Basin

CONCLUSION

Finding out places of salt water immigration towards the land, and To Implement all ways and methods possible to slop this Immigration through filling the wide spread deep water reservoirs In the area for the creation of pressure partier to prevent sea water From infiltration to land, by pushing it back towards the sea.

It is suggested that scientific study for the exploration of the Libyan territorial waters through short term aerial surveying Electric sound of infra Red, this would enable us to know the Structural Geological situation along the North coast of Great Jamahiriya.

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5. Foundation Libya water Cross Section From Al Jifara Basin , (1993)

EVALUATION OF BORON IN DRINKING WATER IN SOME VILLAGES OF SEYDISUYU WATERSHED (ESKISEHIR) OF TURKEY

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Turkey holds approximately a 72% share of the total boron deposits of the world. One of the biggest borax mining in Turkey is in the Seydisuyu Watershed in Eskisehir Province. The aim of the study is to examine concentration of boron in the water used for drinking water in villages of Seydisuyu Watershed, and to check whether there is a risk for human healthy. Drinking water samples were taken from 8 different villages and 14 different sampling points in 2004 and 2006. Concentrations of boron found in drinking water in the villages were ranged from 0.29 to 2.82 mg/l. The higher existing concentration of boron in drinking water might be attributed to boron contamination due to the fact that there was the boron-rich environments and largely dependent on the leaching of boron from the surrounding geology. In addition, the results are discussed as considering Drinking Water Directive for European Union, WHO Guidelines Drinking Water Quality and Water Pollution Regulation of Turkey.

INTRODUCTION

Boron is a naturally occurring element that is found in the form of borates in the oceans, sedimentary rocks, coal, shale, and some soils. It is widely distributed in nature, with concentrations of about 10 mg/kg in the Earth's crust (range: 5 mg/kg in basalts to 100 mg/kg in shales) and about 4.5 mg/l in the ocean [1].

Turkey's borate mineral resources are the largest known deposits in the world, and Turkey holds approximately a 72 % share of the total boron deposits of the world. The deposits lie in western Turkey as playa beds mixed with clay and marl. Mines have been opened up in six areas namely Bigadic, Kucukler and Sindirgi in Balikesir Province; Kestelek in Bursa; Emet in Kutahya and Kirka in Eskisehir. Thus, one of the biggest borax mining in Turkey is in the Seydisuyu Wa-tershed in Eskisehir Province.

Boraxes are widespread naturally occurring substance found mainly as an inorganic com-pound in sediments and sedimentary rock. It is released to the environment slowly in low concentrations by weathering process. Although few data are available quantifying boron releases from industrial sources. It is estimated that natural weathering releases more boron to the environment worldwide than do these industrial sources. Most ground water comes from rain and melting snow soaking into the ground. Water fills the spaces between rocks and soils, making as "aquifer". Ground water may contain some natural impurities or contaminates, even with no human activity or pollution. Natural contaminants can come from many conditions in the watershed or in the ground. Some ground water naturally contains dissolved elements such as boron. The amount of boron in fresh water depends on such factors as the geochemical nature of the drainage area, proximity to marine coastal regions, and inputs from industrial and municipal effluents [5].

Naturally occurring boron is present in groundwater primarily as a result of leaching from rocks and soils containing borates and borosilicates. Concentrations of boron in groundwater throughout the world range widely, from <0.3 to >100 mg/l. In general, concentrations of boron in Europe were greatest in Southern Europe (Italy, Spain) and least in Northern Europe (Denmark, France, Germany, The Netherlands, and the United Kingdom). For Italy and Spain, mean boron concentrations ranged from 0.5 to 1.5 mg/l. Boron concentration in fresh surface water range from <0.001 to > 2 mg/l in Europe, with mean values typically below 0.6 mg/l.. Similar concentration ranges have been reported for water bodies within Pakistan, Russia, and Turkey, from 0.01 to 7 mg/l, with most values below 0.5 mg/l [10].

In Kutahya Province in Turkey, neigbour city of Eskisehir and mines have been opened, the average boron content in 382 water samples is to 10 ± 4 mg/l [6].
On the other hand, in 1998 the European Union (EU) had received its Drinking Water Di-rective (DWD), which is responsible for regulating the quality of water that is intended for hu-man consumption. The requires that the EU member states comply with a number of water quality standards and healthy parameters, and in 1998 DWD revisions the EU added several new chemical parameters –one of which is a 1 mg/l parametric value for the element boron in drinking water [9].

The risk of adverse effects of boron on the aquatic ecosystem is low, because general le-vels of boron in the environment are below the no-effect concentration (1 mg/liter water). In a few boron-rich environments, natural levels will be higher. However, it is reasonable to assume that aquatic organisms in such habitats are adapted to the local conditions. Humans are primarily exposed to boron through food and drinking-water. There is insufficient toxicity data on humans [2].

Findings from human experiments show is a dynamic trace element that can affect the metabolism or utilization of numerous substances involved in life process, including calcium, copper, magnesium, nitrogen, glucose, triglycerides, reactive oxygen, and estrogen [10].
All of us need clean water to drink. Public drinking water systems service many people. So, it needs to check the water's source and its quality before it is sent through pipes to the community.

The aim of this study is to examine the concentration of boron in the water used for drink-ing water in villages of Seydisuyu Watershed in which have been borate mineral resources depo-sits and a borax mining enterprise. Thus, it might be considered whether there were a natural con-tamination to drinking water and a risk for human healthy. In addition, the results are discussed considering Drinking Water Directive for European Union, WHO Guidelines Drinking Water Quality and Water Pollution Regulation of Turkey.

MATERIAL and METHODS

The study was carried out in villages and towns in Seydisuyu Watershed in which it has been in one of the biggest borax mining in Turkey. The sampling points were considered as representing all the villages and towns in the watershed.

Drinking water samples were collected in March, 2004 and June 2006. The polyethylene bottles were used to collect the water samples. Drinking water samples were taken from 14 dif-ferent settlements (village or town) in two years, 2004 and 2006. The number of samples was to-tally 27. The places in which the drinking water samples were collected are shown in Figure 1.

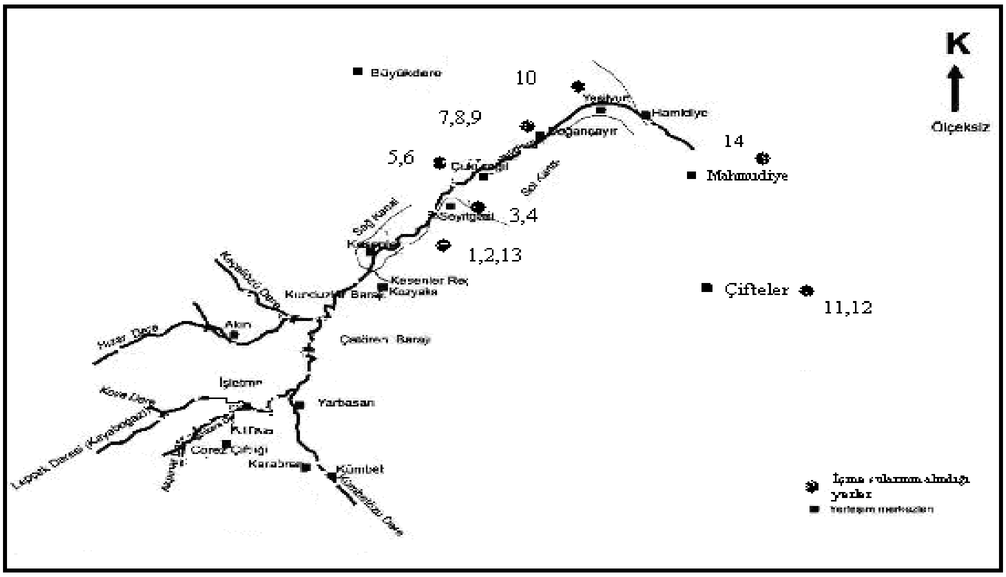

Figure 1. Seydisuyu Watershed and water sampling points

The boron concentration in drinking water was determined by colorimetric analyses using Carmen method [7]. In addition, the other analyses such as anions and cations, electrical conduc-tivity were done by using standard methods [4
The parameters measured in the samples drinking water are boron (B), pH, electrical con-ductivity, hardness, chloride (Cl), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), carbonate (CO3--), bicarbonate (HCO3-).

RESULTS and DISCUSSION

Water sampling and analysis were done in order to examine concentration of boron in drinking water in March 2004 and June 2006. Thus, the analyses were carried out two times at the same points and different years.

Concentration of boron found in drinking water in the villages was ranged from 0.29 to 2.82 mg/l. Considering the study years, there were no significantly differences between the concentrations of boron.

Based on the reference dose for drinking water according to Drinking Water Directive for European Union, Water Quality Guidelines of World Health Organization and Water Pollution Regulation of Turkey, the concentrations of boron in 7 samples of 5 villages were more than the critical level, 1.0 mg/l. Consequently, the boron values more than 1.0 mg/l were ranged from 1.21 to 2.82 mg/l and the concentrations at a few stations exceeded 2.0 mg/liter (Figure 2).

The concentration of boron in the drinking water reaches 2.82 mg/l, it was more than 2.0 mg/liter in only 3 sampling points in 2 villages (Table 1 and 2, Figure 2). Although it has been applied simple purification for drinking water in the sampling point No: 7, the concentrations of boron in the drinking water which both has purification and no puri-fication were almost same, 2.22 and 2.41 mg/l, respectively (Table 1, sample No: 7 and 8).

Existing of boron and/or its exceed levels in the drinking of villages in Seydisuyu Water-shed might be attributed to boron contamination due to the fact that there is the boron-rich environments, and boron from rain and melting snow soaking into the ground in the Watershed. Thus, boron concentrations in water are largely dependent on the leaching of boron from the surrounding geology. So, natural weathering of boron-containing rocks is a major source of boron compounds in water. The quantity of boron released varies widely with the geographic variations in boron rich deposits [5]. The concentration of boron measured in Dogancayir Town was found more than 2.0 mg/l. Considering Drinking Water Directive for European Union, Water Quality Guidelines of World Health Organization and Water Pollution Regulation of Turkey, this concentration level might be considered as an exceed value for drinking water. However, there are some discussion and un-certainty about concentration of boron in drinking water. For instance, the interim maximum ac-ceptable concentration (IMAC) of boron for Canadian Drinking Water Quality is 5 mg/l [3].

On the other hand, because of scientific uncertainty concerning the causes and magnitude of the boron problem in Europe during the regulatory standard-setting process, Weinthal et al. [9] found that full compliance with the new drinking water standard for boron has been hampered. In addition, humans are primarily exposed to boron through food and drinking-water. There is insufficient toxicity data on humans [2]. Furthermore, Yazbeck et al. [11] evaluated health impact of boron in drinking water in Northern France. Men living in municipalities with more than 0.30 mg/l of boron in drinking water had elevated but not significant boron blood levels compared with those living in municipalities with boron water levels of less than 0.30 mg/l. The results of this study do not support the idea of a deleterious effect of boron on human health, at the boron water level contents found in this specific region. In fact, there is a tendency toward a beneficial effect with low-dose environmental exposure (less than 1 mg/l of boron) in drinking water. Murray [8] conducted to derive an appropriate safe exposure level in drinking water of inorganic boron-containing compounds (boric acid and borax) for a human health risk assessment in U.S. The Reference Dose was calculated to be 0.3 mg B/kg/day, resulting in an acceptable daily intake of 18 mg B/day. Considering that the U.S. average dietary intake of boron is 1.5 mg B/day, 16.5 mg B/day could be available for drinking water or other exposures.
Considering the other quality parameters for drinking water such as pH, Ca, Cl, bicarbonate, there were no any quality problems in the drinking water sampled (Table 1 and 2).

Table 1. The results of analysis for drinking water in villages of Seydisuyu Watershed (2004)

Sample No	Sampling points	pH	EC dS/m	Cations me/l Sodium	Cations me/l Potassium	Cations me/l Calcium	Cations me/l Magnesium	Anions me/l Carbonate	Anions me/l Bicarbonate	Anions me/l Chloride	Anions me/l Sulphate	Boron mg/l
1	Fountain 2 in Seyitgazi (spring water)	7,80	0,510	0,47	0,18	3,55	1,85	0,20	4,80	0,85	0,20	0,55
2	Sokbaşı fountain in Seyitgazi (spring water)	7,80	0,417	0,42	0,13	3,10	1,55	0,40	4,20	0,30	0,30	0,50
3	Fountain in front of Ihne village (spring water)	6,80	0,373	0,26	0,01	2,30	1,90	0,40	3,20	0,20	0,67	0,73
4	the tea house of Yazıdere-Ihne (spring water)	7,40	1,213	1,45	0,22	5,85	3,95	0,20	6,60	2,20	2,47	1,79
5	Fountain in Çukuragıl village (spring water)	6,80	0,832	1,10	0,19	5,20	3,30	0,20	5,90	1,25	2,44	2,77
6	Fountain in Çukuragıl village (ground water)	7,80	0,576	0,80	0,13	4,50	1,70	0,40	5,20	0,95	0,58	1,00
7	Market fountain in Doğançayır-(the purified water) (ground water)	6,80	0,136	0,90	0,08	0,45	0,15	0,00	0,60	0,05	0,93	2,22
8	Market fountain in Doğançayır (ground water)	6,50	0,863	0,39	0,06	5,40	3,50	0,00	5,60	1,80	1,95	2,41
9	Fountain in Doğançayır-Melikgazi (spring water)	7,80	0,456	0,36	0,02	3,20	2,00	0,40	4,30	0,15	0,73	0,76
10	House of Head of Yesilyurt village (ground water)	7,30	1,004	1,62	0,18	6,60	2,70	0,40	5,80	2,15	2,75	1,36
11	Fountain in Çifteler (ground water)	6,80	0.916	1,24	0,20	6,80	3,00	0,00	6,00	0,50	4,74	0,59
12	Fountain in Çifteler Post Office (ground water)	7,40	0,659	6,00	0,22	0,75	0,65	0,20	4,00	0,45	2,97	0,56
13	Fountain in Yazıdere Seyitgazi (spring water)-	7,30	0,429	0,51	0,12	1,65	2,45	0,10	3,00	0,35	1,28	0,29
14	Fountain in oil station in Mahmudiye (ground water)	7,10	1,123	2,43	0,19	7,00	4,40	0,00	6,00	1,60	6,42	1,59

Table 2. The results of analysis for drinking water in villages of Seydisuyu Watershed (2006)

Sample			EC	Cations me/l				Anions me/l				Boron
No.	Sampling points	pH	dS/m	Sodium	Potassium	Calcium	Magnesium	Carbonate	Bicarbonate	Chloride	Sulphate	mg/l
1	Fountain 2 in Seyitgazi (spring water)	7,3	0,418	0,46	0,22	2,65	1,85	0,00	4,00	0,60	0,58	0,59
2	Sok.başı fountain in Seyitgazi (spring water)	7,6	0,355	0,42	0,14	2,20	0,90	0,20	2,30	0,65	0,51	0,55
3	Fountain in front of Ilme village (spring water)	7,4	0,378	0,30	0,01	2,35	2,00	0,20	3,50	0,45	0,51	0,72
4	the tea house of Yazıdere-Ilme (spring water)	7,1	1,035	1,50	0,35	7,00	4,00	0,00	8,60	3,25	1,00	1,80
5	Fountain in Çukurağıl village (spring water)	7,3	0,805	1,20	0,22	5,60	2,95	0,20	7,90	0,95	0,92	2,82
6	Fountain in Çukurağıl village (ground water)	7,4	0,555	0,90	0,14	3,50	2,35	0,20	4,30	0,60	1,79	1,21
7	Market fountain in Doğançayırı-(the purified water) (ground water)	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data	No data
8	Market fountain in Doğançayır (ground water)	7,3	0,863	1,22	0,22	5,25	4,00	0,00	7,20	1,75	1,74	2,58
9	Fountain in Doğançayır-Melikgazi (spring water)	8,0	0,394	0,34	0,02	2,20	2,00	0,40	3,00	0,40	0,76	0,70
10	House of Head of Yesilyurt village (ground water)	7,0	0,971	1,60	0,21	7,00	3,30	0,00	10,00	0,85	1,26	1,36
11	Fountain in Çifteler (ground water)	7,0	0,851	0,89	0,08	6,20	3,40	0,00	8,00	0,85	1,72	0,62
12	Fountain in Çifteler Post Office (ground water)	7,9	0,620	6,50	0,35	0,50	0,40	0,00	6,50	0,95	0,30	0,57
13	Fountain in Yazıdere Seyitgazi (spring water)-	7,7	0,405	0,51	0,13	2,10	1,70	0,40	3,20	0,65	0,19	0,30
14	Fountain in oil station in Mahmudiye (ground water)	7,1	1,164	2,80	0,20	7,15	4,25	0,00	10,00	1,95	2,45	1,64

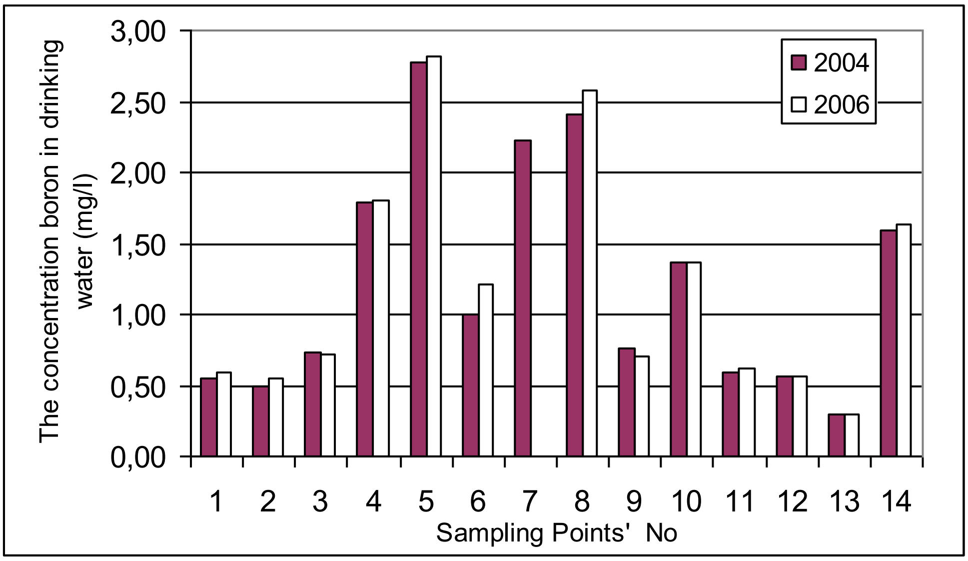

Figure 2. The concentration of boron in drinking water in villages of Seydisuyu Watershed.

CONCLUSION

Concentration of boron found in drinking water in the villages of Seydisuyu Watershed (Eskisehir) of Turkey were ranged from 0.29 to 2.82 mg/l. The boron values more than 1.0 mg/l were ranged from 1.21 to 2.82 mg/l and concentrations at a few stations exceeded 2.0 mg/litre.

The higher existing concentration of boron in drinking water might be attributed to boron contamination due to the fact that there is the boron-rich environments and largely dependent on the leaching of boron from the surrounding geology.

On the other hand, because of scientific uncertainty concerning the causes and magnitude of the boron problem in Europe during the regulatory standard-setting process, it was found that full compliance with the new drinking water standard for boron has been hampered. In addition, humans are primarily exposed to boron through food and drinking-water and there is insufficient toxicity data on humans in the literatures. In addition, it is clear that boron is not removed by conventional drinking-water treatment methods. Conventional water treatment (coagulating, sedimentation, filtration) does not significantly remove boron, and special methods would have to be installed in order to remove boron from waters with high boron concentrations. Ion exchange and reserve osmois process may enable substantial reduction but are likely to be prohibitively expensive.

As a result, it is concluded, in general, that the concentration of boron in villages of Seydisuyu Watershed drinking water would not be expected to pose any health risk to the public. However, the concentration of boron in drinking water of Seydisuyu Waterhed must be frequently examined.

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STOCHASTIC INTEGRATED WATER RESOURCES MANAGEMENT MODELS

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Managing water resources effectively and efficiently has always been a critical issue that touches the very existence of many nations. Although a lot of research has been carried out to study this vital topic, much of it has focused on studying parts of the water resources management problem independently. This generally leads to solutions that are not optimal, myopic, given the conflicting nature of the many objectives of managing water resources that range from generating hydropower, to controlling flood hazards, and providing irrigation water for agricultural purposes, just to mention a few. In this paper, we consider the problem of managing a water resources system that consists of a water reservoir used to satisfy several objectives with the possibility of prioritizing over the prescribed objectives. The model is made further applicable by explicitly considering the randomness in the water inflows. A multistage stochastic programming model is developed and solved using derived dynamic programming formulations. A note on the computational procedure and the future research outlook conclude the exposition.

Keywords: *integrated water resources management, flood control, hydro-electric power, stochastic dynamic programming,*

1 Introduction

The planning and operation of water resources systems have a strategic importance due to the significant associated costs (financial and otherwise) and to the importance of making reliable operational decisions. This stems from the fact that most water resources systems are of the multi-purpose type. Although most have one primary objective such as generating hydropower or mitigating flood hazards, they can also be used to satisfy downstream demand for water for irrigation, enhancing wildlife, store water for drought periods,...etc. In this literature review, we shall focus mainly on the application of optimization models to the management of water resources with an emphasis on integrated management models. Turgeon (2005) finds the optimal daily operating policy of a reservoir subject to yearly probabilistic constraints on floods and shortages. He highlights the difficulty presented by the fact that inflows are stochastic. He then decomposes the original problem into two subproblems that are solved with a set of inflow scenarios. Lamond et al. (1995) propose exact and approximate optimal policies for a reservoir hydroelectric system, where the inflows in successive periods are random variables. The model they analyze is a discrete-time one. Wang et al. (2004) consider the short-term scheduling of large hydro-power systems for energy maximization.

They formulate the problem as a nonlinear program with linear constraints and solve it using a direct search procedure. In Sreenivasan et al.(1996) and Edirisinghe et al.(2000), the authors present a chance-constrained (stochastic) model to take into account the uncertainty in meeting system operation requirements. Edirisinghe et al. added a target-priority characteristic to the model, whereby demand for downstream water targets is given priority.

Turgeon(1981) developed stochastic dynamic programming (SDP) models for the optimization of weekly operating policies of multireservoir hydroelectric power systems. Dorfman(1962) and Dupacova(1980) applied the same idea to the problem of water resources management and planning. In this type of models, the decisions in the consequent periods may be represented by loss functions of not meeting some operational characteristics. Stochastic linear programs (LP) for Markov processes have been studied by Manne(1962) and Thomas and Watermeyer(1962). Loucks(1968) developed a stochastic LP for a single reservoir subject to random, serially correlated, net inflows that were described by a first order Markov chain and transition probabilities were estimated using historical inflows. Houck and Cohon(1978) also assumed a discrete Markov structure for the streamflows. Dantzig(1955) suggested an LP model which includes random variables. In his model, the activity levels are determined in the first stage, then a corrective action is followed in the second stage. This is known as stochastic programming with recourse. In a deterministic environment, Morel-Seytoux (1999) define an optimal daily operating policy for a system of rivers and associated reservoirs. He points in particular to the delicate interdependency in the optimization of the objectives and the hydraulic characteristics of the system. Martin (1995) develop a methodology using both optimization and simulation techniques to evaluate the ability of the hydropower plants to meet weather-related winter peak power requirements. He uses a linear programming procedure to determine the hourly generation schedule for the Lower Colorado River Authority of Texas. The simulation/optimization modeling of water resources has also been studied by Belaineh and Peralta (1999). The integrative approach is quite efficient for solving large complex problems. In this case, the authors integrate linear decision rules with detailed simulations of stream/aquifer system flows. Lamond and Sobel (1995) discuss the exact and approximate solutions of affine reservoir models where autocorrelated inflows are modeled with a linear autoregressive stochastic process. The important finding they report is the fact that a myopic policy, for the case where interbasin transfers are included, is optimal if the deterministic and stochastic portions of the inflow process are always non-negative. Yang et al. (1995) compare real-time reservoir operation techniques and confirm the value of simple optimization methods and the applicability of scenarios methods in real-time reservoir operation. However, deterministic models have important limitations that Philbrick and Kitandis (1999) report. The authors contrast the control policies developed using deterministic optimization with policies using stochastic optimization of probabilistic inflows and conclude that the stochastic approach is more accurate. For a state-of-theart review of the optimal operation of multireservoir systems, the reader is directed to refer to the Labadie (2004) review paper and the closure and discussion of that review by Labadie (2005) and Lund (2005). Other approaches to the management and operation of water reservoirs have been developed in the literature. For instance, fuzzy multi-stage stochastic programs such as in Maqsood et al. (2005), fuzzy-state stochastic dynamic programming such as in Mousavi et al. (2004), and neural networks such as in Chandramouli and Raman (2001). However, as mentioned above, the emphasis of this review is on the linear and stochastic programming approaches.

In this paper, we develop a multi-stage stochastic programming model for the reservoir problem involving multiple periods representing 12 months of operation. The main source of randomness in the reservoir is the monthly water inflow to the reservoir. The downstream demand for irrigation water is prescribed a priori and thus it is not random, see Edirisinghe et al (2000).

During any month, the randomness of inflow will be modeled by a sample of discrete outcomes, generated randomly subject to the history of inflow up until that month. In the sequel, we will develop a scenario tree of potential future inflow patterns. With fairly dense scenario trees, such models tend to become exponentially large as the number of stages and periods increase, and thus the computational cost to solve them also increases exponentially. Therefore, it would be imperative to either use approximation techniques such as Edirisinghe (1999), and/or exploit the structure of the problem and devise decomposition techniques that render efficient solution of the multiperiod reservoir model with scenario trees.

In section 2, the multistage stochastic programming model is developed. In section 3, the corresponding stochastic dynamic program is formulated, and a special solution algorithm that exploits the problem structure is presented. Summary and future research remarks in section 4 conclude this exposition.

2 Multistage Stochastic Model

The reservoir manager must make a release decision before knowing what the inflows will be in the future. Therefore, the model we devise is nonanticipative, and it requires a "here-and-now" solution. The proposed model will minimize the deviations from the specified reservoir operation characteristics, such as the firm energy level and the dead storage level. Operational or recourse costs are imposed on the model so as to penalize the system operation that would tend to violate the specified system constraints. These will be discussed next.

2.1 System Constraints

In CCP models, the system constraints are specified as chance constraints, where constraint violations are allowed and controlled via probabilities. In our model, the degree of violation of a constraint is considered and controlled explicitly. First, the storage level at the beginning of month (t + 1), St, must be at least SD, the dead storage level, for energy to be generated. Therefore the deviation from SD, denoted by _SD, is modeled by the following
equation:

St − SD = _SD
t . (1)
2
Note that _SD
t is a random variable and _SD
t _ 0 indicates the satisfaction of the dead storage constraint in month
t.
The reservoir is also used to mitigate flood hazards during high inflow seasons. The deviation from maintaining a specified flood reserve, Vt in month t, is given by the equation:
St − (K − Vt) = _F
t . (2)

where K is the reservoir size. In order to ensure continued operation of the reservoir in subsequent years provided that the inflow distribution remains unchanged, we require the terminal storage, ST , be close in value to the initial storage, S0. The deviation of ST from the initial storage level S0 is given by the equation:

ST − S0 = _S0
T . (3)

In Edirisinghe et al. (2000), modeling the target priority directly with a linear constraint was not possible since the releases were considered to be deterministic. A surrogate constraint was used to ensure demand for water was satisfied with a certain probability. In the present model, releases, Rt, are not constrained to be deterministic, i.e. releases conform to a nonanticipative policy. Therefore, the deviation of meeting water targets, Tt, are given by:

Rt − Tt = _D
t . (4)

Note that flood reserve constraint violations correspond to _F
t > 0, and water target constraint violations correspond
to _D
t < 0. However, violation of the overyear storage requirement indicates _S0
T 6= 0. Since the operation of a water reservoir is a continuous process in time, the ending storage and the beginning storage are related by the continuity equation,

St = St−1 + It − Rt, (5)

assuming no other loss of water is possible, where It is the inflow realized in period t. In the next section, we consider the case of modeling the energy generation under the stochastic programming approach.

2.2 Energy generation

The firm energy level, defined as the minimum guaranteed energy generated throughout a planning horizon, was maximized subject to the system constraints and that the target priority in the release policy is satisfied. In order to maintain the target priority nature and for computational convenience, a _0 release policy was considered in the CCP model. However, in the present model, such a restriction is not needed and the releases are random functions that depend on the history of inflow realizations. In order to maximize the firm energy level, a certain firm energy level is specified to the model and the deviation of min(EGt, t = 1, . . . , T), is accounted for and minimized as will be explained next .

2.2.1 Energy generation constraint

The energy generated is a function of the release and the average water head on the turbines. Given a transition of
the system form St−1 to St, the energy generated at period t can be represented by the following

EGt = !Rt[e
2
(St + St−1) + f]. (6)

where e and f are constants based on a typical operating range of the reservoir, and ! is a dimensional constant that reflects turbine efficiency. Note that the release Rt will not contribute toward energy generation if both St and St−1 are below the dead storage level. In order to compute the exact value of the energy generation, we define the

variables xt, yt, ht, and zt as follows
xt =
(
1 if St _ SD,
0 otherwise
(7)
yt =
(
0 if St _ SD,
−_SD
t otherwise
(8)
ht =
(
_SD
t if St _ SD,
0 otherwise
(9)
zt =
(
1 if xt−1=1 OR xt=1,
0 otherwise
(10)
Note that (St + St−1) may be restated as:
St + St−1 = 2SD + _SD
t + _SD
t−1. (11)
For the case when both the beginning and ending storages in month t are above the dead storage,
St + St−1 = 2SD + ht + ht−1 (12)
holds. In general, however, 1

2(2SD+ht+ht−1) represent the average "effective storage" available for hydropower generation. We also want to determine the effective release, defined as the released amount of water that contributes toward energy generation. This can be done by subtracting the amount of water below SD from the release Rt as follows
Reff = Rt − yt − yt−1 (13)

The energy generation function can therefore be written as follows
EGt = !zt(Rt − yt − yt−1)[e
2
(2SD + ht + ht−1) + f] (14)
Observe now that only the amount of water released that contributes toward energy generation is taken into account.

Likewise, the average water head on the turbines is not over-estimated by taking the simple average of St−1 and

St as in the CCP model. Now to ensure a given firm energy level, say _, any deviation from _, which we shall represent by _EG, is penalized. Therefore, the energy generation constraint violation can be written as follows:

_ − EGt = _EG
t . (15)

2.3 Multistage stochastic model

2.3.1 Rewriting the constraints

As we mentioned in the introduction, the energy authority has to make here-and-now decisions regarding the releases. This implies that the release in the first period, R1, is independent of the inflow. The same holds true for the target violation variable _D

1 since the target satisfaction depends only on the release. However, the storage at
the end of period 1 depends on the inflows due to the continuity equation (5). This dependence implies that _SD
1 ,
_F
1 , and _EG
1 also depend on the realization of the random event, i.e. which inflow occurred. Note, however, that
the release in period 2 depends on the ending storage of period 1, S1, and does hence depend on the inflow in
period 1, I1. To reflect these dependencies on which of the inflows was manifested, let Ht−1 := I1, . . . , It−1 be
the history of inflows up to a period t. The constraints (5),(4),(2), (1), and(3), are written as follows

St,Ht−1 = St−1,Ht−1 + It,Ht−1 − Rt,Ht−1 ; t = 1, . . . , T (16)
Rt,Ht−1 − Tt,Ht−1 = _D
t,Ht−1 ; t = 1, . . . , T (17)
St,Ht−1 − (K − Vt) = _F
t,Ht−1 ; t = 1, . . . , T (18)
4
St,Ht−1 − SD = _SD
t,Ht−1 ; t = 1, . . . , T (19)
ST,HT−1 − S0 = _S0
T,HT−1
; t = T (20)

The energy generation constraint is more cumbersome since we want to consider a firm-energy level, which is the same over a specified time horizon. Therefore, the penalty _EG
t is taken as the deviation of the firm energy level
from the specified energy level across a scenario. This delicate dependence can be easily represented by

_ − EGt,Ht−1 = _EG
T,HT−1 ; t = 1, . . . , T (21)

2.3.2 The objective function

In the objective function, we want to minimize the penalty from operating the reservoir. The penalty being the cost of deviating from the reservoir operating characteristics. So it can be represented by the following

min F(_EG
t,Ht−1 , _S0
T,Ht−1
, _D
t,Ht−1 , _F
t,Ht−1 , _SD
t,Ht−1); t = 1, . . . , T. (22)

Note, however, that _SD
t need not be considered explicitly in the objective function since it's impact is implicitly penalized in the energy generation function EGt. The cost function in (22) is nothing but the sum of the expected cost of each variable in each scenario. The complete objective function can be written therefore as

min _[
XT
t=1
PHt−1F_EG(_EG
t,Ht−1)+
X
'
PHT−1F_S0 (_S0
HT−1
)+
XT
t=1
(PHt−1F_D(_D
t,Ht−1))+
XT
t=1
(PHt−1F_F (_F
t,Ht−1))]
(23)

where ' is the set of all possible scenarios.

2.3.3 Complete Multistage Stochastic Model

We have defined the variables xt, yt, ht, and zt earlier to define the energy generation constraint. However, we have introduced them as indicator function rather than constraints that can be included in the complete formulation of the model. To convert those to constraints, we proceed as follows. Let M denote a very large number.

M(xt,Ht−1 − 1) _ _SD
t,Ht−1 ; t = 1, . . . , T (24)
−Mxt,Ht−1 − yt,Ht−1 _ _D
t,Ht−1 ; t = 1, . . . , T (25)
yt,Ht−1 _ 0; t = 1, . . . , T (26)
zt,Ht−1 _ xt,Ht−1 + xt−1,Ht−1 ; t = 1, . . . , T (27)
0 _ zt,Ht−1 _ 1; t = 1, . . . , T (28)
ht,Ht−1 = xt,Ht−1_SD
t,Ht−1 ; t = 1, . . . , T (29)
5

With these definitions (constraints) in place, the multistage stochastic model is completely defined. The formulation is presented in its general form as the following MultiStage Stochastic Program (MSSPT).

min _[
XT
t=1
PHt−1F_EG(_EG
t,Ht−1) +
X
'
PHT−1F_S0 (_S0
HT−1
)
+
XT
t=1
(PHt−1F_D(_D
t,Ht−1)) +
XT
t=1
(PHt−1F_F (_F
t,Ht−1))]
s.t.
St,Ht−1 = St−1,Ht−1 + It,Ht−1 − Rt,Ht−___________1 ; t = 1, . . . , T
Rt,Ht−1 − Tt,Ht−1 = _D
t,Ht−1 ; t = 1, . . . , T
St,Ht−1 − (K − Vt) = _F
t,Ht−1 ; t = 1, . . . , T
St,Ht−1 − SD = _SD
t,Ht−1 ; t = 1, . . . , T
ST,HT−1 − S0 = _S0
T,HT−1
; t = T

M(xt,Ht−1 − 1) _ _SD
t,Ht−1 ; t = 1, . . . , T
−Mxt,Ht−1 − yt,Ht−1 _ _D
t,Ht−1 ; t = 1, . . . , T
yt,Ht−1 _ 0; t = 1, . . . , T
zt,Ht−1 _ xt,Ht−1 + xt−1,Ht−1 ; t = 1, . . . , T
0 _ zt,Ht−1 _ 1; t = 1, . . . , T
ht,Ht−1 = xt,Ht−1_SD
t,Ht−1 ; t = 1, . . . , T
_ − EGt,Ht−1 = _EG
T,HT−1 ; t = 1, . . . , T
(30)

This is a general formulation in all aspects. The time horizon is left as a parameter, T, and so are the penalty cost functions. Note that this is a nonlinear program due to the nonlinear firm energy constraint. Now that the model is complete, a solution procedure needs to be devised. In the next section, we discuss the different alternatives to solve this model efficiently.

3 Stochastic Dynamic Programming Model

Dynamic programming (DP) is a solution procedure credited largely to Bellman(1957). The popularity and success of this technique can be attributed to the fact that most multistage optimization problems can be translated into a sequence of nested evaluation problems. In addition, it has the advantage of effectively solving highly complex problems with a large number of variables by decomposing them into a series of subproblems which are solved recursively, see Yeh (1985). To decompose a general problem into multiple stages with decisions required at each stage, the value of every stage should satisfy the separability condition and the monotonicity condition, see Nemhauser (1966). The problem at hand has these separability and monotonicity properties. However, Yeh (1985) states that the usefulness of the technique is limited due to the computational complexity arising from the curse of dimensionality. The model will be solved efficiently by exploiting its special structure.

3.1 Stochastic Dynamic Programming Model

By inspecting equations (1),(2),(3),(4), and (5), it is evident that all constraints depend on S_{t-1} and R_t. In other words, given the beginning storage and the release at period t, one can compute the deviations and the value of the objective function explicitly. This reduces the model in (30) to an evaluation problem. One can, therefore, consider a grid of discretized S_{t-1} and R_t and compute all other values, including the energy generated, and find which combination optimizes the objective function.

3.2 Dynamic Programming General Recursion

Define the state space as being the pair (Ht−1, St−1). The state of the system is completely defined by this state space definition. The history of inflows Ht−1 provides the information on what scenario of inflows has realized up until period t. The model is to select the release Rt that would minimize the expected penalty cost, less energy benefits, relative to the inflows. The value function, denoted by _t(.), at the node Ht−1 of uncertainty resolution is then defined by the following, for a given value of St−1:

_t(Ht−1, St−1) = min
Rt
EIt|Ht−1 [F(Ht−1, St−1, It,Rt)
+ _t+1(Ht, St)]
s.t.
St + Rt = St−1 + It
St − SD = _SD
t
Rt − Tt = _D
t
St − (k − V) = _F
t
_ − EGt = _EG
t
ST − S0 = _S0 , if t = T
Rt _ 0.
(31)

Where,
F(Ht−1, St−1, It,Rt) is the net cost function due to the penalties _SD
t , _D
t , _F
t , _EG
t , and _S0
T and benefit due to
the firm energy _. Also, EIt|Ht−1 [.] denotes the conditional expectation with respect to the random inflow It given
Ht−1.

3.3 Dynamic Programming: Independent Inflows Model

Solving the dynamic program (31) requires the solution of a nonlinear program at each node Ht−1, for a specified
St−1. This is an orenous task as the number of such nodes increases exponentially with the addition of periods
and/or outcomes. Furthermore, the latter computation need to be performed for every possible St−1, as determined
by a suitable grid of values for St−1. In this section we present an efficient version of the above DP under the
assumption that the monthly inflows are independent.

Assumption 1 The monthly inflow at period t, namely the random variable It, is independent of the history of
inflows, Ht−1.

3.3.1 Modeling Inflows in the DP model

Under assumption (1), note that random variables Qt−1, the cumulative inflows up to period t − 1, and It are stochastically independent. If the lognormal distribution is assumed for Qt, then we generate a large number of random variates and place them into appropriate subintervals. A frequency count divided by the total number of random variates generated would yield the needed probabilities. The final approach is to simulate the individual monthly inflows from the cumulative monthly inflows distributions which have been determined to be lognormal.

To generate a scenario branch at a particular node of a particular period, we generate a random variate qt−1 from
Qt−1 and a random variate qt from Qt, and define variate it (for It) as qt − qt−1 provided that qt > qt−1. The
variates it thus generated are placed in appropriate subintervals. A frequency count is made, and the probability of each outcome is computed as the frequency of variates in each subinterval divided by the total number of variates generated.

7

3.3.2 Model Description

Under Assumption (1), the outcomes at period t are determined independently of the historical scenario being followed until period t. Thus, the outcomes and their corresponding probabilities of occurrence in each node in period t are identical. Therefore, the DP model in this case can be presented as follows:

_t(St−1) = min
Rt
EIt [F(St−1, It,Rt) + _t+1(St)]
s.t.
St + Rt = St−1 + It
St − SD = _SD
t
Rt − Tt = _D
t
St − (k − V) = _F
t
_ − EGt = _EG
t
ST − S0 = _S0 , for t = T
Rt _ 0.
(32)

Note that the value function does not depend on Ht−1, and hence, for a given beginning storage St−1, the value function is identical for all nodes Ht−1 in period t. This is a very important result since it implies that we only solve P the model in (32) once in each period. For instance, for 12 periods with 10 outcomes, instead of solving 12
i=0 10i problems corresponding to the number of nodes, we only need to solve 12 problems of the format (32)
for each value of St−1. We also propose to solve the minimization in (32) by a grid search on Rt, thereby avoiding
a possibly difficult nonlinear programming procedure.

3.3.3 Pseudo Code

Given a set of discretized beginning storages Sn
t−1, for n = 1, . . . ,N, and a set of discretized releases Rj
t , for
j = 1, . . . , J, we compute the value function for one node in period 12 and copy it to all other nodes in the period.

Step 0:Initialization

1. Set reservoir size and maximum firm energy level
2. Obtain inflow data (mean, standard deviation, and number of outcomes per period; determine probability of
each outcome if a distribution other than the uniform distribution is used)
3. Set t= T-1, where T= number of periods to be considered in the model

Step 1:DO WHILE n _ N
1. Set St−1 = Sn
t−1, Let __(St−1) = M, where M denotes a large positive number.
Step 2: DO WHILE j _ J
1. evaluate _t(St−1,Rj
t) as described in (32)
2. for __(St−1) < _t(Si
t−1,Rj
t)
let __(St−1) = _t(Si
t−1,Rj
t) and R_t (St−1) = Rj
t .
END DO
END DO
Step 3:
1. Set t=t-1.
2. if t < 0, STOP,
else go to Step 1
8

4 Conclusion

We have presented a multistage stochastic programming model to study the planning and operation problem for a single multi-purpose water reservoir. The stochastic programming models have the flexibility of accounting for inflow dependence to a much higher degree. This is due to the fact that these models actually consider the randomness in the inflows explicitly in the search for a solution through a scenario approach, whereas the CCP model only uses the marginal distributions. While the proposed model provides a good long-term operation tool, its focus is limited to monthly decision periods. An operational model would have to take into account a decision period much shorter than a month, and would need to have the flexibility of providing better solutions as random events unfold. An other alternative is the rolling horizon approach, where the model is re-solved at the end of each operational period, the model being revised with new observations of inflow data. These avenues would certainly be worth considering and should be the subject of future research.

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FORECAST OF WATER DEMAND USING ARTIFICIAL NEURAL NETWORKS: A CASE STUDY IN ISPARTA

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Water resources are very important for human life. Because of the limited water resources in the world, water must be used economically. Domestic water use is generally the most important component of urban water consumption. Some socio-economic factors are effective on domestic water consumption. One of them is income. Income effects other factors directly. So it is important to investigate relations between income and water consumption. In this paper, the relatively new technique of Artificial Neural Networks (ANNs) is proposed to model and forecast the water demand in urban areas under income effects. Results indicate that the model offers an effective way to formulate relationship between domestic water demand and economic standards in Isparta in TURKEY.

Key words *Water demand, domestic water consumption, income, Artificial Neural Network.*

1. INTRODUCTION

Water resources are very important for human life. Because of the limited water resources in the world, water must be used economically. Turkey is a lucky country about water resources but is not rich. Protecting water resources is vital for Turkey. For using water resources economically and protecting water resources, water demand models must be formed under different effects.

Factors such as climate, population, water prices, income, education state and water quality are effective on water consumption delivered to residential regions by drinking water network systems. Domestic water consumption is the most important part of the total water that is consumed at residential regions.

Especially socio-economic factors are effective on domestic water use. Education level, income, life standarts and consumer population can be shown as an example for socio-economic factors. Income effects the other socio-economic factors so it is necessary to analyze income influence on domestic water consumption.

Rajala ve Katko (2004) studied to describe and analyse the trends and levels of water consumption, especially of households in Finland. Bougadis ve Adamowski (2005), by using data for Ottawa and Ontario in Canada, made short-term water demand forecasting. Zhang ve Brown (2005), mentioned that domestic water consumption is the most important part of total water consumption in Beijing and Tianjin cities in China.

The ANNs have to be trained in order to generate the desired output. Artificial neural networks have been shown to give useful results in many fields of hydrology and water resources research (Chen *et al.*, 2006, Tingsanchali & Gautam, 2000). Liu, Savenije ve Xu (2002) formed water demand forecasting model for Weinan City in China. At this model house population, income and water prices were used as inputs while water consumption was an output.

At this study, Water Demand Forecasting Model with ANNs is formed for Isparta as using water consumption and income data. With this model domestic water demand will be able to find for Isparta and it will be possible to have an opinion about the relation between income levels and water consumption. Also with the help of this model we can estimate how the changes in time about socio-economic conditions will effect water consumption.

2. ARTIFICIAL NEURAL NETWORKS

Neural Networks are promising new generation of information processing systems that demonstrate the ability to learn, recall, and generalize from training patterns or data. Artificial neural networks (ANNs) are systems that are deliberately constructed to make use of some organizational principles resembling those of the human brain. They represent the promising new generation of information processing systems. ANNs are good at tasks such as pattern matching and classification, function approximation, optimization, vector quantization, and data clustering, while traditional computers, because of their architecture, are inefficient at these tasks, especially pattern-matching tasks. However traditional computers are faster in algorithmic computational tasks and precise arithmetic operations.

ANNs have a large number of highly interconnected processing elements (nodes or units) that usually operate in parallel and are configured in regular architectures. The collective behavior of an ANNs, like a human brain, demonstrates the ability to learn, recall, and generalize from training patterns or data. ANNs are inspired by modeling networks of real (biological) neurons in the brain. Hence, the processing elements in ANNs are also called artificial neurons, or simply neurons. A human brain consists of approximately 10^{11} neurons of many different types. A schematic diagram of a typical biological neuron is shown in Fig.1(a). A typical neuron has three parts: the cell body or soma, where the cell nucleus is located, the dendrites, and the axon. Dendrites are tree like networks of nerve fiber connected to the cell body. An axon is a single, long, cylindrical connection extending from the cell body and carrying impulses (signals) from the neuron. The end of an axon splits into strands or a fine arborization. Each strand terminates in a small bulblike organ called a synapse, where the neuron introduces its signal to the neighboring neurons. The receiving ends of these junctions on the neighboring neurons can be found both on the dendrites and on the cell bodies themselves. There are approximately 10^4 synapses per neuron in a human brain.

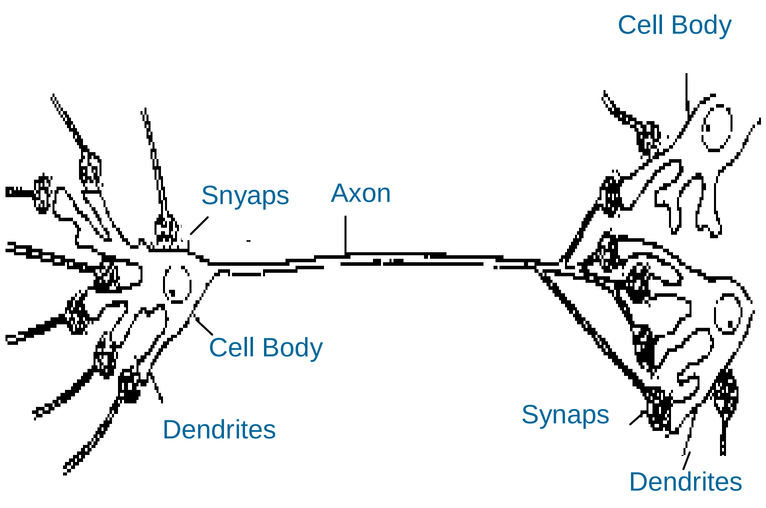
The signals reaching a synapse, and received by dendrites are electric impulses. Such signal transmission involves a complex chemical process in which specific transmitter substances are released from the sending side of the junction. This raises or lowers the electric potential inside the body of the receiving cell. The receiving cell fires if its electric potential reaches a threshold, and a pulse or action potential of fixed strength and duration is sent out through the axon to the axonal arborization to synaptic junctions to other neurons. After firing, a neuron has to wait for a period of time called the refractory period before it can fire again. Synapses are excitatory if they let passing impulses cause the firing of the receiving neuron, or inhibitory if they let passing impulses hinder the firing of the neuron.

Fig.1(b) shows a simple mathematical model of the above mentioned biological neuron proposed by McCulloch and Pitts (1943), usually called an M-P neuron. In this model, the *i*th processing element computes a weighted sum of its inputs and outputs $y_i=1$ (firing) or 0 (not firing) according to whether this weighted input some is above or below a certain threshold θ_i:

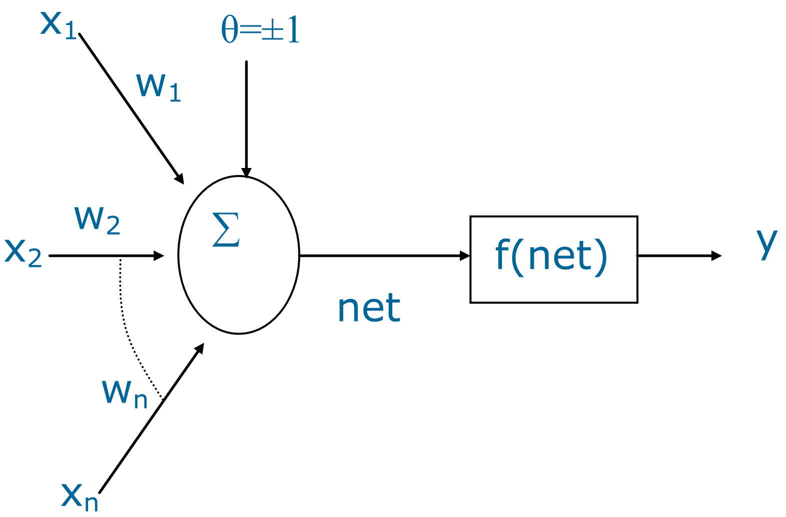
$$y_i(t+1) = a\left(\sum_{j=1}^{m} w_{ij} x_j(t) - \theta_i\right) \qquad (1)$$

where the activation function a(*f*) is a unit step function:

$$a(f) = \begin{cases} 1 & \text{if } f \geq 0 \\ 0 & otherwise \end{cases} \qquad (2)$$



(a)



(b)

Fig.1 Correspondence between a biological neuron and an artificial neuron. (a) Schematic diagram of a biological neuron. (b) Schematic diagram of a McCulloch and Pitts neuron.

The weight w_{ij} represents the strength of the synapse (called the connection or link) connecting neuron j (source) to neuron i (destination). A positive weight corresponds to an excitatory synapse, and a negative weight corresponds to an inhibitory synapse. If $w_{ij}=0$, then there is no connection between the two neurons. In Eq.(1), it is assumed that a unit relay elapses between the time instants t and (t+1). This assumption will also be used in our further discussion of this subject.

Although simplicity models a biological neuron as a binary threshold unit, a McCulloch-Pitts neuron has substantial computing potential. It can perform the basic logic operations NOT, OR, and AND when weights and thresholds are selected accordingly. Since any multivariable combinational function can be implemented by these basic logic operations, a synchronous assembly of such neurons is capable of performing universal computations, much like an ordinary digital computer (Lin and Lee, 1996).

3. CASE STUDY

At this study, Isparta city was chosen as an application area. Input and output data were obtained and water demand forecasting model was formed for Isparta.

Isparta is located in the south of Turkey. Its total area is 8.933 km^2 with a population of approximately 513.681 people which means a population density of 58 people/km^2. Among the whole people, %33 of them are living central town. At this study, model has been formed for the central town of Isparta.

Fig.2 Isparta City Location Map

4.WATER DEMAND FORECASTING by ANNs

All data used for this study were obtained from Turkey Stastical Institue(TSI). Three inputs and an output have been used for the model.Low level income, middle level income and high level income rates were used as inputs and under income effect water consumption has been used as an output. Collected data represents nearly %60 of total water use in the city.

Isparta's central town has 30 main districts. Data that were used for the model comprises all main districts of Isparta. As said before income levels were used as inputs. Income levels were taught as three parts. Income under 500 $ were accepted as low level income, income between 500-1200 $ were accepted middle level and income over 1200 $ were accepted high level income.

People population under each income group were divided total population. So percent rates were detirmened for each group.

At the model, monthly water consumption data were used for 14 months. Before using at the model, monthly water consumption data was divided total population for each district in Isparta. So per person water consumption data were found and used as an output.

Fig. 3 Model Structure

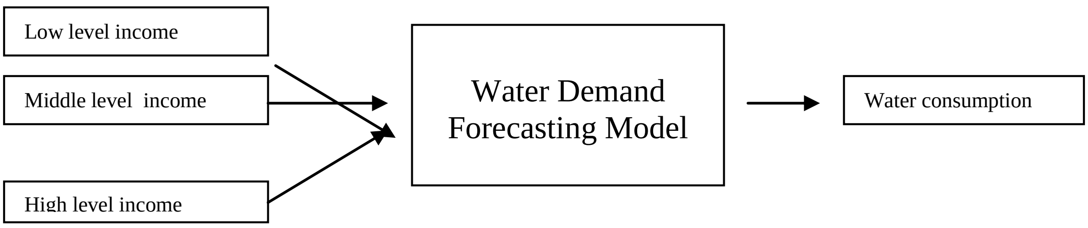
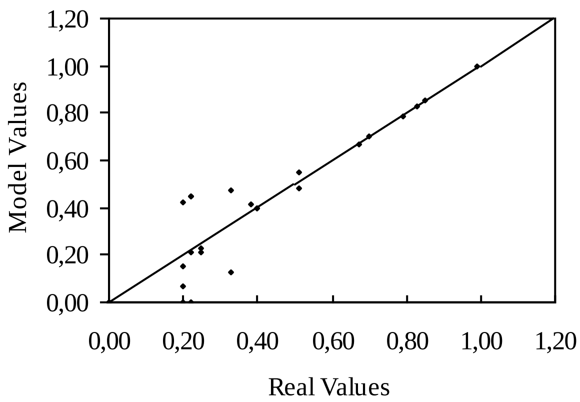


Fig.4 Scatter Diagram



The adequacy of the ANNs was evaluated by considering the coefficient of determination (R^2) and the mean-square error (*MSE*) definitions based on the flow estimation errors as:

$$R^2 = 1 - \left(\left(\sum_{i=1}^{n} \left(W_{i(\text{observed})} - W_{i(\text{model})} \right)^2 \right) \Big/ \left(\sum_{i=1}^{n} \left(W_{i(\text{observed})} - W_{(\text{mean})} \right)^2 \right) \right)$$

and

$$MSE = \frac{1}{n} \sum_{i=1}^{n} \left(W_{i(\text{observed})} - W_{i(\text{model})} \right)^2$$

where n is the number of observed data, $W_{i(\text{observed})}$ and $W_{i(\text{model})}$ are observed values and

ANNs results, respectively, with respect to the total monthly water consumption values, W_{total}. For water consumption prediction by ANNs using observed data, R^2 and *MSE* values were found to be 0,83 and 35,08.

5. CONCLUSION

Much literature couldn't find about the ANNs technique about water demand forecasting. As seen from scatter diagram in Fig. 4, it is large enough to indicate that the ANNs model is accurate for predict water demand under income affect. But it is realized that method developed in this study need forecasted information such as the population, education and water price. It is hoped that the model performance will be better than this study if above parameters are added, in future

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WATER RESOURCES MANAGEMENT IN ARID REGIONS OF IRAN

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Mismanagement of water and land resources is putting human health and sustainable social and economic development at risk. Explosive growth of arid regions, unsustainable exploitation of natural resources, increasing water demand for food production, and expanding populations lacking proper environmental sanitation have led to progressive depletion and degradation of freshwater resources. Many of the problems in the water supply and sanitation sector are related to the improper management of water resources. Iran is lack of water resources, especially in its arid regions. So the management of water resources in these areas is very important. This article deals with the problem of effective water management in the Majnabad arid land of Iran. In this region, the provision of irrigation water is one of the most important factors for increasing agricultural production which is vital since, at present, the region imports 50% of its food requirements. To help make additional water available surface storage reservoirs have been or are being built, a number of smaller dams are in different stages of planning or execution, and groundwater basins are being developed. However, the article points out that due to population growth, rapid agricultural, and the process of desertification it is essential that decision makers in Iran of this region devise ways to optimize the use of available water resources and to augment these resources by non-conventional means. The bulk of the article presents techniques being devised for water development and management and for water conservation. The water development and management techniques described include water harvesting, recycling of water, the utilization of groundwater, the conjunctive use of water resources, the desalting of saline water. The water conservation methods described include improved irrigation methods and water management at the field level, reducing evaporation from water surface, conservation of water in soils, underground water recharge, controlled environment and reducing transpiration.

Keywords: *Water resources, Surface, Management, Water harvesting, saline water, Iran.*

1-Introduction

Today, successful management of water resources requires achieving a delicate balance of multiple uses. These uses the support of fish populations, municipal and industrial water supply, navigation, recreation, hydropower, agriculture and flood control. As a result of increase in population and development in many regions, this balance is becoming more difficult to sustain and the potential adverse impacts of water supply shortage are becoming more significant especially in arid and semi-arid regions. When shortages do occur, the potential for conflict among multiple interest groups is high. This conflict is aggravated by a variety of factors including a lack of communication among groups with different interests, inadequate understanding of complex interactions in a water supply system, lack of common data agreement on assumptions, and inexperience with extreme or unusual events. Many regions, in a effort to mitigate social, ecological and economic damage during future water shortages are in the process of reevaluating existing for resource allocation during drought and examining new management options for the future. To be successful, these planning efforts must explicitly recognize the concerns of the different interest groups whose welfare is impacted by this resource and build consensus among them regarding an appropriate water management strategy (Bingham 1989).

2-Study Area

The study area (Majnabad) is located in the Zouzan Plain sand land (33° 56′ 41” to 34° 17′ 32” N, 59° 57′ 17”to 60° 24′ 37”E,) in the Northern part of Lout Plain, which belongs to the continental arid climate in the temperate zone. Mean annual precipitation is 117 mm, mean annual potential evaporation is 1375 mm, and the mean annual temperature is 16.6°C.

3-Materials & Methods

3-1-Water Resources

3-1-1-Surface Water

Shour River is a seasonal river and located in Majnabad desert that flows in wet months (February to April). Studies show surface water in Shour river is very slight. Runoff coefficient determined by Justin and ICAR methods and respectively was 0.06 and 0.063 and high of runoff in year were 0.71 and 0.74 cm.

Table1- Precipitation data of Majnabad (mm)

Months	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Ag.
Precipitation	0	3.3	11	16.6	19.9	30.3	26.3	8.9	0	0	0	0

Table2- Runoff Estimated by Justin and ICAR Methods

Basin	Area(Km^2)	Justin(cm)	ICAR(cm)	C1	V1(m.c.m.)	C2	V2(m.c.m.)
Majnabad	2513.8	0.71	0.74	0.06	17.93	0.063	18.83

3-1-2-Flood

Flood studies were done by Regional Analysis Method that shows in follow table.

Table3- Flood Estimated by Regional Analysis Method in Majnabad (m^3/s)

Basin	Area (Km^2)	Return Period (Year)						
		2	2	10	20	25	50	100
Majnabad	2513.8	58.5	118.7	168.2	219.3	236	288.9	343

3-1-3-Ground Water

3-1-3-1- Wells

Investigations show that thickness of alluvium is 60 to 250 m. Upper limit of water table was 18 to 120 m. Regarding hydrograph average reduce of water table is 0.7 m. Most of wells in Majnabad were for livestock drinking.

Table4- Data of livestock drinking Wells Majnabad

Location	Depth of Well (Meter)	Water Table (Meter)
Majnabad 1	130	33
Majnabad 2	125	25
Majnabad 3	98	28
Majnabad 4	135	35
Majnabad 5	140	39
Houz –e Khan	165	58

3-1-3-2-Qanats

Qanat is a traditional method for ground water harvesting especially in arid regions. A qanat system has a profound influence on the lives of the water users. It allows those living in a desert environment adjacent to a mountain watershed to create a large oasis in an otherwise stark environment. The United Nations and other organizations are encouraging the revitalization of traditional water harvesting and supply technologies in arid areas because they feel it is important for sustainable water utilization. In this region people use of Qanats for drinking supply. regarding shortage of water in Majnabad watershed management office were built a number of smaller dams that because Miocene formation in highland river basin, water in small dams reservoirs are very saline and irrigation agriculture lands by this water resources destruct most of lands.

Table5- Data of Qanats Majnabad

Location	Depth of Main Well (Meter)	Length (Meter)	Discharge (Liter / Sec.)
Mohsenabad	45	24000	41.3
Karion	30	----	2
Biftry	100	----	50
Behdadin	150	42000	40
Hoseinabad	25	12000	17.5
Glisabad	100	----	28

4-Conclusion

The studies show that small dams built could not be suitable water resources supply in Majnabad, because formation of this region decrease quality of surface water and should this surface water resources move to ground water resources for aquifer recharge and by this action to prevent and control movement surface water on ground and be saline water. One of the methods is use of water spreading. A major part of water requirement in this region with low precipitation rate is maintained by groundwater. There fore, if the extraction amount from groundwater is more than natural recharge, a significant loss in groundwater level will established for which the use of artificial recharge can be considered as an approach for prevention of this loss and the consequent effects Generally, decreasing of flood detriment by reserving them in aquifers, prevention of saline waters seepage and separating of organic and inorganic materials from wastewaters are main goals of artificial Recharge. Recharge reservoirs and dams, wells and water spreading are some of the artificial methods. All these methods are classified into two categories. The first includes the direct recharge or recharge using a well and the second comprises the indirect methods including water spreading, reservoirs and dams recharge. Water spreading over coarse grain alluvial or aquifer management is of more importance.

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GLOBAL AND REGIONAL FRESHWATER AVAILABILITY AND FUTURE DEMAND

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The freshwater problem is not restricted to any one nation, it is a global phenomenon. Water pollution has been the inevitable outcome of the human craving for betterment of living standards through increasing efforts and activities manifesting as heavy industrialization and constant urbanization, leading to progressive aquatic system pollution. Water is one of the most important natural resource for all living organisms.

The availability and quality of freshwater resources around the world are of growing concern to the international community. Human well-being, ecosystem health and functions, and economics and politics all depend on how much, when, and where water is available. Clearly, understanding the stocks and flows of water through the world's hydrologic cycle is essential to any discussion of the world's water problems. One of the most pressing global issues currently facing mankind is the increase in world population and its impact on the availability of freshwater. Recent estimates of water stocks and flows through the world's hydrologic cycle and their spatiotemporal variability illustrate the nature of current and projected water disparities throughout the world. As all such problems manifest themselves at smaller scales, a major challenge in freshwater assessments is how to handle this on different geographical scales. Increasing use of water is creating water shortages in many countries that are projected to have significant population increases in the next 25 years. Humankind is projected to appropriate from 70% to 90% of all accessible freshwater by 2025. Agriculture is the dominant component of human water use, accounting for almost 70% of all water withdrawals. Hence, many of the solutions to water-related food and environmental security come from within agriculture by increasing the efficiency and productivity of water use. Many factors significantly impact the increasing water demand, including population growth, economic growth, technological development, land use and urbanization, rate of environmental degradation, government programs, climate change, and others. Demand management, not increasing supply availability, is the realistic way forward. If we are to balance freshwater supply with demand, and also protect the integrity of aquatic ecosystems, a fundamental change in current wasteful patterns of production and consumption is needed. Recognition of the links between rapidly growing populations and shrinking freshwater supplies is the essential first step in making water use sustainable.

Key Words: *world population; water use and future; water pollution; water scarcity.*

Introduction:

Uncontrolled urbanization modifies the physical, chemical and biological systems of our living environment. As a result, millions of people in and around the urban agglomerations of the world get exposed to unhealthy environment. Water is crucial for humans' survival and for the development of their economies. It is also a crucial element in the protection of the environment. The availability of fresh water has already been an important concern in many parts of the world. The world's population is now increasing about a quarter of million people per day. With this phenomenal population growth, there is, in addition to the water requirements for domestic use, an increasing demand of it for energy generation, agricultural and industrial production.

Nearly 40 percent of the world's population, most of it in the developing countries, is already facing serious water shortages. More and more nations are gradually joining the list. By the middle of the next century, it is anticipated that nearly 65 per cent of the world population's may experience conditions of water stress and water scarcity.

Water scarcity has been already a serious problem in most of the countries in the Middle East and North Africa. According to the hydrologists, if the annual per capita fresh water availability of a country goes below 500 cubic meters, the country reaches the category of "absolute water scarcity." After crossing this mark, the country is almost certain to face inherent water deficit problems, which may threaten public health and socio-economic development.

The World Water Problem

The world has very serious problem on water system surrounding people. In the whole world, especially most of the developing countries, there are still one billion people who cannot access safe drinking water, and 2.4 billion people don’t have sanitation system for discarding such human excreta (WHO, 2004). The most serious problem on water system is:

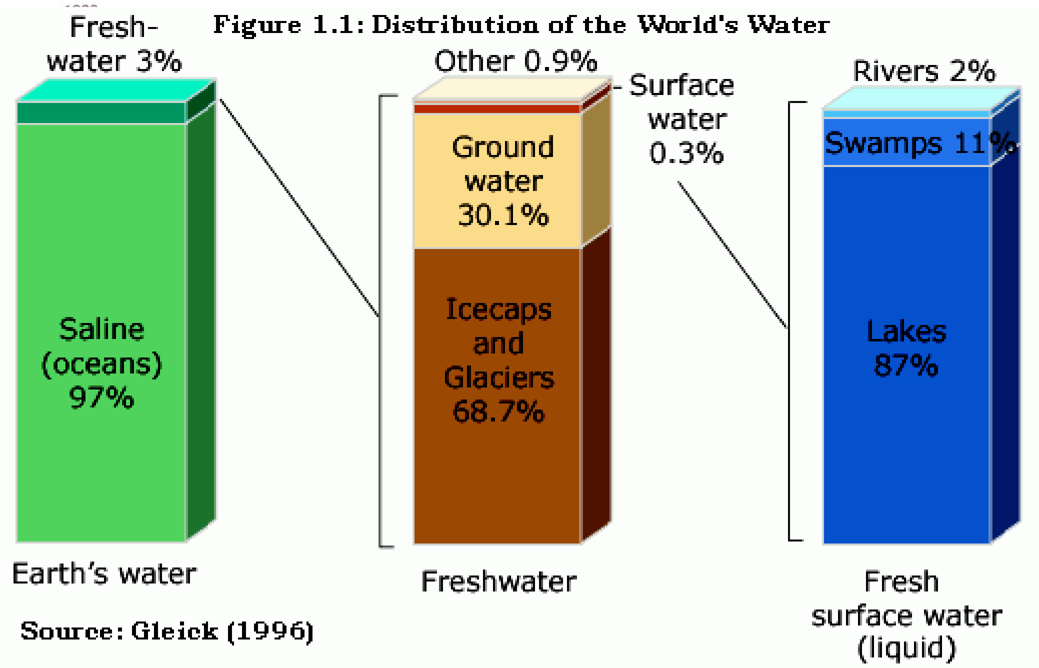
- 1.1 billion people do not have access to clean drinking water (UN Human Development Report 2002).
- Two thirds of the world's population will not have enough fresh drinking water by the year 2025 (World Bank 2002).
- By 2050, 4.2 billion people, estimated to be over 45 per cent of the global total population, will be living in countries that cannot meet the daily requirements of 50 litres of water per person to meet basic needs (UN World Population Report for 2001).
- Preventable water-related diseases kill 10,000 to 20,000 children every day in the developing world (World Environment News, Reuters News Service 2002).
- 95 percent of sewage and 70 percent of industrial waste were being dumped untreated into water sources in developing countries (UN World Population Report for 2001).
- World population increased three fold in the last century, stretching the use of water resources by 6 fold, according to the United Nations.
- 3 million people die every year from disease caused by unsafe water (UN Environmental Programme).
- 2.4 billion people in the developing world lack access to basic sanitation (UN Human Development Report 2002).
- 4 billion people are without a safe wastewater disposal system (World Bank 2002).

Global Water Availability and Future Demands

An evaluation is made of water availability per capita and regions of the world are identified where the present and future disparity between uses and renewable water supply will be the greatest. Future demand will be greatest in the developing countries because of population growth, and increasing agricultural and industrial sector utilization.

However, more than 97 percent of the world's water is salt water and we depend for our basic vital needs on freshwater. Most freshwater is locked in the polar ice caps. Less than 1 percent of the earth's freshwater is accessible in lakes, rivers, and groundwater aquifers (Figure 1.1). The global demand for fresh water has become much more of an issue than in past decades. The largest user of water in every country is agriculture. Trying to farm in hot, arid countries is difficult, if not impossible at times. Agriculture uses 70% of the world's supply, with industry coming in second with 22% of global use, and only 8% used for domestic household purposes.

Globally, annual withdrawals of water for human use amount to at least 3,600 km^3 (FAO, 2002), including an estimated groundwater use of 750–800 km3 (Shah and others, 2000). These annual water withdrawals, compared to the vast groundwater reserves or to the accessible surface water runoff that is economically available for human use year after year, may give the impression that an abundant quantity of water is available that could be withdrawn for human use. However, only a fraction of the world's freshwater resources are economically available for use. In addition, part of the available surface water must be left in the rivers and streams to ensure effluent dilution and safeguard the integrity of the aquatic ecosystem. Exactly how much water needs to be left in a river varies with the time of the year and many other factors specific to each river basin. Currently, instream flow needs are estimated at 2,350 km^3 per year (FAO, 2002). If this is added to the amount withdrawn for human use, then almost 6,000 km^3 of easily accessible freshwater resources are already committed. Taking into account the increasing population and water demand projections, these global estimates of water allocation suggest a dangerously low water availability security prospect. Because of spatial imbalances in the occurrence of water and populations, and the special characteristics of water that make it hard to transport and allocate, water availability is already critical in many countries and regions. According to the Food and Agricultural Organization (FAO, 2003), an estimated 9,000–14,000 km^3 (20%–31% of the renewable water resources) is all that is economically available for human use. The dynamics of growth in water use up to 2025 differ considerably by region. In developed countries and in those countries with limited water resources, water withdrawal is expected to rise by 15-35%. In developing country regions with sufficient water resources, the water withdrawal growth could be 200-300%.



The available freshwater is distributed regionally as shown in figure 1.2. The global overview of water availability versus the population stresses the continental disparities, and in particular the pressure put on the Asian continent, which supports more than half the world's population with only 36 percent of the world's water resources. Globally, of the annual available freshwater, 54% is being used. If consumption per person remains steady, by 2025 we could be using 70% of the total because of population growth alone. If per capita consumption everywhere reached the level of more developed countries, we could be using 90% of the available water each year.

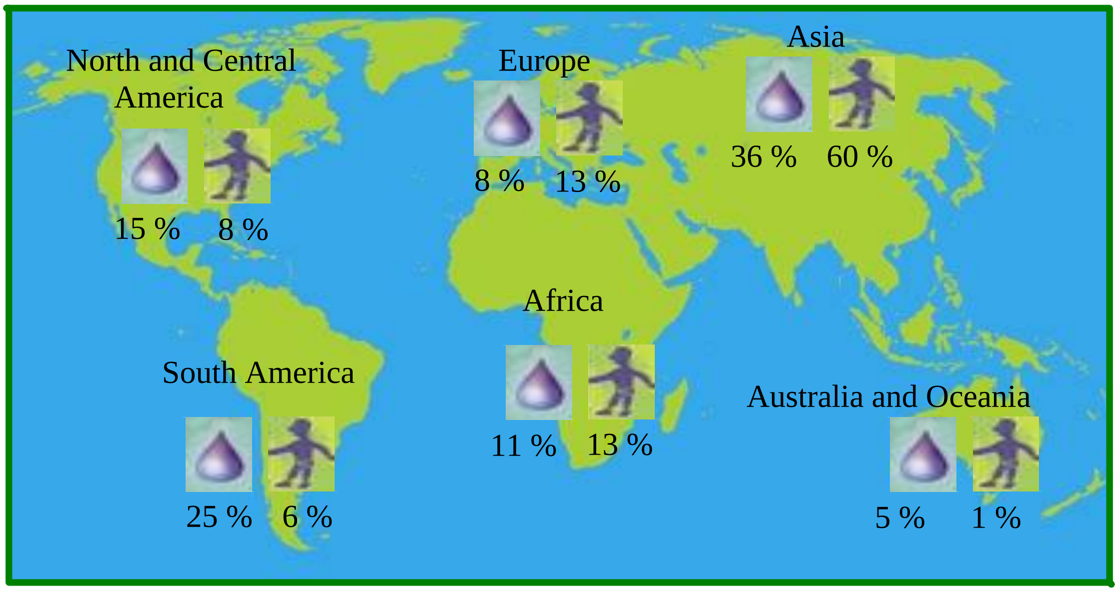


Figure 1.2: Water Availability Versus Population

Source: Website of the UNESCO/ IHP Regional Office of Latin America and the Caribbean

Global and Regional Water Scarcity

World population passed 6 billion in 2000, up from 2.5 billion in 1950 and 4.4 billion in 1980.World population is projected to grow to about 8 billion in 2025, to 9.3 billion in 2050, and to stabilize eventually between 10.5 and 11 billion (UNDESA, 2002). Almost all this growth will occur in urban areas of developing countries. This increased population, combined with higher standards of living, particularly in the developing countries, will pose enormous strains on land, water, energy, and other natural resources. The growing population and its demand for water is one of the most pressing global issues currently facing mankind.
The World Health Organization (WHO) published the most recent assessment in 2000, providing information for 89 percent of the world's population (WHO 2000). According to the WHO, 1.1 billion people around the world lacked access to "improved water supply" and more than 2.4 billion, or roughly 40 percent of the world's population lacked access to "improved sanitation" in 2000. In response, an increasing number of nations, international water conferences, and aid organizations have announced efforts to improve global access to fresh water and water- related services.

A country is said to experience water stress when annual water supplies drop below 1,700 m3 per person. When annual supplies drop below 1,000 m3 per person, the country faces water scarcity for all or part of the year (Falkenmark, 1990; Falkenmark and Widstrand, 1992). Using these criteria, in 1995, 31 countries home to nearly half a billion people regularly faced either water stress or water scarcity. In 2025, 48 countries, with about 3 billion people, are projected to face water shortages (Gardner-Outlaw and Engelman, 1997). The 20 countries of the Near East and North Africa face the worst prospects. Furthermore, if water stress and water scarcity were calculated for regions instead of countries, parts of many other countries would be considered at risk (Hinrichsen and Robey, 2000). For example, while periodic flooding afflicts southern China, the northern part faces chronic water shortages. The world's 6 billion people already are appropriating about half of all the accessible freshwater contained in rivers, lakes, and aquifers. By 2025 humankind's share will be at least 70% (Postel, Daily, and Ehrlich, 1996). This conservative estimate reflects the impact of population growth alone. If per capita consumption of water resources continues to rise at its current rate, humankind could be using about 90% of all available freshwater within 25 years, leaving just 10% for the rest of the world species (Hinrichsen and Robey, 2000).

The world's population is growing at a rate of 80 million people each year. This means that each year we need to find a way to add about 64 billion cubic meters of water to the global water supply. The two fastest-growing areas are Africa and the Middle East. The Sub-Saharan African population is growing at a rate of 2.6% people a year, and in the Middle East it is growing at a rate of 2.2%. Africa is already one of the driest continents in the world, and with this constant change its are facing water stress and water scarcity.

The Asian Development Bank estimates that "between 1950 and 1995 the per capita availability of water resources dropped by almost 70 per cent in South and Central Asia, by about 60 per cent in North Asia and by about 55 percent in South East Asia. In 2025, water availability per capita in the region will be between 35 and 15 per cent less than the level in 1950. In fact South Asia, with one-sixth of the global population, has the lowest level of water resources per capita". By 2025, half of Asia's projected population of 4.2 billion is expected to live in urban centers and together with industrialization will exert enormous pressure on the availability of water. In Asia, the combination of domestic and industrial water demand is expected to grow at rates between 70 and 345 percent between 1995 and 2025. In this scenario where demand outstrips supply and coupled with various competing needs the burden of a water crisis will be unfairly borne by the poor.

In the world 61 countries in 2000 that were using less water than the basic water requirement (BWR) with combined populations of 2.1 billion people. By 2025, from population growth alone, these countries will be the home to 2.7 billion people; by 2050, 4.2 billion people (over 45% of the global total) will be living in countries at this average, below BWR, consumption level.

Currently 2.3 billion people (about 38% of the world population) live in water river basins that are at least stressed; 1.7 billion live in basins where scarcity conditions prevail. By 2025 these numbers will, respectively, be 3.5 and 2.4 billion.

Water-Related Diseases

The WHO/UNICEF/WSSCC (Water Supply and Sanitation Collaborative Council) 2000 Report provides information on the current status of basic water and sanitation services throughout the world.

Water and health are related in a number of ways. Firstly, there is the direct impact of consuming contaminated water. This is known as *'waterborne disease'* and includes diarrhoea, typhoid, viral hepatitis A, cholera, dysentery. Secondly, there is the effect of inadequate quantities of water being available for personal hygiene or the of un-hygienic practices which contaminate water and cause diseases. Without enough water, skin and eye infections (including trachoma) are easily spread, as are the faecal–oral diseases. These diseases are known as *'water-washed diseases'*. Thirdly, there are *'water based diseases*' and **"***water-related vector-borne diseases***"** in which the aquatic environment provides an essential habitat for the mosquito vectors and intermediate snail hosts of parasites that cause human diseases. Malaria, schistosomiasis, lymphatic filariasis, onchocerciasis and Japanese encephalitis are examples of these diseases. Fourthly, there is *chemically contaminated water* such as water containing excessive amounts of arsenic or floride. Some contaminants are added to drinking water as a result of natural processes and some due to human activities such as industry and mining. Poor communities, especially in urban fringe areas, are particularly susceptible to dangers from polluted water from a variety of sources due to lack of or poorly enforced regulation of water pollution. The impacts on health of these factors are at a very large scale and accounts for more illness and death than any other factor in developing countries [WHO, 2001]. The following impacts are the most severe:

• There are approximately 4 billion cases of diarrhoea each year cause 2.2 million deaths, mostly among children under the age of five. Water, sanitation, and hygiene interventions reduce diarrhoeal disease on average by between one-quarter and one- third.

• Intestinal worms infect about 10% of the population of the developing world. These can be controlled through better sanitation, hygiene and water supply. Intestinal parasitic infections can lead to malnutrition, anaemia and retarded growth, depending upon the severity of the infection.

• It is estimated that 6 million people are blind from trachoma and the population at risk from this disease is approximately 500 million.

• 300 million people suffer from malaria - 1 million people die of malaria in sub-Saharan Africa each year.

• Arsenic in drinking water is a major public health threat. It is estimated that in Bangladesh, 100,000 cases of skin lesions caused by arsenic have occurred and there may be many more.

• Fluoride in low amounts in drinking water can be beneficial to dental health but excessive amounts can be toxic. An estimated 30 million people suffer from chronic fluorosis in China alone.

• 200 million people in the world are infected with schistosomiasis, of whom 20 million suffer severe consequences.

Indian Water Crisis

A world water development report of the United Nations has categorized India among the worst countries for poor quality of water, as well as their ability and commitment to improve the situation. The Asian rivers are the most polluted in the world, with three times as many bacteria from human waste as the global average. These rivers also have 20 times more lead than those of the industrialized countries, says the report. Rivers such as the Yellow River (China), the Ganga (India) and Amu and Syr Darya (Central Asia) top the list of the world’s most polluted rivers (World Commission on Water 1999).

Out of remaining about 14 crore households of India, which are waiting to have proper sanitation 10 crore are located in rural areas. India is facing a huge water crisis; there is an enormous unmet demand for water, in India 85% of water is used for farming, 10 % for industry and 5 % for domestic use. The competition between these three is increasing day by day. The supply is reducing because of increasing population and pollution due to human activity.

According to world watch institute, India will be a highly water stressed country from 2020 onwards. In India, water is understood to be "life itself, on which our land, our food, our livelihood, our tradition and culture depends. In India, the per capita average annual freshwater availability has reduced from 5177 cubic meters from 1951 to about 1869 cubic meters in 2001 and is estimated to further come down to 1341 cubic meters in 2025 and 1140 cubic meters in 2050. Among the countries projected to fall into the water stress category before 2025 is India (1990 annual per capita water availability: 2,464 cubic meters), currently the second most populous country in the world with nearly 900 million people. By 2025, India's population is expected to exceed 1.4 billion under the UN's medium projection, and the chronic water scarcity that already plagues many regions of the country is all but certain to intensify.

As much as 21 percent of the area of the countries receives less than 750 (mm) of rain annually while 15 percent receives rainfall in excess of 1500 mm. It generally exceeds 1000 mm in areas towards the east of Longitude 780 E. It extends to 2500 mm along almost the entire west coast and over most of Assam and sub-Himalayan West Bengal. The large areas of peninsular India have rainfall less than 600 mm. Annual rainfall of less than 500 mm is experienced in western Rajasthan and adjoining parts of Gujarat, Haryana and Punjab. Rainfall is equally low in the interior of the Deccan plateau east of the Sahyadris. A third area of low precipitation is around Leh in Kashmir. Rest of the country receives moderate rainfall. Snowfall is restricted to the Himalayan region.

Demand for water is rising and is estimated to have risen six to seven times from 1900 to 2001, more than the rate of population growth. It is a rise, which seems likely to accelerate in to the future, because the population is expected to reach 1.3 billion by the year 2025 and 1.6 billion by 2050. A tentative study indicates that total annual requirement of freshwater for various sectors in the country will be about 1093 b.cu.m by 2025 AD. This freshwater requirement by 2025 AD will be almost at par with exploitable water resources including both surface and ground water. Thereafter additional supply will be necessary or else scarcity conditions would prevail in majority of our river basins.

Conclusion

Water is recognized as a vital resource for life, human and societal development and environmental sustainability. Related to this basic view, is also a wide acceptance that water should be treated as an economic and social good and that management must aim for the most worthwhile use ensuring equity concerns, efficiency and environmental sustainability.

Water planners and managers have to deal with many challenges as we approach the 21st century. Among the multiple functions that water fulfils, the basic human and ecosystems needs are of paramount importance. Water is also indispensable for food production, for industrial development and for a wide range of activities and processes in the landscape as well as in society. Involvement of users and sharing of responsibilities and management tasks is a pre-requisite for proper choice of technological and organizational approaches.

Global environmental collapse is not inevitable. Nevertheless, the developed world must work with the developing world to ensure that new industrialized economies do not add to the world's environmental problems. Politicians must think of sustainable development rather than economic expansion. Conservation strategies have to become more widely accepted, and people must learn that energy use can be dramatically diminished without sacrificing comfort. In short, with the technology that currently exists, the years of global environmental mistreatment can begin to be reversed.

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KARST WATER AT NACKARUD,MAZANDARAN, IRAN

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Nackarud's karst formation is located between Behshahr and Sari Cities in Mazandaran District in north Iran. The area is part of Elburz mountains with about 850 square kilometer at varying elevation from 400 to 2 000 meter SSL.

The climate of the area differs from Winter to Summer, where the temperature varies from zero degree Centigrade in Winter and 37 degree in Summer. The average annual precipitation in the region is about 900 mm. Therefore, the area is considered to be a moderate semiarid with 80%moisture with a mean evaporation of about 2000mm.

The rock of the region is mainly carbonated formation, the aquifer of which is divided into two zones,namely zone one Lar carbonated formation with dolomite and zone two with only carbonated rocks. The geological as well as the geophysical investigations confirm these findings. Lar formation (zone one1) is found to be a better water potential than zone two. Therefore, it is suggested to develop producing wells in both zones. The location of which are indicated, which were proofed to be so, when wells were drilled.
Keywords: *karst, water, resources, Nackarud,Iran.*

1 Introduction

The name karst is taken from an area in north west Yugoslavia (near the border of Italy). This area contains a variety shapes of carbonated rocks with a special geomorphology that exists over and/or under earth surface. In this area, there are caves, dolines, sinkholes…etc. and valleys that are covered with sedimentary soil in which rivers and springs are flowing continually with a lots of water.

Studying similar rock phenomenon was recorded 825 years before Christ. Nowadays, similar studies have been carried out on water containing carbonated rocks at different parts of the world.

Mountains like Elburz(north of Iran) and Zagros(west of Iran) contain karst water similar to above case.

2 Studied Area

2.1 Location

The area under study is located in the district of Mazandaran in north Iran with an area of about 850 square kilometers with a variable elevation from about 400 up to 2000 meter SSL and between 36° 28' - 36° 40' attitude and 5 3° 15' – 54 ° 00' longitude(Figure1)

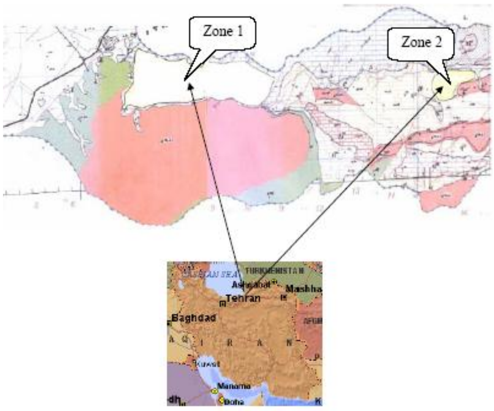

Figure1:Nackarud's karst location in Mazandaran District ,Iran

This area is located also between Bihshr and Sari Cities in almost E-W direction along Nackarud River (Figure 2)

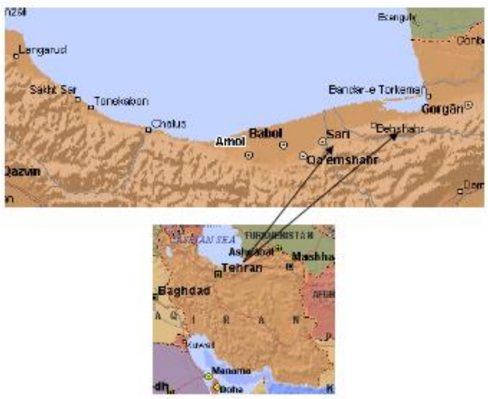

Figure 2: E-W Nackarud River that flows in the karst's zones

Nackarud's karst is covered with a heavy forest. It is also isolated from above mentioned mountains by two big faults, namely Elborz at south and Khazar at north (Figure 3).

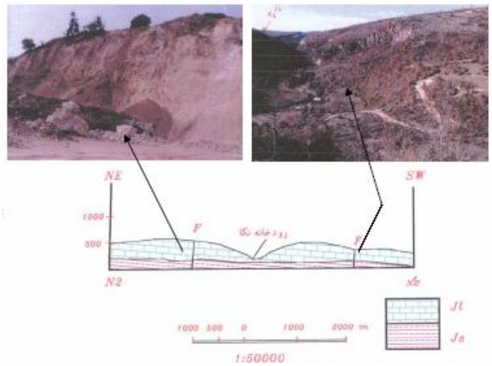

Figure 3:Cross section of Nackarud area showing Elborz and Khazar faults

2.2 Geology of the area

Based upon the type of the rocks, the area was divided into two zones namely zone one and zone two, which are described as follows
Zone one is the south side of the Boshta Naz anticline which is located between Nacka and Oward Cities. It is consisted of Lar Carbonated formation and carbonated-dolomited rocks with limited number of springs.
Zone two, however, is located south of Nackarud’s River that consists of Jurassic carbonated rocks. There are a lot of springs here with much water.

2.3 Geomorphology

The geomorphology of the area is known as carbonated and non carbonated rocks existence based on interior and exterior factors. The interior factors include type of rock and tectonic movement, while the exterior factors are water runoff and sedimentation, weathering, temperature and atmospheric moisture. Moreover, faulting process and their parameters that influence the existing hydro geomorphology of the region. However, these parameters have been very active in due chronological time upon the area.

The carbonated rocks consist of upper Jurassic Lar Formation , and dolomites, where the carbonated rocks formed suitable water aquifers in the area(Figure3).

2.4 Climatology

The average elevation of each of zone one and zone two is equal to 430 and 910 mSSL respectively. From ten weather stations (7 precipitation and 3 evaporation) and for ten years data, following average data were obtained:

The temperature in the two zones varies between zero degree Centigrade in Winter up to 37° C in Summer with an average annual temperature of 18 ° C.

The area is considered to be a moderate semiarid region with an average yearly precipitation in zone one and zone two of 780 mm and 990 mm respectively.

The atmospheric moisture in the area is relatively high with a value of about 80%.

Moreover, the evaporation in the area is about 1200mm.

2.5 Hydrology and Hydrogeology

Water resources in this area consists of surface and ground waters. Nackarud is the main source of surface water. shallow and deep aquifers are for the ground water. The rainfalls are the main sources of both surface and ground waters.

The average annual water flow in Nackarud region based up on recorded data is about 160 MCM. As to ground water and since there are different formations in the area with different hydrologic flows led to divide the studied area in to two zones as indicated before.

2.6 Hydro geochemistry

The hydrochemistry of the water aquifer is studied through checking and analyzing the water of the springs that exist in the area. There are more than one hundreds samples were taken from different parts of the region , which indicate that the PH varies from 7.2 up to 7.5 and the EC varies from 315 up to 404 um/cm without any other remarkable contaminations

.

2.7 Geophysics

The Schlumberger's electrical method was used to study the area and to indicate that the carbonated rock has 150 -300 um, marl carbonated rock equal to 40 -60um that meet with other study to indicate that there is fresh water at greater depth in each of zones one and two.

3 Results

-Studying the area geologically and geophysically led to subdividing it in to two zones ,namely zone one and zone two that directed the study to identify a new water potential at a greater depth.

-Lar carbonated formation was shown to be a better water potential also as zone one.

-Zone two was not water potentially because of a big difference between inflow and outflow (i.e. water would not be saved in the zone). But producing wells can be drilled with limited production .

-Allocating proper new producers in each of zone one and zone two as X1=709660 Y1=4052829
X2=709202 Y2=4056623 respectively that were proved later on to be good producers.

4 Conclusions and suggestions

-There are different litho logy in the area along EW Nackarud River which was thought to be usefully effective if the area is divided into two zones, namely zone one and zone two.
-Faults in the area (main and minor) have a great influence in creating and/ or flowing fresh water in zones one and two , whose water flow mainly into the west direction.
-Nackarud River has a role of drainage in zone one, where it diffuses its water in to the local Lar carbonated formation.
-The changes of the formation in zone one indicate that water of the zone may transfer into neighboring formation.
-In zone two, there are a variety of litho logy and layers and a big potential difference between inflow and outflow that causes in halting water in the zone, relatively small.
-Zone one is a better zone than zone two and therefore, producing wells are suggested to be drilled there at locations (X1=709660,Y1=4052829) and (X2=709202,Y2=4056623) .
- Piesometer network and sampling wells for each of zone one and two are necessary to control well quality and quantity
- It is suggested to study the water flow direction and its exchanging by using radio active material.
- Emphasis should be drown upon microbiological contamination and heavy metals analysis of water because of heavily fractured area in which industry is developing. nowadays.

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ARIDITY PROBLEM IN CYPRUS

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The Mediterranean climate is dominant on the isle of Cyprus. The features of this climate are mild and rainy winters and hot and arid summers. Thus the Mediterranean climate is formed by two opposite seasons, one arid the other moistly. Insufficient rainfall and excessive evaporation causes an arid climate on the isle. The aridity problem does not only influence the vegetation but also the drinking and irrigation water reserves. This problem, because of the geographical situation of the isle, is more effectively felt in the valleys whereas this effect decreases towards the mountainous regions. In order to meet the drinking water supplies many wells were dug. Therefore it is sometimes possible to find 150-200 wells in one village. Since the aboveground water is insufficient the underground water level decreases due to excessive use. Because of this arid climate new environmental problems emerge like soil erosion and increasing rise in the salt percentage in the underground water. This study, by applying aridity formulas, aims at determining the intensity of the aridity and also to show the beginning and the end of the aridity period. As a result the environmental problems caused by the aridity climate in Cyprus and their negative influence on human life and activities are shown.

Introduction:

Montesquieu: “The Empire of the climate is the first, the most powerful, of all empires”. After putting forward the climatic characteristics of the Island of Cyprus in detail, the draught problem, the result of the climate, is examined carefully. Cyprus is located within the subtropical climate zone which seems to be one of the most appropriate climates for humankind. The climatic condition in the Mediterranean region in which the winters are warm and rainy and the summers hot and dry is also called Mediterranean climate further those who study plant geography call this climate as the olive climate because olives do not grow in every climate. Therefore the olive is the plant that best adapted itself to this region. In Cyprus the winters are warm and rainy and the depressions coming from over from the Atlantic carry humid and cold air masses. Besides, continental and cold air masses of Siberian origin which become warmer towards the south result in some cold days in Cyprus, days in which sometimes even the waters freeze. Except these few cold raids there is generally no cold weather in Cyprus.

In summer all parts of the Mediterranean basin is under the influence of air masses of tropical origin.

The air masses, of continental tropical origin, which over the Arabian and African deserts advance towards the north do not bring rain but dry horrid temperatures. As a natural result, the plants' and humans' need for water, increases and it becomes difficult to meet the increasing water demand which in turn increases the problem of drought. In terms of geography, arid climates and arid periods have a great importance to determine especially the economic potential of regions, to influence plant and soil cover as much as growing cultural plants and besides to arrange the fertility of soil. A.Penck is the first person who describes the drought notion scientifically and his approach is based on climate classification. According to him the climates are:

a- Nival climate: Glacier operation is active and it is snowy.
b- Humid climates: Annual rainfall is more than the evaporation and thus there are rivers with flow continuity.
c- Arid climates: Annual evaporation is higher than the annual rainfall[13]

The cumulative appearances of atmospheric events and their recurrence throughout the year make up a region or countries climate. Drought is also an outcome of the climate. Cumulative effects of climates' elements and factors, especially the drought as the result of the physical relation between rainfall and evaporation have kept man busy since very old ages even since times the first settled life began. Human beings have used various precautions against the drought. In spite of developing scientific and technical possibilities, the drought problem has been studied by many scientists. But there has not been any consensus about the definition of the drought and its way of expressions.[14]

1-Aspects of Physical Geography and The Drought Relation.
Cyprus Island with its 9251 km square area is the third biggest island of Mediterranean. The Island is about 70km to Turkey, 110 km to Syria, 370 km to Egypt and 550 km to Greece. Cyprus Island in terms of geomorphology mainly consists of Beşparmak Mountains in the North, the Torodos in the south and the Meserya plain existing between these two mountainous masses.[15]

In terms of its area Cyprus, does not embrace a large area but shows changes in its climate even in short distances due to factors such as high altitudes of mountains. As the Torodos Mountains altitude is about 2000 meters, the west and northwest slopes of these mountains get about 1000 mm rainfall average yearly. Thus, due to excessive rain quantity and decrease of heat depending on altitude, the intensity of the drought problem is very little. The Beşparmak Mountains, in the north of the island, exist roughly from east to west. Since the north slopes of these mountains are open to humid air masses, have plentiful rain and for having less sun radiation, they keep evaporation less(Photo 1).

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1 NİŞANCI, A., 1983, Kurak Bölgeler-Türkiye'de Kuraklık. Atatürk Üniv. Fen-Ed. Fak. Edebiyat Böl. Course Notes Issue: 50, Department of Geography Chapter Vol:. No: 5, p. 2, Erzurum-Türkiye

[14] NİŞANCI, A., 1983, Kurak Bölgeler-Türkiye'de Kuraklık. Atatürk Üniv. Fen-Ed. Fak. Edebiyat Böl. Course Notes Issue: 50, Department of Geography Chapter. 5, p. 14, Erzurum-Türkiye

[15] KODAY,Z., 1995, "Kuzey Kıbrıs Türk Cumhuriyeti Devletinin Coğrafi Özellikleri." Atatürk Üniv. Türkiyat Araştırmaları Ens. Dergisi. Issue: 2, p. 17, Erzurum-Türkiye

Photo 1. A view from the northern slopes of Beşparmak Mountains

There is low intensity of the drought in the north slopes. As the south slopes of Beşparmak Mountains are at the opposite of the north of the Torodos Mountains, they are under the influence of the humid air masses and again for being on a south slope, are exposed to more sun radiation. In this case the intensity of drought on the south slopes of the Beşparmak Mountains is very high compared to the north slopes. The intensity of the drought is most clearly seen on plant cover. The areas, which have more rain, are covered by forests; the areas, which have average degree of rain, are covered by bushes, and the areas which have less rain, are covered by step formation. The Meserya Plain, existing between Beşparmak Mountains and Torodos Mountain, has 85 km length between Lefkoşa and the Salamis gulfs. The plain, when it is crossed through from west to east, opens like a fan and has 40-45 km width between the Beyarmudu and İskele settlements.

The plain being completely in the borders of the Turkish Republic of North Cyprus[16] is also the granary of the island. This plain, having 300-350mm average rainfall annually, is the area in the island which has lesser rain. The plain, which is under the influence of humid air masses due to the Torodos Mountains and Beşparmak Mountains, is the area where the drought problem is seen clearly and intensively. The east side of the plain is open to the sea. But for being in the opposite direction of general atmospheric circulation, which generally moves from west to east, the plain takes no rain from the East. The humid air masses, coming from west, first come across the Torodos Mountains and leave plentiful rain and after passing over these mountains, the humid air masses begin to descend and when they reach the plain they get a fan characteristic so the quantity of humid lessens and air's capacity to keep humid increases and so the possibility of rain lessens, too. As Larnaka and Limasol surroundings are under the influence of the Torodos Mountains, the drought becomes an important problem. Since more than half of the island's population live on this plain and its surroundings and have insensitive agricultural areas. The significance of the drought problem is understood better when all these are considered. The drought problem is tried to be put forward more scientifically by preparing Cyprus' water sheet with diagrams and tables according to average rain and heath rates in the island.

[16] Hereafter reffered to as TRNC.

Table 1. The Water Balance-sheet of Lefkoşa (According to Thornthwaite) Latitude : 35. 10

Months	JAN	FEB	MARCH	APRİL	MAY	JUNE	JULY	AUGUST	SEPT	OCTOBER	NOVE	DEC	ANNUAL
Temp. C	14.00	14.00	15.00	18.00	21.00	24.00	29.00	29.00	25.00	23.00	18.00	13.00	20.25
Temp. value	4.75	4.75	5.28	6.95	8.78	10.75	14.32	14.32	11.44	10.08	6.95	4.25	102.62
PT. ETP (mm)	32.17	32.17	37.57	56.62	80.07	108.12	165.47	165.47	118.52	98.25	56.62	27.23	978.30
COR.. PE (mm)	27.99	27.35	38.70	61.81	96.89	131.01	203.81	191.95	122.07	95.30	48.69	23.10	1,068.67
Rainfall (mm)	103.60	38.70	47.30	19.30	14.70	6.00	0.10	0.60	5.80	31.40	44.50	100.30	412.30
ACC. WATER EX.(mm)	22.80	0.00	0.00	-42.51	- 57.49	0.00	0.00	0.00	0.00	0.00	0.00	77.20	
ACC.. WATER(mm)	100.00	100.00	100.00	57.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	77.20	
ABS. EVAP. (mm)	27.99	27.35	38.70	61.81	72.19	6.00	0.10	0.60	5.80	31.40	44.50	23.10	339.54
LACK. WATER(mm)	0.00	0.00	0.00	0.00	24.70	125.01	203.71	191.35	116.27	63.90	4.19	0.00	729.13
EXC. WATER (mm)	52.81	11.35	8.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	72.76
WATER FLOW (mm)	26.40	32.08	9.98	4.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	72.76
HUMİDİTY RATE	2.70	0.42	0.22	-0.69	-0.85	-0.95	-1.00	-1.00	-0.95	-0.67	-0.09	3.34	

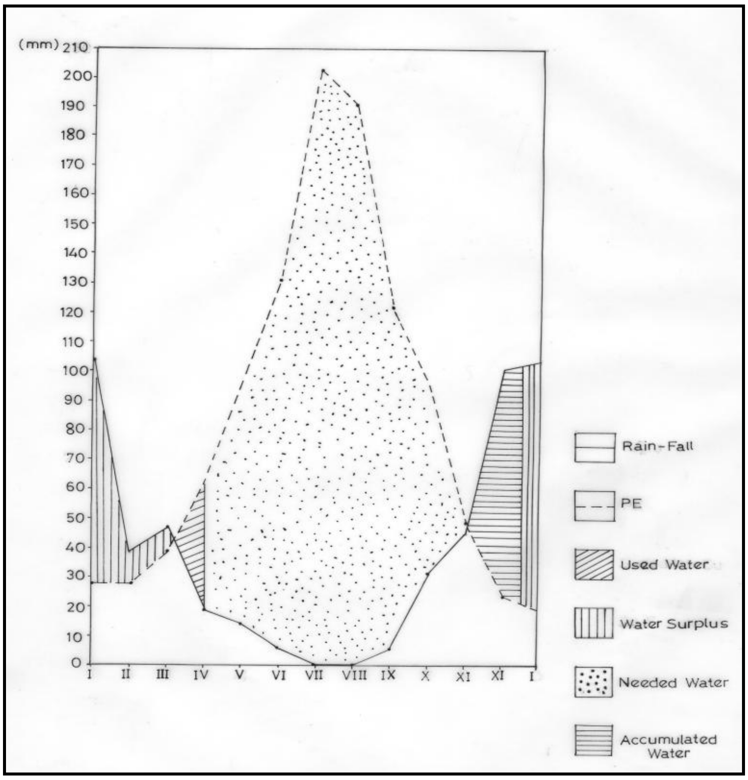

Figure 1. Water Balance-sheet of Lefkoşa

As it is seen from the water sheet table and graphics, January, February and March are humid and the soil is full up with water. The drought period begins in April and the very intensive drought period is seen in June, July and August, from November on, accumulation begins in soil and the soil is full up with water through the end of December. To Tornthwaite the climate type is d b'4 d b'4. As a result Lefkoşa is semi drought, of 4th degree mezzo thermal, its type of climate close to naval conditions without excessive water. According to the ombrothermic diagram developed by Gausen = when the drought condition of Cyprus is examined, similar drought problem is clearly seen. In this diagram months are marked on apses heath (left) rain (right) values are marked on ordinates drawn on the diagram. As heat scale is the double of rain scale and since the points, where the rain bent begins to cross under the heat bent, here lack of water begins for plants (Figure 2). It is seen that the rain factor, which has a great effect on lives of the plants is only evaluated correctly by considering heat. For example although the rain quantity is the same in some places of Tundra areas and tropical desert, there

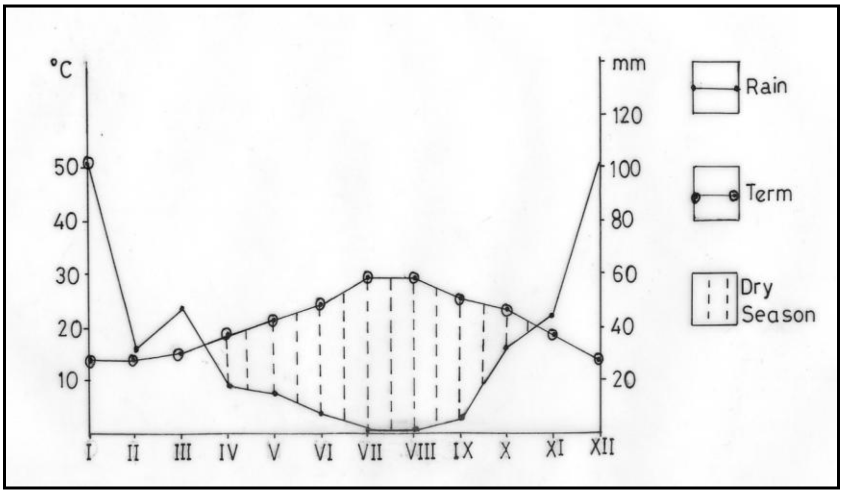

Figure 2. The Ombriometrik Diagram of Lefkoşa.

is no similarity between the plants of these areas.[17] This case occurs due to their differences in terms of heat evaporation. In the places where there is almost no rain, the intensity of heat increases the intensity of drought.

Plants have to adapt themselves to the climate in which they live in order to survive. For, there is rain in winter and spring seasons the grass gets green but with the increasing of heat the intensity of the drought also increases and this immediately makes the grass turn yellow.[18] Bushes and trees, forming the vegetation have taken some precautions against the drought. These precautions are: they have polished leafs, their roots are going deeper and their bodies get thick.

[17] İNANDIK, H., 1969, Bitkiler Coğrafyası. İstanbul Mat. pp.43-44, İstanbul-Türkiye.
[18] KODAY,Z., 1998, "Kuzey Kıbrıs Türk Cumhuriyet'inin Doğal Bitki Örtüsü ve Orman Varlığı." Türk Coğrafya De. Issue: 33, p.281, Istanbul.

2-Social Geography Aspects and the Drought Problem

People have had water trouble and they have been forced to struggle against the drought problem. At first, collective village setting is the best example for it. As it is known, water is the most important factor to bring houses together or to separate them, as human beings can't get water from everywhere they have built their buildings in the areas where they could get water easily.[19]

Aqueducts belonging to previous ages are the proof of precautions taken by human being for drought. Presently (2006) about 900.000 people live in the island. The demands on drinkable water sources have increased due to reasons such as increasing population, agricultural activities, industry and tourism. As a result of this water in aquifer has lessened, lots of dwell which have less depth, have dried and underground water has became salty. As a result of this people have built depots to keep water reserves. They even have built big water tanks to meet their animals' water demand. The biggest problem of Cyprus Island is drought. People have spent great efforts to solve this problem for centuries but the solution of the problem has not been possible yet. Water leaking into the underground of T.R.N.C is less than water taken from the aquifers. According to the 1997 T.R.N.C underground water sheet, feeding is 10.000.000 cubic metre[20], taken water quantity is 15.000.000 cubic metre thus there is a gap between these values which is growing day by day. As a result people's demand on dwells increase and as the dwells can't support it, they dry and the quantity of saltiness gets higher. Since water resources are scarce, people consume water very carefully and they try not to squander it.

This study, since it is about the drought problem of the whole of the island of Cyprus, does not take into consideration technical details and local differences. But as it is mentioned before the drought problem is felt best in the Meserya Plain which has little rain quantity. When you visit the villages in this area, you can see that almost every house has a water tank, and that there is a big common water depot and also that water tanks are carried by tractors in order to water animals (Photo 2).

It mustn't be thought only that insufficient rain only causes draught, but the pollution but also pollution of underground waters is responsible for such an outcome. In Cyprus where resources are scarce, underground water is polluted by putting manure and chemical products on soil. When this pollution reaches a certain degree, using of water becomes impossible. This case increases the intensity of drought problem indirectly. According to a report published on 21/08/2006 which is the first day of the 'world water week', one of three persons in the world experiences water problems.[21]

[19] KODAY,S., 1995, "Kuzey Kıbrıs Türk Cumhuriyet'inde Yerleşmeler." Atatürk Üniv. Türkiyat Araştırmaları Ens. Dergisi. Issue: 2, s. 2, Erzurum-Türkiye

[20] KIBRIS TÜRK FEDERE DEVLETİ'NİN YERALTI VE YERÜSTÜ SU OLANAKLARI. 1978, Kıbrıs Türk Federe Devleti Tarım ve Doğal Kaynaklar Bakanlığı Su İşleri Dairesi Jeoloji ve Maden Dairesi Report. Kıbrıs.

[21] http/www.gezegenimiz.com

Photo 2. A water tank for the watering of animals.

3-The Drought Problem in Cyprus and Agricultural Activities

For human being, water is among the indispensables of life. There is no life without water and every living creature needs water. But human being mostly uses water to water agricultural areas. Agricultural activities need proper heat conditions and water. The drought problem in the areas where there is insufficient rainfall is tried to be solved by watering the fields and gardens. To do this, people benefit from rivers, lakes and underground water. But in the areas in which there are no rivers or lakes, the demand for underground water increases. In Cyprus the drought is intensive and besides the underground water is also insufficient. As a result, people take water as possible as from dwells. Thus water level has gone deeper, saltiness quantity has raised and especially in coastal areas sea water fills the aquifers where underground water level lessens. Farming is very difficult in Cyprus due to the drought problem. In the areas where there is insufficient water, farmers try to use less water. To do this, they water through a line or use dropping method of watering in which water drops on the roots of the plants. Since the farmers' lives as well as their economic activities depend on water, drought has a great negative effect on him. (Photo 3).

Since roots of trees go deeper in fruit garden it is easer for plants to get underground water. But as the roots of vegetables are very close to the surface, the drought causes bigger problems in vegetable gardens. Especially in June and August vegetables begin to dry unless they are watered in every three or four days.

The drought problem exists in most of the regions of the world. But this problem in the areas, which have underground water in their surrounding, can be solved by watering fields. But the solution of this problem is very difficult in the areas where there is no underground water. We can describe drought simply in agricultural activities as the plants inability to get sufficient water. The more the intensity of drought increases, the more its negative effect on agricultural activities increases. The drought problem is not only related to farmers but all people. But it is more related to farmers for their economic activities. Although there is insufficient rain in some areas the drought problem is tried to be solved by getting water from a river or lake or underground water in the areas. The solution of the problem is getting hard where underground water does not exist. Even rich Middle East countries have difficulty to use sea water in agricultural activities by refining due to high cost.

Photo 3. A view of soil cracked because of drought.

The drought problem, being a natural disaster in the world, is a common problem for all living creatures. Many developments have been done to solve the problem. In the limits of opportunities until now huge dams have been built, water has been carried by pipes of which the length reached km's, dwells whose depths were almost hundred meters were opened. But in spite of these technological developments, the solution of the problems is impossible. In this case Cyprus is a bit unlucky. Because the island's existing water resources are not sufficient for drinking and using. There is even a difficulty to provide just sufficient water for drinking and using in some areas. The parcel seizes of watered agricultural lands are very small. As water resources lessen, lands of watered agricultural also get smaller. For example when the size of fruit gardens is 10-20 decare in Güzelyurt, it is 1-2 decare in the Meserya Plain. Especially in the Meserya Plain watered agricultural lands consist of 1-2 decare gardens which are close to water wells. But in dry agricultural lands used for grain agriculture the size of parcels is very big and consists from 50-100 decare.

The world's all water reserves consist of salty sea water and ocean water (97%) frozen water in the poles (2%) underground water and surface drinkable water in all continents (1%).According to F.A.O. studies drinkable water just consists of (%2) water reserve of all water reserves of the world and 98% of existing water in the poles can not be used. In spite of all these problems world water consume has been increased to 400 % in the last fifty year. Again 14 of 26 countries which have water problems are in the Middle East.[22]

[22] ÖZEY,R., 1997, Dünya Denkleminde Ortadoğu. Öz Eğitim Yay. No: 9, p.300, İstanbul.

Generally, in an area where the more the climate is humid the more the river's network is dense. As the climate is getting drought river's network intensity lessens (Photo 4). The river network is more around Torodos Mountains depending on water and there is no water in the Meserya Plain. The real reason of this is human intervention. The Rivers' water flowing from the Greek part to Cyprus is barrelled. Having some minerals, ground's lithological structure is very important for drinkable water reserves. Excessiveness of some minerals such as salt in water lessens the drinking and using water. In terms of this, the Meserya Plain again is in a very bad position, because the salt quantity of the soil is very excessive. In drainage channels opened edges of the fields are filled up with winter rains, become completely evaporate in spring and summer. But 8-10 cm thick salt layer on the sole remains

We need to pay attention to another issue. If drinkable water resources become sufficient in Cyprus, The fields should not be watered plentifully. For example, all lands should not be watered unconsciously as it has done in South East Asia countries for rice fields. Because in this case salt in soil melts and by the help of water comes to soil's surface and forms a salt layer on the surface. So these areas need to be consciously watered. Otherwise agricultural lands would turn to be salt lands. As Tümertekin and Özgüç mention, watering, which is the only way for farming in drought areas, is a method which requires technical details, because, both excessive and insufficient water is harmful[23]. It is very important to water in proper time with proper quantity.

Photo 4. A view of the bushy and salty soil of Cyprus.

CONCLUSION AND SUGGESTIOS

The drought problem is the most important problem of the island. Insufficient rain, long periods of summer drought, insufficient underground water and excessive water using factors increase the intensity of the drought. Some precautions have been taken to decrease the intensity of the drought problem. These are water depots, water tanks in houses and water tanks carried by tractors to provide water for animals. Beside these, they use as possible as little water for agricultural lands. In T.R.N.C. the quantity of water taken from underground is more than the quantity that leaks into underground. In this case water sheet has a gap every year. This gap should be solved soon. Otherwise underground water goes deeper.

[23] TÜMERTEKİN,E.,-ÖZGÜÇ N., 1999, Ekonomik Coğrafya. Çantay Kitabevi, p. 171, İstanbul.

As a result, the cost of taking water from undergrounds would increase and quantity of salt would increase too and what is more worse these aquifers which have lost drinkable water would be filled up with salty sea water. If it would happen, disaster is inevitable e.g. natural balance would breakdown and we would destroy the underground. It would be impossible to restore everything again. The existing drought problem in Cyprus indeed is the sign of another disaster. Thus the drought problem should be considered as the problem of settling and lands of agriculture. The problem should be considered as the whole island's problem and solution ways should be found according to this. We have a conviction that the best solution is to bring water from Turkey by water pipes at all cost. We know that there are studies related to this issue. So we should give priority to these projects and we should accelerate them. To bring water from Turkey should not be considered only as a support for human needs but also should be considered as the prevention of environmental disaster that would appear in the future due to excessive use of underground water. We hope if the drought problem, which is one of the biggest problems of the island, is solved the best service for the island would be completed.

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PROTECTION OF WATER RESOURCES AND AQUATIC LIVING FROM THE DAMAGES OF AGRICULTURAL CHEMICALS

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Agricultural production without using the chemicals is almost impossible. Most of these chemicals are toxic components for aquatic living. When these reach to water sources from the agricultural areas with different ways, they alter the properties of water. This is the first and indirect effect of pesticides and the other chemicals. After than, the direct and more important effects begin for aquatic living. According to the concentrations; toxic chemicals may inhibit the egg production, alter fish behaviors, food efficiency, and weight gaining, healthy and finally may kill or force fish to migration.
In this paper; the agricultural chemicals (agrochemicals), the effects of these on water reservoirs - aquatic livings will be reviewed and be discussed the awareness in the using of these chemicals for protection of water sources and aquatic living.

Key Words*: Pesticide, fertilizers, aquatic living, water pollution, toxicology,*

1. INTRODUCTION:

Water is renewable resource, but its availability is variable and limited. While only less than 2.5 % of earth's water is fresh water, the rest (97.5 %) accounts for salty water, which is found mostly in oceans and inland seas. Only about 0.2 % of earth's fresh water is available for our use (Aydemir *et al.*, 2005). This quantity decreases because of the water pollution, day by day. One of the important sources of water pollution is the chemicals, which used in agricultural applications.

2. AGRICULTURAL CHEMICALS

These chemicals are pesticides (fungicides, insecticides, herbicides and rodenticides), fertilizers, plant growth regulators (agents to promote or inhibit the growth of field crops), attractants (agents that attract mainly harmful insect pests by odor or other means, Repellents (agents for having repellent action on harmful mammals and birds that damage field crops), spreaders (agents that are mixed with other agricultural chemicals to enhance the adherence of these chemicals), disinfectants and therapeutants. Among these chemicals, pesticides and fertilizers gain importance because of their harmfulness for aquatic livings (Anony., 2006). Water sources introduce these controlling chemicals in different ways; direct application of pesticides to waterway and reservoirs for weed and mosquito, with the discharge of sewage, washing the chemicals from the agricultural areas by rain, the cleaning equipments and package of pesticides (Atamanalp and Yanik, 2001a). These agrochemicals can however be easily washed into the streams or infiltrate the soil, eventually contaminating ground water reserves (Muyunda, 2003).

2.1. Pesticides

The use of pesticides has increased with the growing awareness about their utility in the agriculture production, animal husbandry, post harvest technology, public health and welfare of humanity. The pesticides, carried away by rains and floods to larger water bodies like ponds and rivers and alter the physico-chemical properties of water (Richardson, 1988).

The role of pesticides is to kill pests, but the properties that make these pesticides efficient at controlling pests may also pose a danger to other animal life, including humans (Brady and Weil, 1999).

Pesticides dissolved in runoff water or attached to eroded soil particles may be washed into streams, river, lakes and estuaries. Pesticides may also evaporate into the air or leach into ground water. Pesticides can also find their way into water resources via direct application to control aquatic weeds, wind drift, or overspray from aerial applications (Shortle *et al.,* 2001).
These chemicals are used in both urban areas and agricultural settings. Pesticides are used by a wide spectrum of users, from individuals, to companies, to municipalities (Aydemir *et al.*, 2005).

The history of pesticide development and use is the key to understanding how and why pesticides have been an environmental threat to aquatic systems, and why this threat is diminishing in developed countries and remains a problem in many developing countries. Stephenson and Solomon (1993) outlined the chronology presented in Table 1.

The modern era of pest control with synthetic organic pesticides began in the early 1940's with the introduction of the insecticide DDT and the herbicide 2,4-D. Since that time, many other pesticides have been developed for a variety of crop protection purposes, and their volume of use has increased tremendously. Pesticides have been found frequently in surface water; in the last several years, they have also been found in groundwater (Ongley, 1996)

Table 1. Chronology of pesticide development (Stephenson and Solomon, 1993).

Period	Example	Source	Characteristics
1800-1920s	Early organics, nitro-phenols, chlorophenols, creosote, naphthalene, petroleum oils.	Organic chemistry, by products of coal gas Production, etc.	Often lack specificity and were toxic to user or no target organisms.
1945-1955	Chlorinated organics, DDT, HCH, chlorinated cyclodienes.	Organic synthesis	Persistent, good selectivity, good agricultural properties, good public health performance, resistance, harmful ecological effects.
1945-1970	Cholinesterase inhibitors, organophosphorus compounds, carbamates.	Organic synthesis, good use of structure-activity relationships.	Lower persistence, some user toxicity, some environmental problems.
1970-1985	Synthetic pyrethroids, avermectins, juvenile hormone mimics, biological pesticides.	Refinement of structure activity relationships, new target systems.	Some lack of selectivity, resistance, costs and variable persistence.

2.2. Fertilizers

Fertilizers are inorganic chemicals that are used by crop farmers to improve production. Inorganic fertilizers have been widely adopted by farmers because of its wide range of benefits: their cheapness, their cleanliness and ease of handling, their ease of storage and transport (Briggs and Courtney, 1994; Muyunda, 2003).

High levels of nitrate, from NO_3 and NH_4, in surface or ground water and excess phosphate, from PO_4, in surface water are common pollutants associated with fertilizers (Thompson, 1996). Water pollution associated with fertilizers usually occurs because of adding more nutrients to the soil than can be taken up by the crop (Tan, 2000). These materials travel from fields to ground water or surface water, by water, by the process of leaching or runoff. In areas with intensive livestock production manure may be applied to cropland primarily to dispose of the waste and only secondarily as a fertilizers (Shortle *et al.*, 2001).

3. NEGATIVE EFFECTS of AGROCHEMICALS

The sublethal effects of many agricultural chemicals on aquatic life are not well known. Any misused chemical can cause serious problems to an aquaculture operation. On the other hand, even the most toxic chemical can be used safely if it is used properly (Morgan and Brunson, 2002).

Pesticide residues reaching surface water system may harm fresh water and marine organisms, damaging recreational and commercial fisheries (Pait *et al.,* 1992). Pesticides washed into lakes, rivers and estuaries can lead to fish kills, and numerous cases have been documented. Aquatic species and their predators can suffer chronic effects from low levels of exposure to pesticides over prolonged periods. Pesticides can also accumulate in the fatty tissue of animals such as shellfish to levels much higher than in the surrounding water, and consumption of these animals may lead to chronic effects in predators. Moreover, the effects can be "biomagnified" as "bioaccumulated" pesticides are passed up the food chain. Herbicides and insecticides can kill the aquatic plants and insects upon which birds and other wildlife feed (Shortle *et al.,* 2001).

Hydrophobic properties pesticides cause a rapid sorption to soil particles that can be washed into the water. If the pesticides reach aquatic ecosystems in dissolved form, they quickly associate with organic matter in suspension or in the sediment. Sorbet contaminants tend to be less degradable than their dissolved counterparts, since they are less accessible to the degrading action of UV-light, dissolved oxidative chemicals, and microorganisms (Ying and Williams, 2000; Schwarzenbach *et al.,* 1993). This increased persistence following sorption and sedimentation, coupled to the extensive use of pesticides, may cause an accumulation of these compounds in sediments of freshwaters and estuaries. (Widenfalk, 2005)

Heavy contamination of the pesticides in water in turn leads to oxygen depletion and cases of poisoning, and mass mortality of fishes. The recently introduced synthetic pyrethroids with multiple beneficiary qualities have attracted farmers to use these compounds in pest control. However, these compounds are found to be highly toxic to fish (Agnihothrudu, 1988).
Fish takes these chemicals into their bodies with their gills, with eating the contaminated foods or directly from skin. The effects of pesticides occur as direct killing, forcing to migrations, inhibiting the ovulation or increasing the sensitivity of fish to environmental stressors or diseases etc. (Atamanalp and Yanik, 2001b).

The first negative effect of pesticides is altering hematological parameters of fish. For example; Among organic pesticides, chlorinated hydrocarbons stimulate erythropoiesis; aldrin, chlordane and pentachlorophenol are all in this chemical group. Aldrin caused a dose-dependent increase Red blood cell (RBC) count and total hemoglobin concentration, but the mean corpuscular hemoglobin actually went down. This suggests a large increase in cell formation; so much that hemoglobin synthesis did not keep up with it.

The mechanism of this stimulatory effect of chlorinated hydrocarbons insecticides is unclear. In part, it may be due to impairment in oxygen transfer at the gills, but that is only speculation. Metasystox, an organophosphate insecticides, Natarajan (1984) increased hematocrit, RBC count, and hemoglobin concentration. He attributed this hematological stimulation entirely to hypoxia produced by damage to the gills; however, there was no direct evidence to support that hypothesis. Malathione (another organophosphate insecticide) caused a severe drop in erythrocyte count in catfish. Another pesticide, DDT is a potent inhibitor of Na, K-ATPase (in vitro) in a variety of different fish tissues (Heath, 1987).

Cypermethrin (a synthetics pyrethroid) decreased blood serum Ca and P levels of rainbow trout (Atamanalp *et al.*, 2002 a). The same pesticides increased RBC, hemoglobin concentration, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, thrombocyte count and erythrocyte sedimentation rate (Atamanalp et al., 2002 b). Mancozeb had some effect on the hematological parameters of rainbow trout (Atamanalp and Yanik, 2003).

Histological alterations occur as one of the other effect. Organophosphate and organochlorine pesticides observed histological changes on fish livers. These symptoms include increased vacuoles in the cytoplasm, enlarged lysosomes, changes in nuclear shapes, focal necrosis (death of cells in a localized area), ischemia (blockage of capillary circulation), fatty degeneration, and loss of glycogen (Heath, 1987).

The complex biological interactions that exist in an aquatic ecosystem make it very difficult to predict the ecological consequences that could be caused by pesticide exposure (Widenfalk, 2005). The effects of pesticide exposure on the organisms of aquatic ecosystem may be acute or chronic, as well as direct or indirect. Acute effects, for example death of organisms, are often easily detected in toxicity tests during assessment of the pesticide. Chronic effects, on the other hand, such as disturbances in behavior, decreased reproduction success, and changes in community structure are far more difficult to detect and are often promoted by long-term pesticide exposures at low concentrations. Both acute and chronic effects may result in altered abundances and taxon richness which may have serious implications for ecosystem health. A direct effect of pesticides on aquatic organisms is for example mortality and disappearance of zooplankton following insecticide exposure. This could lead to an indirect positive effect on phytoplankton due to a decreased grazing pressure (Wendt-Rasch, 2003).

Pesticides in groundwater are an extremely serious problem. The turnover rate for groundwater may be as short as a few months, but more commonly years and decades are needed to replace the water in an underground aquifer. Oxygen is absent in ground water, and the microorganisms that live in an oxygen free environment are much less effective in breaking down pesticide chemicals (Aydinalp and Porca, 2004) .

Microorganisms contribute significantly to primary production, nutrient cycling, and decomposition in estuarine ecosystems; therefore, detrimental effects of pesticides on microbial species may have subsequent impacts on higher trophic levels. Pesticides may affect estuarine microorganisms via spills, runoff, and drift. Both the structure and the function of microbial communities may be impaired by pesticide toxicity. Pesticides may also be metabolized or bioaccumulated by microorganisms. Mechanisms of toxicity vary, depending on the type of pesticide and the microbial species exposed. Herbicides are generally most toxic to phototrophic microorganisms, exhibiting toxicity by disrupting photosynthesis. Atrazine is the most widely used and most extensively studied herbicide. Toxic effects of organophosphate and organochlorine insecticides on microbial species have also been demonstrated, although their mechanisms of toxicity in such nontarget species remain unclear. There is a great deal of variability in the toxicity of even a single pesticide among microbial species (DeLorenzo et al. 2000).

The most important negative effect of fertilizers is loading huge quantities of nutriment to water bodies. In addition, they increase the turbidity levels of waters. In a process known as eutrophication, increasing nitrogen and phosphorus levels in slow-moving waters stimulate algae growth and the resulting effects on the aquatic ecology can be dramatic. As algae bloom, they take up dissolved oxygen available for fish and other aquatic life. They can also block the sunlight needed by aquatic vegetation, causing the vegetation to die off. This loss in vegetation then moves up to food chain, leading to the dead of fish and other aquatic life. Eutrophication of fresh water is usually due to phosphates, while nitrates are usually the cause of coastal water eutrophication (Shortle *et al.,* 2001).

The negative effects of fertilizing on the ground waters occur because of the insensible usage of nitrogenous and phosphorus fertilizers (Taskaya, 2004):

- Increasing the nitrate amount in the water resources,
- Increasing the phosphor amount in the water resources,
- nitrit and nitrate accumulates in the plants which are in the food chain of the animals and they brings these compounds to water sources

4. PRECAUTIONS

When a pesticide must be used, select a product that is registered for the use intended and is the least toxic and least persistent of the products available. Always follow exactly the directions on the label (Morgan and Brunson, 2002; Atamanalp and Yanik, 2001).

The ideal pest control agent would:

- kill only target species,
- have no long- or short-term effects on non-target species,
- break down into harmless chemicals in a short period,
- not select for genetic resistance in the target organisms,
- not affect predator/prey relationships or competitive interactions
- be more economical than not using pest control (Williams and Feltmate, 1994).

The risk of pesticide drift can be reduced by; (Morgan and Brunson, 2002):

- using low-volatility formulations;
- using low pressure and high volume;
- using the largest nozzle that is practical;
- not spraying when the temperature is high;
- spraying when the wind is low and blowing away from aquaculture facilities; and

- using spray thickeners when appropriate.

Reduce the risk of runoff by:

- delaying application if rain is expected;
- irrigating in accordance with pesticide label instructions and monitoring to avoid runoff and the accumulation of excess surface water;
- using no-tillage or minimum tillage cropping systems that reduce pesticide runoff;
- using soil-incorporation methods;
- using adjuvants that promote the retention of pesticides on treated surfaces;
- grading the surface and constructing
- drainage ditches and dikes; and
- planting border vegetation.

These cases are necessary for reducing the pesticide - fish interactions (Atamanalp and Yanik, 2001a):

- Before the building the ponds, soil has to be analyzed about the residue of pesticides
- The ponds have to be built far from the areas, which has rarely pesticide applications.
- If there are contaminated flows from the agricultural areas, you can prevent it with digging ditches.
- If there is prolonged pesticide contamination, underground water can be used.
- The movable of pesticides in water is about with their formulations. So, use the formulations which quick decompose.
- Select the pesticide which has less toxic
- Do not wash the pesticide packages or application equipments in the water sources.

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EXAMPLES OF THE SUSTAINABLE ARCHITECTURE IN BOSNIA AND HERZEGOVINA

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There is a saying in my country (Bosnia & Herzegovina): All living – „comes“ from water!

Following examples confirm this saying:

1. River Buna

River Buna's spring is in Blagaj, at foothill of the high side of Litica. In fact, it is just an extension of underground (subterranean) accumulation of water, so far unexplored. (First explorations – not until the year 2005).
On the very spring dervishes of Nakshibendisk order built TEKIJA (18th century). At the spring of life, i.e. river Buna's spring, the God is being praised and secrets of the world revealed.
But, at this same place people are showing utmost practicality: they are arranging Buna's riverbed, re-directing from the main axis its two branches, in order to use huge water power to set in motion (to start) water-hand wheel, i.e. to grind grain
Downstream, wealthy owners of large estates – Velagic – are erecting their own hand complex next to the river. Installing running water into the housing complex (Begovina river as well, near Stolac, and Blue water in Travnik, and others) is frequently done in the traditional housing architecture of Bosnia and Herzegovina. (since 15th century and up till now).
Besides that, Velagic's housing complex uses other principles of sustainable architecture, seen in:

a) disposition of complex and single bulidings(structures)
b) materialization of elements of the main building structure, as well as processing of areas with architecturally defined space.

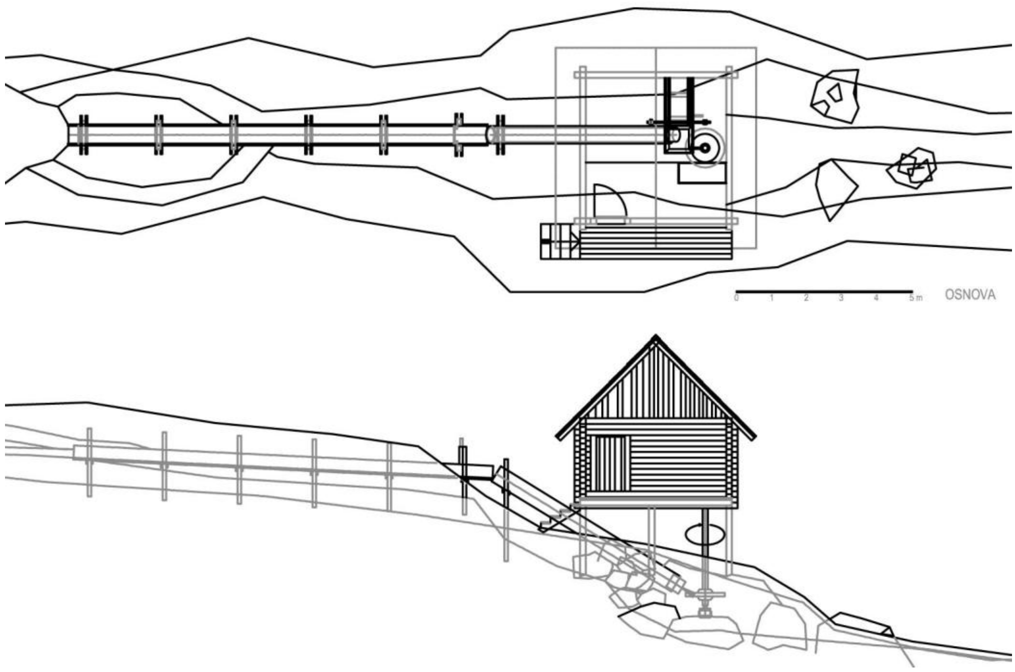
With general location of the complex a convenient micro-climate is assured, especially the high psychological-aesthetic criterion of the life.

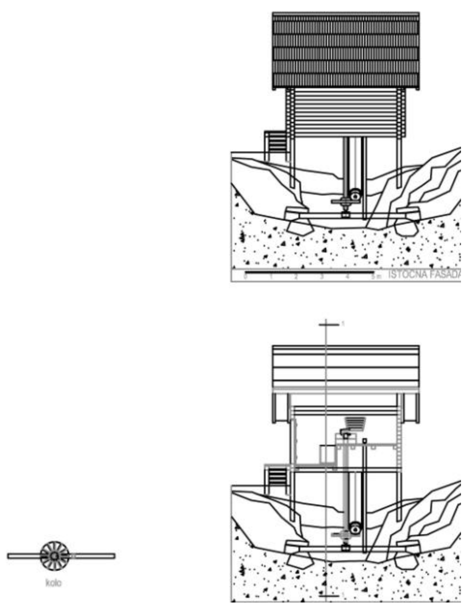
In the disposition of single structures delicate transitions are felt, open(natural) and closed (handmade). Crypto-climate is assured by disposition of vertical and horizontal plan to satisfy high human comfort.

Natural materials are used in the construction: stone, wood, plaster. The stone on the walking areas (courtyards, indoor and outdoor stairways, walls, roofer) seems to be the best solution, which integrate demands of function, aesthetics, and economy.Heavy stone walls and roofer with their weight(mass) assure great 'warm stability in summer regime'. On Kajtaz's house (Mostar) and on houses in Stolac we can see the same principles of encirclement of the housing area in the context of natural surrounding.

2. Water mill

This is an architectural program mainly of utilitaristic purpose – grinding grain into flour. Water mill, which is situated on the waterflow (river, stream), and its ways of re-directing the water to a simple but brilliantly justified mechanism that transforms the water power into rotating movements, is one of the most brilliant examples of sustainable architecture in Bosnia and Herzegovina.





3. Mejdan (s) – blacksmith shops

This is an unsurpassable example of sustainable (utilitaristic) architecture, where water power, along with two other inputs (wood and iron), is used in one - through centuries strategic, human need – iron processing. This handicraft in Bosnia and Herzegovina dates from the 15th century, and is still active.

At the pictures we can see Mejdans (situated along the Olovo – Vares road, and river Ocevica), also the ways of redirecting the course of a river into accumulation, as well as the way of transforming potential energy of water accumulation into kinetic, and further more into rotating and tactical motions.

4. Bosnian house – "Cardaklija-dimalucara"

Bosnian belvedere house is a complex structure, with disposition, construction, materialization and bio-physical function in natural context.

Classical type of the house has a basement “magaza”, ground floor and the first floor belvedere – “cardak”. The basement is partly buried, built of stone with a purpose to serve as a pantry for the most important foodstuffs.

The ground floor is intended to be a living room with open fireplace, as a centre for family gatherings. “Hatula” is used as a console for food preparation and also for a disposal of dishes. Rooms above the basement are hosts’ living rooms “baškaluci”, and the little bath is for a ritual washing before a prayer.

On the first floor there are rooms used as bedrooms for the rest of the family.
The fireplace at the ground floor is open all the way to the roof; the smoke from it permanently wrapps the roof shell, and therefore ‘impregnates’ the roof covering – shingle. The open space is a kind of protective buffer zone of the main constructive corpus, which in the winter period (when roof openings are closed) functions as a thermo – insulating buffer zone of closed air, while during the summer period (when roof openings are open) this is a form of ventilation of the main constructive corpus.

Divanhanas on the first floor are ajar relaxing places, but at the same time those are a solution for double façade, which is, in summer, used to make a shade, and in winter as a protecting buffer zone.

Construction materials (stone and wood) are from the near natural surrounding. stuco is made of sand – “kuma”, which is taken from a nearby river, and also from lime. It is sometimes made of clay, which is reinforced with straw.

Final white colour of the walls is whitewash, which has aesthetic dimension and is also a disinfectant.

It is interesting to compare concept design of the Headquarters for breate London Authority (Foster & Partners) and Bosnian belvedere house.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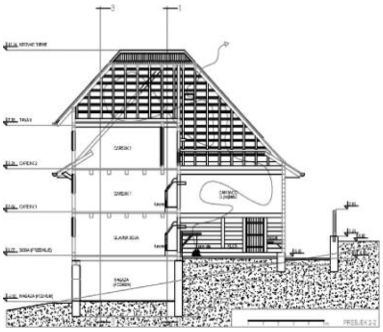

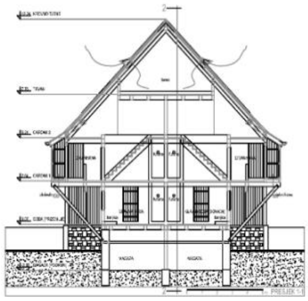

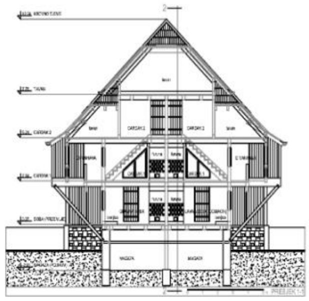

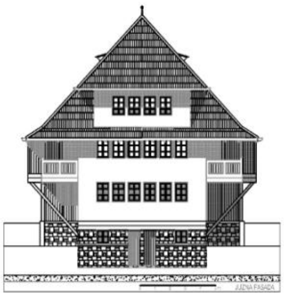

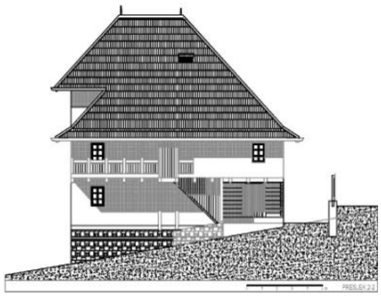

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AN INTERFACE BETWEEN METROPOLITAN AREA AND PERI URBAN EDGE

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Interface can be considered different patterns of mix between developed and natural landscapes. This paper aims to find out the issues, challenges and opportunities of an interface. The studied area is Keçimuhsine village which lies just outside the southwestern fridge of the Konya metropolitan area and encompasses the communities and landscapes around the Altınapa Watershed. Keçimuhsine village has natural, historical, cultural, ethnographical, folkloric and architectural value which forms environment by community identity and traditional rural patterns. This descriptive study provides contribution to academic milieu by analyzing traditional rural pattern, land use, building use, effects of water, local products like light rugs (jijims), defining community identity and its spatial properties in untouched interface between watershed and urban area namely Keçimuhsine village and its environment.
***Key Words**: Urban Interface, Peri-Urban Edge, Architectural Identity*

1. Introduction

Although urban interface has existed since people created settlements, studying this phenomenon associated with spatial is relatively new occurrence. Interface can be considered different patterns of mix between developed and natural landscapes. This paper aims to find out the issues, challenges and opportunities of an interface between watershed and urban area considering spatial, social, ecological and managerial aspects of studied area. The studied area is Keçimuhsine village which lies just outside the southwestern fridge of the Konya metropolitan area and encompasses the communities and landscapes around the Altınapa Watershed. This village settled in around Altınapa watershed is a good and authentic example of wildland/urban interface. Keçimuhsine village has natural, historical, cultural, ethnographical, folkloric and architectural value which forms environment by community identity, water resources, and traditional rural patterns. Like many other countries, the boundaries of urban areas are moving outward due to growth of residential developments, retail districts, and other related land uses. These planning movements threaten not only Keçimuhsine village and its environment but also its community identity. Community identity is often anchored in tangible environments and events of a community, and has the potential to serve as visions for urban planning processes.

1.1. The Concept Of Urban Interfaces in Literature

Cortner et al (1990) describes the interface as an intermingling of wildlands with interpersonal and adjacent development. Davis (1990) describes three types of interface: classic, intermix and isolated. Classic interface situations can be seen in many of the regional parks, state and forests where subdivisions and other development have grown to the very borders of the park or forest. In this sense, the interface has a clearly identified line of demarcation. In an intermix situation, developments such as homes or other structures are scattered throughout the wildland area. This "shotgun" pattern of land ownership presents the resource manager with a particularly vexing set of management problems.

As argued by Bradley (1984) and Kelly (1980) and extended by Ewerd (1993), the interface can be considered different patterns of mix between developed and natural landscapes; an area that managerially reflects advanced society values such as congestion; or an area that can be thought of as a natural resource "ecotone". Defining ecotone as an area of transition between two communities also has a set of unique characteristics.

Urban interface has existed since people created organized settlements, studying this phenomenon associated with spatial is relatively new occurrence. This growing interest and the concept of urban interfaces in literature can be classified in four groups.

First group of studies about urban interface is related with wildlands. Wildlands-urban interface issues such as land use allocation and water rights have immense economic, social, political and legal ramifications. These areas serve important social as well as ecological functions for a society that has become more urbanized. In the second group, these areas serve important social as well as ecological functions for a society that has become more urbanized. From the perspective of research and scholarship, the urban interface between watershed and urban area presents a wide range of possibilities. A sampling of these would include the influence of cultural, ethnical and racial diversity, fire on the interface, vandalism, recreational behaviors and policy implications. Third groups take urban interface concept as a social issue. Conflicts associated with use patterns, resource allocations and goal attainment have become more intense and polarizing. The studies in fourth group are hazards to a life and property have evolved as urbanization and other uses spread into the interface where fire and flood present serious and periodic threats. Except that these four groups, in literature interface has also different dimensions. Interface has been categorize the various attributes commonly associated with the wildland-urban interlace info four dimensions; social, spatial, ecological and managerial. Further compounding this dilemma are the many different issues surrounding the interface: eg. existing uses, boundaries, differing public perceptions of the most appropriate, uses of wildlands in close proximity to large urban centers. In the isolated interface, wildland areas are essentially surrounded by developments. Prime examples of this type of interface include urban and municipal parks and greenbelts. Often, this was the land that was deemed as too prone to flooding, too steep, or containing some other factor that precluded early development (Ewerd et all 1933). These attributes can be classified as

- Social (changing land ethics, broader spectrum of demands, emphasis on recreation)
- Spatial (degradation of natural entrainment close proximity to large cites ease of access)
- Ecological / biological (greater impact upon ecological systems, reduction in wildlife habitat, soil/water quality deterioration, high levels of site pollution)
- Managerial (changing zoning strategies, emphasis on law-enforcement and visitor regulation, discontinuity between visitor and manager attitudes saturation of available resources

That is, one group's activity is difficult to ignore from that of others. However spatial and ecological attributes will be emphasized on this study. Spatial attributes that are often associated with the wildling-urban interface include: relatively small size, close proximity to large population centers, ease of access and the clustering nature of many sites. Ecological attributes of the urban interface imply reduction in bio-diversity anal wildlife habitat, often through human action. Other ecological attributes include: increased pollution from off site a reduction in the amount of nutrient recycling and corresponding increase in water run off from the loss of woody ground material and soil compaction and an increase in soil toxicity through heavy metal can concentration (Cole 1987). In general, boundaries are dividing and connecting at the same time, marking the transition between different uses or territories. From this follows, that urban boundaries can be defined as the change-over from the urban to the rural area, e.g. indicated through different land-uses that reach from high density commercial uses at the CBD to low density agricultural uses at the edge of the city including differences in their built-up density - villages that are connected to the urban area by some development may also be related to the city. Beside the definition through land uses, the population density also gives information about where the separation of the "city" from its environment takes place - from high density or urban to low density or rural area (Batty and Londley 1994). It is obvious that the course of the urban boundary ultimately depends upon the definition of the changeover that is which kind of land-use is included and what the limiting value of population density is respectively.

What is the "interface" between wildlands and urban society? In terms of societal survival, it encompasses environmental elements such as water shed, fire, air quality, and biodiversity. In economic perspectives, wildlands provide resources, often unique- for power, medicines, building materials, and food and other goods as well as space for recreation a growing segments of the economy (Kelly 1992). Culturally interfaces may be the context of the history and development of ethnic societies and even of religions. Despite the image of separation, interfaces are tied to ongoing life in a modern society in multiple and inter woven ways.

2. Method

This study has a modest aim to contribute to academic milieu in untouched area considering architectural value. In other words this is a descriptive study. Holistic approach is used for this study another tool for describing this specific area to construct on matrix between the properties of Keçimuhsine and its space/community identity, water resources and traditional urban pattern for using photographs. Photographs basic vehicle of expression in transferring knowledge and explaining truths are one of the most important tool for this kinds of study.

3. The Case Study

Konya is a city of southwest-central Turkey south of Ankara. Konya is one of the first centers of history of mankind and its own many traces of various civilizations. During the ancient times, Konya had been located on the most important main roads of trade like silk and spice roads. Konya, ancient Iconium, is one of the oldest urban centers in the world. Excavations in the city indicate a settlement dating from at least the 3rd Millennium BC. According to a Phrygian legend of the great flood, Konya was the first city to rise after the deluge that destroyed humanity. Still another legend ascribes its ancient name to the Eikon (image), or the Gorgon's Head, with which Perseus vanquished the native population before founding the Greek city. After the collapse of the Hittite Empire, the Phrygians established a large settlement there. It was Hellenized gradually from the 3rd Century BC and became a self-governing city. When Kapodakya become part of Roman Empire, Konya also become a religious center of Christianity with St Paul who is one the apostle of Jesus. Then, Iconium was taken from the Byzantine Empire by the emerging Seljuk Turks in 1072, and became the capital of the Seljuk Empire. Renamed Konya, it reached its greatest prosperity under Seljuk rule and was accounted as one of the world's most brilliant cities of that period. Its enlightened rulers were great builders and patrons of art who endowed the city with many buildings, including some of the finest existing examples of Seljuk architecture. Konya later became known as the world's most important center of Islamic Mysticism, following the tradition of the world-famous philosopher Mevlana (known as "Rumi" in the West), who lived and preached in this city. Konya is also famous for its whirling dervishes, who follow the teachings of Rumi. The studies area called Keçimuhsine or in some sources Küçükmühsine is in Konya, in the boundaries of Selçuklu and next to Altınapa Basin (Figure 1).

Figure 1. The Location of Studied Area

Altınapa Dam is in the boundaries of Konya and it is located on the Dolav River 20 km for away Konya. Altınapa Dam is constructed in 1967 for protecting Konya from flooding and supplying water distribution system. There are 19 settlements in the Altınapa river basin. Basarakavak, Tepekoy, Akpinar, Selahaddin, Saraypinar, Mulayim, Ulumuhsine and Kücükmuhsine are some of the important and larger settlements around Altınapa River Basin. The nearest of these settlements to the Konya Metropolitan is Keçimuhsine in different sources called Kücükmühsine which is far from Konya about 20 kilometers. Since Keçimuhsine village on mountainous terrain, there is not as much research as other Altınapa river basin settlements like Basarakavak, Tepekoy, Akpinar, Selahaddin, Saraypinar, Mulayim, or Ulumuhsine.

3.1. As an Interface the Properties of Keçimuhsine

Keçimuhsine is an interface related with wildlands but this settlement belongs to second interface explained before. It serves important social as well as ecological function for a society that has become more urbanized. Keçimuhsine has also some properties belongs to third groups of urban interface which is related with social issue. The best definition of Keçimuhsine as an interface is “intermix interfaces” as Davis (1990) found out. According to Davis (1990) definition in an intermix interface structures are scattered throughout the wildlands area. The settlement of Keçimühsine is periurban edge far from Konya metropolitan area about 20 kilometers.

The location of Keçimuhsine: The central Anatolian region encompasses an extensive high plateau separated by numerous mountain ranges from the Black Sea the north and by the Toros mountain range from the Mediterranean regions of the south. Konya situated the grassy plain lands but the area studied on Toros Mountains. Keçimuhsine village is separated from flat area, Sarayönü in the north and Altınekin in the north-east by mountain called Boz. Another mountain called Takkeli Dağ exists in the east far from Keçimuhsine about 5 kilometers. The mountain of Boz lays 50 kilometer length from east to west and 1300 meter height. An archaeology tumulus, Sulutaş, next to Takkeli Mountain has historical importance. Around Sulutaş there is trace of settlements continuously from Neolithic age to Byzantium terms. Thus, it can be considered that there was a transportation web between Küçükmühsine and Basarakavak, Tepekoy, Uzundere, Güneyköy, Derbent and Ulumuhsine. Küçükmühsine Village was settled down the Lykaonia Region surrounded with Toros Mountains and their branches in the south and south west. Keçimuhsine is located where Konya Plain ends and where mountains start (Figure 2).

Keçimühsine Village exists in the boundaries of Konya Metropolitan in Selçuklu district located on Konya-Beyşehir main road. There are Başarakavak and Tepeköy villages in the north, Sulutaş, Ulumuhsine and Akpınar villages in the east, Değirmenköy and Salallı in the south of Keçimuhsine. In the east of Keçimuhsine there are mountains called Sivri and Şahin. There is also a mountain named Asbıray in the west of the village.

Climate: Cool, cold and rainy Mediterranean climate is seen in Keçimuhsine village. The temperature differences in winter and summer is too high and spring relatively passes quickly. Winter days are too cold and snowy. Summer days are too hot, dry and rainless. Thus village has barren flora with rainless plants.

Water resource: Drinking water is provided from Uluçay, Tepeköy and Başarakavak rivers in the west of the village. Water quality is poor in Keçimuhsine village because of several factors. The major reasons why water quality is poor is run-off and other reason is improper use of pesticides and herbicides in spite of limited agriculture.

KEÇİMUHSİNE VİLLAGE AND MOUNTAINS AROUND

THE SYMBOLS OF KEÇİMUHSİNE; CAVES AND GOATS

Figure 2. The rural pattern is defined by natural characteristics of the environment

Vegetation and Cultivation: The region is almost mountainous. The land for agriculture is so less that only it is enough for people who live in Keçimuhsine village. Little fruitful land for cultivation supplies wheat, barley and oaf. There are few fruit trees like apple, pear, plum, and apricot. Since 1980 juniper, oak, elm has been raised by afforestation studies. Natural plant cover of this settlement is wild pear, Mediterranean medlar, red dogwood, wild plum.

Social accessory: In this village there is a primary school, a village clinic and two mosques. There is almost no social facility in this settlement. Although in ancient times this settlements was a king of center, today migration is seen to Konya metropolitan because of unemployment, lack of fertile soil, lack of education opportunity. The population decrease more and more in every year.

Mainstay: Not only properties of climate and run-off also properties of flora force Keçimuhsine village to concentrate on livestock rising like goats, ships, and cows. (Figure 3) Infertility of soil, limited water and climate prevents make fit for cultivation in this region. Thus, raising animal is the mainstay of village. Other mainstay is local products like light rugs. In Keçimuhsine Village, Istar, a special carpet loom is widespread. 50 high in quality carpet and prayer rug are produced in a year.

Kilims in this region are generally woven in slitweave or plainweave, there are also some lovely jijims made here, kilims come in many sizes and shapes, and their color palette is allembracing. These ascertained particulars have led some authorities to say that Keçimuhsine kilim offers great variety in the range of designs and color combinations (Tunç, 1997).

3.2. Traditional Rural Pattern of Keçimuhsine

In the middle of village there is a river and both sides there are two 100 meter height mountains. The land of Keçimuhsine is volcanic properties having large amount andesite. In this mountain there are hundreds of caves. Some of these caves are used as storage. However, the caves far from Keçimuhsine almost 1 km were used as grave in ancient times .

Continuity in the traditional characteristics of the social group living in these environments has been observed in the settlements in the mountainous Mediterranean regions of the south. The rural pattern is defined by natural characteristics of the environment. In Keçimuhsine Village dwellings can not be thought of as single isolated units. Their relationship with nearby environment should also be studied in order to achieve a comprehensive understanding. It is almost impossible to understand where the rock caves finishes and where the dwellings start. Dwellings made of stone with soil flat proof roof were constructed in an imbricated way. Dwellings separated from each other by a garden are generally one or two stories. Ground floors of the dwellings are made up local stone found easily in this region called "*sille taşı*".

Service spaces are defined and designed according to social and economic requirements of the users. House forms respond to the social, economic and cultural characteristics of the family. The rural pattern is the physical demonstration of land ownership systems. The spatial organization of the dwelling unit directly reflects neighborhood relationships. The social use of space and privatization of territory comprise hierarchical relationships of private to public represented by living area and service area organization. There is hierarchy of spaces enabling the individual in the pathway. Most of the houses were organically and directly linked to the street, which itself become the semi-private communal meeting place extending from the house at ground floor level. With volute soil pathways are reached to the dwellings located on both hillsides.

The width of the street is changeable. In some sections the passageway is so narrow that the visual continuity is broken and the space is well suited for social interaction. However, the continuous wall created by the outer walls of the houses and the courtyards contribute to the formation of a particular identity .

Cultural and historical background of the inhabitants and also social composition and structure of the inhabitants is important in Keçimuhsine Village. The concept of neighborhood was not only physical entity within village but also social unit providing social and economic collaboration among neighbors. Residents' felt senses of their community can play substantial roles in determining visions for landscape change. Community identities are often anchored in tangible environments and events of a community, and have the potential to serve as visions for landscape planning processes (Steward et all 2004).

Since today migration is seen to Konya metropolitan because of unemployment, lack of fertile soil, lack of education opportunity. The population decrease more and more in every year. Today this authentic village is abandoned

4. Conclusion

The contribution of this study is to bring an overview to the urban interface phenomenon. Keçimuhsine settlement chosen for this study is not only a good example of interface between metropolitan area and peri-urban area but also it is unknown. This descriptive study provides contribution to academic milieu by analyzing traditional rural pattern, land use, building use, effects of water, local products like light rugs (cicim), defining community identity and its spatial properties in untouched interface. Rich architectural and rural heritage, including history, nature and community life pattern of this village are not valued. Since it is an interface between metropolitan and periurban are.

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EVALUATION OF ACOUSTICS FOR MEASURING SUSPENDED SEDIMENTS IN RIVERS

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The measurement of suspended sediments is important for understanding the pollution of lakes and oceans and for the accurate planning and management of water storage structures. The traditional technique of measuring concentration is direct water sampling method. However, this technique is restrictive in its ability to provide detailed spatial and temporal profiles of suspended sediment concentration. This has led to an interest in alternative methods for measuring suspended sediment concentration, and in particular, the application of acoustic methods. Acoustic methods involves propagating sound at around the megahertz frequency range sound through the water column. Short bursts of high frequency sound between 0.5 MHz-5.0 MHz transmitted from a transducer and directed towards the measurement region. Sediment in suspension will scatter a portion of this sound back to the transducer. Some main advantages of this method are that it allows profile measurements of the suspended sediments and the flow simultaneously, with high spatial and temporal resolution. In this paper, acoustic devices and the methods of operation are described. In addition the other advantages and some limitations especially for rivers, such as necessity of adequate flow depth, influence of turbulence and bubbles, and the requirement of calibration for different conditions are considered.
Keywords: Suspended sediment, Acoustic, ABS

1. Introduction

Knowledge of the erosion, transport, and deposition of sediment is important for the development and management of water and land resources. The measurement and analyses of suspended sediment is relatively difficult and expensive in comparison with other kinds of hydrologic data.

The primary traditional measurement method has been to take periodic water samples for water analyses. Two different sampling methods are used in rivers to determine thesuspended sediment. Point integrating samplers are designed to be lowered to a specific depth within the water column. By this means, a time averaged sample is taken that represents a specific point in the water column. Taking a series of measurements at different depths allows an analysis of suspended sediments with height above the bed. Depth integrating samplers are lowered and raised through the entire water column and accumulate a sample which integrates all points, thus giving a sample which reflects the entire content of the water column, but does not indicate the distribution of the contents within the column. The velocity at the entrance of the intake tube should be equal to the local stream velocity for an ideal suspended sediment sampler (ASCE, 1975).

Application of these traditional methods is simple but labor intensive to collect and process. Besides, this method is restrictive in its capability to provide detailed spatial and temporal profiles of suspended sediment concentration. For this reason, the use of acoustics to measure sediment transport processes has gained increasing acceptance within the sedimentological community over the past two decades. (Sheng and Hay, 1995; Thorne and Campbell, 1992, Holdaway et al, 1999; Thorne et al, 1998, Thosteson and Hanes, 1998). The application of acoustics to the measurement of suspended sediments has been validated by a combination of laboratory, field and theoretical studies.

2. Principle of acoustic method

The acoustic method involves the propagation of sound around a megahertz through the water column. Short bursts of high frequency sound, 0.5 MHz -5.0 MHz, are transmitted from a transducer are directed towards the measurement volume. Sediment in suspension will direct a portion of this sound back to the transducer. The strength of the backscattered signal allows the calculation of sediment concentration. The arrangement is illustrated in figure 1. The backscatter amplitude depends on the concentration, particle size, and acoustic frequency. This can be exploited by using multiple frequencies to determine both particle size and concentration. The strong signal from the bed can be used to measure the bed forms. Acoustic devices measure the concentration in a range-gated vertical profile of 1-2 m in depth. (Wren and Khunle, 2002; Thorne et al., 1991; Hay and Sheng, 1992)

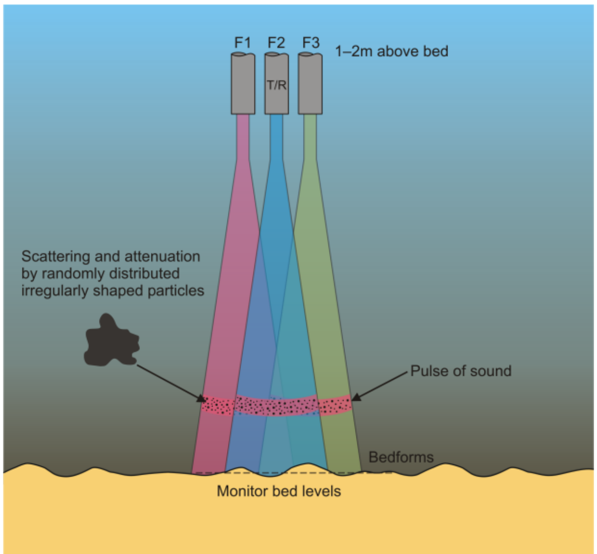

Fig. 1. The acoustic beam an ABS transceiver and the scattering from a particle on the axis of the.

Acoustic backscatter technology is still under development, however, commercially available hardware/software system to acoustically measure suspended sediment concentration profiles and mean particle size is available. Generally, the commercially available three-frequency acoustic backscatter system that contains three separate transducers and a data logger module is used. Each transducer operates both as a transmitter and as a receiver. Fig. 2 shows an instrument in its transport case (Smerdon , 1996).

Fig. 2. An acoustic backscatter system in its case.

4. Acoustic methodology

Interpretation of backscattered signal from suspensions of sediments is given this section. The following approach precise recent works (Sheng and Hay, 1988;Thorne and Campbell, 1992; Hay and Sheng, 1992; Thorne et al., 1993; Thorne and Hardcastle, 1997). The suspended sediment concentration *M*, can be expressed as:

$$M = \left\{ \frac{V_{rms} \psi \ r}{k_s k_t} \right\}^2 e^{4r(\alpha_w + \alpha_s)} \tag{1}$$

M is the suspended sediment concentration, V_{rms} is recorded voltage from the transducer, ψ, accounts for the departure from spherical spreading within the transducer nearfield.

$$\psi = \frac{1 + 1.35z + (2.5z)^{3.2}}{1.35z + (2.5z)^{3.2}} \tag{2}$$

where;

$z = r/rn$, $r_n = \pi \ a_t^2 / \lambda$

a_t is the effective radiating radius of the transducer, λ is the sound wavelength and *r* is range from transducer. k_t is a constant and found from calibration, α_w is the attenuation coefficient due to water absorption; its dependence upon water temperature, depth and salinity can be obtained from tables or by formulae. The absorption of sound for freshwater at atmospheric pressure can be written as (Fisher and Simmons, 1977):

$$\alpha_w = (55.9 - 2.37T + 4.77*10^{-2} T^2 - 3.84*10^{-4} T^3) 10^{-3} f_r^2 \tag{3}$$

T is in degrees Celsius, f_r frequency in MHz. α_s is the attenuation due to scatter in suspension and can be described by

$$\alpha_s = \frac{1}{r}\int \xi(r)M(r) \tag{4}$$

$$\xi = \frac{3}{4a\rho}\chi \tag{5}$$

χ, is the normalised total scattering cross-section. a_s is the radius of the particles in suspension. ρ_s is the density of the particles in suspension(~2650 kg.m^{-3} for sandy sediments).

$$k_s = \frac{<f>}{\sqrt{<a_s>\rho_s}} \tag{6}$$

f is form function and describes scattering properties of the particle. The normalised total scattering cross-section and form function values are related with particle radius and wave number of the sound in water. This relation was given by Thorne and Hanes (2002) as;

$$\chi = \frac{1.1(4/3)k_\alpha (ka)^4}{1+1.3(ka)^2+(4/3)k_\alpha (ka)^4} \tag{7}$$

$$f = C_0 \frac{k_f (ka)^2}{1+k_f (ka)^2} \tag{8}$$

$$C_0 = 1.1\{1-0.25\exp[-((ka-1.4)/2.2)^2]\}\{1+0.37\exp[-((ka-2.8)/2.2)^2]\} \tag{9}$$

$k_f \approx 1.1$, $k_a \approx 0.18$

Calibration constant, k_t, *is* determined from the acoustic backscatter strength of homogenous suspended sediment of known particle size and concentration level.. Eq. 1 is rearranged for k_t as;

$$k_t = \frac{V_{rms}\psi \; re^{2r\alpha}}{k_s M^{1/2}} \tag{10}$$

An example of a sediment calibration tower is shown in figure 3. Glass spheres are normally used for the suspension since they are readily available in the required size range and the scattering characteristics of spheres can be accurately predicted (Thorne et al., 1992)

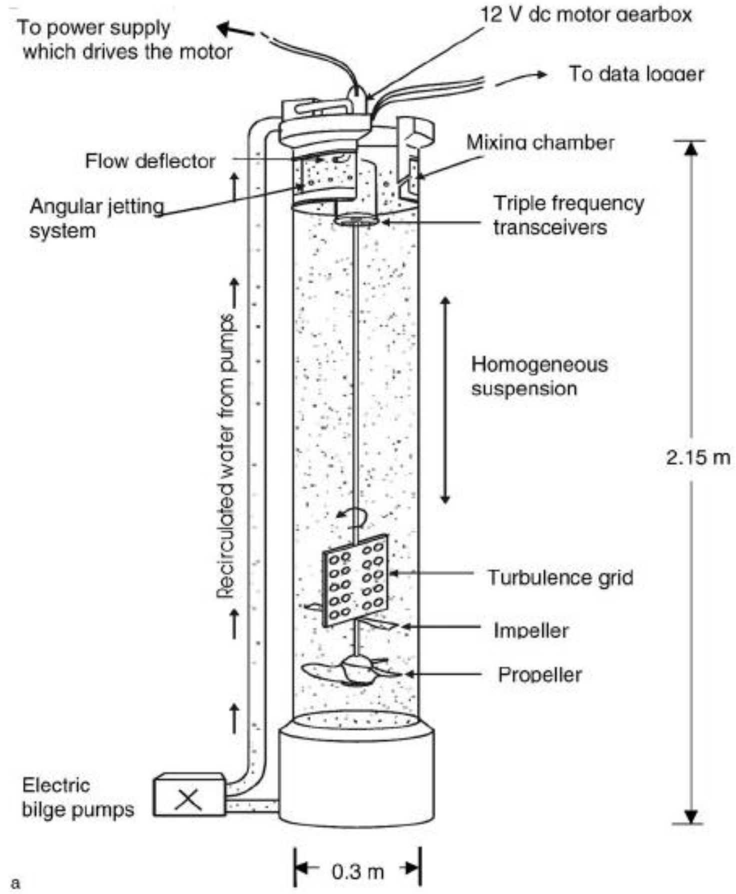

Fig 3. The sediment tower used for the calibration of the acoustic backscatter system. (Thorne and Hanes 2002)

5. Discussion and conclusions

The requirement for monitoring of suspended sediment concentration with temporal and spatial resolution has led to the development of acoustic measurement. But acoustic measurement is on going developmental phase and there are limitations and shortcomings

- Signal highly susceptible to absorption and scattering by air bubbles
- Evaluation difficulties of backscatter signal from the biological materials (especially at river which is effected by agricultural irrigation)
- Flow depth limitation for shallow rivers
- Calibration requirement for different particle size and different devices conditions.
- Software difficulties to learn and data processing labour intensive
- Expensive when compared to traditional sampling method

This method has been demonstrated and utilised successfully under laboratory and field conditions by several investigators. Results showed that sediment concentration and particle size can be measured relatively non-intrusive, with high spatial and temporal resolution with acoustic backscatter systems. Finally acoustics measurement is an alternative with the potential for further developments.

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ASSESSING GROUNDWATER VULNERABILITY: CASE STUDY FOR KARST AQUIFERS

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Groundwater from karst aquifers is among the most important drinking water resources in Europe: Carbonate terrains occupy 35 % of the land-surface and a significant portion of the drinking water is abstracted from karst aquifers. In some European countries, karst water contributes 50 % to the total drinking water supply and in many regions it is the only available source of fresh water.

In order to protect the existing groundwater resources, the estimation of the pollution potential of groundwater is essential. The methods used for this purpose have common properties: They are relative methods and help to calculate the pollution potential of groundwater by taking into consideration various hydrological parameters. These methods are grouped on overlay-index methods, process-based simulation models and statistical methods.

DRASTIC and COP are basic overlay and index methods used to evaluate and to rate the vulnerability of groundwater in the world, which use the common characteristics of groundwater resources such as geological, hydrological and hydrogeological conditions. Additionally, they can be integrated within geographical information systems, by which the groundwater protecting zones can be determined.

In this study, DRASTIC and COP methods which are used to evaluate the vulnerability of karstic aquifers to diffuse pollution sources in the USA and EU respectively, are applied to Antalya city aquifer which is mainly karstic.

Keywords: *Groundwater, Aquifer Vulnerability, DRASTIC, COP, COST Action 620, GIS, Antalya.*

INTRODUCTION

Groundwater pollution has been a major concern in recent years of the world involved with the management of water quality and quantity, and their relationship to human health. Particularly, with population growth, both drinking and potable water demand are increasing whereas due to contaminative human activities available groundwater resources are decreasing in their recharge areas (Yildirim and Topkaya 2006).

The groundwater system responds slowly to contamination events and the travel times to reach the groundwater zone are often long (Lindström and Scharp, 1995). However, karstic systems show some different properties such as high permeability rates, recharge mechanisms, and contamination events which affect the groundwater rapidly. Cleaning and restoring contaminated groundwater is often technically problematic and costly, and finding alternative sources for water supply is not always possible. Therefore, the most effective and realistic solution is to prevent the contamination of groundwater through adequate land-use planning and groundwater management (Linstörm 2005) and it need to be considered in regional scale without political boundaries.

For this purpose, in order to protect the existing groundwater sources and resources, first of all, the estimated pollution potential/vulnerability of groundwater should be determined. In this respect, groundwater vulnerability evaluation methods are widely used in the world. In 1987, GOD method is developed by Foster and is described as an empirical ranking system for the rapid assessment of aquifer vulnerability to contamination. DRASTIC index method used by US-EPA is also developed by Aller et al. in order to protection the groundwater resources in USA. In Europe, for a better assessment of vulnerability in small scale as required in Italian highly diversified hydrogeology, SINTACS method is developed by Civita et al. in 1990's.

In 1991, the Groundwater Group of the EC Commission decided to uniformize the criterias and procedures to evaluate, rank and map of groundwater pollution potential, used by each member state. The "vulnerability and risk mapping for the protection of carbonate (karst) aquifers" (COST Action 620) which was established by the delegates of 16 European Countries, worked from 1997 to 2002 to develop an approach to vulnerability and risk mapping that took into account the particular characteristics and the known high vulnerability to contamination of carbonate (karst) aquifers. The major task of the COST Action was to develop a general, non-prescriptive approach to intrinsic vulnerability mapping, which could be adapted into methods appropriate for use in individual karst areas of Europe. This action is include many disciplines as hydrogeology, karst geomorphology, environmental chemistry and microbiology, and other disciplines dealing with karst aquifers, and makes reference to several methods for mapping vulnerability areas. For this purpose, EPIK is developed by Dörfleiger & Zwahlen in 1997 and COP method is also developed by Vias et al. in 2006, which are recommended in the COST Action 620 that is used to assessment of karst aquifers.

In this study, US-EPA and EU approaches to groundwater vulnerability are discussed and compared. As case study, the DRASTIC method (US-EPA), and COP method (EU) are applied to Antalya Karst Aquifer System.

CONCEPT OF THE VULNERABILITY

In hydrogeology the term vulnerability was first used in late 1960s by French hydrogeologist J. Margat, and since then it has been used more widely in 1980s (Haertle, 1983; Aller et al., 1987; Foster and Hirata, 1988; Vrba and Zaporozec, 1994; Lindstörm 2005; Babiker et al., 2005). Currently, the term is commonly used all over the world. Upon a common definition of groundwater vulnerability has not been agreed and various definitions of vulnerability have been proposed. The report COST 65 (1995) of the European Commission presents an overview of the various definitions. One often-used definition is: "Groundwater vulnerability is the tendency of or likelihood for, contaminants to reach a specific position in the groundwater system after introduction at some location above the uppermost aquifer" (NRC, 1993). The basic premise underlying the concept of aquifer contamination vulnerability is the variation of groundwater recharge mechanisms and the natural attenuation capacity of soil and subsoil profiles. Thus, instead of applying universal controls over potentially contaminating land uses and effluent discharges, it is more cost effective to vary the type and level of control according to this attenuation capacity (Foster et al., 2002; Lindstörm 2005).

Groundwater vulnerability can be defined as intrinsic and specific vulnerability (Vrba and Zaporozec, 1994; Gogu and Dassargues 1999; Lindstörm, 2005; Babiker et al., 2005, Vias et at. 2006). Intrinsic vulnerability to groundwater pollution is the degree of attenuation capacity that is independent of the nature of the contaminants and the contamination scenario. The intrinsic vulnerability takes into account the geological, hydrological and hydrogeological characteristics of an area (Zwahlen, 2004). The specific vulnerability takes into account the properties of a particular contaminant or group of contaminants in addition to the intrinsic vulnerability of the area.

There is no general methodology of intrinsic and specific vulnerability assessment; nevertheless, several approaches are developed. These approaches are separated three categories (Anthony et al. 1998; Tesoriero et al., 1998; Thirumalaivasan et al. 2003; Lindstörm, 2005; Babiker, 2005): I) Overlay and index methods, II) Process based simulation models, III) Statistical methods.

Overlay and index methods combine factors controlling the movement of pollutants from the ground surface into the saturated zone resulting in vulnerability indices at different locations. Their main advantage is that some of the factors such as rainfall and depth to groundwater can be available over large areas, which makes them suitable for regional scale assessments (Thapinta and Hudak, 2003; Babiker, 2005).

Process-based simulation models are used for examining vulnerability from a quantitative point of view and for establishing clearly identified reference criteria for quantification, comparison and validation purposes. Process-based models use current scientific understanding to incorporate the most important and relevant processes, using the governing equations for water flow and solute transport. The focus is on computing travel times or concentrations of a contaminant in the unsaturated and groundwater zones (Anderson and Woessner, 1992; Lindstörm 2005).

Statistical methods use statistics to determine associations between spatial variables and actual occurrence of pollutants in the groundwater. Their limitations include insufficient water quality observations, data accuracy and careful selection of spatial variables (Babiker et al. 2004).

US-EPA Approach to Vulnerability and DRASTIC Index Method

DRASTIC, is developed by *Aller et al.* and US-EPA in 1987, is a groundwater quality index for evaluating the pollution potential of large areas by using hydrogeologic settings (factors) of the regions in USA. DRASTIC evaluates pollution potential based on seven hydrogeologic factors (Figure 1), which make up the acronym DRASTIC: **D**epth of the water table, net **R**echarge, **A**quifer media, **S**oil type, **T**opography, **I**mpact of the vadose zone and hydraulic **C**onductivity (Navulur and Engel 1997).
The DRASTIC Index, a measure of the pollution potential, is computed by summation of the products of rating and weights of each factor as follows:

$$DRASTIC\ Index\ (DI) = 5.D_r + 4.R_r + 3.A_r + 2.S_r + 1.T_r + 5.I_r + 3.C_r$$

Where D_r, R_r, A_r, S_r, T_r, I_r and C_r are ratings for rates of each factor.

The higher DRASTIC index, the greater is the relative pollution potential. The DRASTIC index can be further divided into four categories (Table 1): Low, moderate, high, and very high. The sites with high and very high categories are more vulnerable to contamination and consequently these needs to be managed more closely (Engel et al. 1997). The weights assigned are relative, therefore a site with a low pollution potential may still be susceptible to groundwater contamination but it is less susceptible to contamination compared to the sites with high DRASTIC ratings (Aller et al.1987) In the framework of this study, the generalized DRASTIC index is divided into six categories, in order to classify the vulnerability of the study area more accurately.

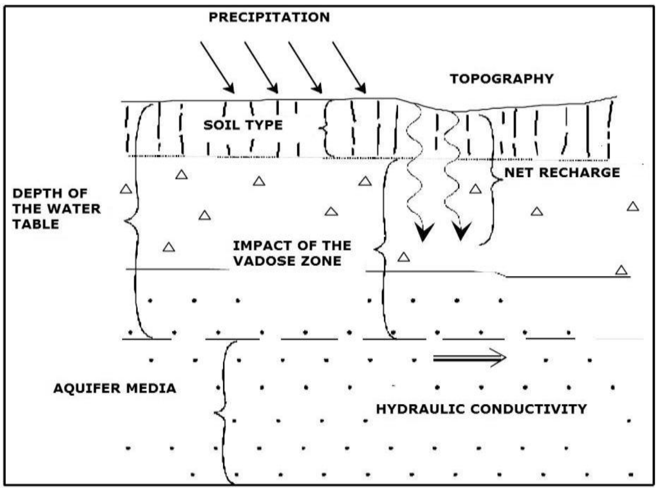


Figure 1. The Elements of DRASTIC Model (US-EPA). Hydrogeological settings.

Table 1. DRASTIC Index (DI) Ratings (Aller et al. 1987)

Pollution potential	Index Ratings	Index Ratings in this study
Low	DI≤100	0-100
Moderate	100<DI≤140	100-120 120-140
High	140<DI≤180	140-160 160-180
Very High	180<DI	180<

European Approach to Vulnerability and COP Method

The European Approach to vulnerability, hazard and risk mapping is based on an origin pathway – target model, which applies for both groundwater resource and source protection. Origin is the term used to describe the location of a potential contaminant release. The target is the water, which has to be protected. For resource protection the target is the groundwater surface, for source protection it is the water in the well or spring. The pathway includes everything between the origin and the target. For resource protection, the pathway consists of the mostly vertical passage within the protective cover, for source protection it also includes horizontal flow in the aquifer (Figure 2) (Zwahlen, 2004). According to the European approach, COP method can be used for evaluating vulnerability of groundwater resources.

The European Approach uses four factors in assessing vulnerability of karst aquifer: Overlying layers (O), Concentration of flow (C), Precipitation regime (P) and Karst network development (K) (Figure 3). The factors O, C and K represent the internal characteristics of the system, while the P factor is an external stress applied to the system. The O factor may comprise up to four layers – soil, subsoil, non-karst rock and unsaturated karst rock. The C factor recognizes that in karst areas the overlying protective layers may be bypassed by runoff, which is concentrated at or near the surface of the ground and which then enters the groundwater system via a doline or a stream sink. For resource vulnerability mapping, where the target is the top of the saturated zone, the factors O, C and P should be taken into consideration, while, in addition, the K factor should be taken into account for source vulnerability mapping where the target is a karst water supply such as a borehole or a spring (Daly et al. 2002; Goldscheider and Popescu 2004).

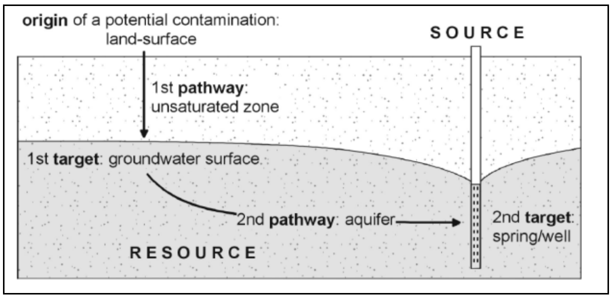


Figure 2. European approach to vulnerability (Zwahlen, 2004)

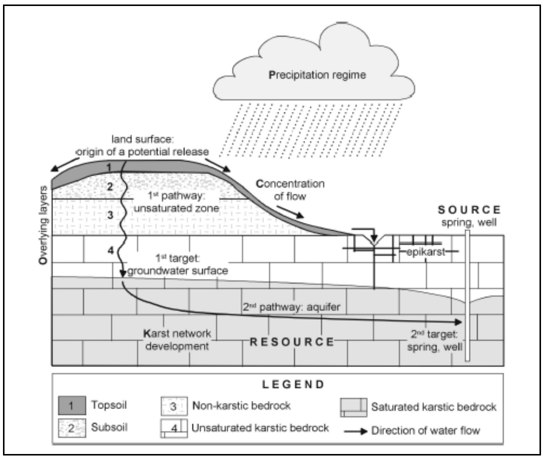
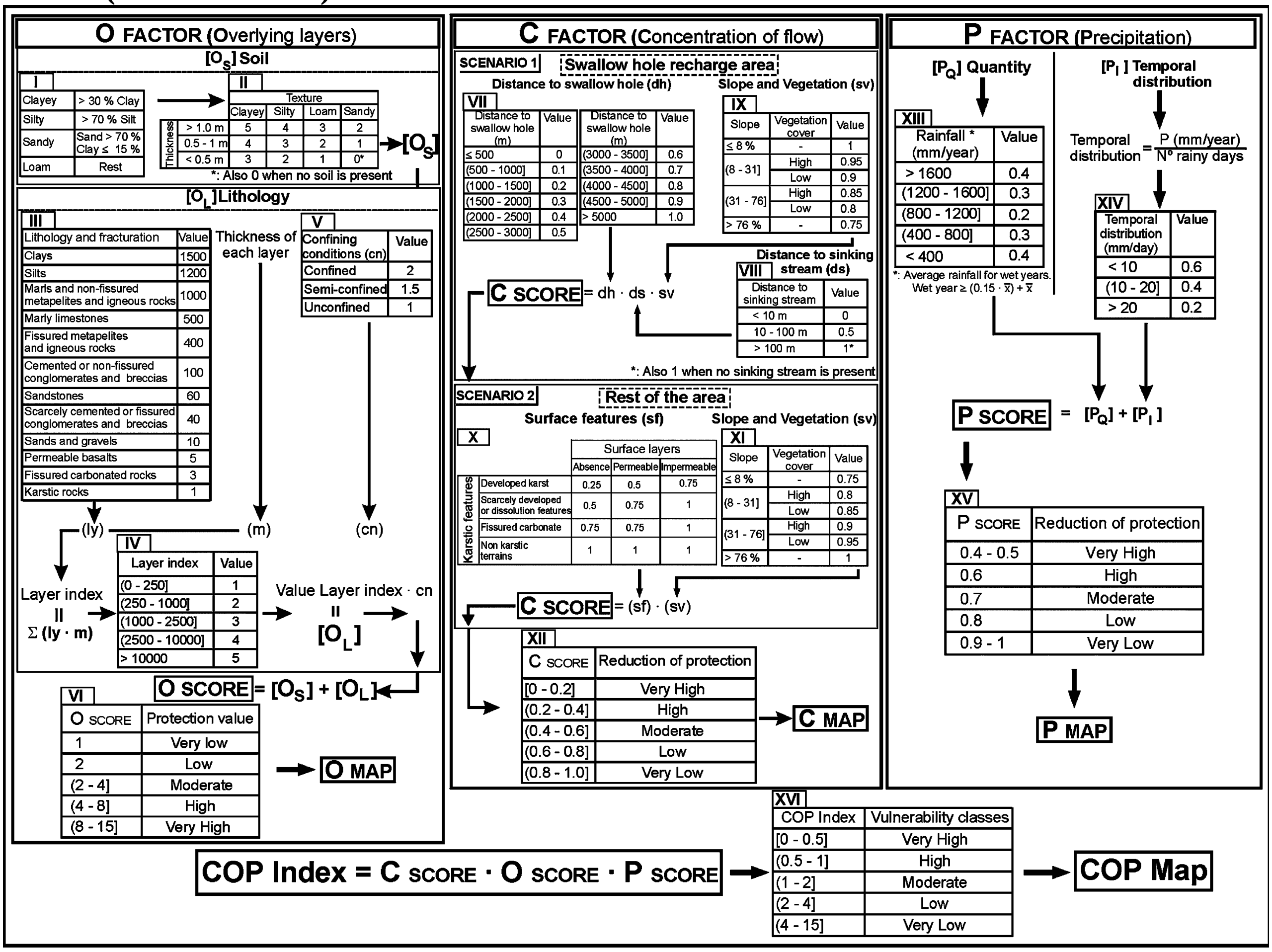


Figure 3. The main factors of the karst aquifer vulnerability, according to the EU approach (Daly et al. 2002; Goldscheider and Popescu 2004).

The conceptual basis of the COP method, according to the European Approach (Daly et al. 2002; Goldscheider and Popescu 2004), is to assess the natural protection of groundwater (O factor) determined by the properties of overlying soils and the unsaturated zone, and also to estimate how this protection can be modified by the infiltration process – diffuse or concentrated – (C factor) and the climatic conditions (P factor – precipitation) (Vias et al. 2006). Calculation of COP value can be seen in Table 2.

Table 2. Diagram of the COP method, showing the differentiation of the C, O and P factors (Vias et al. 2006)



Study Area and Mapping Groundwater Vulnerability of Antalya City

The main residential areas of Antalya City are located on groundwater rich travertine formation where precipitation and surface runoff can easily and rapidly penetrate through the ground. The porous rock forms the water bearing stratum from which the whole city and the surrounding settlements obtain their drinking water via springs and wells that are drilled in the karstic limestone. It is assumed that the groundwater flows through three main Duden Channels (rivers in the subterranean), and reaches to the Mediterranean Sea. Tracer tests have demonstrated that flow velocity in the travertine is about 200 m/day (Yildirim and Topkaya, 2006).

The study area which extends to approximately 758 km^2, consists of two travertine plateaus, separated by a 100 m high cliff. The city of Antalya is located on the lower plateau. It is terminated by a cliff (on average 40 m high) separating it from the sea (Figure 4).

The population increase rate of Antalya is considerably higher than the Turkish overall increase rate. Between years 1975 and 2002, the population has increased five fold whereas the residential areas have expanded 25 fold and the population density decreased five fold (Yildirim and Topkaya, 2006). According to the population census results and the calculated projections, it can be forecasted that the residential areas will increase more than 290 km^2 until the year 2010. Together with increasing expansion of the city area, groundwater sources may beneath the urban areas and groundwater pollution is majority problem for drink water demand of Antalya city.

On the other hand, only a part of the city has a modern sewerage system, where the wastewater is disposed via percolating septic tanks in the remaining majority of the inhabited areas. Historically, the porous travertine formation, on which the major part of the city is settled, has been a convenient and inexpensive disposal option for wastewater and storm water, by simply percolating into the porous rock. Although numerous projects on amendment of the sewer system are ongoing, the rate of urbanization shadows these efforts. Therefore it is most probable that in the near future, septic tanks would continue to be the major disposal system (Yildirim and Topkaya, 2006).

The other pollution sources which can affect the groundwater sources in the study area are sinkholes, industrial districts and petrol stations (Figure 5). The data related to the hydrological settings are obtained by monitoring wells in the region (Figure 6).

Groundwater Vulnerability According to DRASTIC Method

In order to create the DRASTIC vulnerability map of groundwater sources, seven DRASTIC factors are transferred by using GIS software. *D*, *A* and *I* factors are derived from data of 173 wells (Figure 6). *S*, *T* and *C* factors are derived by digitizing to soil maps (1:25 000), using topography maps (1:25000 scale) and hydrogeology map, respectively. Also, *R* factor is calculated by using Williams and Kissel equation (Czymmek et al. 2003).

Additionally rating ratios for each setting are assigned and using the GIS map calculator, spatial results are calculated. These results are interpolated by using Kriging interpolation method and finally vulnerability map for the study area is obtained (Figure 7). This map shows that the pollution potential of groundwater is rated as “very high” in Topcular – Airport zone whereas the entire coastal zone of the city has “high-very high” pollution potential.

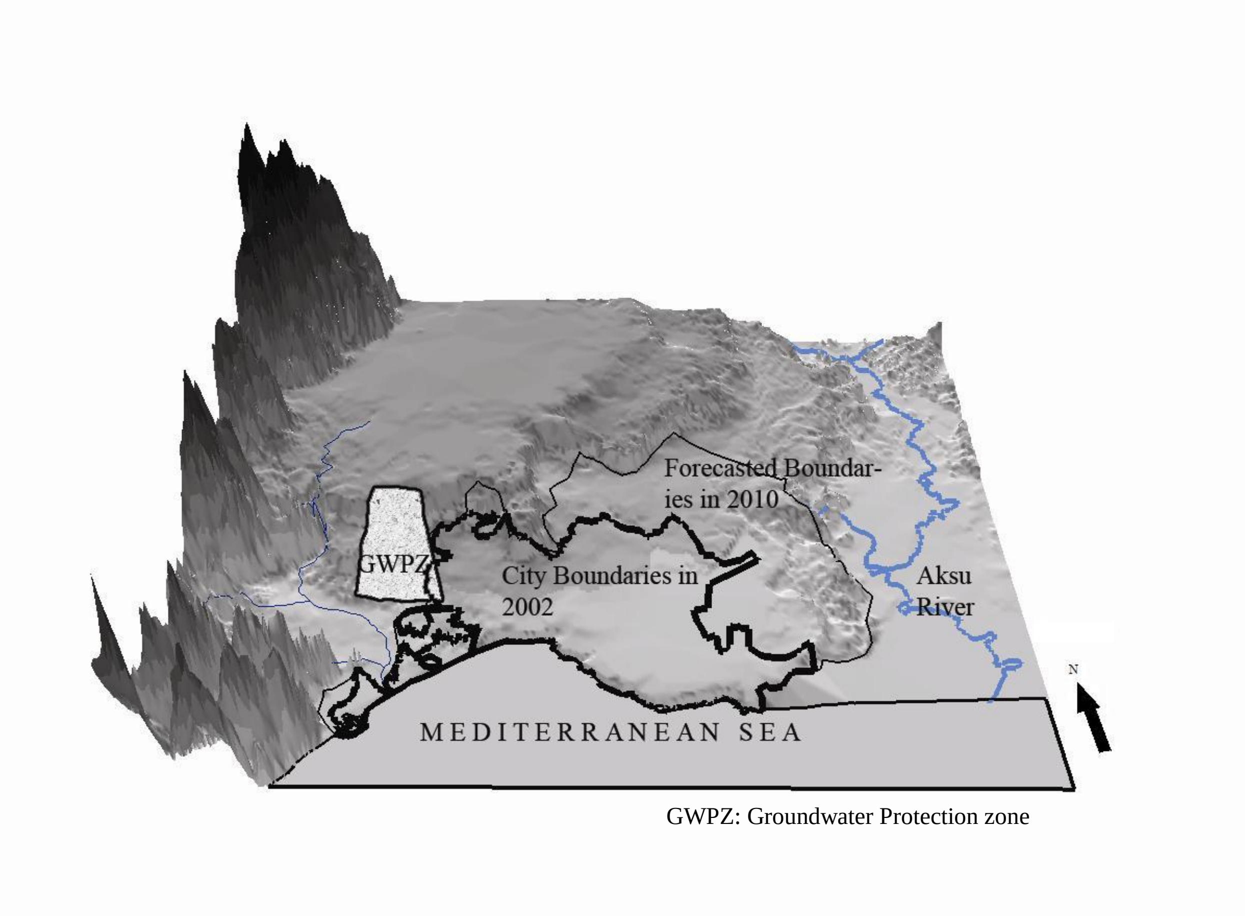


Figure 4. Antalya City's 3D model and city boundaries

Groundwater Vulnerability According to COP Method

The *C* factor is derived from data of swallow/sinkhole locations and slope and vegetations, according to Table 2. For the scenario 1, locations of sinkholes, vegetation cover and slope are determined, using GPS, landsat 2002 satellite image and 1:25000 scale topography maps, respectively. It is show that sinkholes are intensively located to northwestern part of Antalya city and vegetation cover is developed in high inclined areas at the boundary of upper and lower plateau. For the scenario 2, karstic feature in whole area is high developed and permeable.

The *O* factor is determined by two sub-factors: Soils and lithology. When the O_S sub-factor is created, according to Table 2, texture and thickness of soil groups are investigated. Great part of soils in the study area is terrarossa, clay content of which is high (more than %30) and other soils of the study area are kolluvial, regosol, brown forest soil and alluvial. For the O_L sub-factor creation, Lithology, fracturation and confining conditions of the area are obtained from well data, spreading to whole study area. Summating of O_S and O_L, O factor is calculated.

The P factor is evaluated by two sub-factors: Quantity of precipitation P_Q and temporal distribution of precipitation P_I (Table 2). The P_Q sub-factor describes the effect of rainfall quantity and the annual recharge on groundwater vulnerability. It corresponds to the mean annual rainfall of a historical series of wet years (Vias et al. 2006). Evaluation of P_Q and P_I sub-factors are carried out by meaning annual average precipitation and number of rainy days of 21 years period.

The factors of the COP method have been combined to evaluate the vulnerability of groundwater resources of Antalya city (Figure 8), as proposed in the following formula; "*COP Index* = $C \cdot O \cdot P$". This map shows that, the vulnerability class is rated *"high"* and *"very high"* in northeastern part of the study area where sinkholes are intensively located, and in the south part of the study area where the city is located.

As the sinkholes are not taken into consideration at the DRASTIC method; the differences between the methods are occurred. In order to take adequate measures against the pollution threat, the locations of each pollution sources should be coincided with the vulnerability maps (Figure 6).

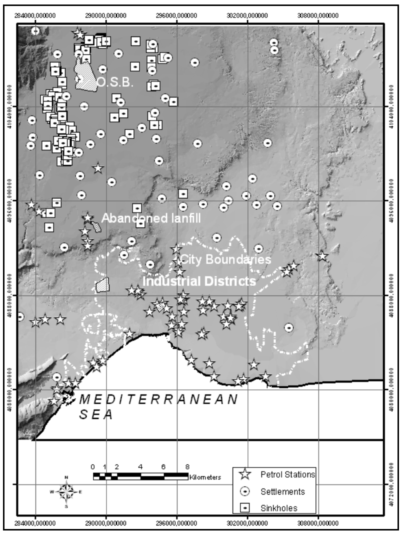


Figure 5. Locations of Pollutant Sources: Sinkholes, Industrial Districts, Settlements and Petrol Stations

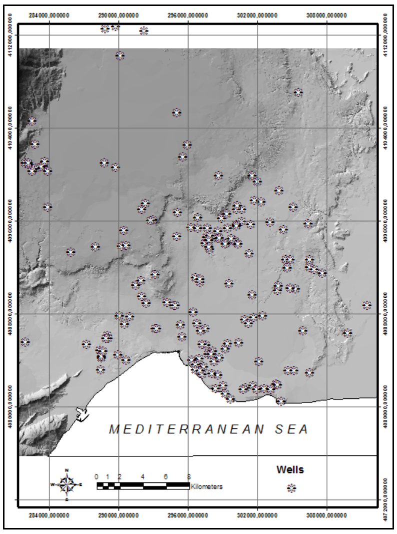


Figure 6. Locations of Monitoring Wells

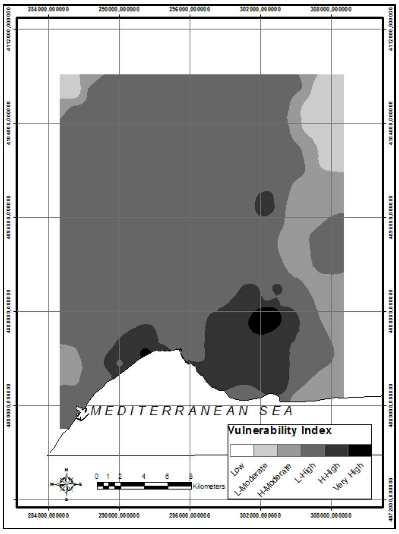


Figure 7. Vulnerability Map (DRASTIC)

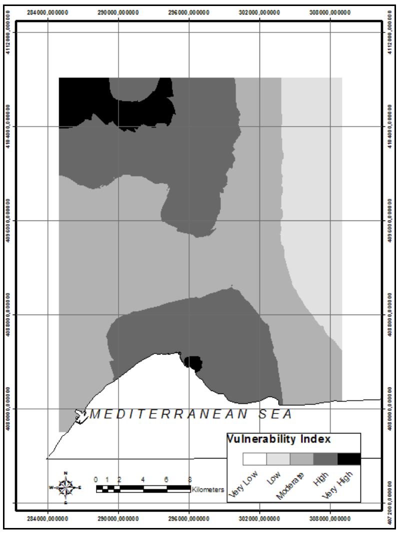


Figure 8. Vulnerability Map (COP)

CONCLUSIONS

In this study, DRASTIC and COP methods are presented as a tool for the assessment of pollution potential of groundwater affected by various sources, and is applied to Antalya city area. The vulnerability maps show the activities that take place in the whole city and the surrounding area, and represent a pollution threat for the groundwater resources where immediate measures should be taken. In the DRASTIC method, sinkholes are not taken into account and uncertainties are occurred while investigation of the northwestern part of the study area. However, COP method which is developed for the assessment of pollution potential of karst aquifers showed more certain results.

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CHARACTERISTICS OF SPRING WATER IN THE MID-BLACK SEA REGION

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Main sources of water are surface and ground water. A spring is a point where the aquifer surface meets the ground surface. Dependent upon the constancy of the water source (rainfall or snowmelt that infiltrates the earth), a spring may be ephemeral (intermittent) or perennial (continuous). Spring water is often taken for granted, but recent circumstances indicate that spring water is seriously vulnerable to pollution and depletion. Recently, the increased needs for supplies in Turkey, as well as in other countries, have necessitated a better understanding of water quality, so that it has become imperative to monitor water quality systematically by means of an objective- based network. Thus, with respect to environmental pollution control, determination of sudden and continuous change in spring water quality and further, the delineation of natural and/or man-made impacts which underlie such changes require the establishment of a systematically operating monitoring network. In Mid-Black Sea Region, pollution poses the greater threat. Contaminants which threaten people's health have been found in many of the region's important groundwater reservoirs. Some of the contaminants may be so expensive to remove that they make the water virtually unusable for years. Because of this threat, it is important to understand the processes that make ground water available for use how human activities sometimes threaten this resource. Water is the single most important nutrient for sustaining human life. In this study, 10 spring water samples which are collected from Mid-Black Sea Region have been analyzed. These samples are taken from Amasya, Ordu, Samsun and Sinop. Physical and chemical properties of above mentioned spring waters are determined. Measured parameters are turbidity, color, pH, electric conductivity, total alkalinity, carbonates, bicarbonates, total hardness, calcium, magnesium, iron, chlorine, sulphate, nitrite, ammonium and organic materials. Results had been evaluated according to TS 266 (2005).

Keywords: *Spring water, Drinking water quality, Physical and chemical properties*

Introduction

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it. Developed countries have long identified major environmental hazards and have successfully implemented monitoring and remediation programs to minimize the risks involved. On the other hand developing countries lack such measures or they are lagging far behind (Koukal et al., 2004).

Water is generally classified into two groups: Surface Water and Ground Water. Surface water is just what the name implies; it is water found in a river, lake or other surface impoundment. This water is usually not very high in mineral content, and many times is called "soft water" even though it usually is not. Surface water is exposed to many different contaminants, such as animal wastes, pesticides, industrial wastes, algae and many other organic materials. Ground water is that which is trapped beneath the ground. Rains that soak into the ground, rivers that disappear beneath the earth, melting snow are but a few of the sources that recharge the supply of underground water (Sarkar et al., 2006). Because of the many sources of recharge, ground water may contain any or all of the contaminants found in surface water as well as the dissolved minerals it's long stay underground. Most human activities at the land surface cause some change in the quality of water in the aquifer beneath them (Correljé et al., 2006). The importance of the effect of a particular activity is related to the amounts and types of contaminants released. The severity of an occurrence is also related to ability of the soil and ground water system to degrade or dilute the contaminants and the degree to which the contamination will interfere with uses of the water. Contamination is usually more serious in a drinking water supply than in water for other uses (Chapman, 1997).

In Mid-Black Sea Region, awareness of environmental problems is rapidly increasing. Information physical and chemical properties in sources of spring water from Mid-Black Sea Region are limited. Due to high annual rainfall in the region, floods result in transport of contaminants from agricultural areas to spring waters. The study presents a snapshot assessment of the water quality in the region of Mid-Black Sea based physicochemical investigation carried out in winter and summer.

2. Materials and Methods

Mid- Black Sea region is northern in Turkey. The study area is 27 228 km^2. In Mid-Black Sea Region, main sources of drinking water are spring and surface waters. Physical and chemical parameters of spring waters detections tended to be more frequent and more concentrated during the summer and winter months. 20 samples collected, two times from ten locations. The spring waters Soğuksu, Balıklı, Suçıkan, Kertil, Karpuz, Güllük, Hoşkadam, Karamahmutlar, Hızarındere and Yanevler. At each location, samples were collected by strapping 3 –l glass bottles. Measured parameters are turbidity, color, pH, electric conductivity, total alkalinity, carbonates, bicarbonates, total hardness, calcium, magnesium, iron, chlorine, sulphate, nitrite, ammonium and organic materials. The water quality parameters were estimated following the standard methods (APHA, AWWA, 1995).

3. Results and Discussion

The physicochemical characteristics of spring water samples are given in Table 1 and 2. The results are compared with the Turkish Standard for drinking water (TS 266, 2005) and the concentrations falling above the guideline values, are identified and discussed. The color values of Soğuksu, Balıklı, Kertil, Güllük, Karamahmutlar and Yanevler Springs are higher than Turkish Standards guideline levels. The color values of Hızarındere and Karpuz Springs are only high in winter months. According to Table 2, color values of Hoşkadam Spring is higher than standard Maximum Admissible Concentration. The iron values of Soğuksu, Balıklı, Karpuz, Güllük, Hoşkadam and Yanevler Springs are higher than standard guideline levels (Table 1 and 2). The estimated iron value at location Balıklı (0.18 – 0.17 mgl^{-1}; Table 1) approaches the maximum level (0.20 mgl^{-1}) acceptable for drinking water. This element may cause unsightly stains and produce a brown precipitate (Koukal et al., 2004). The pH values of spring water samples are within the recommended range 6.5 – 8.5 potability. The estimated nitrite, ammonium and organic matter values are acceptable for drinking water (TS 266, 2005). The levels of water quality parameters like conductivity, hardness, calcium, magnesium, chlorine, sulphate, bicarbonates are acceptable for drinking water (TS 266, 2005).

Table 1

Physicochemical parameters of spring waters at Mid-Black Sea Region from summer and winter months

Parameter	Sampling Locations				
	Soğuksu	Balıklı	Suçıkan	Kertil	Karpuz
	I[a] – II[b]	I[a] – II[b]	I[a] – II[b]	I[a] – II[b]	I[a] – II[b]
Turbidity (NTU)	0.00 - 1.00	1.00 - 0.00	0.00-0.00	1.00-1.00	0.00-3.00
Color	7.00 - 8.00	4.00 - 2.00	0.00-1.00	14.00-19.00	1.00-8.00
pH	7.67 - 7.91	7.33 - 7.89	7.42-7.64	6.93-7.13	7.06-7.32
E.C. (μS cm^{-1})	418.00 - 403.00	580.00 - 578.00	431.00-418.00	73.00-70.00	347.00-348.00
Alkalinity (mmol l^{-1})	165.40 - 165.20	211.20 - 175.80	170.80-167.80	27.00-26.00	154.00-158.00
Calcium (mg l^{-1})	46.00 - 49.00	60.00 - 60.00	59.00-60.00	9.00-10.00	63.00-59.00
Magnesium (mg l^{-1})	13.16 - 9.17	21.09 - 19.00	10.65-7.00	9.68-9.17	2.82-1.96
Hardness (mmol l^{-1})	16.91 - 16.01	23.67 - 19.00	19.13-17.00	6.23-5.80	16.91-15.68
Nitrite (mg l^{-1})	0.002 - 0.001	0.003 - 0.001	0.000-0.001	0.002-0.020	0.000-0.012
Ammonium (mg l^{-1})	0.00 - 0.01	0.01 - 0.00	0.00-0.00	0.00-0.02	0.00-0.03
Organic M. (mg l^{-1})	0.00 - 0.00	0.00 - 0.00	0.00-0.35	0.00-0.20	0.00-0.42
Iron (mg l^{-1})	0.04 - 0.09	0.18 - 0.17	0.05-0.01	0.04-0.05	0.18-0.11
Chlorine mg l^{-1})	3.50 - 3.70	1.20 - 2.10	1.20-1.00	0.50-0.50	2.70-3.00
Sulphate (mg l^{-1})	6.00 - 5.00	15.00 - 14.00	28.00-30.00	15.00-14.00	12.00-11.00
Carbonates (mg l^{-1})	n.d.	n.d.	n.d.	n.d	n.d.
Bicarbonates (mg l^{-1})	201.79 - 201.54	257.66 - 214.48	208.37-204.72	32.94-29.46	187.88-193.70

n.d.: Not detected

[a] Summer months of sampling

[b] Winter months of sampling

Table 2

Physicochemical parameters of spring waters at Mid-Black Sea Region from summer and winter months

Parameter	Sampling Locations				
	Güllük	Hoşkadam	Karamahmutlar	Hızarındere	Yanevler
	I[a] – II[b]	I[a] – II[b]	I[a] – II[b]	I[a] – II[b]	I[a] – II[b]
Turbidity (NTU)	1.00-1.00	6.00-3.00	4.00-0.00	0.00-2.00	2.00-4.00
Color	10.00-4.00	18.00-38.00	3.00-0.00	0.00-6.00	4.00-5.00
pH	7.75-7.31	7.12-7.29	7.25-7.65	6.70-6.72	7.98-7.22
E.C. (μS cm^{-1})	547.00-511.00	391.00-379.00	415.00-419.00	380.00-385.00	211.00-244.00
Alkalinity (mmol l^{-1})	212.80-209.40	165.20-171.00	159.00-165.50	145.60-134.20	73.40-80.00
Calcium (mg l^{-1})	90.00-85.00	57.00-55.00	58.00-58.00	51.00-53.00	30.00-35.00
Magnesium (mg l^{-1})	2.63-2.52	0.83-1.00	7.15-7.19	9.02-8.56	4.47-5.60
Hardness (mmol l^{-1})	23.58-21.00	16.00-15.00	17.44-18.21	17.00-16.00	9.34-10.26
Nitrite (mg l^{-1})	0.000-0.001	0.020-0.001	0.001-0.001	0.000-0.003	0.005-0.001
Ammonium (mg l^{-1})	0.00-0.00	0.01-0.00	0.00-0.00	0.00-0.26	0.00-0.00
Organic M. (mg l^{-1})	0.00-0.00	0.00-0.16	0.00-0.00	0.00-0.46	0.16-0.20
Iron (mg l^{-1})	0.07-0.04	0.07-0.09	0.05-0.04	0.00-0.00	0.08-0.05
Chlorine mg l^{-1})	2.00-3.00	4.20-5.00	0.40-0.30	1.90-1.70	0.90-0.85
Sulphate (mg l^{-1})	14.00-16.00	7.00-6.00	21.00-20.00	22.00-21.00	15.00-14.00
Carbonates (mg l^{-1})	n.d.	n.d.	n.d.	n.d.	n.d.
Bicarbonates (mg l^{-1})	259.61-255.47	201.54-208.62	193.98-201.80	177.63-173.72	89.54-93.20

n.d.: Not detected

[a] Summer months of sampling

[b] Winter months of sampling

The water quality of spring waters in Mid-Black Sea Region is acceptable in comparison with the World Health Organization (WHO) guidelines for drinking water and Turkish Standard (Koukal et al., 2004; Coskun et al., 2006).

4. Conclusion

The spring waters in the Black Sea Region were characterized in terms of their water physicochemical properties. The results indicated severe pollution, especially with respect to color. To achieve the target of regional sustainability, socio-economic issues must be considered with proper management of water resources involving stakeholders, business-sector, non-governmental organizations and the public. The following basic components should be given priority: (I) baseline and monitoring studies, (ii) water quality criteria establishment (iii) identification of sources, pathways and analysis of pollutants. Identification of the appropriate policy strategies for maintenance of water quality of Mid-Black Sea Region is urgently needed.

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SOME INFORMATION ABOUT NEAR EAST UNIVERSITY

Near East University was established in 1988 and since then has grown to become one of the fastest growing universities in the world setting itself the strategic goal of joining the "top 500 universities in the world".

From 1988 until now, the University has managed to expand its physical infrastructure and improve its quality of education and scientific research to meet international standards. Near East University is a member of the European University Association, the International Association of Universities and the Federation of the Universities of the Islamic World. The University has over 3,000 staff, of which 1,000 are academic personnel. 17,000 students from 53 different countries are attending 14 faculties and more than 60 departments at the university. It has luxury halls of different sizes which in total cover an area of 350,000m^2 and have the capacity to hold a total of 5,000 people. There are also 14 dormitories with a capacity of 5,000 students, but the construction of new dormitories is also planned.

Near East University has adopted life long education as its main mission. Thus, we begin with our Kindergarten, Junior College and Secondary High School which have a total number of 2,000 students. The faculties and departments offering undergraduate and graduate degrees are as follows:

FACULTIES

1. Faculty of Architecture
    - Architecture
    - Interior Design

2. Faculty of Arts and Sciences
    - English Language & Literature
    - Mathematics
    - Turkish Language & Literature
    - Psychology

3. Faculty of Economics & Administrative Sciences
    - Banking & Finance
    - Business Administration
    - Computer Information Systems
    - Economics
    - European Union Relations
    - Human Resources Management
    - International Business
    - International Relations
    - Marketing
    - Political Sciences
    - Information & Records Management

4. Faculty of Communication
   - Radio-Television-Cinema
   - Motion Picture Production
   - Journalism
   - Public Relations & Advertising

5. Atatürk Faculty of Education
   - English Language Teaching
   - Computer & Teaching Technologies
   - Pre-school Teaching
   - Elementary Teaching
   - Turkish Language Teaching
   - Guidance & Psychological Counseling
   - Human Resources
   - History Teaching

6. Faculty of Engineering
   - Civil Engineering
   - Computer Engineering
   - Electrical & Electronic Engineering
   - Mechanical Engineering
   - Biomedical Engineering

7. Faculty of Fine Art & Design
   - Graphic Design
   - Plastic Arts

8. Faculty of Maritime Studies
   - Department of Deck
   - Maritime Management
   - Marine Engineering

9. Faculty of Law
   - Law

10. Faculty of Performing Arts
    - Dramaturgy & Dramatic Authorship
    - Acting

11. Faculty of Pharmacy
    - Pharmacy

12. Faculty of Dentistry
    - Dentistry

13. Faculty of Health Sciences
    - Nutrition and Dietetics
    - Nursing

14. Faculty of Medicine

SCHOOLS

1.School of Physical Education & Sports
-Coaching Education
-Physical Education and Sports Teaching
-Sports Administration

2.School of Tourism & Hotel Management
-Tourism & Hotel Management

3. School of Maritime
-Deck
-Marine Engineering
-Maritime Management

INSTITUTES

-Institute of Education Sciences
-Institute of Sciences
-Institute of Social Sciences
-Institute of Health Sciences

With the opening of the NEU Grand Library in December 2005, the University has passed a new and critical mileage stone entering truly the information age. The Grand Library is fully computerized and linked to many major world libraries and research institutions throughout the world. The library has a collection of more than 600,000 printed materials and access to more than 110 million electronic articles. The library has recently been elected as the central library for the Turkic world and now serves universities of several different countries such as Azerbaijan, Kyrgyzstan and Turkmenistan. The library is open 24 hours a day serving not only the university but the whole community.

The University has until now organized 14 International Conferences & Congresses and many local and regional conferences, seminars and panel discussions on a variety of subjects. Near East University believes that the role of the University is not merely to provide formal education but to establish close relations with the wider community. As such, it places special emphasis on strengthening and developing campus-community relations. The University set up a Lifelong Education Centre (YABEM) which provides a wide variety of adult education courses. The University also makes the use of its facilities for cultural, sports and recreation activities available to the public.

As you can see, NEU is one of the fastest growing Universities of the world. The last two years has been devoted towards Health Sciences. This year, we began education in the Faculty of Dentistry, Faculty of Pharmacy and Faculty of Health Sciences. Another important improvement that has been made in our university regarding Health is that in September 2008, education has begun in the Faculty of Medicine. The Faculty of Medicine Research Hospital will be opened in July 2009. The Hospital will have a capacity of 500 beds with a 4,5000m^2 closed area. The faculty will be giving full service but a special emphasis will be given to researches on Oncology and Cardiology.

NEU does not have boundaries in development. Therefore, a protocol was signed with IBM International in June 2007 for the construction of the NEU Innovation Centre. The building having a closed area of 8,500m^2 was opened last year. It consists of 3 sections: NEU-IBM Innovation Centre, NEU-IBM Advanced Research Centre and the NEU Technopark. The 'super computers' used in the building have a capacity of 12 trillion processes per second. The research areas consist of Global Warming, Earthquake Stimulation, Defense Research (military), Space Research, High Physical Energy, Nanotechnology and Biotechnology research and product design, Medical, Pharmaceutical, Microbiological, Health Science and Social Sciences. NEU Innovation Centre is unique with its facilities in Eastern Europe, Middle East, Central Asia and Northern Africa.

BRIEF INFORMATION ABOUT
TURKISH REPUBLIC OF NORTHERN CYPRUS

History: Cyprus has been occupied successively by Assyrians, Babylonians, Egyptians, Persians, Romans, Lusignans and Venetians who have sought the island's wealth of minerals and timber since the 8th century BC. The Ottoman Empire conquered the island in 1571 and ruled it until the island was leased to the British Empire in 1878. In 1963, the Republic of Cyprus was established by the Turkish Cypriot and Greek Cypriots, based on political equality. The Turkish Cypriots were forcefully ejected from the state mechanism in 1963. Intercommunal clashes which broke out in 1960 continued until 1974. A military coup by Greece in 1974 aiming to annex the island to Greece was aborted by the intervention of Turkey, which was one of the Guarantor Countries. Following the Exchange of Populations Agreement in 1975, Turkish Cypriots moved to the north and Greek Cypriots moved to the south of the island. Consequently, the Turkish Cypriots established their own administration and in 1983, the Turkish Republic of Northern Cyprus was proclaimed.

Negotiations between the two sides under the auspices of the UN started in 1968, with the aim of finding a comprehensive settlement in Cyprus. The latest negotiation process came to an end when the compromise plan, Annan Plan, prepared by the then UN Secretary General Kofi Annan, was overwhelmingly rejected by the Greek Cypriot people. During the referendum held on 24 April 2004, whilst 65% of the Turkish Cypriots voted "Yes", 75% of the Greek Cypriots voted against the plan; thus, eliminating the possibility of establishing a new partnership republic. Despite their obstructionist attitude, the Greek Cypriot administration unilaterally entered the European Union under the usurped title of the "Republic of Cyprus", on 1 May 2004. The then UN Secretary General Kofi Annan, expressed his regret and noted that *"he hoped ways would be found to ease the plight in which the (Turkish Cypriot) people find themselves through no fault of their own"* (24 April 2004). In his report to the Security Council, he called upon the international community to *"cooperate both bi-laterally and in international bodies to eliminate unnecessary restrictions and barriers that have been the effect of isolating the Turkish Cypriots and impeding their development"* (S/2004/437). The current UN Secretary General Ban Ki-moon also referred to the economic and social isolation of the Turkish Cypriot people in his report to the UN Peacekeeping Force in Cyprus (UNFICYP) in December 2007, pointing out that promoting the development of the Turkish Cypriot people would make the reunification of the island "occur in as seamless a manner as possible." Observing the injustice against the Turkish Cypriots, who have been experiencing all kinds of inhuman restrictions for years, the EU also expressed its will to enhance the economic development of Turkish Cypriots through an aid package. The EU Commission adopted a proposal, which had foreseen the transfer of 259 million Euros financial aid. However, the Turkish Cypriots have not been effectively benefiting from the EU aid due to Greek Cypriot administrations' pressures.

After the Presidential elections in February 2008 on the Greek Cypriot side, President Mehmet Ali Talat has reiterated once again his readiness for a new process of full-fledge negotiations and expressed his sincerity towards a solution.

Places to visit: In Lefkoşa (capital): Selimiye Mosque, Mevlevi Museum, Sultan Mahmut Library, Dervish Pasha Mansion and Lapidary Museum. In Gazimağusa: Antique Ruins of Salamis, Kantara Castle, Othello Castle, Lala Mustafa Paşa Mosque, Canbolat Museum, Ruins of Ayios Philion, St. Barnabas Icon Museum and Apostolos Andreas Monastry. In Girne: Kyrenia Castle, Bellapais Abbey, St. Hilarion Castle and Buffavento Castle, and in Güzelyurt: Soli Ruins, St. Mamas Monastry and Vouni Palace.

Nature: North Cyprus hosts over 1,600 plant species (22 are endemic), 350 species of birds (7 are endemic), and there are 26 different species of reptiles and amphibians. Every year, 250 different kinds of birds, around 100 million, migrating from Europe to Egypt pass through North Cyprus. The country also became home to some 50 different varieties of butterflies. Visitors are amazed to see that there are 30 different varieties of orchids on the island, 7 of them unique to North Cyprus. Rich underwater plant life and 200 different types of fish are making the blue Mediterranean waters attractive for sea lovers. 30% of the turtles in the Mediterranean, amongst them Carretta Caretta, Chelania Mydas (Green Turtle) and Dermachelys Corniacea, come to the coasts of North Cyprus for breeding.

Life-style, Culture: Turkish Cypriots are well-educated, social and hospitable people. North Cyprus is popular with its handicrafts, cuisine, traditional music and folk dancing. The Turkish Cypriot Cuisine is famous for its kebab dishes and starters called “mezes”. Daily fresh fish, meat, vegetables and fruit used in the Turkish Cypriot cuisine make the dishes both tasty and healthy. Local alcoholic drinks include rakı, brandy and red and white wine. Baklava, kadayıf and katmer are deserts favoured by most and Turkish Coffee is a must at the end of every dinner. The cultural and art facilities make the country attractive both for the tourists and foreign students. During the hot summer months, people prefer to relax by the sea whereas during the fall season, people go on picnics and long walks in the mountains and countryside. Indoor activities like exhibitions, cinemas, theatres and concerts are always available.

Electricity: 240 volts A/C. 50 Hz.

Traffic: Driving is on the left and international traffic and road signs are used. Maximum speed on highways is 100 km/hr. Vehicles entering North Cyprus must be insured upon arrival. Please refer to the Turkish Embassy or TRNC Representative Office in your country to check visa requirements.

Climate: North Cyprus enjoys a Mediterranean climate with long, dry summers and short wet winters. The average annual temperature is 19ºC. The weather in winter is very mild with temperatures ranging between 9ºC-12ºC. Average annual rainfall is 500mm.

Emergency telephone numbers: Fire 199, Police 155, First Aid 112


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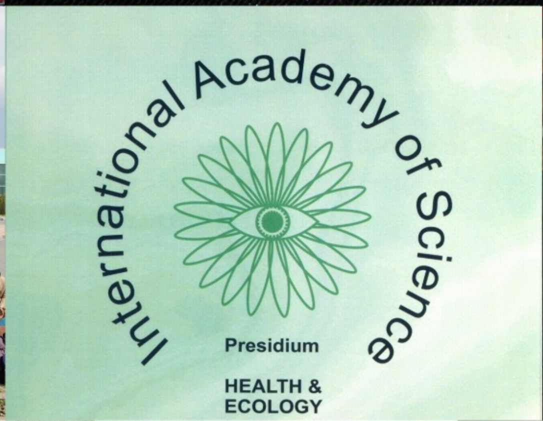
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