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International Hydrological Programme of UNESCO

Innovations in Groundwater Governance in the Mena Region

Middle East North Africa Seminar Report from World Water Week 2008

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1 Seminar on Innovations in Groundwater

During the World Water Week in Stockholm 2008 a seminar on innovations in groundwater governance in the Middle East North Africa (MENA) Region was organised. It demonstrated that there are lots of innovative activities being tried and tested in the region, for example in managing groundwater better at the local, national and cross border level, increasing the efficiency of use, creating new water, monitoring, decision support systems, and building management and business skills.

The discussions at the World Water Week brought forward needs and examples of innovation in three different areas; 1) tools and techniques/knowledge; 2) development, implementation and management; and 3) policy and planning. Examples from the region included; using expertise from different countries in the region to learn from each other and introduce new technologies to improve data sharing and dissemination; the use of regional institutions to promote groundwater management; zone management of aquifers; use of economic instruments for water conservation; ways of bridging the gap between technology and policy implementation.

This report highlights how some of these and other innovations and new thinking can be an important part of the solution of the complexity in managing groundwater in the MENA region. It builds on the presentations at the MENA seminar at the World Water Week in Stockholm 2008 and refers to recent publications on the subject.

2 Introduction to the Need for New Thinking in Groundwater Governance

There is a large number of water related meetings taking place in the MENA Region each year. This is not surprising in a region where this essential resource for ensuring livelihoods is scarce. The shortage of water is a technicality for the rich countries in the region. Most of the countries on the Arabian Peninsula invest in desalination and create "new water". It is a response to a limitation in local conditions, which also provide these countries with great wealth through its oil reserves. This does not apply to all countries in the region. The poorer countries, without large oil deposits, rely on their agriculture as the main source of income to the state, with contributions from foreign development aid and retributions from their nationals working elsewhere. For these countries there is little margin for error and no (financial) space for experimenting. Innovative solutions in groundwater management need to be sustainable and preferably self-sustaining even in the short run, since capital for investment is often lacking and money for running facilities is uncertain.

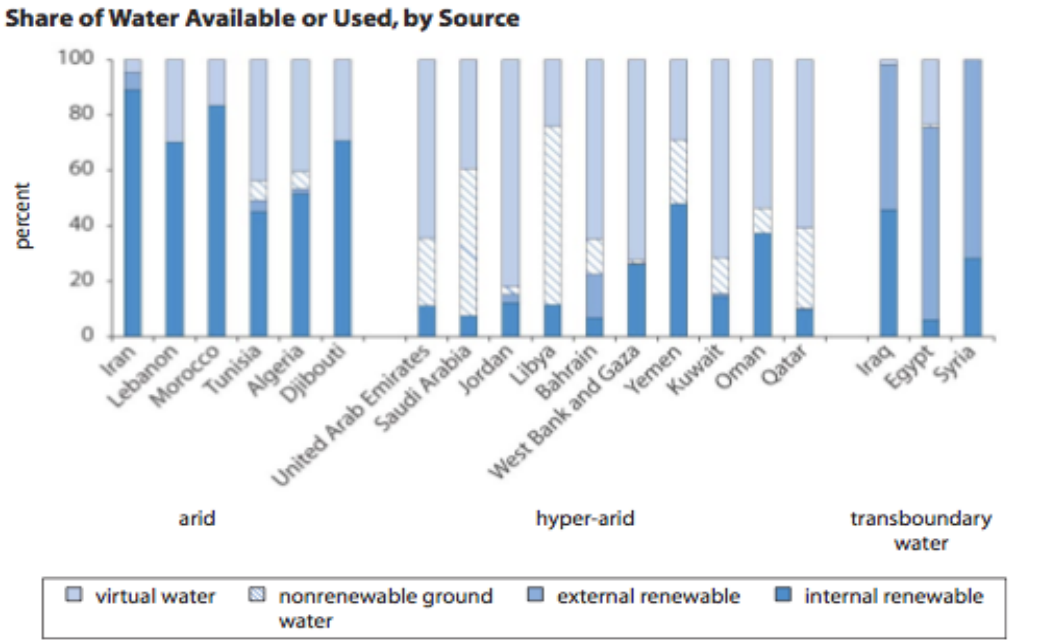
Aquifers – most of which straddle international boundaries – are of major strategic importance. Underground aquifers are often the only natural source of water in arid and semi-arid areas and therefore in most of the MENA region – 95% of freshwater withdrawal in Saudi Arabia (2006), 73% in Tunisia (2001) and 65% in Jordan (2005)[1]. Irrigation systems also depend largely on groundwater resources in many countries – 90% in Libya.

Increased use of water due to population and economic growth and a reduction in recharge due to climate change will lead to an increasing pressure on the available water – innovation is needed.

3 The Groundwater Resource

In the case of the MENA region it is important to distiguish how much of the groundwater is renewable and how much is non-renewable. Large parts of the groundwater resources, both in areal extent and total volume, are not replenished under current climatic conditions. The non-renewable, finite part of the resource is in fact the major water resource in some countries in the region. An overview produced by the World Bank is shown in the figure below.

[1] From FAO Aquastat, 2009 (http://www.fao.org//nr/water/aquastat/main/index.stm

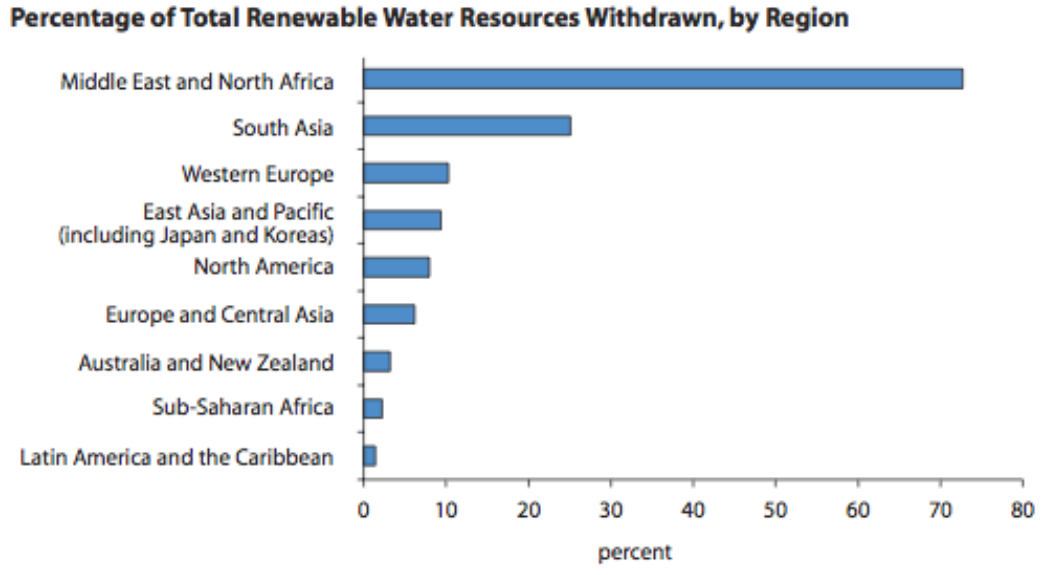


Sources: FAO AQUASTAT; UNESCO-IHP 2005; Hoekstra and Hung 2002; Chapagain and Hoekstra 2003.

Note: External renewable water resources refers to surface and renewable groudwater that comes from other countries, net of that country's consumption. Virtual water refers to water embedded in food that is imported, net of exports, average over 1995–9. This figure doesnot include water used for environmental purposes.

Figure 1: Share of water available or used by source. From the World Bank, 2007[2]

The region has the highest use of renewable water than any other region in the world.



Source: Compiled from FAO AQUASTAT for 1998–2002.

Note: The figure shows the simple percentage (that is, summing up withdrawals across all countries in a region and dividing by the sumof all the renewable water available in each country). As with figure 1.1, the definition of "region" significantly affects the data, because of the heterogeneity between and within countries.

Figure 2: Percentage of total renewable water resources withdraw by region. From World Bank, 2007[2]

[2] "Making the most of Scarcity – accountability for better water managenent in the Middle East and North Afrika, The World Bank, 2007.

The amount of renewable water is based on the average annual precipitation as well as on seasonal distribution, rainfall intensities and other parameters. Increasing levels of uncertainty can be attributed to all of these variables as a consequence of climate change and variability. In the latest report from the IPCC the Middle East region is shown to have an overall increase of drought pressure.

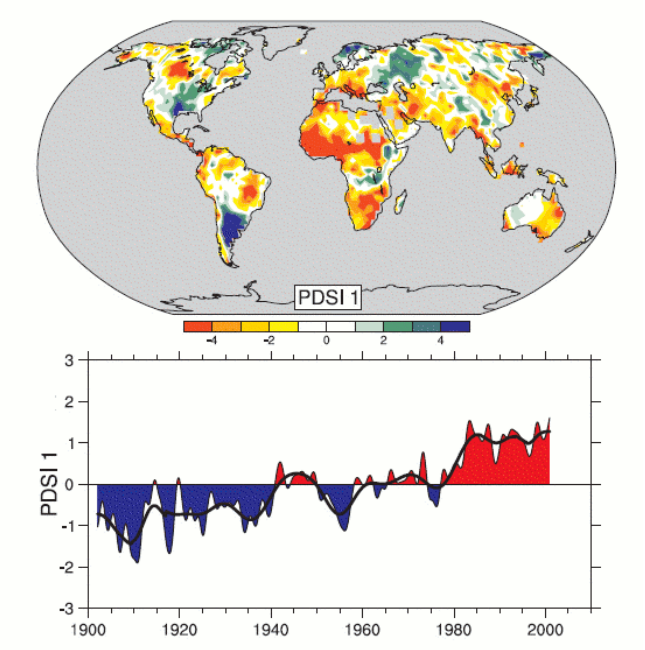


Figure 3: (a) Geographical distribution of the trend in Palmer Drought Severity Index (PDSI) during the period 1900-2000. (b) Annual variations of the globally averaged PDSI. The PDSI is a measure of drought severity based on precipitation and temperature information. Positive values imply more severe drought conditions. Source: IPCC (2007), Chapter 3.

Climate Change Impacts – Morocco Case

For Morocco, estimation has been made for various climate predictions from IPCC, combining the rise in sea-level, the decrease in precipitation and the decrease in recharge. The simulations show that here will be a significant decline in the renewable freshwater resources, including groundwater, and that salinity increases can be quite substantial but still limited to restricted areas (Zarhloule, WWW 2008).

3.1 UN Law on Groundwater

With an increasing pressure on groundwater, the need for a global set of rules, a legal framework, is increasing as well. There are still enormous untapped resources, like the aquifers in Africa, which contain 100 times the volume of freshwater that can be found on the Earth's surface. They are among the largest in the world and since they generally expand over several national boundaries, their exploitation presupposes an agreed management mechanism.

Mechanisms of this kind have begun to emerge, such as the agreement in the 1990s between Chad, Egypt, Libya and Sudan which established a joint authority to manage the Nubian aquifer system, but such arrangements are the exception, according to UNESCO.

A draft Convention, presented to the General Assembly of the United Nation in October 2008, is intended to facilitate the creation of such mechanisms for administering transboundary aquifer systems

by calling on aquifer states not to harm existing aquifers, to cooperate and to prevent and control their pollution.

This UN Law of Transboundary Aquifers was prepared in the committee on Shared Natural Resources of the UN International Law Commission (UN ILC). The resolution was adopted by the UN GA on December 11 2008. The resolution contains the draft articles, as well as a decision to discuss the format of the draft articles at a later session of the UN GA.

The two step approach was chosen so that the articles could start playing a role as soon as possible. As in many instances, international law is often used in guiding countries to resolve their problems rather than to be forced through the international court in The Hague. The guidelines that are later to become the Law on Transboundary Aquifers are expected to become an important building block in the formalisation of the management o the shared aquifers in the region (UN International Law Commission 2008[3], New Scientist 2008[4]).

4 Managing Shared Groundwater

UNESCO and BGR presented in 2008 a detailed map identifying underground water resources that are shared by at least two countries, using data compiled since 2000 by the WHYMAP consortium for a groundwater database. The map includes information about the quality of water and rate of replenishment of 273 transboundary aquifers (68 in the American continent, 38 in Africa 65 in Eastern Europe, 90 in Western Europe and 12 in Asia.

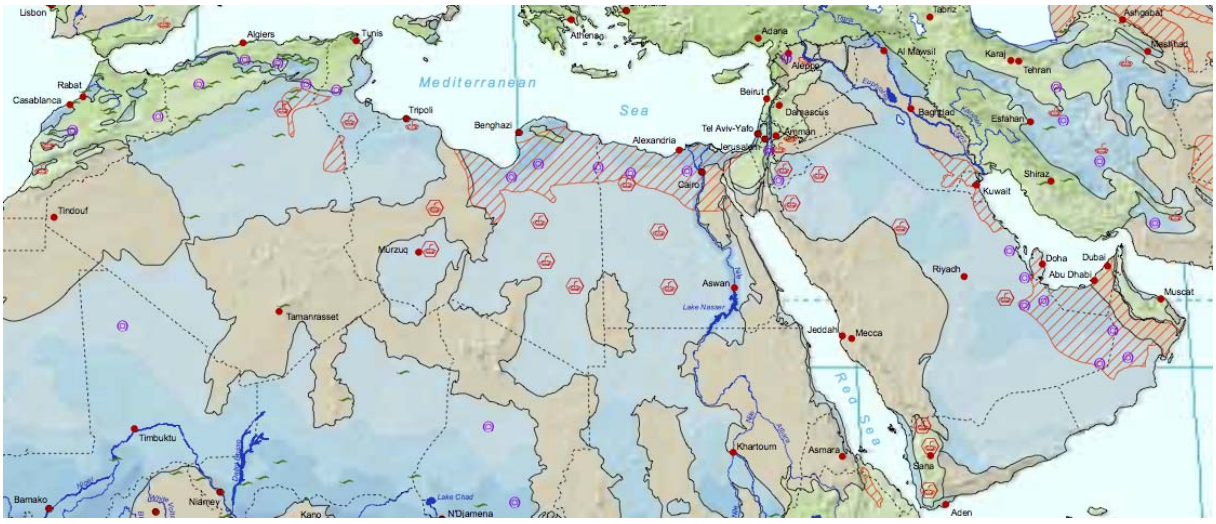


Figure 4: Groundwater in the MENA region, selection from UNESCO and BGR 2008[5]

State wide integrated surface water management is a challenging endeavour. Effective governance of groundwater resources at the international level is undoubtedly even more challenging. Power asymmetry and limited knowledge of the resource are two of many factors influencing the efficiency of governing shared groundwater.

[3] http://untreaty.un.org/ilc/sessions/60/2008_DC_Chairman_SNR.3June2008.pdf

[4] Article in the New Scientist, November 2008, Can legislation stop the wells running dry? (http://media.newscientist.com/article/mg20026814.000-can-legislation-stop-the-wells-running-dry.html?page=1)

[5] http://www.whymap.org/nn_1055978/whymap/EM/Downloads/Global_maps/whymap_125_pdf,templateId=raw,property=publicationFile.pdf/whymap_125_pdf.pdf

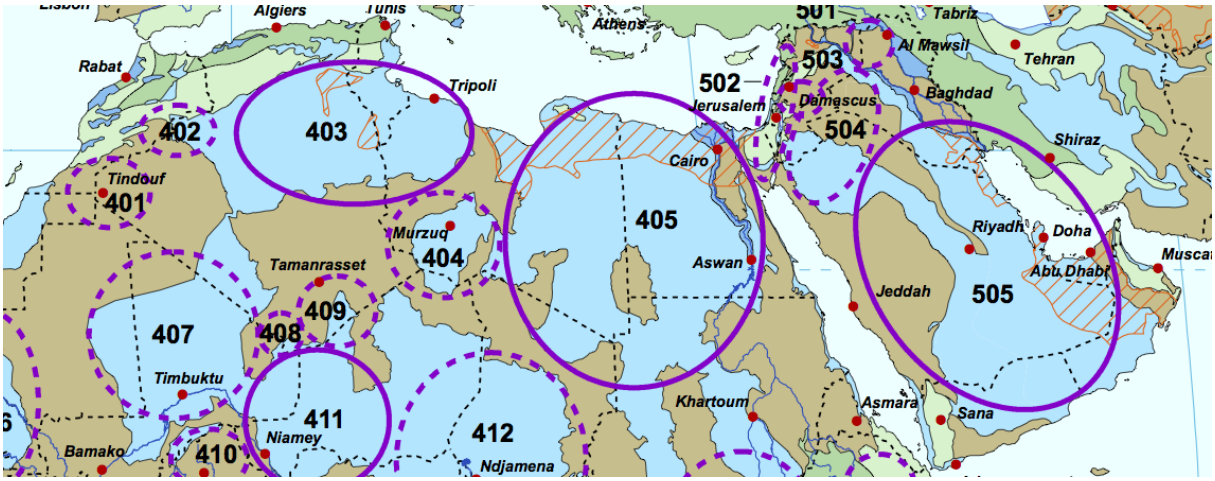


Figure 5: Shared Aquifers in the MENA region, selection form UNESCO and BGR 2006[6]

Through the efforts of UNESCO and the Draft Articles of the International Law Commission and decades of experience from surface water governance there is an opportunity to take important steps forward on managing groundwater at this point in time.

Different management focus is needed for renewable and fossil aquifers. The latter is much less affected by international tensions brought about by seasonal droughts or the longer term effects of changes in climate. Renewable aquifers are often hydrologically connected to surface water resources and are affected by drought, pollution or other interventions to the surface water.

The invisible nature of groundwater poses two further particular challenges. First of all, the knowledge base to ensure sustainable management must be built up through thorough investigations and monitoring of aquifer size and quality. Second, unlike a river whose quality and flow is directly experienced by users, groundwater is more readily subject to manipulation. Policymakers may choose to ignore, or are not aware of mismanagement until the situation often have gone too far with over-allocation and pollution as a result.

5 Innovative Management Projects at the World Water Week

Most of the innovative management projects presented during the MENA seminar 2008 could be fitted into three broad categories; 1) tools and technical resources/knowledge; 2) development, implementation and management; and 3) policy and planning. Some of the projects presented could fit into more than one category, but are here placed under the category best describing the effect of the project. Other examples from the region of new approaches to governing the groundwater resource have also been included.

5.1 Tools and Technical Resources/Knowledge

When managing a scarce resource such as water in the MENA region it is essential that the resource is not subject to pollution. In Jordan a programme has been developed to protect the main drinking water resources through water protection zones. The implementation of water protection zones has consequences for the land use which makes it important to make sure that the protection zone is as large as necessary for protecting the resource, but is restricted to areas where it is proven needed. The main problem for the delineation of the protection zones is the lack of reliable data, while the difficulty of implementation is the lack of awareness in all levels of the general public (Subah, WWW 2008).

[6]http://www.whymap.org/nn_1055978/whymap/EN/Downloads/Global__maps/spec__ed__2__map__pdf,templateId=raw,property=publicationFile.pdf/spec_ed_2_map_pdf.pdf

Shared between Israel and the occupied Palestinian territory is the Mountain Aquifer. It provides high quality water to both Israelis and Palestinian and is a vital water source for both. Municipalities play a pivotal role in managing pollution and use of the Mountain Aquifer. The Friends of the Earth Middle East, FoEME (an Israeli-Palestinian-Jordanian NGO) identified municipalities as a promising avenue for progress on managing the water in an integrated way.

Currently, sewage from more than two million Palestinians and Israelis is discharged into the open environment every year without adequate treatment, or completely untreated. Eventually, this pollution will reach deeper layers of groundwater, since the geological structure allows easy percolation of surface water into the ground. Thus, the water of the Mountain Aquifer is directly threatened. If the underlying water resources become contaminated, then the already existing water scarcity will become even greater and exacerbate the difficult political situation in the region.

The FoEME and the House of Water and Environment (a Palestinian NGO) runs a project called "Pro-Aquifer", which promotes solutions to these pollution problems and encourages cooperation between the two people on a municipality level. The project involves conducting scientific research and modelling of potential and existing sources of groundwater pollution that threaten the aquifer; training of municipal staff on sewage treatment technologies, management techniques and GIS among other things (FoEME, WWW 2008).

As it was mentioned earlier, the pollution of ground water is increasingly becoming an issue. In Tunisia the wastewaters from urban centres are being treated before being reused or being used for recharge of aquifer. In Lebanon there are currently experiments with constructed wetlands, as a sustainable solution for curbing the water pollution in the Litani River Basin (Harfouch, WWW 2008).

In Kuwait and the UAE there is an increasing use of aquifers for storing fresh water. This is done to manage peaks in water use and to buffer over-production from desalination, but also for preventing the risk of running out of water during drought periods or environmental disasters. The countries have grown very dependent on using desalination for their fresh water. In the UAE new legal instruments and demand management measures, such as water tariffs and other economic incentives have been introduced to tackle the depletion of the country's water resources and the ever-growing dependence on desalination. This is a challenge since it often involves restricting people that are not used to being restricted in their actions. However, progress is being made towards changing the behaviour of people to reduce wastage of water.

5.2 Development, Implementation and Management

When managing (ground) water resources there is a large variation of issues that needs to be considered. These concern the allocation of water (what type of use, for which sector etc), the possibility to increase the efficiency in the use of water, but also the possibilities of mixing various resources to end with the appropriate quality for each area of use.

In Jordan, the occupied Palestinian territory and Egypt there has been an attempt to develop local level water resources management. Through a regional partnership, EMPOWERS, an approach that includes stakeholder involvement and scenario development has been developed to enable a more decentralised, local level management of water resources. The EMPOWERS guidelines are based on a project cycle management framework and thirty-two associated methods and tools that can be used by water professionals and practitioners to improve water governance. Although many components of the approach are tried and tested, others are more innovative especially those that have been adapted from the business sector. The guidelines also advocate an approach to developing adaptable water management strategies that uses scenario building as an integral part of strategy development and planning processes. The aim is to take implicit account of uncertainty and external factors, often from outside the water sector that can have a big impact on the success or failure of strategies and plans (Batchelor, WWW 2008).

In Yemen there has been an attempt to improve the management of groundwater through a community based water management project. The project enabled Water User Associations (WUAs), including both men and women, to develop management plans. The long term result is envisaged to be a better local

management of groundwater and a better economic basis for the local livelihood. The WUAs were trained and were involved in implementing local management plans. Throughout the project it became clear that local communities are indeed ready to take the lead when they have the chance and that the enthusiasm and willingness of the communities to work collectively saves precious non-renewable water through the adoption of new technologies. It was also clear that the communities have a great deal of experiences and can provide logical solutions to the problems that come up. It was also observed that there is a difference in the planning process. The involved communities suggested that the government could be much more active in preventing water scarcity by providing support and services and implementing the water law (Taher, WWW 2008).

The Disi aquifer shared by Jordan and Saudi Arabia consists of fossil water. It is currently the subject of pumping from both countries. In Jordan development of a major project to pump water from the Disi Aquifer to Amman via a 325 km pipeline is ongoing, but no agreement with Saudi Arabia on the issue has yet been signed. The innovations that have been proposed for this case study cannot be considered as "truly innovative ideas" but at the same time they are somehow pioneering because of the difficulty in obtaining them under the given political context. The Disi Aquifer could possibly be managed jointly by the two countries if the following concepts were implemented:

- Transparent data, data sharing: The Disi Aquifer plays an important role in the national water discourse being presented as the best solution to water shortage in Jordan. For this reason data about the life span of the Disi Aquifer at the projected pumping rates are very controversial. A transparent use of data and better information about the controversial aspects of the Disi project, both within Jordan and between Jordan and Saudi Arabia, could solve the uncertainty of the project.
- Sharing water between two countries equitably: The unclear relationship between the countries would be solved by showing each country's exploitation of the Disi Aquifer and setting up a fair agreement between them (Greco, WWW 2008).

In Tunisia there has been a programme running over the last 10 years aiming at making optimal use of all the groundwater resources. This included mixing the variation in levels of salinity to arrive at a water quality that would still be suitable for the targeted use (ref. BESBES / GEORE project / Min. of Water, Tunis).

Along the coast of Lebanon and Syria the groundwater is stored in large carbonate aquifers. These aquifers are karstified at great depths below sea level. This leads to natural sea water intrusion, sometimes far from the coast, and groundwater discharge at submarine springs which can be permanent or seasonal at depths up to 70 m below sea level.

Human activities in the region put specific pressures on this system. In the area of Beirut over-pumping is leading to salt water intrusion. It is suggested that the sustainable exploitation of the coastal karst aquifers is possible by combining a strict control of withdrawals, organised in a plan adapted to the aquifers characteristics. Examples of possible actions are management of the recharge, controlling and recycling the surface runoff from urbanised areas which is normally prevented from infiltrating the aquifer, using artificial or controlled recharge in order to maintain sea water intrusion at acceptable limits. This kind of proactive groundwater resource management requires a detailed knowledge of the aquifer and of its relationship with the sea (Bacalowicz, WWW 2008).

An example of transboundary cooperation of managing a shared aquifer is shown by the countries sharing the North Western Sahara Aquifer System (NWSAS) in North Africa. The process of developing the shared management was facilitated and supported by the Observatory of the Sahara and Sahel (OSS). The NWSAS, shared by Algeria, Libya, and Tunisia contains considerable water reserves, which are nevertheless only slowly renewable and not fully exploitable. During the last thirty years, the exploitation of NWSAS waters by drilling increased from 0.6 to 2.5 billion m^3/year. Because of the intensive and non-concerted withdrawal, the resource is now confronting many risks such as water salinity, reduction of the artesian pressure, and natural discharge depletion. This seriously threatens the sustainability of socio-economic development of the area. In order to address these risks, a cooperation process between the three countries is crucial. The joint work has focused on scientific exchange in the first place, enabling a

significant knowledge improvement of the aquifer system based on information exchange and a joint definition of working hypotheses among the countries. The scientific and technical cooperation have gradually led to the establishment of a formal institutional framework for the management of shared water resources among the three countries (Diallo, WWW 2008).

5.3 Policy and Planning

In Iraq the use of groundwater has been limited in the past, as the surface water has been enough to supply water for the country. But there is a decrease in the flow of the Iraqi rivers due to upstream use, both outside and within Iraq's borders, which has increased the interest for groundwater as an option. There are however limitations, due to the quality of the groundwater. Only in the North East of the country can groundwater be used without quality limitations. Some of the water is also non-renewable. When planning for future groundwater use it is important to consider certain questions such as:

- Should groundwater that is suitable for human drinking be used for agriculture?
- Should non-renewable groundwater resources be sued?
- What should be done if aridity hits the region for several years?
- What will be the effects of climate change?
- Should newly established communities be encouraged to depend on groundwater resources?
- Are there means to augment the nation's groundwater resources, restore, or partially restore the storage of an aquifer that has undergone heavy draft?
- What does the country need in terms of legislations, measures, or planning in order to be able to use groundwater in a sustainable way?

(Jawad, WWW 2008)

Even if these questions have been found important for the Iraqi context, these are all questions that need to be considered for the whole region.

5.3.1 Decision Support Systems

In Jordan an interactive decision support tool (DST) has been developed to help stakeholders formulate and assess alternative policies for sustainable and efficient management of the Amman-Zarqa Aquifer, a vital water resource in water-impoverished Jordan. Through an intuitive graphical interface (Fig. 7), the user can manipulate different parameters including: selection of allocation policy among the municipal, industrial and agriculture sectors; water productivities, pumping fuel cost; discount rate; and planning horizon in addition to several other parameters. The user can observe the progress of several variables during different scenarios including water levels, remaining stocks and net present values of water allocated to different sectors. Warning messages are displayed upon occurrence of potentially adverse conditions such as low water levels. The DST was developed based on groundwater and economic principles using the STELLA modelling environment (Assaf, WWW 2008).

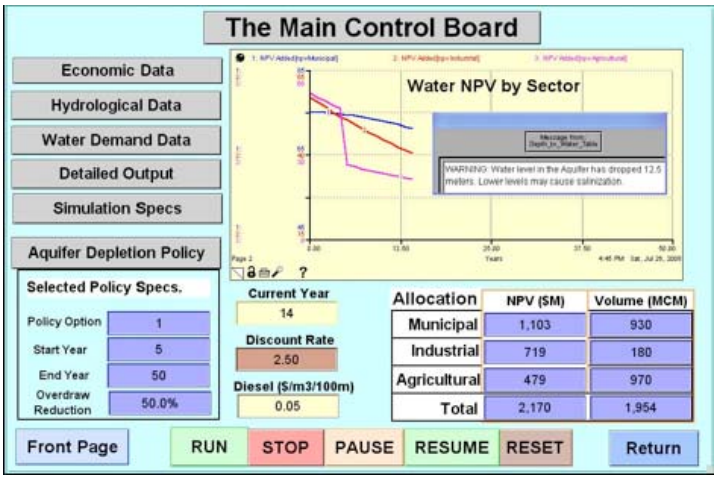


Figure 7. Graphical Interface for Water Management of the Amman-Zarqa Aquifer.

Another decision support system is being field tested in Syria and Morocco. This system provides a dynamic link between a groundwater model (MODFLOW) and water resources and land-use planning and management software (WEAP21). This system will give decision makers the necessary insight into the current water status in a given basin and allows for the interactive building of scenarios for future development (population growth, agriculture development, etc.). In two pilot areas (Zabadani Basin, Syria and Berrechid Basin, Morocco) a water conflict between concurrent water uses already exists. A process will be established in these two basins where representative water users jointly decide after the winter rains on the water shares for the current hydrologic year and future ones, based on the estimated stored groundwater volumes provided by the DSS (Al-Sibai, WWW 2008).

In the West Bank the Palestinian Water Authority is faced with a particular complex situation when managing water related to overall relations with its neighbour Israel. This causes uncertainty in planning the use of scarce water resources for economic and livelihood purposes. This has triggered the development of the West Bank Water Planning, Management and Analysis Tool specifically designed for planning under uncertain political situations. The tool integrates demand projections, hydrologic data and development actions in an interactive environment. Users can develop and evaluate water management scenarios. The ability to meet forecasted demands and see the full cost of implementation is part of the tool. Comparative analysis of scenarios for three approaches to water management; internal water development, external resources development and demand management, have identified immediate management actions for the West Bank which are common to all scenarios (Froukh, WWW 2008).

6 Conclusion

Innovative concepts in groundwater management in the MENA region is developing due to the growing need to manage the resource better for sustaining livelihoods. It became obvious during the MENA Seminar at the 2008 World Water Week in Stockholm that many institutions, organisations, researchers, engineers and others engaged in the water situation in the region produce many innovative solutions to improve groundwater management. To utilise this innovative capacity it is important to share good experiences and to have a well trained workforce and institutions that can capitalise on the new thinking. The governance structures must also be open to new approaches and new techniques.

The creativity shown in the region to deal with the urgent issue of improving groundwater management gives hope. The obstacles identified in implementing these innovations are presently lack of funding, political unwillingness, regional instability, as well as lack of knowledge of the aquifers.

Annex: Summaries of Presentations during the WWW 2008 MENA Seminar

Seminar oral presentations

1. *A Decision Support System for Water Resources Management incorporating MODFLOW and WEAP*, presented by Dr. Ariane Borgstedt, Federal Institute for Geosciences and Natural Resources (BGR), Germany
2. *Climate change and human activities impact on the groundwater of the Eastern Morocco: case of Triffa plain and shallow coastal Mediterranian aquifer at Saidia*, presented by Prof. Yassine Zarhlole, Laboratory of Hydrogeology-Environment, Faculty of Sciences, Morocco
3. *Joint management of the North Western Sahara aquifer system,* presented by Eng. Ousmane S. Diallo, Observatory of the Sahara and Sahel, Tunisia
4. *West Bank water planning, management and analysis tool under uncertain political situation,* presented by Dr. Loay Froukh, occupied Palestinian territory & Jordan
5. *Uncertainty and power asymmetry: impediments or catalysts to equitable allocation of transboundary groundwater?,* presented by Dr. Mark Zeitoun, Grantham Institute on Climate Change and the Environment, London School of Economics and Political Science, UK
6. *EMPOWERS Approach to Water Governance,* presented by Dr. Charles Batchelor, IRC International Water and Sanitation Centre, UK
7. *Community based water management project,* presented by Dr. Taha Taher, Water and Environment Center, Sana'a University, Yemen
8. *Delineation and implementation of water resources protection zones in Jordan – practical experiences,* presented by Eng. Ali Subah, Ministry of Water and Irrigation, Jordan
9. *Pro-Aquifer: A promising example of cooperation between Israelis and Palestinians to protect transboundary groundwater resources from pollution through research, training and guidelines for Israeli and Palestinian municipalities,* presented by Ms. Ladeene Freimuth, EcoPeace/Friends of the Earth Middle East, Israel-occupied Palestinian territory-Jordan, in cooperation with the Palestinian House of Water and Environment.

Seminar poster presentations

1. *A hydro-economic decision support model for sustainable management of scarce groundwater resources,* presented by Dr. Hamed Assaf, American University of Beirut, Lebanon
2. *Groundwater management in Yemen,* presented by Dr. Abdulla Noaman, Water and Environment Center, Sana'a University, Yemen
3. *A regional approach for the management of transboundary groundwater aquifers; the case of the North Western Sahara Aquifer system,* presented by Associate Prof. Mounir Bellouni, Faculty of Law, Economics and Political Sciences of Sousse, Tunisia.
4. *Innovative approaches proposals for the management of the Disi fossil aquifer shared between Jordan and Saudi Arabia,* presented by MSc. Francesca Greco, Italy
5. *Coastal carbonate aquifers in the Levantine countries require a great care and specific management of their groundwater resources,* presented by Prof. Michel Bakalowicz, HydroSciences Montpellier, CREEN, ESIB, Université St Joseph de Beyroth, Lebanon
6. *Constructed wetlands – sustainable solution for the water pollution in the Litani River basin,* presented by Mr. Rami Harfouch, ESIB, Université St Joseph de Beyroth, Lebanon
7. *Cooperation in Solving Groundwater Problems, Epistemic Community Addressing Groundwater Problems in the Euphrates-Tigris Region,* presented by Dr. Ayman Abdulrahman, Al Furat Univeristy, Syria
8. *Sustainable management of groundwater resources in Iraq,* presented by Mr. Sadeq B. Jawad, Ministry of Water Resources, Iraq
9. *Optimal engineering design for dependable water and power generation in remote areas using renewable energies and intelligent automation socio-economical analysis for integration of renewable energy desalination systems in rural areas,* presented by Mr. Abedelkrim Sadi, Centre de Développement des Energies Renouvelables, CDER, Algeria

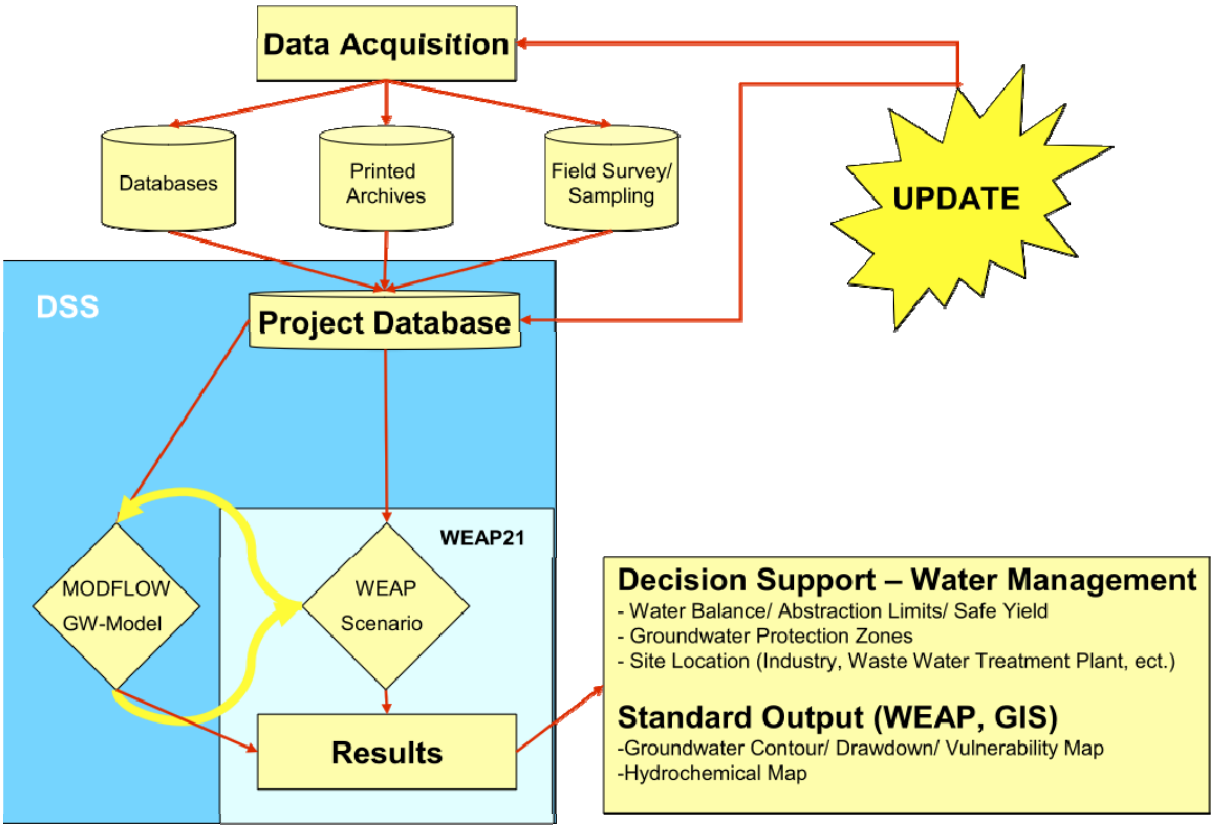
Seminar Oral Presentations

1. A Decision Support System for Water Resources Management incorporating MODFLOW and WEAP

Al-Sibai, M.; Droubi, A.; Abdallah, A.; Zahra, S.; Wolfer, J.; Huber, M.; Hennings, V.; Schelkes, K.

As most countries of the MENA Region rely on groundwater as the main water resource, the groundwater extractions often exceed the natural recharge volumes, resulting in a decline of the groundwater table and in a deterioration of the water quality. To allow for sustainable water resources management, a Decision Support System (DSS) was developed.

It consists of three major components, a project database, a groundwater flow model (MODFLOW2000) and a user-friendly water evaluation and planning software (WEAP21). The tight link between MODFLOW and WEAP enables the data exchange between both models for each time step.



The DSS was tested and applied in two pilot areas, Zabadani basin, Syria and Berrechid basin, Morocco, where water conflicts between concurrent users already exists and no abstraction limits or abstraction monitoring are implemented, so far. To consider the needs of the prospective users, the responsible authorities and stakeholders were involved from the beginning, e.g. via a steering committee.

The DSS-applications proved the strengths of this tool especially considering the impacts of climate change, changes in demand and supply, waste water reuse and artificial recharge scenarios on water availability. The DSS has been giving the respective authorities and decision makers a valuable base for their current and future water resources management.

2. Climate change and human activities impact on the groundwater of the Eastern Morocco: case of Triffa plain and shallow coastal Mediterranean aquifer at Saïdia

Y Zarhloule1, A Fekkoul[1], M Boughriba[1], A Kabbabi [2], J. Carneiro[3], A. Correia[3], A. Rimi[4], B. Houadi[5].

[1]Laboratory of Hydrogeology-Environment, Faculty of Sciences, Oujda, Morocco [2]:CERPHOS, Water & Environment laboratory, Casablanca, Morocco [3]Geophysical Centre of Évora, University of Évora, Évora, Portugal [4]Scientific Institute, Department of Physics of the Globe, Rabat, Morocco [5]Hydraulic Basin Agency of Moulouya, Oujda, Morocco.

Summary

Located at the North-eastern part of Morocco the plain of Triffa and the area of Saïdia are under a semi-arid climate (Fig1). The water resources in this zone are rather fragile and influenced by a highly irregular rainfall distribution, both in time (annual and inter-annual distribution) and in space with a yearly average which does not exceed 240 mm.

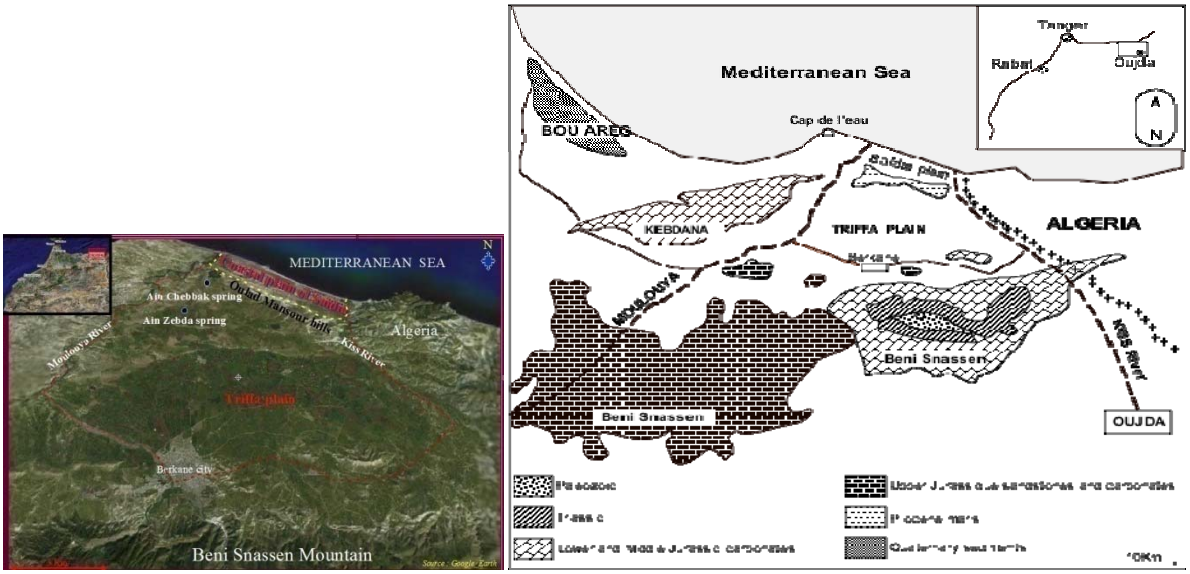


Fig.1. Geological map with areas studies (Triffa and Saidia plains)

A/ Impact of Human Activity: case of Triffa plain

In the Triffa plain the impact of anthropogenic activity on the groundwater resources is reflected both by: a) the decrease in the piezometric level due to the over exploitation and droughts; and b) the deterioration of the chemical quality of water. Currently, this situation is felt mainly by the farmers.

The unconfined aquifer is under stress due to increase of the pollution rate, especially nitrates (Fig.2), which is above the WHO standards, and salinity (Fig.3). Pesticides such as aldrin, lindane, heptachlor, etc (samplings 2007), have also been detected (Fig.4) and are indicators showing the need to reduce the pressure on groundwater quality by informing and training farmers on the use of fertilizer and pesticides.

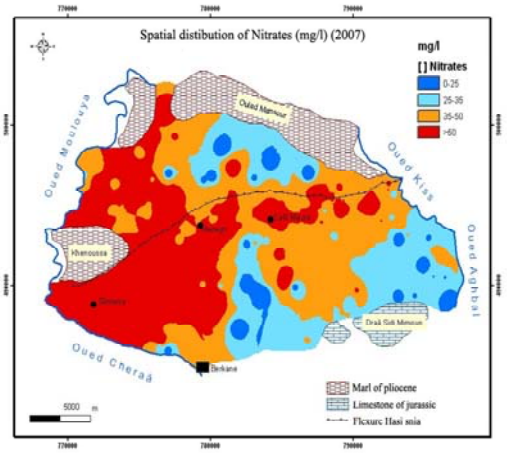


Fig.2. Map of Nitrates (mg/l.2007)

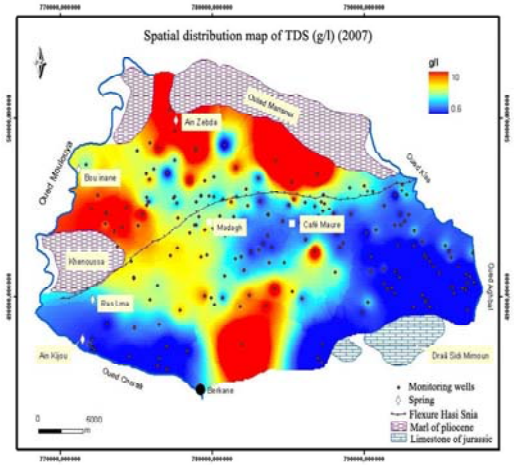


Fig.3. Map of TDS (mg/l. 2007)

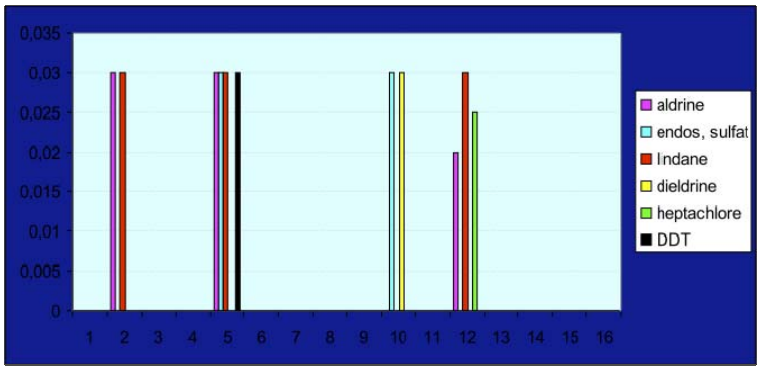


Fig.4. Histogram of pesticides (µg/l.2007)

B/ Impact of climate change: case of Saïdia coastal plain

The Saïdia plain (Fig.5), in the Mediterranean coast Morocco is undergoing fast changes in land-use and the planning did not take into account sea level rising and likely salinity increase. Several golf courses are planned and the irrigated areas will increase considerably. This motivated building a density dependent groundwater flow and transport model for studying the climate changes impact on this unconfined shallow aquifer.

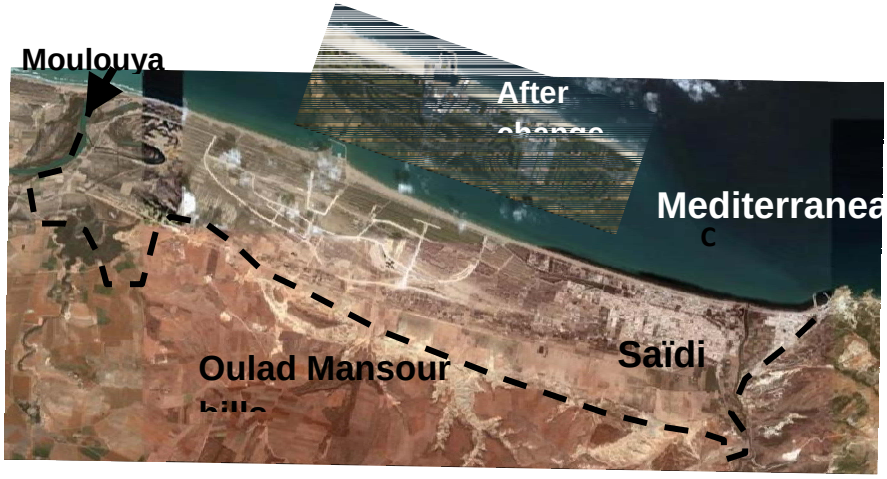


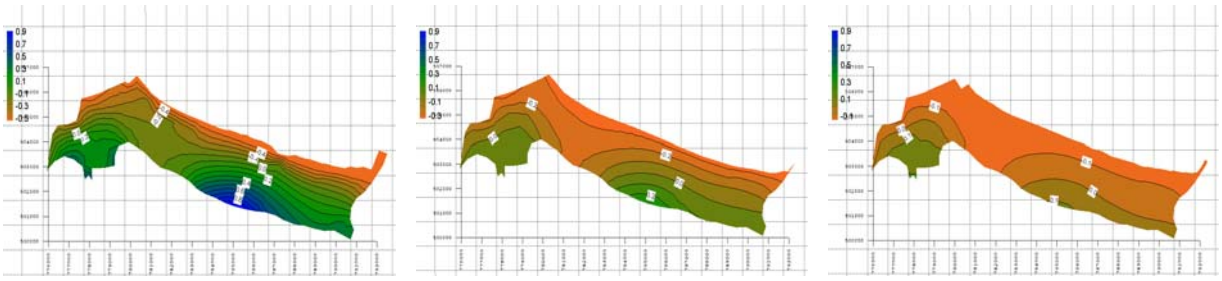
Fig.5. Saïdia Coastal plain before and after change

The stresses imposed to the model were derived from the IPCC (2007) emission scenarios and included recharge variations, rising sea level and advancing seashore.

Table II. Stresses imposed by climate change

IPPC scenario	Temperature change (ºC)	Seal level rise (m)	Precipitation decrease	Recharge decrease	Observations
B1	1.1	0.18	6%	9%	*B1 lower values*
A1B	2.8	0.35	12%	19%	*A1B mean values*
AIF1	6.4	0.59	38%	47%	*A1FI higher values*

The simulations show that there will be a significant decline in the renewable freshwater resources (Fig 6a.b.c), and that salinity (Fig.8) increases can be quite large but still limited to a restricted area.



A B C

Fig.6. Decrease in groundwater level (100 years): a) A1F1 scenarion, b) A1B scenario, C) B1 scenario.

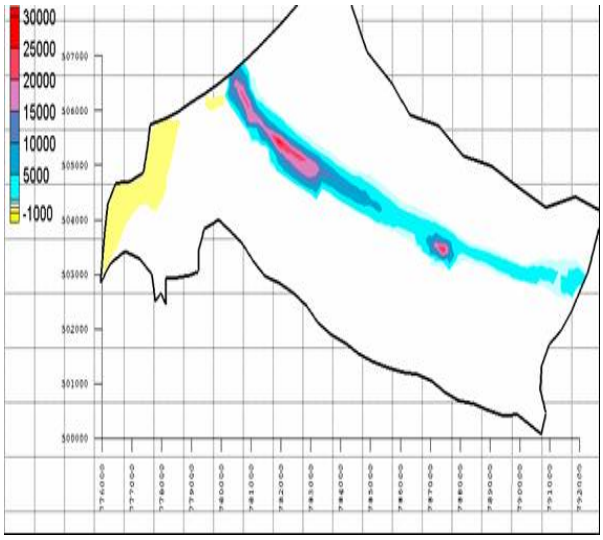


Fig. 7. Change in Salinity (A1F1 Scenario)

3. Joint Management of the North Western Sahara Aquifer System

Ousmane S. Diallo, Coordinator of the Water Programme, Observatory of the Sahara and Sahel (OSS), BP 31-1080 Tunis, Tunisia

The North Western Sahara Aquifer System (NWSAS), shared by Algeria, Libya and Tunisia contains considerable water reserves, which are nevertheless lowly renewable and not fully exploitable. During the last thirty years, the exploitation of NWSAS waters by drilling increased from 0.6 to 2.5 billion m^3/year. Because of the intensive and non-concerted withdrawal, the resource is now confronting many risks such as water salinity, artesianism reduction, natural discharge depletion, drawdown, or interferences between countries, thus seriously threatening the sustainability of socio-economic development of the area.

In order to address these risks, a cooperation process between the three countries is crucial. This is the spirit of the NWSAS works facilitated and implemented by Observatory of the Sahara and Sahel (OSS) in collaboration with the three countries. The joint work has focused on the scientific stakes in the first place, enabling a significant knowledge improvement of the aquifer system, based on information exchange and a joint definition of working hypotheses among the countries. The simulations by the mathematical model built within such framework have highlighted the most vulnerable areas in the medium and long terms. They have also enabled identify new withdrawal zones that could increase the current exploitation while ensuring risk control through a reinforced consultation among the three countries. To this effect, the scientific and technical cooperation gradually led to the establishment of a formal institutional framework for the management of shared water resources among the three countries, i.e. the consultation mechanism.

Balanced geographical coverage:
The NWSAS designates the superposition of two main deep aquifer layers in North Africa: the Intercalary Continental (IC) and the Terminal Complex (TC). The system covers an area of over 1 million km^2 including 700,000 km^2 in Algeria, 80,000 km^2 in Tunisia and 250,000 km^2 in Libya.

Innovation:
The activities on the NWSAS made possible to significantly improve the knowledge of NWSAS hydrological behaviour, the risks it faces, and the related socio-economic and environmental conditions. The three countries' built knowledge base represents a fundamental element in the system's joint management through:

- Improvement of the knowledge of the aquifer system
- Establishment of a common database
- Assessment of current and future water resources availability
- Identification of the risks faced by water resources and uses and environmental threats
- Agreement and establishment of a consultation mechanism

Relevance to current situations and to others actors:
How then to exploit the Saharan basin beyond the recharge rate by pumping in the accumulated reserves within a sustainable management perspective? How can we ensure maximum water withdrawals for the region's best development without irremediably degrading the resource? These are the challenges for the NWSAS water resources.

Today, the activities on the NWSAS are moving towards a third phase, aimed at continuously improving the technical tools by using remote sensing for a precise irrigated land cartography and pursuing the socio-economic and environmental investigations. These elements will undoubtedly constitute an additional step to achieving the overall objective of the OSS approach aimed at developing "shared basin awareness" towards a sustainable development of the arid and semi-arid zones.

Technical and governance orientation:
The paper presents the main achievements of the work done from 1998 to date, related to (i) knowledge improvement and joint management tools (assessment of water resources through hydrogeological data

collection, analysis, and synthesis; elaboration of a common database and an information system; development and exploitation of the NWSAS mathematical model and the regional sub-models), and (ii) sub-regional institutional framework for transboundary cooperation among the countries (socio-economic and environmental studies on water use, establishment of a consultation mechanism for the basin joint management).

4. West Bank Water Planning, Management and Analysis Tool under Uncertain Political Situation

Loay Froukh, PhD, CE., Senior Water Consultant

Summary
The management of limited water resources in the West Bank is complicated by a political situation. In spite of the uncertain political situation, government agencies established under the Palestinian Authority have continued to plan for development of the water sector.

The water issue is one of the difficult issues to be discussed and resolved in the final agreement. Palestinian Water Rights and Equitable Sharing of Regional Water Resources such as the Jordan River and Groundwater Basins are among the main issues that need an equitable solution. Although, an agreement on ownership of groundwater has been elusive, several hydrologic issues are clear. The demand for water greatly exceeds the available supply, and demand will increase if refugees are given the right of return to West Bank. The Israeli side stills the primary user of the groundwater basins within West Bank.

Currently, the West Bank groundwater basins are almost depleted. If the current situation continues the Israeli side drills more wells to pump water for settlements and irrigational activities, and Palestinian side drills wells to meet high demand, the groundwater elevation will drop significantly. Groundwater elevations will continue to drop if the drought conditions continued. The pumping costs will increase with decline in groundwater elevation. In addition to the quantity issues, the quality of water is emerging as a critical issue. Threats to groundwater quality include disposal of untreated wastewater, increasing salinity due to agricultural activities and intrusion of native groundwater of poor quality. Widespread use of herbicides and pesticides also represent a threat to drinking water supplies.

As part of integrated water resources management planning efforts, the West Bank Water Management Analysis Tool was created by the Palestinian Water Authority to evaluate the effectiveness and viability of a range of water management approaches. The tool integrates demand projections, hydrologic data and development actions in an interactive environment where users can develop and evaluate water management scenarios in terms of their ability to meet forecasted demand and the overall cost of implementation. Social and environmental impacts of the scenarios can also be inferred from the analysis.

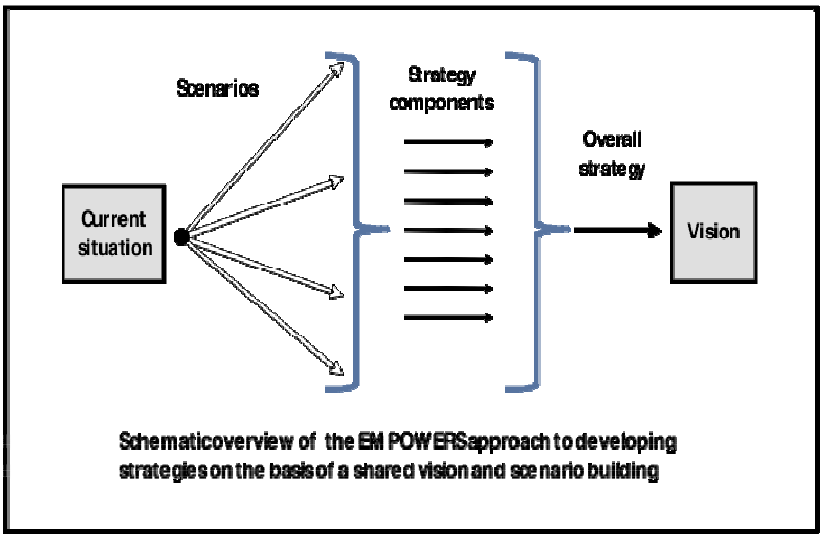
Scenarios were developed for three general approaches to water management (development) in the West Bank: internal water resources development; external resources development and demand management. Comparative analysis of these scenarios demonstrates the urgency of the present water crisis and identifies immediate water management actions for the West Bank common to all scenarios. The analysis also elaborates the limits of internal resource development and demand management and indicates the potential need for development of external resources over the long-term.

5. Uncertainty and Power Asymmetry: Enabling Factors of Poor or Effective Transboundary Groundwater Governance

Mark Zeitoun, Centre for Environmental Policy and Governance, London School of Economics and Political Science

This paper explores two under-examined features influencing transboundary aquifer governance: a) the uncertainty regarding their physical characteristics and low visibility, which make them particularly susceptible to political manipulation, and b) the cross-border power asymmetry that locks-in otherwise unsustainable outcomes. A further distinction is made between fossil and renewable aquifers, with analysis applied to resources shared by Palestine - Israel, and Jordan - Saudi Arabia.

With attention concentrated on the level of the Lake of Tiberias, for example, drops in groundwater in the Western Aquifer Basin go un-noticed. Israeli groundwater abstractions routinely exceed the aquifer's sustainable limits, and dwarf Palestinian abstractions. The 'race to the bottom' of the Disi aquifer between Saudi Arabia and Jordan also occurs out of sight. The competition precludes optimal water use, with crops in the desert irrigated with non-renewable fossil water. Power asymmetry prevents Jordan from executing its plans to pump the water for drinking purposes to Amman. The paper concludes that while they discourage sustainable cooperative efforts in the cases examined, both uncertainty and power asymmetry are enabling (not determining) factors. Under enlightened political leadership, they may in fact lead to more effective transboundary water governance.



Schematicoverview of the EM POWERSapproach to developing strategies on the basis of a shared vision and scenario building

6. EMPOWERS Approach to Water Governance

Charles Batchelor

Water is an increasingly contested resource in the MENA region. There is widespread agreement on the need to improve the management of water resources and the provision of water-related services if the needs of current and future generations are to be met in a sustainable and equitable manner and if the environment is to be protected. There is also general agreement about the need to improve governance – i.e. the process of making and implementing decisions about water.

The EMPOWERS guidelines are based on a project cycle management framework and thirty-two associated methods and tools that can be used by water professionals and practitioners to improve water governance. Although many components of the approach are tried and tested, others are more innovative especially those that have been adapted from the business sector. The guidelines advocate a process of collaboration through dialogue that aims to bring about a change in the way that water sector professionals and water users work with each other. The guidelines also advocate an approach to developing adaptable water management strategies that uses scenario building as an integral part of strategy development and planning processes. The aim being to take implicit account of uncertainty and external factors, often from outside the water sector, that can have a big impact on the success or failure of strategies and plans.

English and Arabic versions of the guidelines and other outputs the EMPOWERS Project can be downloaded from www.empowers.info.

7. Community Based Water Management Project (CWMP)

Dr. Taha Taher, Water & Environment Center - Sana'a University, Yemen

Concept

The development of replicable models of community groups and associations to manage collectively and sustainably their groundwater resources and sustain better income. The objectives are, therefore summarized as follow.

1. To enable Water Users Associations (WUAs) both men and women to develop management plans.
2. To build up an economic derive for the communities for better livelihood.
3. To explore the scope for local regulations of groundwater.

Methodology

The approach developed is covered through three levels:

1. Building up the capacity of the local communities by organizing them into Water Users Groups (WUGs) both men and women utilizing social mobilization tools.
2. Building up the capacities of the WUAs to develop local management plans.
3. Implementing the local management plans by WUAs.

Lesson learned

1. Local communities are ready to take the lead when they have the chance
2. The enthusiasm and willingness of the communities to work collectively, save precious non renewable water and adapt new technologies
3. Communities own great deal of experiences and can provide logical solutions
4. Traditional leaderships in the pilot areas differ from Shieks in Dhamar. educated people in Taiz and religious people in Hadhramout
5. The communities think the government has a role on causing water scarcity by not providing the support and services and not implementing the Water Law

8. Delineation and Implementation of Water Resources Protection Zones in Jordan

Ali Subah, Ariane Borgstedt, Armin Margane

The delineation of the different water protection zones faced by technical difficulties, since zone 2 should principally be based on present-day groundwater contour maps and an estimation of the groundwater flow velocity. However, recent water level measurements are lacking. Therefore the groundwater contours have to be interpolated based on monitoring data of nearby wells. Due to these high uncertainties, sufficiently large safety margins are added in the delineation process.

According to the guideline, MWI, WAJ (wells and springs) or JVA (dams) are responsible for the implementation of protection zone 1. The MWI in coordination with the Ministry of Environment is responsible to control/supervise protection zones 2 and 3 and will undertake the required measures according to existing regulations and laws. The MWI in coordination with the Ministry of Agriculture is responsible to control agricultural activities in protection zones 2 and 3.

In 2006 the Environmental Rangers have been established as a special task force of the Ministry of Interior, with the goal to protect and conserve the Jordanian environment and increase the public awareness on environmental issues. The environmental rangers are part of the police force and have the right to prosecute criminal offences in the field of water and environment and are therefore a true means of enforcement.

With regard to the acceptance of the proposed land use restrictions, it is very important to raise awareness on possible pollution and protection of water resources at different levels.

Outlook
Concerning the delineation of water resources protection zones, the BGR-MWI project focused on the most important resources which provide large amounts of water. However, there are still a large number of scattered wells which also need to be protected from pollution. With a limited number of staff, the MWI will not be able to conduct this task by its own but will have to contract out and supervise the delineation of protection zones so that universities and other scientific institutions will be integrated into the training program provided by the BGR-MWI project.

9. Pro-Aquifer: A Promising Example of Israeli-Palestinian Cooperation to Protect Transboundary Groundwater Resources from Pollution through Municipal Research, Training, and Guidelines

Ladeene A. Freimuth, Friends of the Earth Middle East, Dr. Amjad Aliewi, Khaled Rajab, Najwan Imseih, House of Water and Environment, Amnon Saltman, Gidon Bromberg, Friends of the Earth Middle East

The sewage of over two million people – Palestinians and Israelis – is discharged, largely untreated, ultimately threatening the Mountain Aquifer, which is a vital shared groundwater resource that provides high quality water for Palestinians and Israelis. If the Aquifer becomes contaminated, then the overall water situation will deteriorate and could exacerbate the political conflict.

This "Pro-Aquifer" project, being conducted by Friends of the Earth Middle East (an Israeli-Palestinian-Jordanian NGO) and the House of Water and Environment, a Palestinian NGO, applies an innovative approach to solving these pollution problems and encouraging cooperation between the two peoples.[7] Two pilot case study municipalities are selected, based on pollution sources, hydrological sensitivity, and other criteria.

The project consists of:

1. Conducting scientific and institutional research to better understand the factors that threaten the Aquifer;
2. Providing specialized training courses for municipal staff on sewage treatment technologies, management techniques, and on Geographic Information Systems; and
3. Developing policy guidelines for the two municipalities that will be extrapolated more broadly for Palestinian and Israeli municipalities

This unique approach provides scientific and policy tools, training, and recommendations to the pilot municipalities to help alleviate groundwater contamination in a sustainable manner. It is replicable in other areas of conflict.

[7] This project is funded by the European Union LIFE Third Countries Program and Green Cross France.

Seminar Poster Presentations

1. A Hydro-economic Decision Support Model for Sustainable Management of Scarce Groundwater Resources

Hamed Assaf, Ph.D., P.Eng., M.ASCE, Department of Civil and Environmental Engineering, American University of Beirut, Lebanon

Water scarcity is a common concern of policy makers and the public alike across the MENA region. Countries of the region are faced with the dilemma of supporting vastly expanding populations with dwindling water supplies. The problem is exasperated by unsustainable water policies based on depleting fossil aquifers and overdrawing renewable stocks to support extensive and inefficient agricultural activities.

An interactive decision support tool (DST) was developed to help stakeholders formulate and assess alternative policies for sustainable and efficient management of the Amman-Zarqa Aquifer, a vital water resource in water-impoverished Jordan. Through an intuitive graphical interface the user can manipulate different parameters including: selection of allocation policy among the municipal, industrial and agriculture sectors; water productivities; pumping fuel cost; discount rate; and planning horizon in addition to several other parameters. The user can observe the progress of several variables and states over the planning horizon including water levels, remaining stocks and net present values of water allocated to different sectors. Warning messages are displayed upon occurrence of potentially adverse conditions such as low water levels. The DST was developed based on groundwater and economic principles using the STELLA modelling environment.

2. Groundwater Management In Yemen

Dr. Abdulla Noaman, Water and Environment Center at Sana'a University, Yemen

Yemen is facing one of the most complex development problems and its most serious challenge, namely: the problem of water resources scarcity and over-exploited aquifers. As a result, the water shortage is worsening one year after another, agravated by the continued imbalance between annual recharge and the growing water demand.This water reality imposes on the country the challenge of reducing the existing unsustainable use of water resources through improved management and better planning for its rational utilization, and the challenge of providing safe drinking water and sanitation service to the great majority of urban and rural populations who still lack such services.

Groundwater has played a key role in responding to demand for water and will continue to be one of the dominant sources of Yemen bulk water. Its use has been essential for meeting water demands and household food security. In addition to being a regular source of water under normal climatic conditions it plays a critical role in food supply and livelihood security during dry periods, in view of its ability to act as a buffer against drought and precipitation variability.

Due to the rapid population growth, renewable water resources per capita have decreased from about 250 m^3 to about 130 m^3 (1980 – 2000), and are expected to decrease further to about 80 m^3 in 2015. Over the same time span, the MENA regional average also decreased from about 1700 m^3 to 1000 m^3 (1980-1997) and is expected to decrease to about 700 m^3 in 2015 (Table 1).

Table 1: Renewable Water Resources Per Capita (m^3/capita/year) Source: WB, Data base

Country Name	**1980**	**2000**	**015**
Egypt,	**1,424**	**966**	**735**
Jordan	**396**	**198**	**128**
Morocco	**1,531**	**1,088**	**830**
Portugal	7,069	6,998	7,142
Saudi Arabia	257	120	69
Yemen, Rep.	246	130	82
MENA	1,678	1,045	742
World	10,951	8,336	6,831

Table 2 lists the proposed solutions according to the principal problem each might resolve - but of course water flows, and each action may have some impact on all three problems.

This paper includes a review of the available groundwater data; current groundwater development; and a discussion of possible groundwater management measures. It will provide an overview of the experience gained in Yemen and elsewhere and of the constraints facing groundwater management. It will presents the future prospects and needs in light of this experience and propose key strategic options for lifting the issues and constraints identified and fulfilling the needs.

Table 2: Summary of Proposed Solutions

Problem	Macro Solutions	Sector Management Solutions	Longer Term Agenda	Local Level Solutions
Groundwater Mining	Move to efficiency pricing for water National debate Act on qat Reorient public expenditures	Regional planning Try regulation Water conservation programs for agriculture	Capacity building Policy and strategy Water law Long Term Perspectives Study	Community partnership
Cities are short of water		Regional planning Water markets		
Limited access to potable water		Urban water sector restructuring Promote local private supply Action plan for rural water supply		

3. A regional approach for the management of transboundary groundwater aquifers: The case of the North Western Sahara Aquifer System

Mounir Belloumi, Associate Professor of Economics, Institute of High Commercial Studies, Tunisia

The North-West Sahara Aquifer System (NWSAS) is one of the largest groundwater systems of the world. It is a transboundary aquifer system between Algeria, Libya and Tunisia. Present day recharge is approximately 30 m^3/s while the total abstraction is being 80 m^3/s.

The question is therefore how to exploit the system in a sustainable way, ensuring the best development for the region, without at the same time risking the irreparable and irreversible deterioration of the system. The three countries concerned with the future of the system have to come together and find a way to jointly manage the NWSAS and undertook a joint study of the system under the supervision of the Observatoire du Sahara et du Sahel (OSS). The achieved results of this study was an improved knowledge of the basin's hydrogeology, which could lead to the establishment of a common data base between the three countries serving as an exchange information tool, and the design of a model simulating the hydrodynamic behaviour of the aquifer system and making it possible to forecast the impact of abstraction. The results of this study have been enlightening for the decision-makers of the three countries.

4. Innovative approaches proposals for the management of the Disi fossil aquifer shared between Jordan and Saudi Arabia

Francesca Greco, Consultant, Italy

The innovations proposed for this case study cannot be considered as " truly innovative ideas " but at the same time they are somehow pioneering because they are very "difficult to obtain" under the given political context.

Innovations proposed: the Disi case could be managed in an easier way if it was only possible to put in practice the following actions:

- Transparent data, sharing data
- Sharing water between two countries equitably
- Sharing water among the jordan population equitably

Transparent data, sharing data: Disi plays an important role in the national water discourse being presented as the best solution to water shortage in the country. For this reason data given by the press about the duration of Disi are very controversial. A transparent use of data and a better information about the controversial aspect of the project both within Jordan and between Jordan and Saudi Arabia, could solve the uncertainty about the project once and for all.

Sharing water among the same population equitably: Move the population instead of moving the water. This is the solution suggested by some expert in Jordan supporting the idea that Disi water could be used for the development of the South reducing in that way both the cost of the water transfer and the environmental and social cost of the over urbanization of Amman area.

Sharing water between two countries equitably; the unclear relationship with Saudi Arabia would be solved by showing each country's exploitation of the Disi and setting up a fair agreement between the two countries.

5. Coastal carbonate aquifers in the Levantine countries require a great care and specific management of their groundwater resources.

Michel Bakalowicz (1) (2), Walid Daher (1) (2), Jean-Pierre Delhomme (3), Angeline Kneppers (3) and Wajdi Najem (2)
(1) HydroSciences Montpellier (2) CREEN – ESIB, université St Joseph de Beyrouth (3) Schlumberger Water Services

Along the Levantine coast, essentially Syria and Lebanon, the main water resource is groundwater in large carbonate aquifers. Considering the particular conditions driving the evolution of carbonate rocks all around the Mediterranean, all these aquifers are karstified at great depth below the present sea level. This situation leads to the following main phenomena:

- the natural seawater intrusion, sometimes far from the coast
- the groundwater discharge at submarine springs, permanent or seasonal, at depth up to 70 m below sea level

These phenomena are driven first by the relationship between the head of groundwater in the karst conduits connected to the sea and the opposite head by the sea water level and the difference in density between the two water bodies. This relationship varies seasonally in intensity, so that brackish water may discharge at submarine or coastal springs.

The man activities developing in the coastal areas put particularly the pressure on coastal groundwater, what may modify permanently or seasonally the situation. For instance the sea water intrusion progressed by a few kilometres at south of Beirut, or may occur locally or momentarily, as it is observed in the Chekka aquifer, North Lebanon.

The increase in water demand jeopardizes these abundant and unique resources. Different ways of exploitation are suggested. First of all, the direct exploitation of the submarine discharge is often pointed out. Our recent studies show that this is generally a unrealistic solution, because either the actual discharge is much lower than claimed in the literature, or the groundwater quality is not suitable for water supply. Pumping from on-shore wells requires a good knowledge of the aquifer structure and functioning, linked with a appropriate control network for controlling the sea water intrusion.

From our experience the sustainable exploitation of the coastal karst aquifers is possible by combining a strict control of withdrawals, organised in a plan adapted to the aquifer characteristics, for example by integrating brackish water exploitation for desalination plants, a management of the recharge, by controlling and recycling the surface runoff of urbanised areas normally preventing the infiltration, and by using artificial or controlled recharge in order to maintain the sea water intrusion in acceptable limits. This pro-active groundwater resource management requires a detailed knowledge of the aquifer and of its relationship with the sea.

6. Constructed wetlands – a sustainable solution for the water pollution in the Litani River basin

Rami Harfouch and Nadine Badaro

The pollution of the surface and groundwater in the Bekaa valley (Lebanon) has become a priority issue for the local population in the last decade. Water sampling campaigns, are showing the contamination of aquifers in many locations with coli-forms and nitrates, bringing them below drinking water standards. The contamination is a result of uncontrolled wastewater discharges and of irrigation practices.

The Lebanese government is tackling the problem with a plan to build wastewater treatment plants and sewer networks throughout the Bekaa. But the plan, when completely executed, will leave 15% of the Bekaa population outside the collection network.

Small and remote municipalities in the Bekaa should consider constructed wetlands as an economical and sustainable solution for wastewater treatment. The process consists of filling a parcel of land with water conductive gravel that allows underground, gravity driven, movement of water from an inlet to an outlet structure, the gravel matrix is planted with specific wetlands vegetation. The process allows a natural treatment for water. It has the advantage of requiring little maintenance costs, in comparison with a conventional wastewater treatment plant.

Many factors contribute to making this process effective and safe in the Bekaa. The land is available at a relatively low cost and has a flat topography. The silty cover soil can reach a barrier layer low conductivity requirement with minor treatment without using any synthetic liner. Finally, wetlands are a natural ecosystem in the Bekaa valley. Constructed wetlands would help reintroduce the original ecosystem and habitats for native fauna and flora. A pilot project would be a good start to begin the trend. Source: Adapted from drawing by S.C. Reed, 2000.

7. Cooperation in Solving Groundwater Problems, Epistemic Community Addressing Groundwater Problems in the Euphrates-Tigris Region

Ayman Abdulrahman Al Furat University, Syria and Faisal Rifai

The proposed fields that ETIC seeks to achieve are sustainable socioeconomic development, riparian initiative promotion, planning and implementation of joint projects and improved prospects for cooperation. Examples from Syria on innovation in pollution control, alleviation of groundwater abuse and scope for cooperation are used to show prospects for regional approach to tackle groundwater problems.

The watersheds of both the Euphrates and the Tigris are situated predominantly in the countries of Turkey, Syria, and Iraq. So far the three riparian countries have not reached a comprehensive agreement to ensure collaborative sustainable water management. This condition resulted in unilateral and country development projects. Each of the riparian countries has tended to develop its water use plans unilaterally, without regard to the needs of the others, the environment, or the actual capacity of the rivers. Although there have been some international efforts to coordinate projects for developing the rivers water, joint collaborative activities have never become a reality.

A recorded continuous drop of the groundwater table in almost all regions is clearly indicating that the groundwater resources are already over-used on a country-wide level.

Establishing a coordinated regional action in the Euphrates-Tigris Region may be a challenge.

It is necessary for Iraq, Syria and Turkey to start cooperation to work within a framework of integrated programs and develop it by phases. The basis of the collaborative activities has to be based on scientific, socio-economic, legal, institutional and environmental principles in the management of transboundary surface water and groundwater. Groundwater issues are more complicated than surface water ones due to several reasons such as: aquifers are rarely homogenous and/or isotropic, so flow patterns can be complicated; transboundary aquifers are not well known to policy makers; hydrologists cannot predict reliable amounts of the shared ground waters in different countries as they can do with surface waters; and present international law have limited application in conditions concerning spatial flow of ground waters.

The goal of ETIC is to promote dialogue and networking among stakeholders from water based development sectors, and foster implementation of collaborative activities in the E-T regions.

ETIC may use national, regional, and international meetings and platforms to inform the relevant communities and the general public of the initiative.

ETIC will identify immediate, medium-term, and long-term areas of research and implementation, design and implement training and visit programs, develop project profiles and may delegate professional consulting work in agreed areas.

ETIC may use national, regional, and international meetings and platforms to inform the relevant communities and the general public of the initiative.

8. Sustainable Management of Groundwater Resources in Iraq

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One of the primary national priorities is social sustainability which is tightly linked to sustainable natural resources. In an arid to semi arid country like Iraq, groundwater used for social development can hardly be described as a sustainable resource unless management is practiced as a national policy. To draw a road map for national management policy, proper assessment of the resources and their use ought to be available including country's main aquifers renewable and non renewable storages, aquifers storage and water quality surveillances, and methods for restoring aquifers storages after heavy drafts.

Groundwater resources planner in Iraq is however faced with various types of limitations; in particular groundwater quality shows high variability even within one aquifer and therefore a shift of water suitability for the different uses. Furthermore, some of the main aquifers in the arid part of the country exhibit non renewable storage condition while others in the more humid parts have renewable storages. Fortunately, these variable conditions could visually be enhanced using a GIS system that may produce maps showing multi themes. These maps will be used to apply the following recommended set of rules of national priorities in a groundwater management policy road map.

1. Renewable and non renewable groundwater resources suitable for drinking should be used to meet communal needs for that purpose as a priority.
2. Renewable groundwater resources suitable for agriculture could be used conjunctively with surface water in river basins, or as supplementary irrigation in rain fed areas to the north and northwest of Iraq.
3. Non renewable groundwater resources suitable for other purposes than human drinking, as in the case of the desert region, may be drafted in accordance with a strict plan that takes in account the stock reserve found in the major aquifers of the region. Since groundwater represents here the major water source for any activity, it is recommended that special attention should go to make water available for: domestic and range land animal resources and to future industrial needs that may appear in the region. Under the condition of uncertain water availability, no new agricultural communities should be encouraged to be established in this region.
4. A well prepared program aiming at augmenting or restoring aquifers storages should go parallel to groundwater utilization plan, this may include: deep drilling to explore new aquifers, injection of treated water to restore the storage of aquifers used for agriculture, and harvesting of storm water for the purpose of artificially recharging non renewable aquifers.
5. Development of legislations and tools that aid authorities to enforce groundwater management measures. A tool which will be highly essential for the verification of a plan that maintains groundwater sustainability and enforce its measures would be the establishment of a nationwide groundwater monitoring system.

9. Optimal engineering design for dependable water and power generation in remote areas using renewable energies and intelligent automation.

Socio-Economical Analysis for Integration of Renewable Energy Desalination Systems in Rural Areas

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Water scarcity in rural MENA regions is one of major cause of desertification, which has to be understood as the degradation of land in arid and semi-arid regions and not as the expansion of existing deserts. This scourge is actually accentuated by the population exodus towards large agglomerations.

The wide presence of underground brackish water in these rural zones is actually promoting the use of Autonomous Desalination Systems –ADS- run by renewable energies for producing fresh water. This technology appears to be an adequate solution for providing rural populations with save fresh water. Intensive research work is actually being undertaken including experimental pilot plants for providing reliable long-lasting systems able to integrate the rural environment in a sustainable manner. The 'Open-Gain' EU funded project is an example.

Fresh water points (as wells, fountains, rivers, springs…) have been the core of rural communities for centuries. The success of implementing such technology relies strongly on a proper analyses and consideration of social, economical and geographical conditions. The operation and management of the system and the water produced have to be adequately implemented in order to improve living conditions while preserving the cultural social values that kept steady and sustainable rural populations. Previous experiences have shown that development scheme did not bring the intended results but in contrary has negatively affected the stability of the society.

As an example one can name the case of providing small villages with water distribution networks. Even though, initially the idea appears to be beneficial for the users, but it can have negative effect on the water resource by changing water consumption habits and by disappearing the gathering point of gender.

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