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# Approach to a conceptual frame of technological perspectives for water resources management in the Mediterranean Region

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**Abstract.** In most Mediterranean countries the availability of fresh water supply is increasingly reduced due to the growing demand. This often creates conflicts among the various sectors and places great pressure on the ecosystems supporting these resources. Therefore, the challenge of water use and allocation is now a major political concern in the Mediterranean Basin and is likely to become even more serious in the next years. This is why integrated water resources management (IWRM) and the search for appropriate technology are high on the policy agenda. Technology development will be aimed at managing both supply and demand and tackling problems relating to water quantity and quality. Therefore the 2nd Melia project workshop, held in Marrakech in November 2008, was intended to face most of these issues and discuss the technological perspectives of sustainable integrated water resources management in the Mediterranean region, focussing on the technology used to enhance water supply, the preservation of resources quality, the social and cultural aspects of water management, the institutional, governance and policy aspects and emphasizing the importance of available technical tools to improve management (GIS and remote sensing). The debate also addressed the various regulations and directives in the field of resources management and the new challenges posed, particularly, by global and climate change, the changing world economy and social and economic disparity between southern and northern Mediterranean countries and the need for bridging this gap in order to promote sustainable management of resources in the Mediterranean Basin. As a result, some key concepts were defined and the final recommendations outlined a number of criteria to tailor technology to the sustainable management of scarce water resources in the Mediterranean region.

**Keywords.** Appropriate Water Technology – Integrated Water management – Stakeholder involvement – Initial stage – Mature stage – Demand management – Criteria – Water Scarcity.

## ***Approche a un cadre conceptuel des perspectives technologiques pour la gestion des ressources en eau en region Mediterraneenne***

**Résumé.** Dans les pays méditerranéens, on constate une réduction considérable de la disponibilité d'eau douce face à une demande croissante, ce qui génère des conflits dans les différents secteurs et une pression importante sur les écosystèmes qui soutiennent ces ressources. Par conséquent, le défi de l'utilisation et de la distribution de l'eau représente une préoccupation politique majeure dans le bassin méditerranéen qui risque de s'aggraver dans les années à venir. C'est pourquoi la gestion intégrée des ressources en eau (IWRM) et la recherche de technologies appropriées constituent actuellement une priorité dans l'agenda politique. Les technologies seront développées en vue de gérer tous les aspects concernant la demande et l'offre et faire face aux problèmes relatifs à l'eau sur le plan de la quantité et de la qualité. Le deuxième séminaire du projet Melia, organisé à Marrakech en novembre 2008, avait donc pour objectif d'aborder ces problématiques et de débattre les perspectives technologiques d'une gestion intégrée durable des ressources en eau en Méditerranée, en parcourant différents thèmes, depuis les technologies utilisées pour améliorer l'offre d'eau à la préservation de la qualité des ressources, en passant par les aspects sociaux et cultureux de la gestion de l'eau, les aspects institutionnels, politiques et de gouvernance et l'importance des outils techniques mis au point pour faciliter la gestion (SIG et télédétection). Le débat a aussi été focalisé sur les différents règlements et directives concernant la gestion des ressources et les nouveaux défis de la gestion et notamment, le

*changement planétaire et climatique, l'évolution de l'économie mondiale, la disparité sociale et économique entre les pays du sud et du nord de la Méditerranée, et sur la possibilité de réduire cet écart pour gérer les ressources d'une manière raisonnée dans le bassin méditerranéen. Le débat a permis d'identifier des concepts clés et de formuler des recommandations sur les critères à satisfaire pour employer les technologies appropriées en vue d'une gestion durable des ressources en eau limitées de la région.*

**Mots-clés.** *Technologies de l'eau appropriées – Gestion intégrée de l'Eau – Participation des acteurs – Stade initial – Stade avancé – Gestion de la demande – Critères – Pénurie d'eau.*

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## I – Introduction

Most of the Mediterranean countries in North Africa, the Middle East and Southern Europe display many similarities in terms of growing water shortage, increased drought events, increased pollution threats, increased overexploitation of groundwater resources and increased threat of sea water intrusion, rapid population growth and rapid tourism growth. In addition, natural surface and groundwater resources do not recognize frontiers, and many of them are shared by more than one country, thus complicating more water sustainable management. The common feature in the Mediterranean area is that water is one of the limiting factors for sustainable development, increased quality of life, and peace.

The regional average annual per capita renewable water has significantly fallen over the last 40 years from 3,300 m<sup>3</sup> in 1960 to 1,250 m<sup>3</sup> in 1995 and is estimated to drop to 650 m<sup>3</sup> by 2025. Estimates of the World Resources Institute (1996) suggest that by 2025 some EMR countries will be among the 45 countries worldwide which will suffer from chronic water stress. An increasing proportion of surface and groundwater resources in the region are polluted mainly due to inappropriate disposal of municipal wastewater, infiltration from onsite sanitation facilities, and excessive use of fertilizers and pesticides in agriculture. Due to a severe shortage in agricultural water, reuse of wastewater has become unavoidable in many countries such as Jordan and Syria. Untreated wastewater was and is still used sometimes in agriculture without adequate health safeguards.

Trends in most European countries indicate that water supply to the population is threatened by man-made pressure and that water ecosystems are undergoing severe processes of quality deterioration (Berbel *et al.*, 2004). About 20% of the whole surface water in the European Union is seriously threatened by pollution. Groundwater supplies around 65% of all Europe's drinking water, and 60% of European cities overexploit their groundwater resources. Furthermore, 50% of Europe's wetlands are identified as "endangered" due to groundwater over-exploitation and the area of irrigated land in Southern Europe has increased by 20% since 1985 (European Commission, 2002). In recent years, there has been a growing concern throughout the EU regarding drought events leading to water scarcity problems, especially in the Mediterranean countries. The competition between various uses, especially agriculture and tourism, which are major components of this area's economy, very often make trade-off allocation decisions too difficult. Hence, conflicts over water are increasing and they are becoming more complex, involving competition among alternative uses, among geographical regions with disparate water endowments, and between water resources development and other natural resources lost due to that development.

The challenge of water use and allocation is now a major political concern in the Mediterranean Basin and is likely to become even more serious in the next years. This is why integrated water resources management (IWRM) and the search for appropriate technology are high on the policy agenda. Technology development will be aimed at managing both supply and demand and tackling problems relating to water quantity and quality. The identified relevant technology shall enhance supply through the use and reuse of available resources in the most efficient way and lead to integrated and comprehensive management. The legal and institutional aspects are also an integral part of the countries' efforts toward overcoming their water problems and helping

reduce poverty, attaining food security and economic growth, while maintaining sustainable ecological systems and their services. (Gbadegesin, 2008).

Over the last decade of the 20th century, new strategies for water resources management have been promoted. These strategies are recommended in several chapters of Agenda 21 and they are also confirmed in the First Paragraph of the UN Program on Integrated Water Resources Development and Management, which states that the “development of appropriate water management requires the application of new sustainable technology both in terms of analysis and of engineering”.

## II – Water Management Techniques and Technology

The rapid advancement in developing water technology related to large pumping equipment, drilling technology and the ability to tap very deep aquifers, filtration and treatment technology, has allowed easier access to water resources and increased the pressure over the sustainable utilization of these resources. In many northern countries the overutilization and the unsustainable use of resources during the forties have left large rivers and lakes heavily polluted and some aquifers extremely overexploited during the sixties in some southern areas of the Mediterranean. These alarming incidents and many similar ones worldwide have drawn the attention of water scientists leading them to consider the need for using resources in a sustainable way. The Mar del Plata conference in 1977 was the first to address this issue. Then the famous Dublin principles came in 1992 during the preparation of the UN conference on the concept of sustainability that was organized in 1992 in Rio de Janeiro. After that, the IWRM concept has become the rule in water resources management in general and accordingly, emphasis has increasingly been laid on the need for developing more efficient technology to ensure the sustainable use of resources, while achieving the goal of social, economic and environmental benefits. Moreover, it is clear that at this point in time, where demand exceeds supply, the available water resources cannot be managed and utilised as they were in the past, when the resources capacity was much higher than the demand and the inter-sectoral conflict over the use of resources hardly existed.

Randall (1981) distinguished two stages in the development and management of resources, the initial or expansive stage, and the maturity stage. During the initial stage of resources development, the volume of economically and technically available natural resources exceeded the demand. Accordingly, the competition was low and the engineering works were designed to allocate water in the areas where water rights were established. He also summarized the characteristics of water resources development and management during the two stages as shown in Table 1.

**Table1. Major Water Resources Development Stages.**

| Aspect   | Stage   |  |
|--|---|--|
|  | Initial   | Maturity   |
| Increasing long-term supply by exploiting new natural resources                  | Mostly possible   | Extremely difficult  |
| Water Demand   | Low and expanding<br>High elasticity at low price and inelastic at high price | Strong and expanding<br>Medium elasticity at low price and inelastic at high price |
| Physical conditions of engineering infrastructure                                | Most of them are almost new and in good condition                             | A large part is old and expensive to repair and renew                              |
| Competition for water among different users.                                     | Minimal   | Intense  |
| Socio-economic and environmental problems  | Minimal, competition for economic resources (public infrastructure)           | Intense, competition for the resource itself                                       |
| Social cost stemming from subsidised water, especially for agricultural purposes | Very low, very low levels of cost recovery                                    | High and expanding, increasing cost recovery schemes                               |

Clearly, depending on the stage of water resources development and management (initial or mature stage), some solutions will be more successful than others. We can deduce that, during the initial stage, focus will be more on the supply side management and on actions aimed at increasing the supply, whilst during the maturity stage the demand side management of existing available resources is much more important. During this stage, water management has, on the one hand, an engineering dimension that aims at meeting demand with the most efficient water use possible and, on the other hand, it must address socioeconomic and environmental aspects that can even lead to the reallocation of the resources, provided that pre-existing rights are respected or duly compensated (López-Martos, 2008).

It was also clear that during the initial stage of water resources development, the main and almost only activity is to quantify and tap the available resources (surface and groundwater). The advances in developing sophisticated technologies and tools such as remote sensing, GIS, various quantity and quality modelling techniques, have fostered the level of understanding and improved the knowledge about physical as well as other characteristics of water resources. However, when pressure over resources increases, resources management in a conjunctive and efficient way becomes a necessity in order to ensure the sustainability of these resources in terms of quantity and quality. This implies that the technology should focus on all possible demand management aspects. Such aspects may vary from improving the main water transmission networks and water supply systems (reducing losses), adopting low flow appliances at household and farm level (efficient irrigation techniques) to developing proper pricing policies that capture the true value of the supplied water as well as developing regulations that support efficient and proper allocation among the different users. In the meantime, more attention is given to the development and utilization of the unconventional water resources or even to consider various other options such as virtual water. Furthermore, good water governance and efficient institutional setup becomes a must in order to ensure a balanced and participatory approach in managing these resources. Such an approach shall ensure the representation of all stakeholders' interests in a given watershed or a river basin or of those who benefit from the same resource in a given territorial unit. The importance of this approach is more challenging in areas where water is scarce. Spain, for instance, was the first country to introduce the notion of watershed or river basin as a legal concept for water management, and consequently, watershed was considered as the territorial unit for water resources planning and management. This concept has also been adopted by other countries including the USA and taken into account by the European Water Framework Directive (2000/60/EC).

During the mature stage, the development and utilization of unconventional water resources (wastewater reuse and/or desalination of seawater or brackish water) become an integral part of the overall resources management and they are considered as part of the water resources budget in a given watershed. This becomes especially significant in areas suffering from water shortage. Despite the fact that the development of these unconventional resources requires expensive and energy-intensive technologies, yet, the need for their integration within the overall resources budget is a must. Here, the relation between water production and energy requirement for the process becomes one of the key determining factors. However, the advancement in technology and engineering has so far led to develop these resources at a reasonable cost. Yet, if this achievement in technological advancement is not met through proper governance, institutional setup and regulatory structures, that can ensure the integration of these resources in the overall management policies, may become a burden and may cause the failure of the overall water management in a given area.

In addition, the stakeholders' involvement in the various phases of resources planning, adaptation and management is really crucial in order to ensure social and cultural acceptability of some of these resources (especially, the reuse of treated effluent). To support the stakeholders' involvement more awareness programmes on resources and advantages and disadvantages of

their potential use are needed along with more capacity building programs, tailored to improve the stakeholders' knowledge of resources and technology used for their management.

Based on the above considerations, any technology used for water resources development and management, whether at the initial stage or mature stage, should fulfil the following requirements:

1. New and sustainable technology should have the capacity to address the challenges with we are facing, but fully respecting the ecological needs.
2. Technical skills and expertise necessary for technology implementation are available.
3. Public engagement in the technology development must be ensured; for example, technology developed through public- private partnership may be considered favourable.
4. Technology should be cost-effective.
5. To make sure that the new technology developed / adopted in agriculture is tailored to save more water and may include:
6. Efficient irrigation technology;
7. Possibility of planting earlier;
8. Shorter crops cycle;
9. Improved draught resistance capacity;
10. Salinity resisting crops;

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The criteria for Appropriate Technology can be classified under several categories as follows:

1. Technical viability
  - Easy to be operated and maintained
  - Technically efficient
  - Capable of addressing real needs
2. Economic Feasibility
  - Cost-effective in specific socio-economic conditions
  - Affordable, i.e. people can afford its adaptation

### 3. Environmentally Sound

- Producing no environmental harm.
- Appropriate, according to the local environmental conditions where it will be applied

### 4. Socially and Culturally Acceptable

- Developed in a real participatory way by all actors (stakeholders)

### 5. In line with the national standards and regulations

### 6. Adequate Institutional setup for its accommodation and customization.

It is important to note that even when the above criteria are fulfilled, the implementation and adaptation of any new technology will face certain constraints.

Constraints to implement new and more efficient technology:

1. Large knowledge gap between scientists, practitioners, policy makers and the public about the different technologies applied.
2. The format and language that describes technology are too technical to be understood by the public and sometimes even by policy makers (lack of appropriate communication language).
3. Lack of mechanisms to create sufficient concerns about the problems and mechanisms to propose appropriate solutions.
4. Lack of people's capacity and reluctance to adopt new technology.
5. Bad experience of people in applying some technologies which affect their willingness to adopt other useful technologies. No public debate on different alternatives.
6. Lack of funds
7. Lack of responsible and independent media coverage
8. Poor governance conditions.

These constraints are commonly encountered and they hinder the possible adaptation of technology. However, mitigation measures can help overcome such constraints.

Mitigation Measures Needed to Overcome the Constraints Facing Technology Adaptation

1. A compulsory institutional involvement in costs & maintenance and especially, in staff training. is needed.
2. Feasibility and Demonstration studies in local conditions are needed in order to assess their applicability according to the real needs and possibilities.
3. Dissemination and Communication Strategies to raise public awareness on the importance of treating wastewater must be elaborated.
4. North-South scientific collaboration and knowledge transfer in this field must be promoted.
5. Public participation in social aspects shall be enhanced through interaction with end users, administrators and stakeholders.
6. End users shall be regularly informed on the costs and difficulties encountered in handling new technology, if any.

### III – The way forward

In order to overcome the constraints to develop new technologies and promote their public appropriation, the following measures can be proposed:

1. Select the technology that best fits the local conditions, and do not to consider that technologies successful somewhere are necessarily successful in another place.
2. Allow all actors being involved in the development of experimental platforms. Scientists and Administration have to work together. The public should be able to follow debates on technology adoption.
3. Promote broad dissemination of successful scientific results to the public, end users and all the actors concerned (translate scientific outputs into simple common language).
4. Promote the participatory approach in decision taking.
5. Increase training opportunities for technical and non-technical staff.
6. Need for institutional and economic support to enhance public awareness on a regular basis, and not on an ad-hoc basis.
7. Promote lobby groups to ensure that policy makers properly understand the problems IWRM, and adopt the appropriate means to handle it.
8. Use unconventional channels to convey the message to the public at large (e.g. use Football teams, actors, etc.).
9. Show the consequences of not taking any action.
10. Develop a communication strategy with media involvement.
11. Improve knowledge sharing among practitioners through the following actions:
  - Support their participation in different scientific events as well as in the experimental work.
  - Build their theoretical capacity to allow them coupling theory with practice.
  - Report on success and failure stories known and on the lessons learnt.
  - Provide communication venue.
  - Allow exchange of expertise (to overcome barriers such as funds, language, etc.)

### IV – Key Recommendations

1. It is necessary to focus more on virtual water concept and consider it as a tool to raise awareness of water cost-effective use water, especially in water deficient regions. The import of a product or the production of a crop could be presented as virtual water Importation or exportation, respectively. Therefore, we can compare water use efficiency according to the crop type, the specific conditions, etc. Any option can be evaluated according to the virtual water needed, and its impact on the overall water budget. The term National Water Footprint reflects the National situation in terms of water balance.
2. Remote sensing is a useful scale-dependent tool which can never be used without ground truth. It is a complementary tool which can reduce the amount and costs of field validation in integrated water management. However, scale and both spatial and spectral resolution must be considered for each individual case. Active remote sensing (i.e. Radar and Interferometer) are additional remote sensing tools for the assessment of water quality and non traditional

water resources. Developing computer models and computation of indices as indicators for water quality and water balance is recommended. The Global Earth Observation System (GOES) provides short intervals of satellite imaging and therefore it can be used for remote sensing in agriculture and in water resources management.

3. More work should be done to enhance on-farm water use efficiency.
4. To Intensify the dialogue among partners is necessary to heighten awareness of the consequences of using fossil water to irrigate the oases.
5. More work shall be devoted to assess the possible impact of the climate and global change over the resources and adaptation measures that must be taken by the different Mediterranean countries.
6. More research is needed to explore the utilization of renewable energy as an important alternative in water management related technology throughout the Mediterranean Basin.
7. Policy alignment among the different countries in the basin is needed to ensure better integrated management of resources.
8. It is necessary to encourage technology preserving water and energy by providing incentives at local, national or regional levels to users and investors.

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