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WATER RESOURCES AND IRRIGATION WATER POLICIES IN THE MEDITERRANEAN

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INTRODUCTION

Presently, water shortages have obliged a number of arid and semiarid countries to increase food imports because the local agriculture sector is no longer able to produce sufficient food to fill the existing food gaps. Food production and its perspectives are not promising, in spite of the fact that agriculture is by far the largest user of water in the world: on a consumptive use basis, in fact, 80 to 90 percent of all water is consumed in agriculture. Unfortunately, the water use efficiency in this sector is very poor, not exceeding 45% with more than 50% water losses, and thereby many countries facing water scarcity and its related problems will never reach appropriate solutions towards the achievement of food security, water security and environment sustainability.

Today, in those countries, the question is whether a water crisis can be averted or whether water can be made more productive. The answer to this question relies on the way we are using and managing water resources in the irrigation sector. The more we produce with less water and/or with the same amount of water, the less the need for infrastructure development, the less the conflicts among sectoral water uses, the greater the local food security and the more water available for agricultural, household and industrial uses, beside ensuring that there remains enough water for the nature.

However, to achieve such goals, major changes are needed in irrigation water policies along with major improvements in water resources use and irrigation technology and management. Meeting such challenges will require far greater efforts and significant changes in how water is managed in the agricultural sector. What needs to be changed in irrigation policies? What are the improvements required to cope with increased water scarcity?

WATER CRISIS: The Emerging Questions

- Whether water crisis can be averted or whether water can be made productive?
- How to meet the ample water demand at a time when pressures on resources are increasing and their mobilization is becoming increasingly expensive?

Those are the issues to be discussed in this paper that highlights major policy issues in the management of agriculturally used water resources as well as addresses the appropriate techniques and proper approaches to be adopted for increasing the productivity of water through water saving, improving water use efficiency and encouraging the conjunctive use of waters of different qualities. In addition, a part of this paper will discuss the food security perspectives and the possible means could be practiced to overcome the food gap in the arid regions and in particular the Mediterranean one.

WATER SITUATION IN THE MEDITERRANEAN REGION

It has been calculated that in 1990 approximately 280 km³ of water were globally used in the Mediterranean region, including all the riparian countries and entities of the Mediterranean Sea, 99% of which comes from natural resources.

The natural renewable water resources in the Mediterranean region equal 1,153 km³/year. In global terms per country, the exploitation index (the ratio of total water withdrawals/average natural renewable resources flow) already exceeds 50% in 8 Mediterranean countries. This means that tensions are originated, at least locally or at certain times. When such rates reach or even exceed 100%, they indicate that the balance is disrupted or that there is a deliberate, but unsustainable use of non renewable resource (Libya) or indeed reuse of part of the non-conventional water resources such as treated waste water or drainage water as in Egypt and Israel. However, those indicators refer to the totality of natural resources: the situation would appear more critical if the indicators referred only

to those resources considered as exploitable. In this case, a new picture will appear and the criteria will differ from country to country.

WATER PROBLEMS IN THE MEDITERRANEAN REGION

The dominant fact that will be strongly evident over the next few decades is the structural imbalance between the constantly increasing demand for water to meet the needs (Fig. 1) and the natural available water resources.

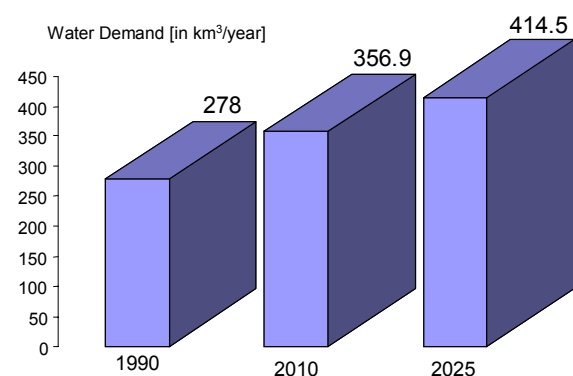


Fig. 1. Actual water demand (in 1990) and foreseen water demand for 2010 and 2025, in km³/year.

As a matter of fact, in the majority of countries in the region such imbalance has already appeared around the year 2000 and beyond. Those countries are facing similar problems that can be outlined as follows (Hamdy, 2000 a):

- declining water withdrawals and water availability per person. It is expected that the available water per capita will be reduced to nearly 50% of the present one (Fig. 2);
- over-exploitation of water at a relatively high rate, with the risk of water quality deterioration;
- excessive reduction in water withdrawals per capita, which will impose its significant effect on the water sectoral use, creating notable competition and conflicts among users in various sectors, in the irrigation and domestic sectors particularly;
- progressive degradation in the quality of atmosphere and available water resources because of increasing waste load discharged into water bodies.

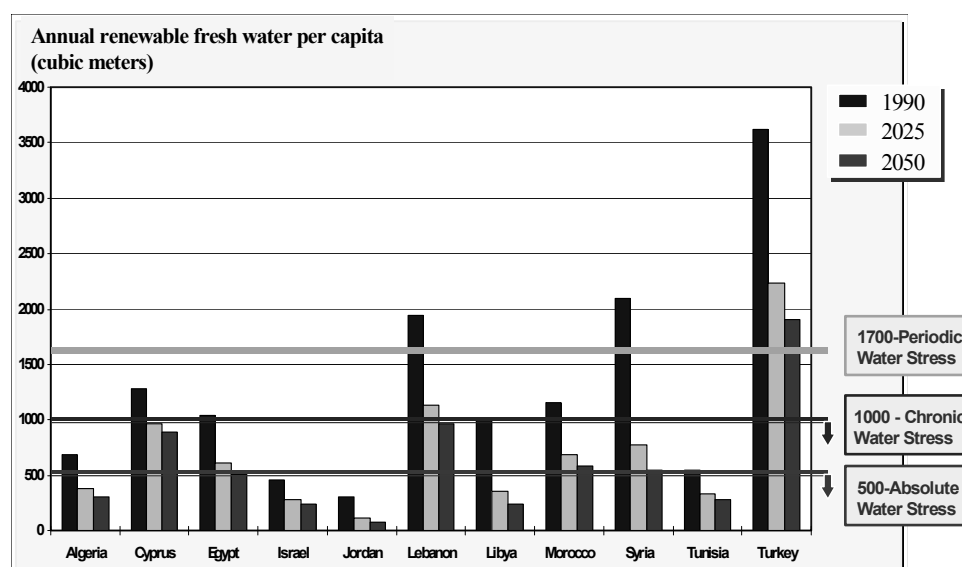


Fig. 2. Renewable fresh water availability per person in the Southern Mediterranean countries, 1990 to 2050.

The question emerging nowadays is how to meet this ample water demand?

The master key for a reasonable answer to the above raised questions as well as to the problems deriving from the presence of such water imbalance are focused and they mainly depend on the way water is used and managed in the agricultural sector. The reason for that is not because 80% of the water is allocated to the irrigation sector, but because of water losses, exceeding 50%. Reducing losses in this field would be a win-win solution permitting not only to obtain ample new water supply for meeting the needs of the expanded irrigated area, and to fill the chronic food gap, but also to satisfy the increasing water requirements in the other sectors, thus eliminating the otherwise unavoidable conflicts; this requires new management strategies which emphasize:

- the co-ordination of land management with water management;
- efficient water allocation;
- demand management strategies that involve policies and activities to reduce unit of activity use rates;
- technologies and institutional instruments which together will enable principles of demand management to be integral to the allocation and management of water;
- economic and financial instruments and regulatory and legal frameworks.

Such situation calls for more attention on water resources policies and the irrigation policies and practices in particular, on how and what we use water for. Water problems and the ways towards solving them are very well known theoretically, but practically, most of the solutions remain vastly unimplemented because water policies and water management strategies, particularly in the agricultural sector, are not favoring the solutions both to the actual and the perspective water problems.

Water Problems in the Mediterranean Arid Countries: MAJOR CHALLENGES:

- To cope with increasing water scarcity and climate change incidence,
- To equilibrate the structural imbalance between the limited and fragile natural water supply and the increasingly water demand,
- To govern the water and to reallocate it to satisfy sectorial water uses,
- To eliminate the rapid deterioration of water quality and to stop its increasingly pollution,
- To improve the institutional capacity building,
- To increase water productivity and to reduce its losses in all sectors and in particular the agricultural one,
- To find the appropriate tools for water valuation and the adaptable mechanisms for water projects cost recovery,
- To increase awareness among the water users to change the attitude in the way the water is used,
- To change the way we are managing water resources from the fragmented approach to the one that integrates the supply oriented management approach with the demand oriented one.

IRRIGATION AND AGRICULTURAL WATER USE

At present, the irrigated areas account for more than 16 million hectares; in 15 years, these areas have increased by 3 million hectares and the growth rate seems to stabilize around 200,000 hectares per year. This implies the use of a supplementary capacity in the order of 2 billion m³ of water per year only for agriculture. This will certainly cause some difficulties for the partitioning of water resources between agriculture and the other sectorial water users.

Irrigation is extremely water intensive. It takes about 1000 tons of water to grow one ton of grain and 2000 tons to grow one ton of rice. In the Mediterranean area, irrigation represents 72% of the total water withdrawals. During the next twenty-five years, sustainable quantities of fresh water supplies will be diverted from agriculture to industry and households in the region. Irrigated agriculture will face two challenges of water shortages and dwindling financial resources.

Irrigated Agriculture and Irrigation Water Management Characterizing Features:

- fragmented management approach is mostly dominant,
- incentives for water conservation are few and disincentives are numerous,
- irrigation is developing faster than the water source mobilization,
- centralized the irrigation water management by governments with the following sequences:
 - poor management practices, inefficient water use and failure to place high economic value on water;
 - resource degradation by water logging, soil and water salinization and pollution of aquifers;
 - increasing demand for water leading to rapid mining of aquifers, water shortages competition and conflicts.

Despite these challenges, irrigated agriculture will have to provide 70 to 75 percent of the additional food grain requirements to the developing countries of the region. This will not be possible without developing effective methodologies and systems for assessing and improving the performance of irrigated agriculture. Such systems have to evaluate the contribution and impacts of an irrigation scheme in terms of production, self-reliance, employment, poverty alleviation, financial viability, farmer's profitability and environmental sustainability (Hamdy, 2000 b).

WATER PLANNING AND MANAGEMENT: THE NEED FOR A NEW APPROACH

The experience gained and the lessons learned clearly emphasize that the fragmented approach we are still using in managing water resources in the agricultural sector resulting in enormous water loss will never provide the region with both water and food security. In the majority of the countries of the region, the increase in water demand under the presence of limited water supply on one hand, and the arising water scarcity problems on the other hand, are steadily mounting; the response to such acute water shortages require immediate actions and plans with appropriate changes in the way those countries are using and managing the water resources.

The ultimate goal for managing water resources in general and irrigation water in particular is Efficiency, Equity and Sustainability, but the desired goals are still so hard to achieve principally due to:

- Market failure.
- Government failure.
- Environmental deterioration.

The Traditional Approach

Traditionally, solutions were fully focusing on the supply-side, relying on an ever-larger number of dams, reservoirs, and aqueducts to capture and store ever-larger fractions of freshwater run-off. Such approach is now criticized for environmental, economic and social reasons. Basic human needs for water still remain unmet and it is becoming harder and harder to find new water resources, or even to maintain the existing ones to supply croplands.

Under such traditional approach, water-planning efforts usually did not include a detailed analysis of how water is actually used. Equally, there was no clear identification of the common goals for water development to seek agreement on principles to resolve conflicts over water. In addition, little attention has been paid to protecting natural ecosystems from which water supplies have been withdrawn. Those are growing calls, beside others including high costs of construction, tight budgets, deep environmental concerns, pushing towards changing the way we are following in planning and managing our water resources.

In the developing countries, given the increased cost of new irrigation development with the scarcity of land and water resources, the emphasis in the future will be more on making efficient use of water for irrigation and less on an indiscriminate expansion of the irrigated area.

What is the alternative? In our opinion, our efforts and re-thinking should be directed to change the traditional approach in managing and planning our water resources to a sustainable soft path putting greater emphasis on development principles that reflect environmental, social and cultural values.

The New Soft Path Approach

It is well recognized that the reliance on physical solutions, although still continuing to dominate the traditional planning approach, failed in satisfying basic water requirements for human activities and, above all, it gave origin to several social, economic and environmental problems.

Nowadays, many developing countries and particularly those of arid and semiarid regions, are changing the way of thinking and approaches in managing their water resources, re-directing them towards the soft path approach through developing new methods to meet the demands of growing population without requiring major new constructions or new large scale water transfer from one region to another. Their focus is mostly on the possibility for efficiency improvements, implement options for managing demand, reallocate water among users and conjunctive water use and recycling of waters variable in their qualities.

Demand Water Management: Enabling Conditions

- institutional and legal aspects,
- utility reforms,
- privatization,
- macroeconomic and sectoral policy.

However, this does not imply to stop increasing water supply through the traditional water approach, but, in the mean time to develop new soft approaches providing additional increase in the actual water supply with fewer resources, less logical disruption and less cost. In this regard, the most appropriate water management approach to be recommended is the one that integrates the supply-oriented management with the demand oriented one. Through this approach, maximum possible increase in water supply could be achieved, particularly for the countries suffering water scarcity, following both structural and the non-structural means.

Supply-oriented Water Management: Main Policy Measures

- surface water capture and storage,
- long distance conveyance and inter-basin transfer,
- groundwater exploitation,
- watershed management,
- conjunctive use of surface and groundwater,
- dual quality water standards,
- desalination,
- other non-conventional solutions.

IRRIGATION WATER POLICY: MAJOR ISSUES

Policy issues here refer to various technical and non-technical issues in managing irrigation water. The list of such issues is long. In this part, emphasis will be given to those highly relevant to the irrigation sector in the Mediterranean.

Technical Issues

Among the technical issues to be ranked as a priority in the region is the non-structural water development with its several techniques leading to the increase in crop water productivity, i.e. producing more with less water, reducing water losses and thereby lowering the water demand in the agricultural activities, and automatically increasing the foreseen water supply needed to increase the rate of irrigated agriculture without the need for any further irrigation infrastructure. This could be achieved through improvements in water use efficiency – or preferably “water productivity”.

Water productivity (water use efficiency) improvement

This is a key component of non-structural approaches to water management in all sectors and in agriculture in particular, the highest in its water consumption and the lowest in its efficiency, and thus the one with the highest potentiality for water saving.

Indeed, almost half the volume of water supplied for irrigation through systems that are costly for local community is not actually used in the field, which is due to leakage during its transport, badly adjusted modes of supply to fields, low efficiency of irrigation systems and excessively consumer-oriented crops (Fig. 3, Hamdy and Lacirignola, 1999).

Increase Crop per Drop: Key Strategic Options

- to increase the productivity per unit of crop consumption (transpiration),
- to reduce non-beneficial evaporation or flows to sinks,
- to reduce pollution,
- to reduce unnecessary out flows, either through improved management of existing facilities or through development of additional facilities,
- to reallocate water to crops with high water productivity.

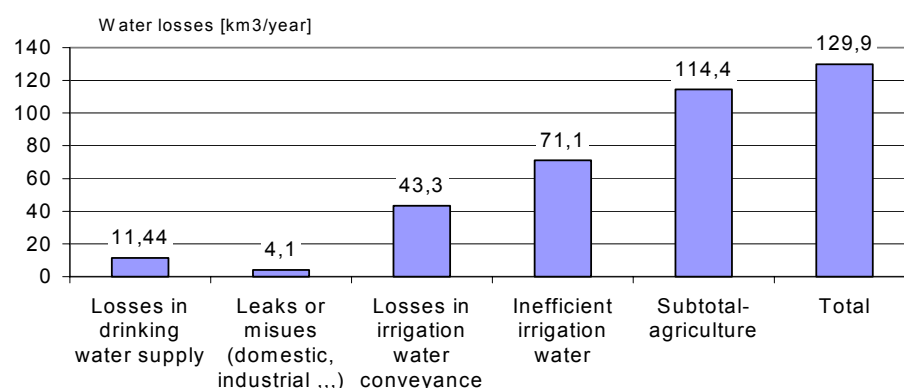


Fig. 3. Actual losses of water per sector in the Mediterranean region (km³/year).

The experience gained by Bari Institute through its network activities on water resources management as well as the findings of the individual research programs and the Regional Action Program (RAP) on water resources management (Hamdy, 2003 a), all evidently indicate the high opportunities for water saving. This could be achieved through a better use of technical and economic tools, as well as the institutional and human resources capability we already have.

For instance, in the irrigation sector, the reduction of conveyance losses by nearly 50% and the improvement of irrigation efficiency from 40 – 50% to 80%, could provide water saving of nearly 52 km³/year, giving an additional water supply of nearly 40% of the expected increase in the water demand in the year 2025 (Fig. 4, Hamdy *et al.*, 2003).

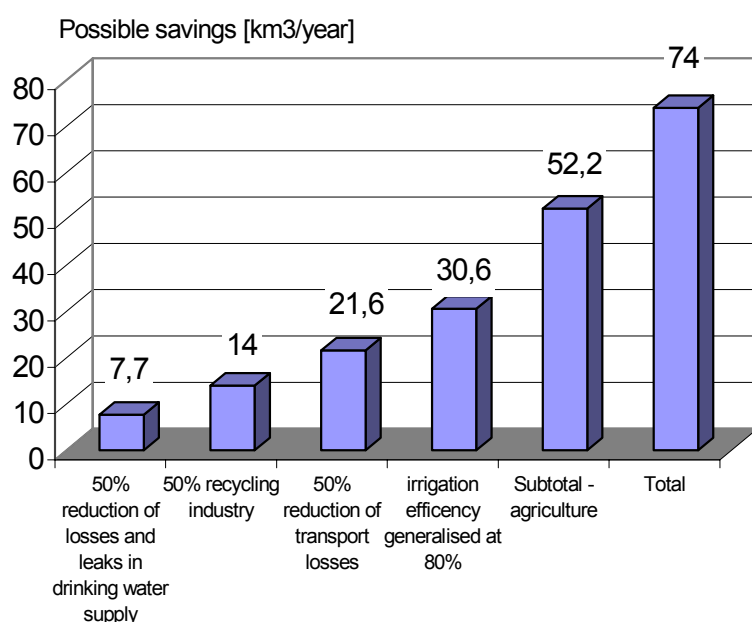


Fig. 4. Possible water saving by sector with reference to the current water demand (in km³/year).

Indeed, in most countries of the region, there is great potential for improving the water efficiency in producing food, by changing cropping pattern towards less water-demanding crops, by reducing wasteful applications of water, by cutting field-to-plate losses, and by alternating diets and functioning of international markets (Hamdy and Lacirignola, 2001).

Furthermore, this also will address some of the Mediterranean countries major environmental problems of waterlogging and salinity, declining groundwater tables, and shrinking lakes. But finding such methods will require that a wide range of alternative approaches such as small-scale irrigation and conjunctive use and re-use of non-conventional water resources be developed, tested and implemented (Hamdy and Sardo, 2002).

However, achieving greater productivity to resolve the water crisis will not happen automatically, it will require great effort and it is especially feasible in the developing countries of the region, where water productivity is far below potential. For cereal grains, as an example, the range in water productivity in dry biomass produced is between 0.2 and 1.5 kilogram per cubic meter. As a rule of thumb, that value should be about 1 kilogram per cubic meter (IWMI, 2000). If a country's demand for grains grows by 50%, one way to match this rise is to increase water productivity by 50%. Meeting this challenge will require further greater efforts and significant changes in how water is managed (Hamdy *et al.*, 2000).

Irrigation Water Policy: Technical Issues

- water productivity (water use efficiency) improvement,
- improvement of irrigation systems,
- utilization of efficient technologies,
- conjunctive use of water supplies,
- non-conventional water resources use, reuse and recycling.

Improvement of irrigation systems

In the developing countries of the Mediterranean, the major physical and technical problems and constraints in irrigation systems are: inefficient water use, shortage of water supply at the source, poor canal regulation, waterlogging and salinity, poor operation and maintenance, small-scale programs and scarce water resources. Such problems and constraints require a set of common supporting actions, namely the development of adequate data bases, adaptive research, institutional strengthening, human resource development, improvements in socio-economic analysis, environmental protection, technology transfer and infra-structure development.

Utilization of efficient technologies

The major constraints to the expansion of such technologies mainly involve the high cost of operation, particularly the cost of energy. Another major constraint is the lack of appropriate maintenance services for modern irrigation equipment, as well as the poor coordination between research institutions and industries.

Modern irrigation techniques need to be carefully selected and adapted to the local physical agronomic and socio-economic development, as well as to the technical and managerial skills of local farmers. Upgrading existing irrigation schemes should, in most cases, be preceded by pilot schemes to test alternative design concepts. Costly improved technologies can only be justified if their agronomic and economic potential is fully exploited.

Water optimization: crop water requirements and irrigation scheduling

In order to optimize water application to different crops in different soil types, irrigation systems and climatic conditions, research should be continued to provide better knowledge on soil-water-plant relationships, reviewing the concept of an optimal water supply. The management of irrigated crops to cope with droughts should receive priority in research. In addition, the link between crop water requirements and irrigation scheme reliability should also be considered.

Reallocation of irrigation water supply to low water consuming and high value crops

In the Mediterranean region, new strategies are needed for changing cropping patterns to suit future water allocation. Such strategies should be based on the availability of water supply and applied through economic reforms and structural adjustments, including private sector development, privatization and trade and price liberalization. They should also focus on lifting controls on agricultural crop patterns and shifting production towards more profitable crops.

Conjunctive use of water supplies

The conjunctive water use is one of the approaches to be highly recommended in the Mediterranean countries and particularly those suffering from acute water shortages. It provides high potentiality for the re-use and recycling of each drop of wastewater from the different sectoral water use, providing additional water supply to the irrigation sector and reducing the fresh water use in this field. Yet, in most countries in the region the conjunctive water use is rarely or not practiced at all.

Indeed, to make the conjunctive use of water fully operational (Hamdy, 2003 b); the following conditions should be satisfied:

- policies and regulation must be in place and enforced to ensure that waters of varying quality are used in accordance with approved standards of use. Difficulties often lie in the enforcement of legislation within an administrative structure, translating the regulatory objectives into a decentralized strategy;

Conjunctive Water Use: Achievable Objectives

- mitigating the effect of the shortage in canal water supplies,
- increasing the dependability of existing water supplies,
- alleviating the problems of high water table and salt intrusion,
- facilitating the use of poor quality water due to appropriate dilution,
- storing water in groundwater basins closer to the users in case of interruption of surface water supply,
- minimizing the drainage water disposal problem.

- scientifically based standards of water use and standards for discharge to water system must be prepared, confirmed and put into effect;
- regulation to enact water use standards must be flexible to allow a structured phase-in of the final standards. A strategy to reach compliance over a specified time period should be built into the phase-in program or else that compliance will never occur;
- a precise database is needed on the availability of each water supply, in quantity and quality, temporally (when it is available) and spatially (where it is located);
- economics comes into the planning process when water supplies are linked to potential water uses.

What we like to emphasize here is that the soft path of water and conjunctive use of all water supplies are core components of an integrated water resources management program that looks at water sources in the context of the entire economic, social and ecologic system of the nation.

Non-Technical Issues

A comprehensive multi-sectoral framework

The cross-sectoral framework is a general map in managing a nation's water resources, in which a broad range of national water policy issues related to the sectoral water users are involved.

The need for a holistic approach to fresh water and the integration of different sectors in water management, within the framework of national policy is now a priority (UNDP, 1992; World Bank, 1993; Asian Development Bank, 1995).

Demand management for irrigation

Today, and for the agricultural sector, it is well recognized that demand management is the main way of managing water resources and that through its appropriate implementation the region will move towards water security which provides the food security.

Demand management is user oriented. It involves mainly soft activities, including regulation, education, pricing incentives, user participation and reallocation of water rights. These activities encourage water user directly or indirectly to adopt efficient water use policies (Hamdy, 2000 b).

However, achieving water security through an appropriate integrated approach based on demand water management in all water sectors, and the agricultural one in particular, is not an easy process as it calls for a three-level action:

- the creation of enabling conditions;
- setting incentives and promo-markets and;
- direct interventions and spending programmes.

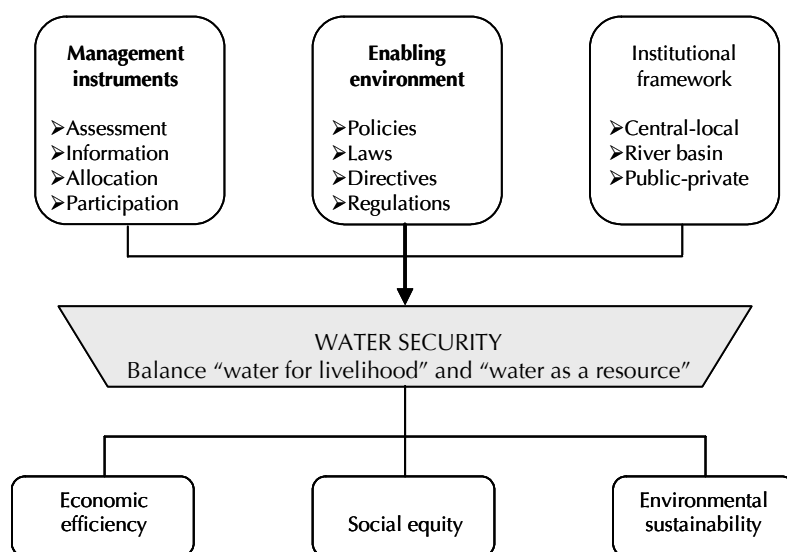


Fig. 5. Demand water management prerequisites and water security balance

Demand water management, to be successfully implemented, requires management instruments, the establishment of the enabling environment together with an appropriate updated institutional framework (Fig. 5).

Strengthening capacity

Improvement of irrigation management in the Mediterranean region requires the implementation of a set of technical actions packed with an efficient institutional capacity and high calibre human resources.

Capacity building in the developing Mediterranean countries should be expanded and improved and interdisciplinary training of water experts should be promoted. The region needs institutions with high capability to collect, analyze and elaborate information on water resources including environmental and socio-economic information, which is essential for sustainable irrigation water demand management (Chioccoli *et al.*, 1998; Hamdy, 2002 a).

Training activities

International, national and regional institutions could play a great role using their training programs and research activities in the development of national capacities to sustain the long-term research needs of developing countries in the Mediterranean: they can also help orienting research to practical and cost-effective solutions that benefit water users and field practitioners.

The Mediterranean Agronomic Institute of Bari, one of the operational institutes of the CIHEAM, will be taken as an example.

Beside offering upgraded annual courses on irrigation and its related aspects, attended by technicians and university graduated from Mediterranean countries, the Institute provides support for designing and organizing regional and national advanced short courses, seminars and conferences for senior researchers, experts and managers working in this field in the Mediterranean countries. In the last few years, the Institute has expanded its activities to cover:

- the creation of networks among institutions in charge of irrigation in the Mediterranean region;
- designing and producing training materials (including audio-visual and printed materials);
- providing assistance to national Mediterranean institutions in developing their training programs;
- conducting surveys and investigations in the Mediterranean region to assess the existing training programs and identify prospective training strategies to improve irrigation projects in the region.

Irrigation Water Policy: Non-Technical Supporting Issues

- a comprehensive multisectoral-framework,
- demand management for irrigation,
- strengthening capacity training and research,
- extension service,
- participatory irrigation management and Water Users Association (WUAs),
- irrigation water valuation charging and cost recovery mechanisms.

Strong effective extension service

In the region, it is of vital importance to establish a real interaction between research and extension. The implication of a one-way process should be dropped. The development and transfer of technology must be an interactive process with a continuous dialogue and a reciprocal feedback between the research team, the extension team and the farmers.

In most countries in the region, it is required to have a strong and effective extension service characterized by the following features:

- 1) a dedicated professional staff, oriented towards understanding and serving the farm family;
- 2) the maintenance of an updated research-knowledge base through links with research organizations;
- 3) an adequate financial support;
- 4) a continuous and effective service training program; and
- 5) a competitive salary system with incentives for professional advancement.

Participatory irrigation management and the promotion of Water Users' Association (WUAs)

In all developing countries in the Mediterranean region, the overall management of large irrigation schemes is still handled by public irrigation institutions. Unfortunately, the participation of the farmer and his role in agricultural irrigation management is completely ignored. To bring this property in the hands of the users; the following actions should be implemented:

- promote water users associations (WUA) to ensure real participation of farmers in managing irrigation schemes;
- move towards transferring services of operation and management from the public institutions to the users; and
- transfer control of each individual irrigation scheme to local WUAs, including the responsibilities for providing agricultural inputs and marketing outlets as well as the authority to borrow funds and finance various operations within the irrigated scheme.

Promotion of gender in the irrigation sector

Mainstreaming a gender approach in the sectorial water uses and particularly the irrigation one is well organized and validated in most of countries of the region due to its beneficial impacts in providing the water use, increasing the efficiency as well as mediating the water conflicts.

However, in most countries, the implementation of a gender approach in the irrigation sector is still far away from what was planned and what was desired. In this regard, major efforts have to be done for promotion and administrating gender approach in the use and management of water in the irrigation sector.

In the region, it is needed to:

- integrate gender approach into state policy,
- appropriate gender analysis should be included in the process of designing implementation public policies in the irrigation,
 - train local communities to know and master techniques that enable a change in role and focus for both women and men in water practices management in irrigation,
 - deep analysis of local cultural realities to set gender policies that fits with prevailing cultural, religious, traditional, social and economic prevailing conditions,
 - work towards establishing a mechanism for networking and sharing information and experiences by involving all those with a task in water resources such as trade union, private sector, NGO's and vulnerable groups, and
 - implementing a participatory irrigation management approach that provides smooth management transfer to the users, the establishment the water user association where women could have a heard voice.

Irrigation water valuation and charging mechanisms

In the Mediterranean countries, and particularly the developing ones, the cultural and socio-economic values of water are still a very elusive subject and in most Islamic countries of the region irrigation water is provided for free or for less than the full cost of providing irrigation services. Such extremely low cost of water encourages the production of crops that are both low-valued and highly water intensive and doesn't offer any incentive to use water efficiently.

For the region, the introduction of irrigation charges is a very important pre-requisite to good management of irrigation demand because it is noticed that despite the observed water shortages, misuse of water in agriculture is widespread in current irrigation management practices. This is due mainly to the failure in the past to recognize water's economic value and the real cost of water services provision. Therefore, it is now widely believed that managing water as a social economic good is an important tool for achieving efficient and equitable water use as well as encouraging conservation and protection of scarce water sources. In this direction, some changes are already beginning to occur in some of the developing countries in the region, but the process is still very slow due to a number of economic, cultural social and institutional problems involved. .

Inappropriate pricing policies and economic subsidies encourage wasteful use of water and conservation programme. Water should be regarded as a **socio-economic good**.

However, to promote the process successfully, water pricing must be based on principles of fairness, transparency and equity. In this regard, to achieve this, the water pricing policies should include the following (Hamdy and Lacirignola, 2002; Hamdy, 2002 b):

- flexible rules must be adopted in determining reasonable tariffs closely related to farm economies, such that farm activity is encouraged rather than limited; tariffs should be determined on the basis of farm net profit, in such a way that the burden does not become excessive to the point of obliging the farmer to abandon or reduce the activity;
- tariffs can be based on a fix, flat, very low rate common to all, plus a variable rate depending, for example, on progressive water volumes (with unit cost increasing with volumes) and/or on the period of the year (with unit costs increasing in the peak consumption period);
- tariffs must be based also on water quality: if it decays along the season (e.g. due to a progressively higher salt content), a parallel decrease in price must be associated to it;
- the farmers have a right to get a lower price for the use of primary or secondary-treated domestic wastewaters, since so doing they polish wastewaters and avoid their release in watercourses, protecting the environment and reducing treatment costs to the community;
- it is unreasonable to expect that farmers pay for the amortization of existing structures, designed and implemented without their participation and often with optimization criteria different from those of farmers themselves;
- it is unfair that farmers be called to participate in the expenses to maintain overstuffed administrative offices, with armies of people hired without their consent, from persons extraneous to the agricultural world;
- an intense action of information and formation should precede and follow the introduction of water pricing;
- participatory water management is of paramount importance to stimulate farmers' awareness for the necessity of a wise water use, their willingness to participate in the expenses and their acceptance of constraints in water allocation.

Alternative Water Supplies (Non-Conventional Water Resources)

In the arid and semiarid countries of the Mediterranean, new supplies of water will continue to be required to overcome the severe shortages in freshwater sources.

Reclaimed water, gray water, recycled water, brackish water, salt water, or desalinated water may all be considered usable for some needs and may have indeed environmental, economic or potential advantages (Hamdy *et al.*, 1995).

Reclaimed water

In the region, it is now widely recognized that treated wastewater (TWW) reuse constitutes an important and integral component of the comprehensive water management programs of the majority of countries, more so in the water scarce ones. This implies that these countries should have national policies and strategies relating to wastewater management, in general, and wastewater reuse for agriculture, in particular, in order to guide programs, projects and investments relating to wastewater collection, treatment, reuse and disposal in a sustainable manner.

This requires the establishment of a clear policy with regard to TWW management supported by modalities for strengthening the national capacity building in this sector. Such policy should be accompanied by an appropriate national strategy for wastewater reuse characterized by the following features (Hamdy, 2001):

- spelling out ways and means of implementing policy directives;
- defining the nature and mechanisms of inter-institutional collaboration, allocation of funds, establishment of pilot wastewater reuse demonstration sites of good management practices and phasing the implementation of wastewater programs;
- fostering the share of responsibilities between involved ministries, agencies and authorities, and the way to link and integrate the activities among them, individually and in combination;

To overcome water scarcity in the arid countries of the region, as priority options to be followed:

- efficient programme leading to increasing water productivity and water saving in all sectors and in particular the agricultural one.
- To collect, to treat, to reuse and to recycle each drop of wastewater.

- identifying economically feasible, safe and socially acceptable set of standards, regulations and codes of practices for sustainable use.

Ideally, policies to TWW reuse and strategies for its implementation should be part of water resources planning at the national level. At the local level, individual reuse projects should be part of the overall river basin planning effort.

IRRIGATED AGRICULTURE, WATER SECURITY AND FOOD SECURITY

Before discussing this issue, we still need to have a precise answer to the question: *how much water do we need for agriculture to achieve food security in the region and to stipulate national self-sufficiency goals for essential crops, particularly the cereal ones?* As a matter of fact, over the last 20 years, there have been tremendous advances in the estimation of crop water requirements at a field scale (Allen *et al.*, 1998). However, as we move up from field to regional, from regional to national and from national to global levels, the degree of uncertainty also grows. Moreover, our estimates of irrigated area, while recently improved (Doll, 1999), are still uncertain. In addition, although groundwater has played a major role in food production, the sustainability of this resource is already questioned. At present, advances in biotechnology may play a major role in increasing food productivity through the development of new crop varieties that could tolerate water and salt stress conditions, highly resistant to diseases and of better water productivity. Those are the new features that could be expected from a further progress in biotechnology, but till now, its potential remains uncertain. Also the vital role of irrigation in increasing crop productivity is well acknowledged, but the exact extent of this is debated. The debate is concentrated on our ability to increase crop productivity on primarily rain-fed areas and thereby there is less need for additional irrigation.

Such uncertainties illustrate the complexities and the inherent problems associated with regional projections of the water to be allocated for agriculture to achieve food security. Regarding water security, it is evidently certain that an increase in this parameter will normally improve the prospects for food security. However, the converse is not true: increasing food security by the expansion of the irrigated area will reduce the security of other water using sectors and aggravate water stress unless it is accompanied by an improved supply or management.

FOOD SECURITY AND MEANS TO ACHIEVE

In the region, food security and stability in food production will increasingly come from improved water management and its sustainable use in the agriculture sector. However, to be realistic, we must have fully in hand the approaches and the alternatives, the actions needed and above all, we should know how to proceed and implement approaches and actions on the ground.

For achieving food security in the Mediterranean region, Abu-Zeid and Hamdy (2003) proposed the followings.

Efficient Water Saving Programmes

In the region, we have the knowledge and tools to increase irrigation efficiency, reduce losses and save more water in the agricultural sector. Each drop of saved water could be used for irrigating new lands and having more food production. However, we have to learn the lessons that putting much stress on only technical aspects for water saving will not yield the results desired; it should be coupled with economic initiatives to reduce the increasing water demand and to use water more wisely in the agricultural sector.

Improving Crop Productivity

By improving the productivity of water in rain-fed and irrigated agriculture, we can have more production in food with less need to expand irrigated area. There are several means to increase the productivity of water: higher yields using the same amount of water through improved varieties, improved soil management practices that save water through reduction in non-productive evaporation or flows to sinks in excess of environmental requirements, and reallocation of water from lower to higher value uses. In a broad sense, increasing water productivity in agriculture contributes not only to the overall food security equation but also to water security.

Rainfed Agriculture Improvement

Generally, rainfed agriculture is often ignored in the water and food security puzzle. In the Mediterranean, rain-fed agriculture contributes by about 60 percent to cereal production and about 70% of the total cereal area. Consequently, a one-percent increase in rain-fed cereal production would have about one and half time the effect than a similar increase in irrigated cereal productivity. This illustrates clearly the influential role that the improvement in rain-fed agriculture could have on the overall food security in the region

Practically, several tools that could be implemented to improve cereal production under rain-fed agriculture include:

- the development of drought resistance crop varieties, frequent tillage practices to conserve water (fallow) and low cost technologies or simple water harvesting structures to provide access to water at the critical growth stages of the growing crops.
- another technical approach which gives very promising results in cereal production under rain-fed agriculture, increasing production up to 30%, is the supplementary irrigation with freshwater and even with low quality and saline or treated waste water at the critical growth stages of cereals and, particularly at the flowering and seed filling stages (Hamdy et al., 2003).

The Reuse and Recycling of Wastewater

Although the quantity of wastewater available for re-use accounts for a small fraction of total water requirements, it represents an attractive option for water scarce countries, since it is a renewable and valuable source of water, which has the additional advantage of being rich in nutrients and organic matter.

In spite of that, unfortunately, in the majority of the countries in the region, a relatively small portion of wastewater is treated and used. To obtain the full advantage of this additional water resource, these countries should have national policies and strategies relating to wastewater management, in general, and wastewater re-use for agriculture in substitution of the fresh one.

To achieve water and food security in the Mediterranean, the only option we have and that should be followed is the use, the re-use and recycling of each drop of wastewater.

Supporting Tools

Beside the previously discussed technical and practical approaches leading to the achievement of water and food security, it is equally important to couple those approaches with the promotion of the following policy imperatives:

- to increase public participation in the management of irrigation systems and decision-making about water and resources;
- to establish mechanisms for effective cost recovery by paying for water services;
- to establish actually acceptable water rights and allocation mechanisms;
- to establish means of accountability between service providers and users.

CONCLUDING REMARKS AND RECOMMENDATIONS

- Managing water scarcities with inherent uncertainties in resources, involves new visions for innovative technologies, institutional reforms and reallocation policies, including valuation of water, enforcement of national and regional laws and other policy interventions that are likely to result in structural changes or adjustments in the economy.

- The new irrigation water policies should focus on high water efficiencies through water conservation technologies, intensive irrigation of high value crops, expanded supplemental irrigation in rain-fed farming zones, reuse and recycling of wastewater and improved irrigation methodology.

- Water security, food security and environment sustainability mainly depend on how we are using and managing water in the agricultural sector and how much water saving could be achieved in this sector. We have to stop the fragmented approach in managing water resources in the irrigation sector. An integrated approach based on demand water management rather than the supply one is an appropriate way towards achieving these goals.

- The ultimate challenge for all water professionals, decision makers and politicians is to put into practice what we all very well know theoretically. It is essential that we translate the ideas,

conclusions, and recommendations to action on the ground. This is the only way of reducing the loads of the present, pushing back the dates of disruption and preparing the resources of the future.

- In the progress towards water and food security in the Mediterranean region actions should be translated into programmes dealing with the following major issues:

- *Integrated water resources management: demand water management*, particularly in the agricultural sector.

- *Water productivity improvement: high crop per drop*. This programme should be based on the use of new technologies to achieve higher water production efficiencies through water conservation technologies, intensive irrigation of high value crops, expanded supplemental irrigation in rain-fed zones, and improved irrigation methods.

- *Re-use and recycling of wastewater in the agriculture sector*. This is the most reasonable approach to increase water supply by saving a part of the freshwater already allocated to agriculture, expanding the irrigated area and reducing food gap in the region and, in general, to sustain the environment without degradation.

- To promote local management of irrigation systems with a strong emphasis on farmer participation, the establishment of Water User Associations (WUAs), acceleration of Irrigation Management Transfer (IMT) programmes and integration the gender dimensions.

- *Capacity Building*. All the above actions or any other should be packed with capacity building development programs to improve the institutional functions and the human resources in the struggle for improving water resources development and management in the region.

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