TECHNICAL FOCUS PAPER

Water Demand Management:

The Mediterranean Experience

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plan bleu

Global Water Partnership

Global Water Partnership (GWP), established in 1996, is an international network open to all organisations involved in water resources management: developed and developing country government institutions, agencies of the United Nations, bi- and multilateral development banks, professional associations, research institutions, non-governmental organisations, and the private sector. GWP was created to foster Integrated Water Resources Management (IWRM), which aims to ensure the co-ordinated development and management of water, land, and related resources by maximising economic and social welfare without compromising the sustainability of vital environmental systems.

GWP promotes IWRM by creating fora at global, regional and national levels, designed to support stakeholders in the practical implementation of IWRM. The Partnership's governance includes the Technical Committee (TEC), a group of internationally recognised professionals and scientists skilled in the different aspects of water management. This committee, whose members come from different regions of the world, provides technical support and advice to the other governance arms and to the Partnership as a whole. The Technical Committee has been charged with developing an analytical framework of the water sector and proposing actions that will promote sustainable water resources management. The Technical Committee maintains an open channel with the GWP Regional Water Partnerships (RWPs) around the world to facilitate application of IWRM regionally and nationally.

Worldwide adoption and application of IWRM requires changing the way business is conducted by the international water resources community, particularly the way investments are made. To effect changes of this nature and scope, new ways to address the global, regional and conceptual aspects and agendas of implementing actions are required.

A **Technical Focus Paper** is a publication of the Technical Committee aimed at harnessing and sharing knowledge and experiences generated by Knowledge Partners and Regional/Country Water Partnerships through the GWP Knowledge Chain.

ISSN: 2001-4023
ISBN: 978-91-85321-88-9

Printed by Ljungbergs
Design and layout by Scriptoria, www.scriptoria.co.uk

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Foreword

Since the dawn of human history and up to the present day, the peoples of the Mediterranean region have always struggled with water scarcity and have learned how to master water management in order to live and prosper. Thus, the civilizations that have flourished for millennia on the shores of their common sea, have left us many testimonies of their ability to understand the mechanisms governing the cycle of water and wisely use this vital resource.

Today, water crisis is already a reality in many Mediterranean countries, threatening their economic growth and the livelihoods of their peoples. We all fear that the problems will only accelerate. Multiple thumbscrews are operating on these finite and vulnerable fresh water resources. The driving forces are strong: population growth and urbanization; tourism and industrialization; globalization; and climate variability and change – decreasing precipitation and increasing the frequency of droughts.

Driven by these challenges and consistent with a worldwide movement towards more integrated water resources management, countries have embarked on reforming their water sector. A change in thinking and action in water management is slowly taking place. The experience suggests that meeting the challenge of water scarcity requires both a supply management strategy, involving highly selective development and exploitation of new water supplies (conventional and non-conventional) coupled with a vigorous demand management involving comprehensive reforms and actions to optimize the use of existing supplies. The appropriate mix of supply and demand management may vary depending on the level of development, the governance structure and the degree of water scarcity in each country. However, as economies grow and the value of water increases, the benefits from and necessity for efficient demand management increase significantly.

Water Demand Management (WDM) requires a holistic approach that recognizes the complexity of the inter-relationships among all the factors affecting water demand. It calls for the creation of an enabling environment based on an adequate set of mutually supportive policies and a comprehensive legal framework with a coherent set of incentives and regulatory measures to support these policies.

However, policies and regulations, though necessary, are not sufficient. Putting WDM into practice also means strengthening and/or creating institutions and mechanisms that can transcend the traditional boundaries between sectors and involve effectively a variety of users and other stakeholders.

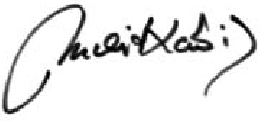
WDM requires recognition of the economic value of water in different uses along with the acceptance of the notion of opportunity cost and attention to cost recovery, though with concern for affordability and securing the human right for access to water for everybody and particularly for the poor.

Last but not least, WDM strategy should be accompanied by a financing strategy able to cover the investment requirements for reducing water losses in the production-supply-utilization systems, control user wastage and also stimulate water efficient economy and consumption patterns away from wasteful water intensive uses.

Interest in WDM is currently growing and the concept is widely discussed across the world. The Mediterranean region has an accumulated wealth of knowledge and experience in managing water scarcity through WDM and this may be useful to be shared with those who face similar problems and are willing to follow a similar pathway.

This *Technical Focus Paper* is prepared with the aim of making this knowledge and experience accessible to policymakers at various levels, the water industry, and all relevant stakeholders in the international water community. It provides a faithful picture of the Mediterranean co-operation process which has grown up around shared water-related challenges and presents specific examples of implementing WDM in certain Mediterranean countries.

Dr Mohamed Aït Kadi
Chair
GWP Technical Committee



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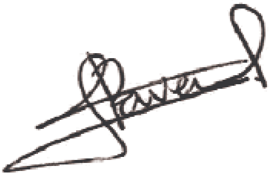

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Box 1: Global Water Partnership (GWP) and Plan Bleu

Global Water Partnership (GWP): 'towards a water-secure world'

GWP was founded in 1996 to foster integrated water resource management (IWRM). IWRM aims to ensure the co-ordinated development and management of water, land, and related resources by maximising economic and social welfare without compromising the sustainability of vital environmental systems.

Worldwide adoption and application of IWRM requires changing the way business is conducted by the international water resources community, particularly the way investments are made. To effect changes of this nature and scope, new ways to address the global, regional, and conceptual aspects and agendas of implementing actions are required.

GWP's vision is for a water secure world. Its mission is to support the sustainable development and management of water resources at all levels. GWP believes that an integrated approach to managing the world's water resources is the best way to pursue this vision – a vision that encompasses all of life.

GWP is an international network open to all organisations involved in water resources management: developed and developing country government institutions, agencies of the United Nations, bi- and multilateral development banks, professional associations, research institutions, non-governmental organisations, and the private sector.

Plan Bleu, 'sowing the seeds of the Mediterranean future'

For more than 30 years, the Mediterranean rim countries and the European Community have been developing an original system for regional environmental co-operation in the context of the Mediterranean Action Plan (MAP) of the United Nations Environment Programme (UNEP), and the Convention for the Protection of the Marine Environment and Coastal Region of the Mediterranean, known as the Barcelona Convention (cf. Box 2).

Continued on next page

Box 1: Global Water Partnership (GWP) and Plan Bleu ***Continued...***

The Barcelona Convention plays a major role in the Mediterranean region, as a sustainable development forum and framework for co-operation in the management of its common assets. The Contracting Parties to the Barcelona Convention now number 22: Albania, Algeria, Bosnia-Herzegovina, Croatia, Cyprus, Egypt, European Community, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Montenegro, Morocco, Slovenia, Spain, Syria, Tunisia and Turkey. Their aim is to conserve the Mediterranean marine and coastal environment, while fostering regional and national plans for sustainable development.

Plan Bleu is a centre for regional activities under the auspices of UNEP/MAP and, as such, one of the agents of this co-operation. One of Plan Bleu's key tasks is to gather knowledge and produce information that alerts decision-makers and other stakeholders to environmental risks and sustainable development issues in the Mediterranean. Another is to map out future scenarios to guide decision-making processes. This work focuses on four strategic core objectives:

- To identify, gather and process, on an on-going basis, environmental, economic, and social information of use to stakeholders and decision-makers;
- To assess how the environment interacts with economic and social development in order to measure progress towards sustainable development;
- To conduct analyses and studies to help shape visions of the future and support decision-making; and
- To disseminate products and outcomes in ways appropriate to the target audience.

The main disciplines and topics of Plan Bleu activities are water, energy, transport, tourism, waste, rural areas and agriculture, urban and coastal areas, and marine and forest ecosystems. There are also related cross-cutting issues such as global climate change. A variety of tools and methods are used such as indicators, spatial analyses, and economic approaches.

1 Introduction

The Mediterranean is a region with many favourable attributes, but it also faces many serious environment and development challenges. It is the meeting point for three continents. It comprises 22 countries and 470 million inhabitants (in 2010), a favourable climate, and a rich diversity of natural and cultural heritage. The Mediterranean is also a place of both contact and demarcation among groups with diverse development paths. It is a region on a quest for stability, which may only be achieved through joint approaches to shared values. Thus, the Mediterranean aptly illustrates the global challenge of sustainable development.

The Mediterranean is an 'eco-region'. The countries on the southern and eastern rim in particular are constrained by limited land and water resources which are unevenly spread both in time and space. France, Italy, and Turkey receive half the region's total rainfall; the southern countries along the North African coast enjoy only one-tenth. The Mediterranean is home to 60% of the world's population classed as living in 'water poverty' – less than 1000 m^3 of water available per capita per year. Nearly 20 million Mediterranean people have no direct access to drinking water, especially in the rural areas of the south and east. Resources are already over-exploited in some places and yet water requirements are set to rise sharply as the population increases in the south and east and the economy grows through tourism, industry, and irrigated agriculture.

This growing water scarcity and the uncertainties which climate change may bring only reinforce the need to adapt both water policies and land planning policies that impact water management. Water needs to be used wisely. Resources must be used sparingly in ways that meet the needs of people, economic growth, and the environment both today, tomorrow, and beyond.

For the past fifteen years, Water Demand Management (WDM) has been emerging as a key issue of sustainable development in the Mediterranean. This comprises a set of measures intended to increase the technical, social, economic, environmental, and institutional efficiency of the various water uses.

Since the 1980s Plan Bleu has conducted strategic foresight studies and organised regional discussion workshops (in Fréjus in 1997, Fiuggi in 2002, and Zaragoza in 2007). The result has been a gradual official recognition that WDM is a priority means of achieving two objectives that are central to sustainable development – to change unsustainable patterns of consumption and production; and to sustainably manage natural resources as inputs to economic and social development. The studies and workshops also showed that most significant progress resulted from the continuous and progressive implementation of combinations of tools such as strategies, institutional organisation, pricing and subsidies.

The Mediterranean Strategy for Sustainable Development (MSSD) therefore incorporates the integrated management of water resources as its main priority for action. MSSD is the 'framework' strategy adopted in 2005 by all the Mediterranean countries and the European Community. It represents the policy change as a result of Plan Bleu's strategic foresights.

2 WDM – a concept developed in the Mediterranean

The relationships between water, environment and development have progressively been put on the international, European, and Mediterranean political agenda since the early 1970s (Box 2).

Box 2: The water, environment and development nexus is now part of the international political agenda – a timeline

1972: United Nations Conference held in Stockholm (Declaration on the Environment, Action Plan for the Environment and creation of the United Nations Environment Programme, UNEP)
1975: Sixteen Mediterranean countries and the European Community adopt the Mediterranean Action Plan (MAP), the first plan of UNEP's Regional Seas Programme
1976: The same countries plus the European Community ratify the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (known as the 'Barcelona Convention')
1977: The Split Conference defines the objectives and mandate of Plan Bleu
1983: Creation of the World Commission on Environment and Development (WCED)
1987: The Brundtland Report is published, defining the concept of sustainable development
1989: Plan Bleu publishes its first strategic foresight exercise, "Futures for the Mediterranean Basin"
1992: United Nations Conference is held in Rio (Agenda 21, signing of the Conventions on Climate Change and Biodiversity)
1995: The Action Plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean (MAP Phase II) is adopted; amendment of the Barcelona Convention (since then known as the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean). The Barcelona Process – Euromed Partnership – is launched
1996: Creation of the Mediterranean Commission on Sustainable Development (MCSD)
1997: The first World Water Forum is held in Marrakech
1997, 2002 and 2007: Regional workshops on water demand management in the Mediterranean (Plan Bleu)
1997: The Contracting Parties of the Barcelona Convention adopt the MCSD proposals on water demand management
2000: The European Commission adopts the European Water Framework Directive (WFD)
2000: Second World Water Forum held in The Hague, with a presentation of the Mediterranean Vision on Water, Population and the Environment
2003: Third World Water Forum held in Kyoto
2005: Plan Bleu's second strategic foresight report is published, looking ahead to 2025: Mediterranean, Blue Plan's perspectives on the Environment and Development
2005: The Contracting Parties to the Barcelona Convention adopt the Mediterranean Strategy for Sustainable Development (MSSD)
2006: The fourth World Water Forum is held in Mexico
2008: Paris Summit launches the initiative "Barcelona Process – Union for the Mediterranean," as water is considered a priority issue
2009: The fifth World Water Forum is held in Istanbul
2011: Bonn Conference on Water, Energy and Food Security Nexus – Solutions for Green Economy
2012: Sixth World Water Forum in Marseille and the United Nations Conference on Sustainable Development in Rio de Janeiro ("Rio+20 Conference").

Over the past 30 years Plan Bleu has generated a number of scenarios (Plan Bleu, 1985 and 1989; and Plan Bleu, 2005), which have served to quantify the imbalances between water supply and demand in the Mediterranean, and encouraged the Mediterranean countries to be guided by WDM. Defining a trends scenario may allow for the visualisation of undesirable pathways and offer a contrasting view with alternative scenarios that highlight more sustainable solutions and pathways. Water management takes a medium to long-term view and so such predictive approaches play an important role in highlighting more sustainable solutions and pathways.

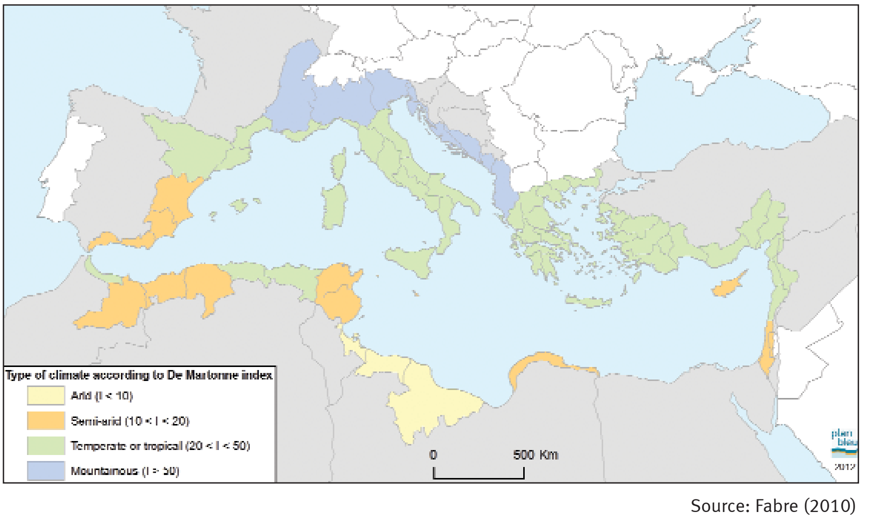
2.1 Scenarios putting water scarcity on the political agenda and promoting WDM in the Mediterranean

2.1.1 Mediterranean climate and water

The Mediterranean has a transitional climate between temperate and tropical. Winters are mild and wet and summers hot and dry. The Mediterranean spans several global regions at latitudes between 30° and 40°. It also has special morphological, geographical, historical, and societal features. Its morphology is complex, with several mountain ranges, islands, and peninsulas which result in marked climatic differences between hot regions with arid or semi-arid climate and mountainous regions with permanent glaciers and, therefore, big differences in albedo.

The maps below show the aridity indices[1] of the Mediterranean watersheds as an annual average (Fig. 1) and for the summer months (June, July, and August) (Fig. 2). These illustrate the positions of many Mediterranean watersheds, which have an annual aridity index of a temperate climate but a summer aridity index tending towards a semi-arid or arid climate.

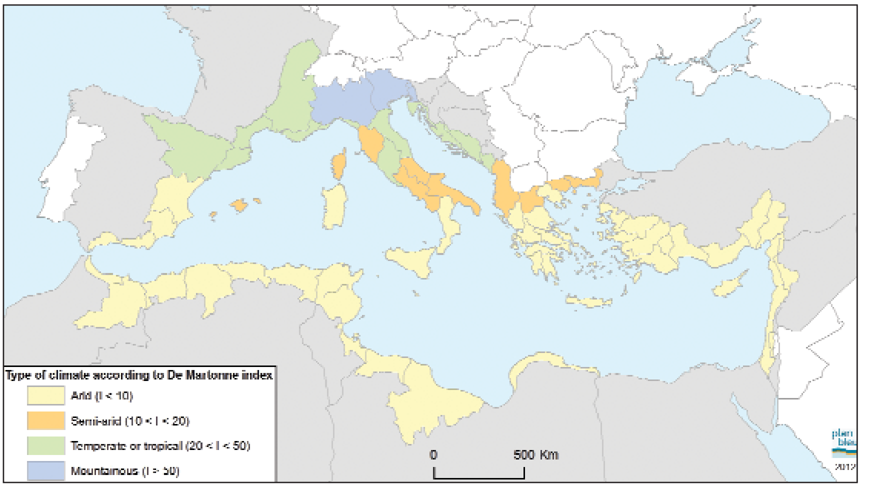
Fig. 1. Average annual aridity indices of Mediterranean watersheds



Source: Fabre (2010)

[1] The De Martonne aridity index is calculated according to the formula: I = P / (T+10) where P denotes total annual precipitation and T, the annual mean temperature.

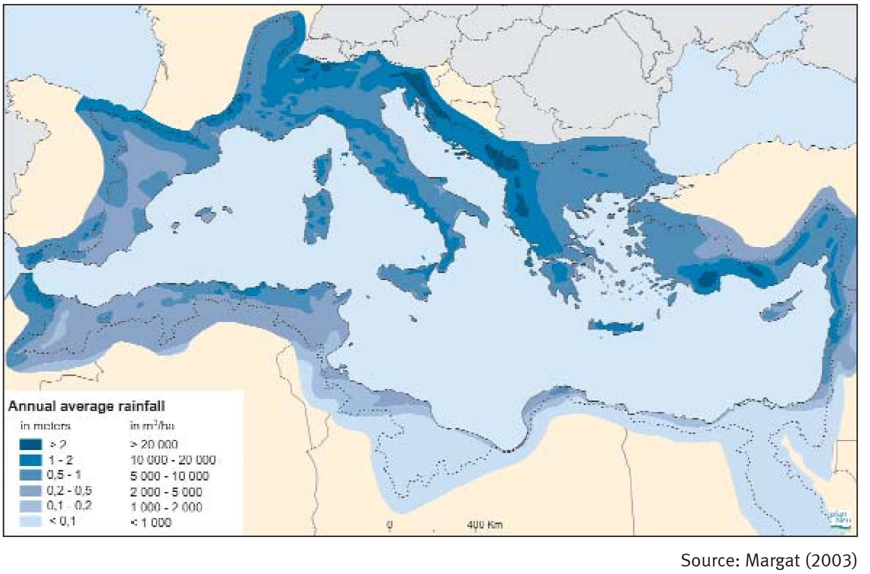
Fig. 2. Aridity indices of Mediterranean watersheds for June, July, and August



Source: Fabre (2010)

The average annual renewable freshwater resources, both surface and groundwater, of all the Mediterranean countries together[2] are estimated to be about 1080 km^3. But this is not evenly spread across the region. Nearly two-thirds is concentrated in the northern countries, while the eastern and southern Mediterranean countries (SEMCs) have only one-quarter and one-tenth of the water resource respectively (Fig. 3). The six least endowed countries and territories are

Fig. 3. Annual rainfall distribution in the Mediterranean Basin



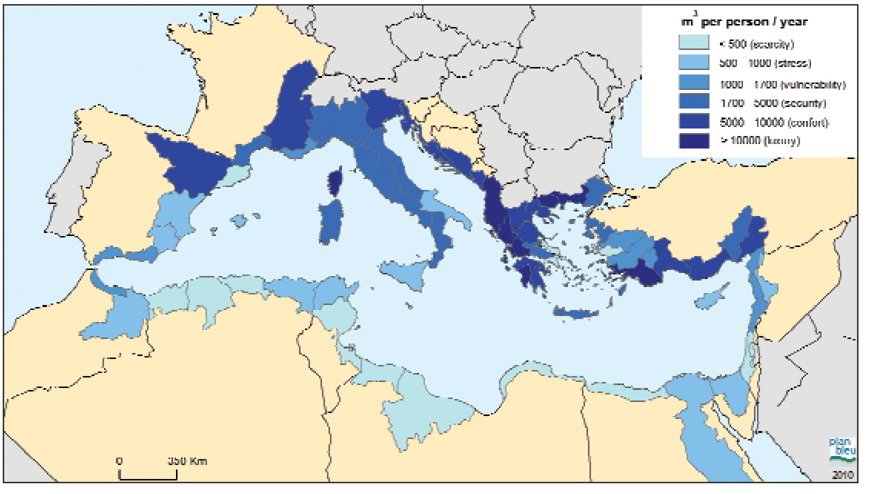
Source: Margat (2003)

[2] Spain, France, Monaco, Italy, Malta, Slovenia, Croatia, Bosnia-Herzegovina, Montenegro, Albania, Greece, Turkey, Cyprus, Syria, Lebanon, the Palestinian Territories, Israel, Egypt, Libya, Tunisia, Algeria and Morocco.

Cyprus, Israel, Libya, Malta, the Palestinian Territories, and Tunisia. Together they have less than 1% of the total freshwater resource.

According to the Falkenmark water stress indicator (Falkenmark, 1989), based on the calculation of water resources per capita per year, most countries on the southern and eastern shores of the Mediterranean are in 'water stress,' with less than 1000 m^3/capita/year. Algeria, Israel, Libya, Malta, Tunisia and the Gaza Strip have less than 500 m^3/capita/year – a situation classed as 'structural shortage.' The same indicator, calculated at watershed level, also reveals wide variations within countries (Fig. 4).

Fig. 4. Natural renewable water resources per capita in the main Mediterranean watersheds



Source: Plan Bleu, based on national sources (2010)

Severe tensions surrounding water resources are a feature of the region. These are illustrated by the exploitation index of renewable natural resources (Fig. 6), which represents the relationship between total water withdrawals and renewable resources (Table 1).

Table 1. Water withdrawals in Mediterranean rim countries and pressure on the resource (2005–2010)

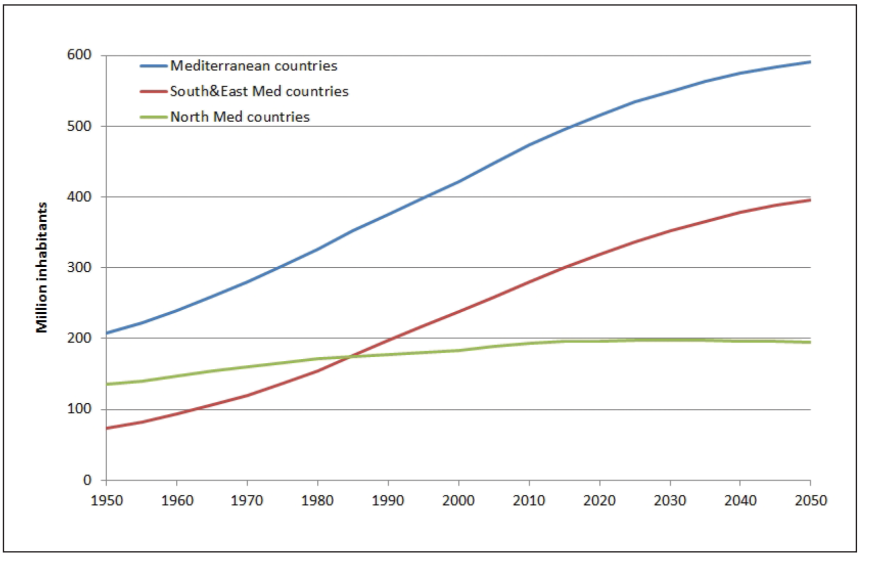
Zones (whole countries)	Total withdrawal of renewable resources (km^3/year)	Withdrawal by sector (volume and % of total)						Exploitation index of renewable natural water resources (%)
		Drinking water		Irrigation		Industry and energy		
		km^3/year	%	km^3/year	%	km^3/year	%	
North	120	22	18	59	49	39	32	16%
East	60	8	13	48	81	4	7	25%
South	74	11	15	55	74	8	11	78%
Total	254	41	16	163	64	51	20	24%

Source: Blinda, Plan Bleu (2011)

Withdrawals for irrigation are high because of the evaporative demand for crops grown in the Mediterranean climate. They are often greater than consumption.[3] Food security in the region depends on irrigation and so this has always received special attention. In some areas, much of the withdrawals are used to generate electricity via storage in hydroelectric dams or for cooling thermal power plants. Though very little of such withdrawals is consumed, they can have a significant impact on the rivers ecosystems by limiting the transit of sediment and fish and increasing the risks of pollution (thermic pollution downstream from thermal power plants, constraining self-filtration rivers capacities when dams releases occur during low-flow periods, etc.). Most of the water used returns to the environment though it may be degraded depending on the treatment given (Fernandez and Mouliérac, 2010).

Concerns about population growth (Fig. 5) and climate change will impact water security. Indeed, the Mediterranean is identified as one of the regions most vulnerable to changes in climate such as a fall in average rainfall and a rise in mean temperatures associated with frequent and intense extreme weather events (cf. Chapter 4.1).

Fig. 5. Mediterranean demographic trends until 2050



Source: United Nations World Population Prospects (2008)

[3] Withdrawal exceeds consumption (corresponding to water evaporated and transpired by cultivated plants) because part of the withdrawal is not directly consumed by cultivated plants. At the plot level, it infiltrates into the soil and recharges the groundwater (and in some cases the watercourses). The difference between withdrawal and consumption is also explained by the 'losses' which occur in the water input systems (either through evaporation from open channels or by infiltration of water into the groundwater and possibly into the watercourses).

2.1.2 Plan Bleu's foresights

■ **"Futures for the Mediterranean Basin" (Grenon and Batisse, 1989)**

Plan Bleu's foresight studies from the 1980s presented the relationships between the environment and development using two broad groupings: 'resources and environments' (water, soils, forests, sea, and coastline) and 'population.' Five main economic sectors were also studied (agriculture, industry, energy, transport, and tourism) for which considerable work has been done in collecting data. Plan Bleu devised five scenarios (Annex 1), based on a quantified presentation of the two broad groupings and the relationships between them. These scenarios were based on contrasting hypotheses concerning levels of economic growth, how far development and the environment was integrated at regional level, and types of regional co-operation (north–south and south–south).

The 1989 report highlighted the risks of a growing gap between the north and south of the region and the on-going and sometimes irreversible degradation of the environment and natural resources. An approach was proposed to achieve fairer, environmentally friendlier development which involved integrating development and environment; strengthening the capacities of governments; and north-south and south-south co-operation. It illustrated the principles of sustainable development which seeks to meet present needs without jeopardising the ability of future generations to meet theirs. The emphasis was on water as a key developmental resource, especially for agriculture.

In the 1980s, water shortages rapidly became a major issue in several countries. This was due mainly to the substantial water demand for irrigation which accounts for 65% of the total water demand across the region and over 80% in the southern and eastern Mediterranean countries. Strong demographic growth compounded the problem. Early scenarios published by Plan Bleu (Box 3) thus raised awareness of the risks of water shortage. They suggested initial approaches to water saving which would make a key contribution to balancing water supply with demand and thus prevent serious social and economic problems from limiting the way forward.

Box 3: 'The constraint of water'

The water scenarios produced by Plan Bleu in the 1980s viewed population level as the decisive variable. The scenarios led to identifying three possible directions of change in the Mediterranean Basin:

The slow economic growth of the aggravated trend scenario (T-2) would make it hard to meet growing demand for water from users and for sanitation. There would be structural shortages due to lack of equipment, a fall in volume of water distributed per capita; stagnation or even decline in connections to main drainage and purification efficiency; little advance in areas under irrigation; and a lack of effort to modernise irrigation methods in ways which might save water. This would tend to stabilise pressure on quantity, but would generally penalise efforts on sanitation and conservation, in the north, south, and east.

Stronger growth, paying insufficient or belated attention to environment (moderate trend scenario T-3) would best serve the increasing demand for water supply from users in the various economic sectors. Such increased supply would be achieved mainly by increasing the pace of conventional water control developments with resultant higher costs of provision, including to enhance water security, rather than

Continued on next page

Box 3: 'The constraint of water' ***Continued...***

by 'managing' demand in ways which would be more costly to users than to the community. With only water savings effected where immediately profitable for users, water wastages in terms of quality and quantity would increase. This would place greater pressure on resources and the environment, particularly with risks in the medium-term of exhausting non-renewable water resources in southern and eastern countries.

Medium to fast economic growth could be accompanied by policies of environmental conservation and water resource management on a more voluntary basis (offering alternative scenarios). This would strike a better balance between: i) water management and deployment by setting up reserved flow rates and quality targets checked by the resource management authorities; and ii) demand adaptation or 'management' in terms both of usage (via water saving, efficiency progress, tariff or other incentives, recycling and reuse) and returns to the environment, and by generalised sanitation and purification efforts improving the quality of the aquatic environment and simultaneously lowering the costs of production of drinking water.

Source: Plan Bleu (1989)

- **"A Sustainable Future for the Mediterranean: Blue Plan's Environmental and Development Outlook" (Benoît and Comeau, 2005)**

This new study updated the major demographic, socio-economic, and political developments in the Mediterranean Basin. The chapter on water was based on studies undertaken between 1995 and 2005 and discussed at WDM workshops (cf. Chapter 2.2.) and presented at World Water Forums in The Hague and Kyoto. Many experts from the three shores of the Mediterranean contributed to these studies.

The objective of the new Plan Bleu strategic foresight report was to offer an up-to-date analysis of the dynamics of development and of the environment in the Mediterranean linked, as much as possible, to their social and territorial dimensions.

The approach related development and the environment to strategic sectors and locations (water, energy, transport, town, countryside, and shoreline) within the region where public policies and social practices would have to change in a major way in order to sustain vast natural assets, reduce risks, diminish gaps, and stimulate the economy. A 2025 horizon was chosen midway between the longer-term changes in population and global climate and shorter-term changes in consumption, production, and distribution patterns.

Compared to the foresight analysis published in 1989, this study chose to focus only on two scenarios. The first scenario was 'business as usual' – a projection of the trends in economic growth and increasing environmental impact over the past 30 years. The second was based on a hypothesis of better integration of environment and development but on a voluntary basis. This was in line with the Johannesburg Earth Summit (2002) which encouraged political commitment of governments and stakeholders to more sustainable development.

The studies highlighted the growing pressure on water resources across all Mediterranean countries but particularly in the south and east.

Scenario 1 – 'business as usual'

This scenario is characterised by growing water demand in the South and East; heightened pressure on water resources; and water policies still skewed towards water supply.

Increasing demands for water to the South and East. Water demand[4] in the Mediterranean basin doubled in the second half of the 20th century and in 2005 it reached 280 km^3/year for all riparian countries. Plan Bleu trend scenarios predicted a further increase in demand of 50 km^3/year by 2025. Most of this growth would come from the southern countries and particularly from the eastern rim (Syria and Turkey – Figs. 7 and 8). The predictions for each sector included:

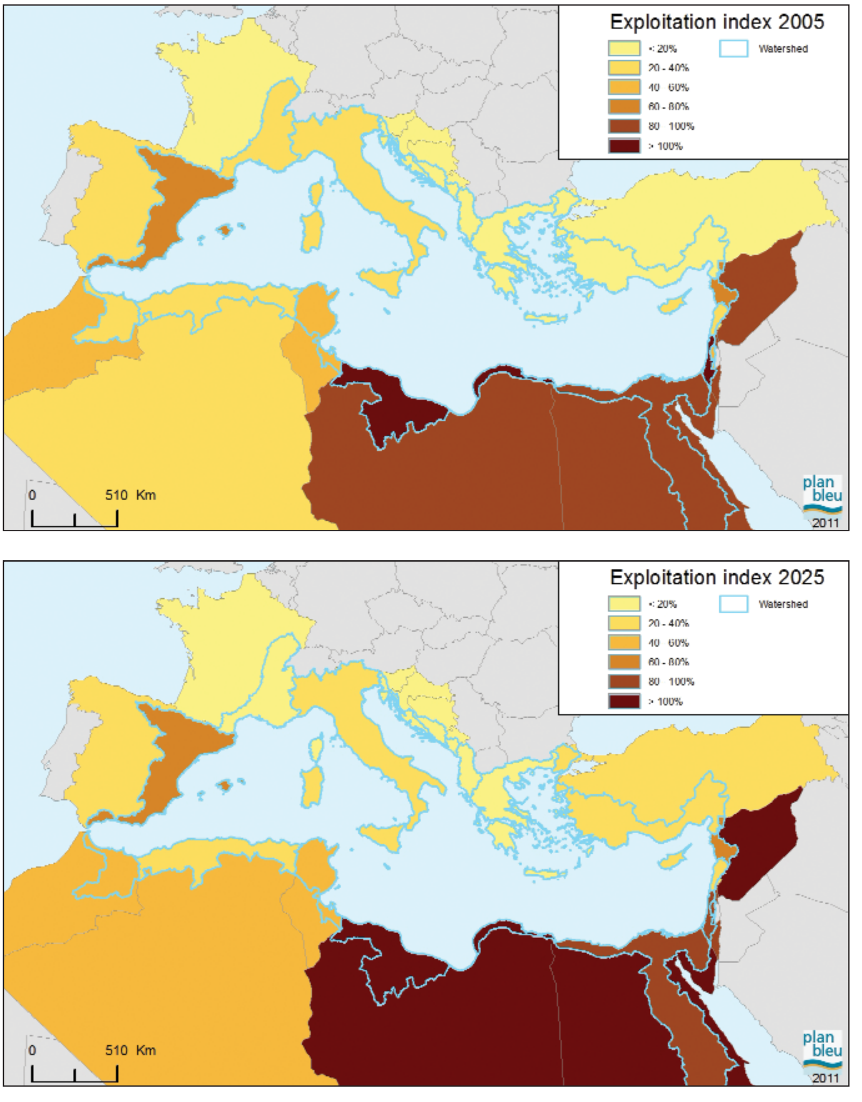
- Irrigated agriculture would remain the principal water user, especially in the south and east. According to FAO, irrigated areas may increase by 38% in the south and 58% in the east by 2030 (compared with 2000). In contrast, agricultural water demand would remain stable in the north, and may even decline (Italy);
- Domestic water demand would continue to rise to meet the drinking water needs of an increasingly urban population. Nearly 100 million more urban dwellers are expected in the south and east by 2025. More tourists are also expected – about 300 million per year by 2025);
- Overall demand for water from the energy and industrial sectors would fall. This would be mainly in the northern Mediterranean countries as a result of expected efficiency gains. In contrast, water demand in the industrial sector is projected to increase significantly within countries in the south and east and could account for over 7 per cent of the total water demand by 2025;
- Environmental demand is expected to grow to ensure proper functioning of water eco-systems, though it is difficult to quantify. More often, this demand is not quantified in supply and demand balance sheets and is considered rather as an attempt to limit resource exploitation (cf. Chapter 4.2).

Despite some encouraging progress, the effective use of water across the various sectors is still far from satisfactory (Annex 2). Indeed, the total leakage from pipes and wastage in domestic water supply and in irrigation across all the Mediterranean countries is estimated to be about 100 km^3/year – almost 40% of total water demand (Blinda and Thivet, 2007). Such losses represent considerable potential for wiser water use. A more active WDM policy may tap at least some of this potential, which is of the same order of magnitude as the projected increases in demand. Though it should be remembered that not all leakage and wastage is completely lost to a basin. Most 'losses' infiltrate into the ground and find their way into aquifers and streams and may be used by others downstream.

Pressure on water resources will increase. According to Plan Bleu's analysis of future trends, measured by the renewable natural resources exploitation index (Fig. 6), water withdrawals will exceed water availability from 2005 to 2025 across the region. Egypt, Israel, Libya, Malta, Syria, and the Palestinian Territories (Gaza Strip) are already withdrawing as much as, or more than, the limits of their renewable resources. Current and future situations are even more alarming when the index is calculated for the Mediterranean watersheds only. The strain on water resources is even more acute when considering only 'exploitable' water resources, which represent about half or one-third of total renewable natural water resources.

[4] Water demand means total withdrawals from resources (95% of the total, including leakage during pipage and usage) and non-standard sources (desalination, reuse of treated wastewater, etc.).

Fig. 6. Exploitation index for natural renewable resources – 2005 and 2025



Source: Plan Bleu (2010)

N.B: an index close to or greater than 80% indicates that strains on water resources are already very severe. A ratio of 60–80% signals major risks of structural strain in the medium term. Countries with a ratio of 20–60% may experience local or cyclical strains.

A growing portion of water demand in some countries is being met by exploiting non-renewable water resources. Other countries may also face this problem unless remedial steps are taken. Plan Bleu defines the unsustainable water production index as the percentage ratio of water withdrawn from non-renewable aquifer reserves to the total volume withdrawn. It is especially high in Libya (86%), the Gaza Strip (40%), Tunisia (29%), and Algeria (29%).

The strains on natural resources are further compounded by anthropogenic degradation and pollution. This impacts the quality of natural resources and further limits their use. The result is increased vulnerability of supply; rising costs (especially for water treatment); health risks; and conflicts of use between users, major sectors, regions, and countries.

Water policies are still skewed towards supply. Strong growth in water demand in all sectors is expected over the next decade yet water strategies and policies continue to favour increasing the supply of water. This is achieved by investing in water infrastructure, developing inter-regional and international transfers, increased 'mining' of non-renewable groundwater reserves (in the Saharan catchment areas), or using non-conventional water resources. The latter includes reuse of wastewater (in Cyprus, Egypt, Spain, Israel, and Tunisia); the use of brackish water from agricultural drainage (in Egypt), or desalination of sea or brackish water (in Algeria, Spain, Israel, and Malta – cf. Chapter 4.3).

But these supply-oriented policies are reaching their physical, social, economic, and environmental limits and as such they pose grave long-term risks. These include over-exploitation of certain fossil and renewable water resources, the destruction of coastal aquifers by seawater intrusion, degradation of water quality and the eco-system services provided by the aquatic systems, loss of investment and jobs, and increased risks of social and political instability.

Scenario 2 – better integration of environment and development but on a voluntary basis
This scenario is characterised by improving management of water resources and water demand to cope with crises and shortages and introducing reforms to curb undesirable trends.

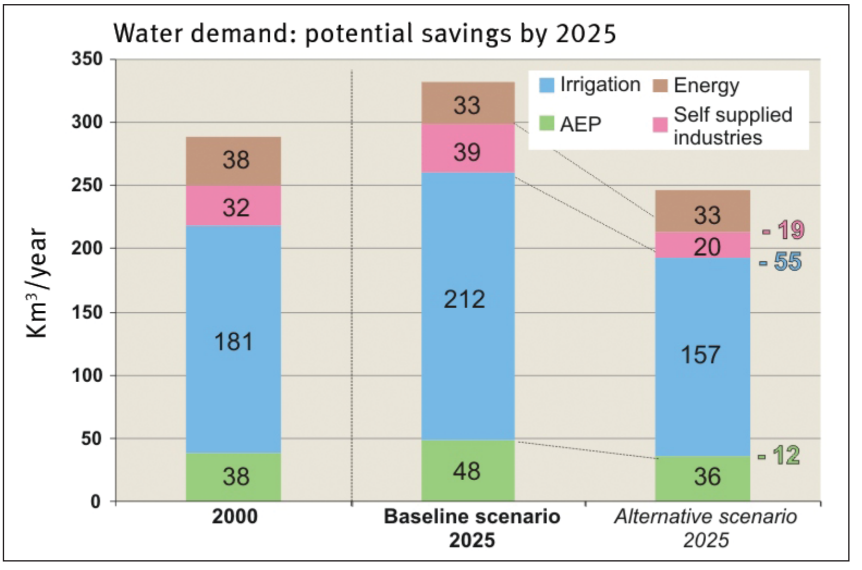
In order to overcome these problems Plan Bleu proposed an alternative scenario based on establishing the following voluntary policies:

- Improve water resource management, storage and protection through pollution prevention, increasing the exploitable potential, improving soil and water conservation practices, and increasing the use of artificial replenishment of groundwater in arid areas;
- Ensure economical and effective use of water by setting up Water Demand Management (WDM) strategies and policies backed by the necessary technical, economic, and regulatory tools; and developing the appropriate institutional capacity through awareness-raising and training.

This alternative scenario highlighted ample room for improvement. Better WDM could save one-quarter of demand – a total of 85 km^3/year by 2025 for all Mediterranean countries (Figs. 7 and 8). Irrigated agriculture represents the greatest potential savings by volume – some 65% of the total water savings identified. This is based on halving distribution losses down to 10% and increasing efficiency in the use of water to irrigate plots from 60% to 80%. Some 22% water-saving potential exists in industry which depends on increasing the rate of water-recycling to 50%. Domestic water supply offers 13% saving achievable by halving distribution losses and reducing leaks on users' premises from 15% to 10%.

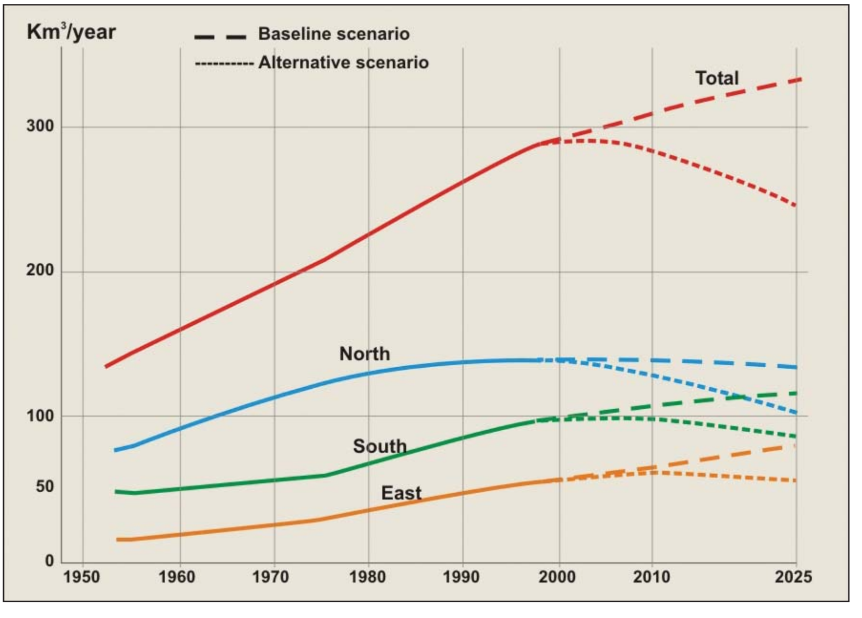
This optimistic scenario is appropriate to all Mediterranean countries. It claims that total water demand may reach 100 km^3/year in the north and 145 km^3/year in the south and east. Overall, this would equate to a fall in total water demand of about 40 km^3/year between 2000 and 2025 over the 'business as usual' scenario (Fig. 7) (Blinda and Thivet, 2006). These water savings would, in turn, save energy and money (cf. Chapter 3.3).

Fig. 7. Sector water demands at the Mediterranean countries level: trends and alternative scenarios



Source: Plan Bleu (2007)

Fig. 8. Total demand for water: trends and alternative scenarios (2000–2025)



Source: Plan Bleu (2005)

These all-in estimates are based on specific studies which demonstrate that reductions are indeed possible (cf. Chapter 3).

Reforms will be essential to curb undesirable trends. Without some significant and rapid changes in the way water is used, water shortages already present in parts of the Mediterranean region, will spread and worsen considerably, especially in the south and east where there is least water resources per capita and where water is most expensive to deploy and distribute. Here, the increase in demand will be strongest and will pose the greatest risk of over-exploitation. Major efforts will be needed for these countries to adapt.

The Plan Bleu scenarios have shown that genuine water policies do exist in the Mediterranean region, though they are not extensively applied. These policies will require amending in order to strike a new balance between the supply-based approach, which has dominated for so long, and the WDM approach favoured in this scenario.

2.2 Political commitment to tackling water shortages

At the 1992 Rio Conference Plan Bleu's scenarios, published in 1989, elicited keen interest. The Mediterranean featured as the world's first region to engage in collective reflection on its future, and on integrating environment with development. Following the Rio Conference, and based on a proposal from Tunisia, the Mediterranean Commission on Sustainable Development (MCSD) was set up. The first item on the agenda was WDM. Plan Bleu supported the MCSD in this activity which led to the first Regional Workshop on WDM in Fréjus, France, in 1997. Many stakeholders were present – ministries responsible for water, the environment, and agriculture; local authorities; businesses; NGOs; experts; financial backers; and others. The Workshop helped participants to share and reflect on the forecasts for the Mediterranean region. This included the realisation that increasing supply was the traditional answer to rising demand, and that this was now reaching its limits. They recognised the increasing social, economic, and ecological barriers to increasing supply in many countries, especially in the south and east. In 1997 the MCSD concluded that WDM (Box 4) was 'the way to enable the most significant progress in water policy development in the Mediterranean', given potential efficiency improvements.

The Plan Bleu regional workshops (Box 5) ensured progressive recognition of WDM as a priority method of helping to achieve the two core aims of sustainable development – the movement away from unsustainable patterns of consumption and production and the protection and sustainable management of natural resources as a factor of economic and social development.

Box 4: Demand for water and Water Demand Management (WDM)

Water demand is defined as total water volume mobilised (excluding 'green' and 'virtual' water) to meet different uses. It includes the water 'lost' during distribution and during use. It therefore equates to the total water withdrawal and includes non-conventional sources, such as desalination and reuse.

Water Demand Management (WDM) seeks to encourage better use of existing water supplies through economical and efficient management before further increasing the supply. WDM comprises a set of interventions and organisational systems intended to increase technical, social, economic, environmental, and institutional efficiencies[5] in the various uses of water.

Continued on next page

5 Efficiency can be understood as output or yield. It seeks to achieve a result with minimum commitment of resources.

Box 4: Demand for water and Water Demand Management (WDM) ***Continued...***

WDM especially seeks to:

- Reduce loss and misuse in the various water sectors (intra-sector efficiency);
- Optimise water use by assuring a reasonable allocation between the various users (cross-sectoral efficiency) while taking account of the supply needs of streamflow processes; resource conservation, renewal, and quality; and the development of *in situ* uses of water – recreational activities, aquaculture and fisheries, energy;
- Add more value per unit of resource mobilised;
- Facilitate major financial and infrastructure savings for countries, cities and companies; and
- Help ease the pressure on resources, especially to reduce or halt unsustainable exploitation of both renewable and non-renewable resources.

The workshops enabled participants to discuss the various tools for implementing WDM policies. These tools have been used progressively and continuously and experience has shown that the most significant progress resulted from a combination of tools such as strategies, institutional organisation, pricing, and subsidies, etc. These workshops led to the development of recommendations.

Box 5: The WDM regional workshops

Fréjus workshop in 1997 – identified WDM-related problems in the Mediterranean. It highlighted the prospects for water saving in the various water sectors. An analysis of the 21 countries and territories adjoining the Mediterranean led to the compilation of four relatively uniform groups in terms of current and future water demand, and impending risks of shortage:

- Group 1: countries not at risk of shortage, even after 2025 (Albania, Bosnia-Herzegovina, Croatia, France, Greece, Italy, Monaco, Slovenia, and Turkey);
- Group 2: countries mostly at localised risk of cyclical shortage (Cyprus, Spain, Lebanon, Morocco, and Syria);
- Group 3: countries with cyclical and/or structural shortage from 2000, despite low demand for water (Algeria, Palestinian Territories, Israel, Malta, and Tunisia);
- Group 4: countries with structural shortage from 2000, aggravated by strong demand for water (Egypt and Libya).

Fiuggi workshop in 2002 and Zaragoza workshop in 2007. At Fiuggi, discussions were organised around the various types of WDM tool – technical, institutional, and economic. Specific examples of possible solutions on a national or local scale were highlighted.

At Zaragoza, discussions centred on each water sector – agriculture, domestic use (including tourism), industry, and the environment. The workshop also offered an opportunity to exploit the national reports drawn up by various volunteer countries. These covered progress monitoring on water and the promotion of WDM policies. The workshop also dealt with the question of incorporating WDM in co-operation and development aid policies.

Continued on next page

Box 5: The WDM regional workshops ***Continued...***

Extracts from workshop recommendations:

- Make WDM a national strategic priority, in line with the Mediterranean Strategy for Sustainable Development, and ensure it is stated, followed up, and evaluated in the various sector policies;
- Ensure clear linking of WDM-related problems with global environmental problems such as climate change and the preservation of biodiversity and ecosystems;
- Encourage various WDM stakeholders (government, academic, private or associations) to participate and take responsibility at the relevant geographical levels;
- Make all arrangements to raise public awareness of WDM and train users in it, taking care to identify, follow and exploit good practices in the matter, especially the maintenance of water supply systems, individual consumption of drinking water, and rational management of agriculture according to geographical context and the need to conserve ecosystems;
- Assess WDM progress, press for the inclusion of WDM in information systems on water, and document the appropriate shared indicators; and
- Strengthen regional scientific and institutional co-operation to favour WDM and contribute to the establishment of a Mediterranean Water Observatory for continuous gathering of data, information, and good practices useful to Mediterranean stakeholders and decision-makers.

Source: Plan Bleu (2007)

In 2005 the Contracting Parties of the Barcelona Convention adopted the Mediterranean Strategy for Sustainable Development (MSSD) which embedded Plan Bleu's foresight studies into national policies. Integrated water resources management, including demand management,[6] is the main priority issue of this common 'framework' strategy. A key objective is to strengthen WDM policies and so stabilise demand. This is achievable by limiting losses and increasing the value added per m^3 of water used (Box 6).

Box 6: Aims of integrated water resource and demand management (MSSD, 2005)

- Stabilise water demand (decrease in the north and controlled increases in the south and east;
- Reduce losses and misuses and increase value added per cubic metre of water used;
- Promote integrated management of watersheds, including surface and groundwater and ecosystems, and foster activities that reduce pollution;
- Achieve the Millennium Development Goals for access to drinking water and sanitation;[7]
- Promote participation, partnership, active co-operation, and solidarity for the sustainable management of water locally and nationally.

[6] Integrated Water Resource Management (IWRM) is a process which encourages the exploitation and co-ordinated management of water, land, and related resources. It aims to maximise the resultant economic and social wellbeing fairly, without compromising the sustainability of vital ecosystems (Global Water Partnership, 2000). The MSSD emphasises the need for integrated management of water resources and demand.

[7] The eight Millennium Development Goals (MDG) were adopted at the Millennium Summit in September 2000, at United Nations Headquarters, New York. Goal 7 (ensure environmental sustainability) relates to access to water and sanitation: "Halve, by 2015, the proportion of the population without sustainable access to safe drinking water and basic sanitation."

WDM was also adopted as one of the priorities of the draft Strategy for Water in the Mediterranean (SWM) in preparation under the auspices of the Union for the Mediterranean.

Finally, since the mid-1990s, policy co-operation on water between the European Union and the Mediterranean countries has broadly strengthened around issues of water shortages and drought. A Working Group on Water Scarcity and Shortage was formed as part of the joint process between the Mediterranean component of the European Water Initiative – Med EUWI – and the Water Framework Directive (2004–2009). The aim is to reinforce the pooling of knowledge and techniques and the exchange of experience between Mediterranean and European countries. The value of WDM measures was especially emphasised as part of this work.

In summary the establishment of Mediterranean-wide co-operation has centred on environmental and developmental issues. This has not only favoured political engagement with the question of water shortages at a regional level but it has also helped some Mediterranean countries to develop their own visions and policies for water.

Some lessons from this shared history include:

- The use of scenarios as a systematic, forward-looking approach to map out futures and enlighten decision-making;
- The importance of a regional co-operation agreement and a technical centre like Plan Bleu, whose brief is to observe the environment and development, conduct systemic and predictive analyses, and hold regional workshops involving stakeholders able to formulate conclusions and share proposals;
- Engaging in outlook research with known experts from many different countries working towards constructing a common vision and then disseminating the findings to a wide circle of stakeholders such as heads of central government departments (water, agriculture, the environment etc.), NGOs, providers of funds, and local authorities;
- The need to reflect on how to move from forecast to strategy, and on to policies;
- The worthwhile nature of discussions and regional pooling of experience which has helped some countries to develop their visions and policies;
- The need to regularly monitor progress over the long term. Examples include the need for regional WDM workshops every five years and a new global forward-looking exercise to be conducted every decade or two.

3 WDM tools and examples

3.1 Balancing water supply and demand

As defined in Box 4, WDM aims to encourage better use of water before plans are made to increase supply. Thus WDM thus seeks efficiency within and across sectors and aims to produce lean, efficient management and reduce water losses and wastage.

WDM consists of very practical action to improve and even transform methods of production and consumption in every major sector of use. It means changing practices and behaviour patterns. It implies moving from a policy of infrastructure to a policy where all stakeholders take responsibility for using water wisely.

In the Mediterranean region, water supply management policies have run up against a number of physical, financial, and environmental limits. As highlighted in the Plan Bleu scenarios (see Chapter 2.1.2), the trend is expected to result in increasing imbalance between water supply and demand in ever more countries, made worse by the effects of climate change on hydrology and evapotranspiration. Improving the efficiency of water use and allocation within and between sectors is now considered to be a serious option to effectively limit water shortages and crises.

3.2 Tools for better WDM

About a dozen countries voluntarily submitted reports on their progress on monitoring and promoting WDM policies in the run-up to the third workshop on WDM in the Mediterranean (UNEP/MAP/Plan Bleu, 2007). Urged by Plan Bleu, national studies of water efficiency were also carried out between 2008 and 2011.[8] All this work highlighted the real progress made over the past 15 years to incorporate WDM into water policies and some sector policies. Growing numbers of Mediterranean countries have gone down this path. Usually they are countries suffering most from water poverty – Cyprus, Spain, Israel, Malta, Morocco, and Tunisia. They have adopted formal national WDM strategies, especially to reduce water use in irrigated agriculture. They have combined laws and regulations, techniques, economic and institutional tools. They have mobilised stakeholders. These strategies often build in arrangements to devolve action to the relevant geographical areas as a matter of principle. For agricultural water use such strategies favour the establishment of local trade organisations and/or strengthening their capacity. These may be associations of agricultural water users, of landowners, and of other agricultural development groupings. They are able to act collectively in dealing with the 'reality on the ground' (at 'discharge basin' level).[9] They can monitor compliance with management rules which they have jointly defined. The change which has actually taken place and favours the emergence of such strategies is the devolution of water resource development and assessment of its allocation at catchment level. Users are increasingly involved and the role of central government is redefined.

Fig. 9 presents various WDM tools used for agriculture water management in the Mediterranean countries. They include technical tools, economic incentives to save water, regulation and control of withdrawals, co-ordination and planning tools, and tools of awareness raising and training.

Table 2 presents various WDM policies and measures implemented or planned in the main water use sectors (domestic, tourist, agricultural and industrial sectors) based on practice in Israel.

More details of the different types of tool presented in Fig. 9 and Table 2 are described in the next section.

8 Studies were carried out in: Algeria, Bosnia-Herzegovina, Cyprus, Croatia, Egypt, France, Israel, Italy, Lebanon, Malta, Morocco, Syria, Tunisia, and Turkey. Available at www.planbleu.org/publications/eau.html

9 A 'bassin-déversant' (literally: discharge basin) is an area of water use corresponding to "the area of hydraulic and hydrological influence which depends on built works and networks using the water." This notion, coined by Martin from a suggestion made by Fayoum as early as 1799, proves relevant in both the northern Mediterranean (Provence, Catalunya etc.) and in the south. 'Bassin-versant' (catchment basin) is a rational hydrographical unit for assessing primary water supply, but this sometimes proves insufficient to portray the complexity of water demand where the patchwork of land is difficult to present and understand (Ruf, Riaux, 2008).

Fig. 9. Tools of agricultural WDM deployed in the Mediterranean

Institutional framework
Coherent strategic framework
Essential to co-ordinate action and to make a firm commitment, monitored in the long term

Technical tools

- Improve canal streamflow processes;
- Improve efficiency of irrigation methods;
- Reduce vulnerability of agronomical models and land use systems;
  - ✓ Improve cultivated species;
  - ✓ Revise crop management and intervals between harvesting and planting;
  - ✓ Choice of crops and optimisation of rotation;
- Use of irrigation as a back-up;
- Irrigation planning and management tools.

Economic incentives to save water

- Pricing;
- Quotas;
- Forms of financial assistance (subsidies, assisted loans);
- Fees;
- Delink aid from CAP;
- Agri-environmental measures;
- Cross-compliance.

Regulation and offtake control

- System of offtake declaration/ authorisation;
- Provisional restrictions linked to hydro-climatic fluctuations
  Obligatory metering of offtake volumes (above certain thresholds, according to type);
- Water Police responsible for control and reporting offenders.

Tools of planning and co-ordination

- Devolved units of management (basin agencies);
- User and irrigator associations;
- NTIC (water management support software for an irrigated area).

Tools of training and awareness raising

- Campaigns to raise awareness of farmers and the general public;
- Agricultural advisory service;
- Training of agricultural professionals, technicians and engineers.

Source: Thivet in CIHEAM-Plan Bleu (2009)

Table 2. WDM policies and measures implemented or planned in Israel (2010–2020)

Sector of water use	WDM policies and measures
Domestic and tourism	1. Compulsory metering on users' premises; 2. Water utilities fully accountable for water losses over 8% during distribution; 3. Installation of automatic, remote controlled meters (N*); 4. A major wastewater treatment programme (existing, with new extensions planned); 5. A significant tariff increase (N*); 6. An incremental tariff system to impose higher charges on larger consumers of water. Addition of supplementary increments planned (existing and N*); 7. A multimedia campaign to raise awareness of water saving (existing measure and N*); 8. Monitoring and specific quotas for municipal green spaces (N*); 9. Treating a larger volume of domestic wastewater for agricultural reuse; 10. Installation of high-capacity desalination units (N*).
Agriculture	1. Compulsory metering on agricultural users' premises; 2. Water utilities fully accountable for water losses over 8% during distribution; 3. Distributed water subject to annual quota (cannot be exceeded); 4. Many policies to encourage research and development, farmer training, water conservancy practices and technology (existing and N*); 5. Policies encouraging the use of brackish water and treated wastewater for irrigation; 6. Tariff increase with a view to full coverage of costs (N* and future).
Industry	1. Compulsory metering of water volume consumed; 2. Water utilities fully accountable for water losses over 8% during distribution; 3. Policies encouraging the use of brackish water and recycled process water (N*); 4. Tariff increase with a view to full coverage of costs (N* and future).

*Recent changes/innovations (initiated in the past few years) are marked 'N'.

Source: Israel Water Authority (2011)

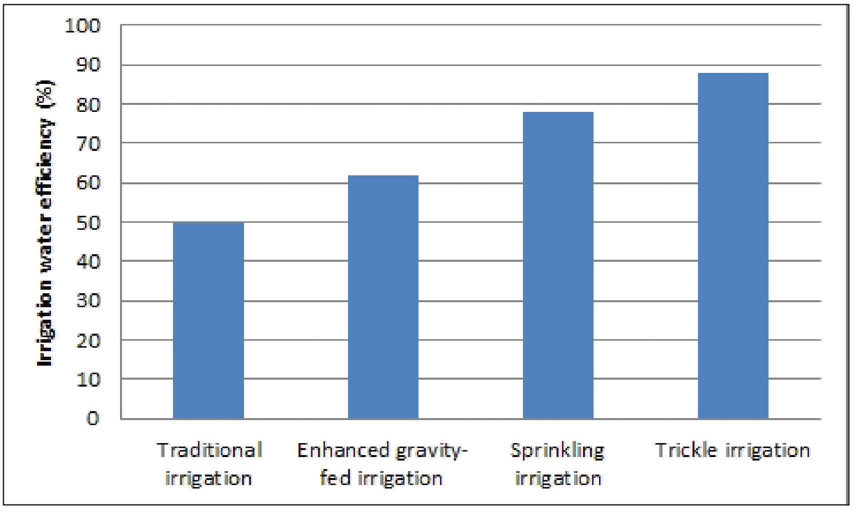
3.2.1 Technical tools – agricultural sector

Various technical measures, described below, have contributed to improved management of agricultural water demand in Mediterranean countries.

Improving streamflows in canals – Significant progress was made over the past 40 years in the management of large-scale systems such as impounding reservoirs and distribution systems. This includes methods of dynamic regulation and automation which have minimised management related losses and improved the management of supply in line with demand. On older systems, such as the River Durance in France, canals were lined and sluices fitted with automatic off-takes to reduce water wastage and to improve water efficiency.

Improving irrigation water use on farms – It is common practice to rank on-farm irrigation methods (surface, sprinkler, trickle irrigation) according to presumed performance. Localised irrigation, for example, is generally considered to perform better than sprinkling which, in turn, performs better than gravity-fed irrigation (Fig. 10).

Fig. 10. Potential water efficiency of different irrigation techniques in Syria



Source: Abed Rabboh in UNEP/MAP/Plan Bleu (2007)

However, this ranking needs some qualification as the effectiveness of an irrigation method is as much a function of management as it is a function on the technology itself. Gravity irrigation, for example, is often classed as the least 'efficient' but it is estimated that more than 80% of the water applied and not used by the crop is returned to the natural environment through seepage and runoff and may be used by others downstream. Hence 'losses' can still play a dominant role in many basins, especially in times of drought by conserving agricultural resources and aquatic environments downstream, and boosting low levels in watercourses. 'Modern' irrigation methods such as sprinkling and localised irrigation do have the potential for more effective and efficient application than surface flooding, but good management is essential if that potential is to be achieved. Poor management will result in poor application efficiencies and water wastage. So it is important to ensure that whatever irrigation methods are used they are properly adapted to each situation, especially soil and crop type and the management skill available among the farmers.

While gravity irrigation predominates in the Mediterranean, the SEMCs in particular have made considerable efforts in recent years to introduce 'modern' methods of irrigation such as sprinkling and localised irrigation (examples are Tunisia and Morocco – see Chapter 3.4.1). The land equipped with modern methods (localised or sprinkle irrigation) varies widely from country to country. It exceeds 50% of the total land irrigated in France, Italy, and Tunisia, and is nearly 100% in Cyprus, Israel, Libya, and Malta.

Reducing vulnerability of current agronomic models and land use systems – To maintain and develop agricultural output in times of drought, while conserving water resources, farmers need options which reduce demand for irrigation water and optimise water use. These include:

- Selecting 'water-saving' or drought-tolerant varieties;
- Reviewing crop management and the interval between harvesting and the next planting: a conservation strategy will aim to reduce evaporation losses and maximise water storage when the crop is sown. An evasion strategy will aim to stagger the phenological stages most prone to water deficit (flowering), while a rationing strategy aims to reduce transpiration during the vegetative period, to return unconsumed water to the filling stage;
- Choosing crops and optimising cropping plans and rotation.

It is difficult to select varieties which are both productive and drought-resistant. Hence the greatest room for progress lies in changing land use (cultivated species and rotation). Operational changes may even be possible such as diversifying and converting when drought conditions are predicted sufficiently far in advance.

Without irrigation, the key to drought adaptation lies in diversifying cropping cycles and species to spread climatic risks and make evasive solutions possible. The choice of species must be adapted to the available soil water.

For irrigated production diversifying the crop rotation may help to better adjust overall water demand to the available irrigation water (in volume and in time). Maximum irrigation is not always the most profitable. One option may be to provide limited irrigation to a wide range of different crops which are reputed to be drought-tolerant (sorghum, sunflower). Another option would be to shift the irrigation calendar by introducing sown crops in early spring or winter (peas and cereals). Water which is otherwise little used can then be exploited in the spring.

Linked cropping systems in irrigated areas is another approach to increasing value added per cubic meter of water used. This relies on reducing the losses and wastage of irrigation water, which occur in a system of monoculture, and on better management of fertilisers. An example is the linked production of potatoes and sulla fodder crops in Tunisia.

However, agriculture's adaptation to the new economic and regulatory context of water management cannot just rest on changing crop rotations. The viability of irrigated crops also depends on the rate of depreciation of irrigation facilities, grants of agricultural aid (which may or may not incentivise irrigation), and the state of the market, etc.

Using supplemental irrigation – Rainfall is a primary source of water supply for crops but in situations where rainfall is insufficient, supplemental irrigation using blue water can make up the shortfall. Experiments in the West Bank and Syria have shown supplemental irrigation achieved both a substantial increase in yields and secured farmers' production and income. In Syria, rainfed wheat yields are around 1.25 t/ha but may reach 3 t/ha with supplemental irrigation.

The productivity of one cubic meter of supplemental irrigation water is, in fact, much higher than that of conventional irrigation for which water input is 7 times higher than for supplemental irrigation.

Establishing an efficient, water-saving irrigation calendar entails moving from the concept of maximum yield to one of optimum yield.

Using irrigation scheduling and planning tools – Irrigation management can be considered at different time and space scales. Improvements can be made at each scale in order to better rationalise irrigation water use in relation to local constraints on the resource. Water savings can also be made in irrigation by planning ahead, such as choice of rotation, deployment of equipment, and irrigation management strategy. Savings can also be made during the irrigation season by using irrigation scheduling methods.

Computer tools are available to help technicians and farmers make the best choices of cropping plan and irrigation strategy. Such tools can help irrigators to review the possible changes in areas irrigated when there are major changes in water law, in agricultural water tariffs, or in aid allocated to growers. They can also help to define a set of strategies which optimise pre-set criteria, such as gross margin, yield and water efficiency, for given limited water availability.

Tools also exist to improve the control of water supply during the irrigation season. These include information on crops' water requirements; predicting soil moisture balance; sink systems (to assess the wetness of the soil); and plant growth modelling. Some tools use satellite imagery to provide information and advice to irrigators.

All these tools provide a means of adjusting water demand to supply. Some of these offer optimal solutions in instances where resources are restricted thus allowing for a reduction in demand. However, progress cannot take place unless farmers receive, accept, and act on the advice available to them. So this is not just an agronomical and technical problem. It is a cross-cutting issue, which involves people, training, and awareness-raising initiatives.

3.2.2 Technical tools – domestic, tourism, and industrial sectors

Annex 2 contains a definition of the efficiency index of potable and industrial water.

Improving the efficiency of water distribution systems – The losses recorded from water distribution systems vary according to country and town but can be as high as 40 or 50%. To deal with this, the water utilities set up system diagnostic operations to detect and repair leaks and renew infrastructure. They do so on the economic principle of preference, costing whether to carry out detection and repair operations (cf. Chapter 3.3.2).

Public-private partnerships (PPPs) have also developed. These have significantly contributed to improving the efficiency of water distribution systems in several Mediterranean cities (Box 7).

Improving the efficiency of use – Consumer water demand, including communities and tourism, can be reduced by:

- Setting up systems which economise on water – flow modulators (pressure relief valves on the network inside the home, small water cisterns for flushing toilets, flow-reducing aerators for taps and shower heads), and domestic electrical appliances which use less water. These systems can save water since it is possible to reduce consumption by 40% without inconveniencing the user. Furthermore, the time of return on investment is short for this type of equipment – generally less than one year;
- Alternatively, developing systems for reusing grey-water for watering gardens, washing cars, and flushing toilets – uses which do not require water to be cleaned to drinking water standards (Box 8).

Box 7: PPPs improve the efficiency of urban water distribution systems

The development of public-private partnerships (PPPs) has led to improved water efficiency in various user sectors.

In Algeria the authorities wanted to make a radical and rapid improvement in the quality and efficiency of water and sanitation services. They decided to draw on the experience of international companies to manage these services under a PPP. The first operation concerned Greater Algiers in 2006. A contract was established between the Suez Environnement and the utility, Société des Eaux et de l'Assainissement d'Alger (SEAAL). The rate of loss of drinking water from pipes is said to have fallen from 40% to 25% in five years. SEAAL was distributing water round the clock to more than 80% of the city's population in 2009. Its aim is to provide continuous (24-hour) distribution in all districts in the near future.

In Morocco a PPP has tackled the financial needs of major programmes to upgrade and renew ageing water mains. The finance was provided under contracts which delegated the distribution of drinking water in four cities (Casablanca, Rabat, Tangier, and Tétouan), which are home to over 8 million people. According to Lydec[10] in 2008 savings of 25 Mm^3 of water were recorded – equivalent to the consumption of 800,000 people. This marked the culmination of a series of initiatives undertaken between 1997 and 2006 to replace meters, find and repair leaks, and adjust pressure (replacing over 470 km of pipes, upgrading 360 km of pipes, and find and repair nearly 200,000 water leaks).

Sources: Benblidia and Thivet (2009), Belghiti (2008)

Box 8: Grey-water recycling in Cyprus

From 1997, the Government of Cyprus has sought to develop domestic water conservation measures, such as on-site water treatment and recycling. This was based on the finding that over 50% of domestic demand could be met by water of lower quality – not necessarily drinkable. The advantage of grey-water recycling over re-use of purified wastewater is that it can be done in the home. A programme of subsidies for grey-water recycling systems was set up for watering gardens and flushing toilets. This reduced water consumption by as much as 35–40% per capita. Grey-water recycling is now embedded in the national WDM policy.

Source: Kambanellas in UNEP/MAP/Plan Bleu (2007)

[10] Moroccan subsidiary of Suez-Environnement Group.

To reduce withdrawals for potable water supply, it is also conceivable to set up rainwater recovery systems. Rainwater is usable after treatment, especially for showers, washing machines, and toilets. In France, such recovery systems can reduce domestic use by 30% depending on the region, with a return on investment in 20 years. Such installations could limit reliance on underground water resources.

Some countries, like Morocco, have rationalised their drinking water supply systems via drinking fountains, by restoring fountains in poor condition, and introducing innovative methods of management (such as a system of automatic drinking fountains for a flat, prepaid charge).

Chapter 3.4.1 contains case studies presenting technical measures applicable more specifically to the tourism sector.

In the industrial sector, action to encourage better control of water demand may focus on improving the management and control of systems, improving process control, modifying equipment, changing technologies, and on-site water recycling and reuse. The need to raise staff awareness should not be overlooked. Such action must be targeted according to the water management diagnostic at the industrial site. Defining and prioritising WDM measures can be supported by using environmental management tools and toolkits for operational management on a voluntary basis, such as company environmental plans or Environmental Management Systems such as the standard ISO 14001 and the EU environmental management and auditing system.

Water recycling is one of the most important ways of water saving. It is also a way of reducing pollution. Table 3 presents some saving water technologies.

Table 3. Examples of technologies and water saving in the industrial sector in France

Industrial sectors	Examples of technologies which facilitate water saving
Paper mills	Recycling some of the process water (alkaline) from the bleaching unit; Collection and recycling of clean cooling water; Operating certain cooling circuits as closed circuits; Recycling water in the ground wood pulping unit; Partial recycling of water after biological processing, etc.
Steelworks	Recycling as much process and cooling water as possible; Operating a closed circuit for wash water.
Agri-foods and dairy industry	Use of analytical measurement and control methods to limit water wastage; Use flow-rate limiters for cleaning operations; Limiting contact between water and food/dairy matter.

Source: Faby et al. in UNEP/MAP/Plan Bleu (2007)

3.2.3 Economic tools

The use of economic tools remains limited – Economic tools (pricing, quotas, subsidies, taxation) can greatly help to reduce losses and wastage. They are also useful in making a more efficient allocation of resources within and between sectors, in improving access to water by the most deprived social classes, and in responding to environmental concerns. They may prompt positive changes in the behaviour of various users. They may also contribute to the essential finance of water management and infrastructure maintenance.

Although they are often seen as the tools of choice for integrated water management, relatively little use is made of economic tools in the Mediterranean, especially in the agricultural sector. Table 4 lists the available range of economic tools. By far the most frequently used are the various forms of charging for drinking and irrigation water (standing and volumetric charges). The main aim is to recover the costs of the water utility from users. The European Union Water Framework Directive (WFD) is especially insistent that water pricing should play a significant role in the recovery of costs.[11] This finding holds good in all the Mediterranean countries. The other tools, such as quotas or subsidies, are much less widespread, or are used jointly with pricing.

In some countries the pricing system includes incentives. These seek balanced management of the resource while safeguarding objectives of more intensive irrigated agriculture to meet national food security targets or balance the budget of the facilities manager, in agriculture.

Table 4. Economic tools and water saving incentives for irrigation

Type of tool	Examples of countries concerned	Degree of incentive to save water
Pricing	Nearly all Mediterranean countries	Tool prioritises recovery of water utility costs, but may lend an incentive to water saving. Incentive varies according to tariff structure and price level (see Table 5).
Quotas	Cyprus, France, Israel	Set a consumption limit which cannot be exceeded, without encouraging water saving within the quota limit, unless some special arrangement exists.
Financial aid (subsidies, loans on easy terms)	Cyprus, Spain, France, Israel, Morocco, Syria, Tunisia	Incentives to save water and prevent wastage, through aid in acquiring modern irrigation systems, which save more water, and planting drought-tolerant crops, etc.

Continued on next page

[11] Extract from Article 9 of the WFD on the recovery of costs for water services: "Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis conducted [...] and in accordance in particular with the polluter pays principle. Member States shall ensure by 2010: i) that water-pricing policies provide adequate incentives for users to use water resources efficiently, and thereby contribute to the environmental objectives of this Directive ii) an adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services, based on the economic analysis conducted [...] and taking account of the 'polluter pays' principle."

Table 4. Economic tools and water saving incentives for irrigation *Continued...*

Type of tool	Examples of countries concerned	Degree of incentive to save water
Royalties for withdrawals (pollution and resource)	EU Member States, Israel, Morocco, Tunisia	Little incentive to save water, as taxation levels remain low.
Delinking aid from Common Agricultural Policy (reform of 2003).	EU Member States	Delinking should remove any incentive to irrigate under the CAP facilities (concerning areas irrigated for cereal-growing and oil seed plants).
Agri-environmental measures (AEM)	EU Member States	AEMs signal a shortage of the resource in the targeted territories. Voluntary measures. Little impact if not taken collectively at catchment level.
Cross-compliance	EU Member States	Strengthening cohesion between water policies and agricultural policies. Granting agricultural aid subject to a specific obligation to meter water withdrawals.

Sources: Thivet in CIHEAM-Plan Bleu (2009)

Addendum to Table 4:
Similar economic tools are used in the domestic, tourism, and industrial sectors. They include water pricing (incremental for domestic water supply and tourism), targeted subsidies and tax incentives for equipment in water-saving systems, rates for sewerage and withdrawals from the water resource, quota setting, conditional state aid to communities and tourism businesses, and funds for industrial decontamination.

For irrigation – Charges for irrigation are low even though this is where the greatest scope for saving in fact lies. Irrigators also make the least contribution towards operating costs, not to mention investment costs (Table 5). Even with low charges and costs the limited aim of recovering costs is rarely achieved.

Most of the countries where agricultural water is free, or where charges do not provide incentives to save water, do not have a strong policy on price rises or tariff amendment. However, new irrigated areas in Spain, Greece, and Lebanon, may introduce volumetric pricing with greater incentives to save water but this will require meters to be installed. Some countries, whose pricing is volume-based, are planning to increase prices (Morocco and Tunisia – Box 9). Others (Cyprus, Israel, and Lebanon) are planning one-off rises which will allow better recovery of water costs.

Offering financial incentives (subsidies) is also a key tool in supporting pricing policies and boosting levels of cost recovery in the agricultural sector. This encourages changes in practices without loss of income for farmers. In the context of the National Irrigation Water Saving Strategy (including a pricing element), the Tunisian Government has offered 40, 50 and 60%

Table 5. Irrigation water pricing and incentives to save water

Tariff structure	Examples of countries concerned	Degree of incentive to save water
None	Albania, Egypt, Palestinian Territories	None.
Standing charge per hectare	Spain, France, Greece, Italy, Lebanon, Syria	Combined with very low prices and subsidies for irrigated output. This has tended to encourage an increase in irrigated areas and a rise in demand for agricultural water.
Incremental standing charge (According to irrigated crop or irrigation technology)	Italy, Turkey	Does not encourage water saving for a given cropping system or irrigation technique, but is usable to discourage irrigation of certain crops which consume a lot of water (e.g. maize and tomatoes in Turkey).
Two-part charge	Lebanon (new areas of South Beqaa), Tunisia (areas of controlled irrigation)	Fixed element based on irrigable area, with incentive to irrigate land which has the facilities. Proportionate element based on volumes of water actually consumed: encourages rational water use.
Uniform volumetric pricing	Cyprus, Spain, France, Morocco, Tunisia	Encourages water saving (according to price level).
Incremental volumetric charging (rarely applies to irrigation).	Israel	Strong incentive to save water within limits of set quota (according to price progression and level).

Sources: Thivet in CIHEAM-Plan Bleu (2009), Chohin-Kuper, Montginoul and Rieu (2002)

subsidies for large, medium-sized, and small farms, respectively to purchase modern irrigation equipment. As a result the extent of modern irrigation systems has risen from 20% of total irrigated area in 1990 to 80% in 2007 (cf. Chapter 3.4.1).

For drinking water – Financial incentives to save drinking water are similar to those used in irrigated agriculture. One element of this lies in how the price is structured – standing charge, uniform or incremental, uniform with two parts, or incremental in one part. The other is the price level. The pricing schemes with the greatest incentive combine a steep progression of incremental pricing with an initial high price (Israel and Turkey). Some countries (Egypt and

Box 9: Irrigation water pricing in Tunisia

Tunisia reformed irrigation water pricing in the 1990s. There were three aspects to this: transparency of cost price, flexibility (regionalised pricing, varying according to the purpose of the irrigated areas), and related national objectives (food security). From 1990 to 2000, Tunisia adopted regular water price increases. The rate was 9% per annum in real terms. Parallel to this, a big effort was made to install metering systems on farms in general.

The price rises between 1990 and 2003 totalled around 400% and served to recover a major share of the increase in the costs of operating and maintaining the water supply systems. The recovery rate over the same period rose from 57% to 90%. Aware of the limitations of the single-element pricing currently in force, the authorities planned a progressive introduction, from 1999, of two-part pricing for the large irrigation areas in the north. The aim was to improve the rate of recovery of the cost of water and offer incentives to irrigate land which already had the facilities.

Some case studies reveal a significant impact of price increase on consumption. The quadrupling of the price of water in Jebel Ammar for example, contributed to a two-thirds reduction in the volume of water consumed.

Sources: Hamdane (2007), Chohin-Kuper, Montginoul and Rieu (2002)

Jordan) apply incremental and volumetric pricing, but offer relatively little incentive. This is because their initial prices are low, and the price progression is modest. In Spain, a seasonal rate is charged. This is an additional factor which can encourage water saving at the time of year when it is most needed.

Price structures are now being modified to create water saving incentives. In practice this means i) a desire to abandon flat rates and move towards a two-part or even proportionate charge (France[12]); ii) an increase in the number of increments, where charging is already incremental (Greece, Morocco, and Tunisia – Box 10).

The general trend is towards increasing the price of water to the user in order to recover a growing proportion of the real costs of supplying drinking water and sewage services (EU Member States, Egypt, Spain, Morocco, Tunisia, and others). This trend should continue in future. Increasingly, environmental factors are being priced in (the scarcity of the resource, purification). This should strengthen the trend driven especially by the WFD. However, these factors remain variable. They depend on whether countries incorporate sewage and purification charges in their prices for drinking water. Apart from sewage, some countries are introducing pollution or resource fees. These increase the price of drinking water and are an incentive to save the resource. They also provide funding for decontamination measures or to develop new resources.

The sensitivity of water demand to price – The main logic of water price rises is better cost recovery. Price rises are rarely applied to save water as a resource. Nevertheless, raising water

[12] The Water and Aquatic Environments Law of 2006 imposes volume consumed as a systematic factor in water billing. Bills consist of a portion for drinking water and a portion for collection and/or treatment of wastewater, where such a service exists.

Box 10: Drinking water pricing in Morocco

Morocco has a progressive charge for domestic water using price bands. These are based on volume used as a disincentive to waste water. The tariff lever and the rigorous management of water metering have contributed to stabilising demand for drinking water in several cities and towns. Major investments were deferred and the finances of the utilities are now more balanced.

In the past, the industrial tariff was the same as the preferential rate. Then, in 1990, the industrial tariff was increased to give companies an incentive to save water by recycling and introducing new technologies.

There were more than 15 increases in the first three price bands between 1980 and the early 2000s. Prices increased 4 to 7-fold according to band. The larger increase was in the upper price bands making the pricing more progressive and adding to the incentive to save water. In 1995 the ratio between the highest price band and the social price band reached three for all Moroccan cities.

In 2006, a new pricing structure was set up. The main changes to the utilities' price scale were as follows:

- Lowering the upper limit of the first price band from 8 to 6 m^3/month, which made the second price band 6 to 20 m^3 for water and sewage;
- Increasing the annual standing charge from MAD 30 to MAD 72/year;
- Differentiated onward charging of the ONEP 3.5% water price rise for certain public corporations and concession-holders. This included the introduction, in 2005, of a withdrawal levy in favour of the basin agencies, of MAD 0.04/m^3;
- The gradual reclassification of hotels, classed as industrial users, granting them the benefit of the single volumetric rate instead of charging by price bands.

Source: Belghiti (2008)

prices helps to signal that this is a scarce resource. The impact on overall water demand may be limited if alternative resources are used, such as the exploitation of underground water in Morocco and Tunisia. To prevent this side-effect, the price tag should be added to all water resources, whether from the surface or underground.

The sensitivity of demand for water to price depends on a number of factors:

For irrigation water:

- Whether alternatives exist. If alternative water resources are not available and alternative cropping systems or even agricultural output are not feasible, this limits farmers' options in response to a price rise;
- Irrigation methods used: water demand is generally less flexible in modern irrigation districts because it costs more to improve technical efficiency than for older systems;
- Water costs relative to the margin earned from irrigated crops: the greater the value water adds to crops, the firmer the demand remains in response to a price revision (Box 11); and
- Features of the pricing: the impact of an irrigation water price increase on farmers' consumption depends on the initial price level, the size of the increase, and how it is implemented over time.

For drinking water:

- Initial level of consumption (consumption band): in the low consumption bands, demand is relatively less sensitive to price because drinking water is essential. The higher bands, meeting non-essential needs, are more price-sensitive;
- The amount of price increase imposed; and
- Feasibility and ease of access to an alternative resource, such as underground water, connection to a network distributing untreated water, or rainwater recovery.

Box 11: Flexibility of water demand in response to price

In Spain – The flexibility of demand for irrigation water in relation to price depends on the productivity differential between irrigated and upland or non-irrigated crops. Thus Spanish modelling studies show that in the areas irrigated from the River Guadiana, pricing the water at EUR 0.03/m^3 reduces demand by 37%. If price levels are high, only fruit trees are irrigated. In the areas irrigated from the Guadalquivir, water demand is less flexible in relation to price because price levels are moderate to low, and there is a greater difference in productivity between irrigated and non-irrigated crops.

Source: Blanco Fonseca in UNEP/MAP/Plan Bleu (2007)

In Tunisia – For the domestic, tourism, and industrial sectors flexibility of pricing varies according to the domestic water consumption band:

Sector	Domestic						Industrial	Tourism
Water use band (m^3/quarter)	0–20	21–40	41–70	71–150	151+	Total	Not significant	–0.22
Price flexibility	–0.4	–0.006	–0.38	–0.15	–1.47	–0.54		

The highest consumption band is fairly flexible with regard to price. This use group is likely to cut back sharply in response to successive price rises. Results for the other bands show that price variables do have statistically significant effects on water demand. This explains the relative decline in water demand observed in recent years.

The use of drinking water for industrial purposes is closely linked to the level of economic activity. Flexibility with regard to income is high for the upper consumption band. However, pricing does not have significant effects as industrial water demand seems to be inflexible. Thus the only constraint on tariff adjustment is the issue of industrial competitiveness. This question arises especially for industries which use a lot of water.

As for use in tourism, estimates indicate that drinking water demand is very inflexible in response to price, but there is also quite a large degree of flexibility in income.

Source: Hamdane in UNEP/MAP/Plan Bleu (2007)

Caution when using economic tools – Greater use of economic tools can ensure better WDM. However, there are certain essential conditions if these tools are to work well and be socially acceptable. In particular, they must:

- Take account of other national interests or policies e.g. town and country planning, avoiding migration from countryside, and securing sufficient food production;
- Be compatible with user incomes. In all countries, the impact on farmers' earnings and the guarantee of access to drinking water for all are factors which constrain thinking about price reform and economic tools. Depending on country, this may mean supplying farmers with free water, increasing prices less than necessary, setting up a special pricing structure with a bonus for water saving, applying a quota system, setting up social pricing for drinking water (via an incremental pricing structure, pricing with discounts based on criteria such as number of children, or linking bill payments to precarious social circumstances). In Morocco agricultural water price rises were staggered over time so that the speed of increase did not outstrip technical progress in agriculture.

The cost of using these tools must not cost more than the benefits they bring, especially in terms of water saving.

A sound knowledge of the terms of water supply and demand permits better adaptation of economic tools to the desired objective. It is easier to choose pricing structures where there is clear knowledge of volumes used, users' responses to prices and incomes, and whether other water resources exist which might enable users to evade the economic tools. The deployment and adaptation of economic measures therefore presupposes a system of follow-up and assessment based on audits and informed indicators of performance. Too often, countries lack such systems.

In conclusion – this round-up of economic tools has shown that they are increasingly used in the Mediterranean, especially in irrigation, though this is still at a low level. They may prove effective in improving water management but they cannot provide a single, bespoke solution to the extremely diverse situations which exist. Their proper functioning is conditional on many factors like setting a clear objective, a coherent framework, and combining with other tools such as regulation and raising awareness.

In particular, the price tool cannot alone persuade users to save water. Price sensitivity is generally slight and price cannot convey sufficient information in a one-off water shortage crisis.

Other measures used include:

- Incentive measures: campaigns to raise awareness of water saving, installation of individual meters, and subsidies for the deployment of equipment which use less water;
- Measures by authorities to control demand – use of restrictions to deal with one-off crises or structural shortage (e.g. the administrative quotas imposed in Israel to reduce demand for irrigation water). 'Taking turns' can be organised when the resource is extremely limited. Seasonal bans may be imposed on certain types of non-priority use such as car washing and filling swimming pools.

3.2.4 Coordination and planning tools

Coordination and planning tools enable all stakeholders to set and pursue shared objectives. These tools are genuine drivers of better WDM within and between the various sectors of water use. They need to be developed at various geographical levels: national, regional, and local.

At the local level, the appropriate institutional frameworks include devolved or decentralised management, for example around a catchment area; a sub-basin constituting a district 'on the ground'; or an aquifer. These arrangements favour subsidiarity:

- The catchment area is an appropriate boundary to set up 'water parliaments' with many stakeholders to monitor, arbitrate, and plan the state and use of the resource. Basin agencies can thus become preferred policy mediators in water management if their ability to listen and their awareness of social needs, their independence, their transparency, and their role as controlling authorities legitimise them in the eyes of users;
- The water table should become an essential, key indicator to prevent over-exploitation;
- To manage irrigation (and urban) water as a public asset, experience shows that collective discipline generally works more effectively when people are personally involved, hence the relevance of authorised syndicates (France), agricultural development groupings (Tunisia), and other associations of agricultural water users (Morocco). User associations are highly effective bodies which co-ordinate, define, and apply rules that support WDM;
- Finally, the town or urban district can be the key to urban WDM.

Many field studies show that it is beneficial to involve users in the management of common resources. Water policing is poor in most Mediterranean countries due to a lack of resources and persistent unlawful practices. So there is an incentive to return to more local self-

Box 12: The value of coordinating initiatives with users

In Morocco – Since the enactment of Morocco's Law on Agricultural Water User Associations (AUEAs) in 1990, more than 600 user associations have formed. They manage the irrigation systems in areas of low to medium water availability where active participatory management has been practised for centuries. In areas of plentiful water supply, AUEAs have also become special co-ordinating forums. They extend involvement in decision-making about irrigation system management (irrigation programmes, maintenance and upgrading of systems, advice on irrigation methods). This has positive effects both on adaptation to user needs and on WDM.

In France – The 1992 implementation of France's Water Law has led to a master plan (SDAGE) being devised for each catchment area for water development and management. The plan defines management and planning approaches for a 10 to 15-year period. In sub-catchments, there is a water development and management plan (WDMP) supported by local structures for managing use and conserving the resource. The WDMP for the River Drôme is linked with the River Contract. It has existed since 1992 and involves all water users. It has resulted in a broad provision to limit demand for agricultural water drawn from the basin by placing a stop on new irrigated areas. Water is discharged from the Rhône and a target flow rate is met. A network of real-time flow measurements was developed to provide information to the operators.

Source: Oubalkace and Faby et al. in UNEP/MAP/Plan Bleu (2007) inspection, which is often more effective, by means of co-ordinated management initiatives. Water table or river contracts, or even water development and management schemes based on the main watersheds are developing in the Mediterranean and illustrate the worthwhileness of these initiatives (Box 12).

However, local management capacity cannot improve without legal and financial reinforcement to establish legitimacy and decision-making power. This is coupled with an increase in the criminal and financial liability of directors and the transparency of their transactions. It also implies a clear separation of the functions of audit and management. The necessary reforms sometimes prove difficult to implement. Thus, in Algeria, the 1996 law instituting the Hydrographical Basin Agencies (ABHs) expressed the political will to change the management of water resources. To date, however, this has only partly been achieved. The ABHs experienced difficulties in establishing themselves as essential tools of integrated, decentralised, and co-ordinated management of water resources. The overlap of powers with the departments and agencies of central government, plus reduced financial resources, go some way to explaining this situation. The basin agencies lack strong political support which would enable them to assert their necessary and useful role.

The position is similar in the agricultural sector. The many associations of irrigators in the Mediterranean cannot genuinely improve water management without reforming their articles of association and methods of finance. In Tunisia, collective interest groupings currently manage nearly 70% of irrigated public land. They hold every power to implement and collectively manage the facilities for this land. Their articles of association enable them to recover costs from users to defray their running expenses.

New information and communication technology can also help to improve WDM at the level of a catchment or irrigated area. Its effectiveness depends largely on following the local, participatory processes necessary to devise innovative water management tools (Box 13).

Box 13: New information and communication technology for WDM

The software 'Ador' was developed to promote traceability and WDM in irrigated zones of the Ebro Valley in Spain. This led to improvements in irrigation water management, especially providing indicators which monitor water consumption (shown on farmers' water invoices). Water quotas were also set up in times of shortage. This avoids conflicts and guarantees fair access to water. The main reason for the tool's success is that it allows participation, via the agricultural users' association, the authorities, and private enterprises.

Source: Playan in UNEP/MAP/Plan Bleu (2007)

3.3 Economic evaluation of WDM measures

Economic evaluation suggests that WDM measures are cost-effective. They allow better allocation of scarce financial resources than, for example, dam building, water transfers, or desalination. This emerges from numerous studies conducted in the Mediterranean region (Fernandez et al., 2010, Rinaudo, 2008 and AFD, 2008) and more widely in regions facing problems of water shortage.

Plan Bleu studied the relevance of potential water savings based on an economic analysis of various water management alternatives. The study took account of the aims of the Mediterranean countries' environmental and social policies in the short and medium terms and sought to evaluate and compare the following in financial and economic terms:

- The costs of water saved via a WDM policy compared to newly provided water via a policy of increasing water supply; and
- The advantages of redistributing saved water compared to those of increasing water supply.

Cost-effectiveness ratios were compared for measures (i) to improve the efficiency of the pipe systems, distribution, and use of water; or (ii) to increase water supply. The comparison focused on domestic and agricultural use. Ten case studies were selected from Spain, France, Greece, Jordan, Morocco, and Tunisia.

To deal with the question of water efficiency and comparing WDM measures in different contexts, it is important to:

- Define or identify the right level of analysis (drinking water utility or irrigation system and use, administrative or catchment area or 'discharge basin'). The appropriate viewpoint must also be defined (that of the water utility operator,[13] of the user and of a local authority administering a larger area than that of the utility, or of a community of irrigating farmers sharing the same resource, etc.); and
- Find out the patterns of use and functions of water demand: withdrawal, use/consumption, 'dry' losses, management and durability of water services, water pollution caused by use, etc.

In Annex 2, the 'hydraulic' efficiency of the water utility, for domestic or agricultural purposes, can be subdivided into: (i) efficiency of water provision and distribution; and (ii) efficiency of water use by the user.

At system level, 'losses' during distribution of drinking or irrigation water are due:

- Either to physical and financial losses: leaks from the mains, i.e. water which enters the system (treated in the case of drinking water) but not used and therefore not billed;
- Or purely financial losses: volumes of water diverted ('clandestine users') or metering faults.[14]

The 'losses' from water distribution (leaks, metering errors or clandestine users) represent financial costs for the system operator. These costs derive from provision (and treatment as drinking water) of water which is then not sold. The main attraction to an operator is better control of production costs, which are determined by the cost of energy and capital, while taking account of distribution costs generated, which are essentially determined by the cost of labour.

For the operator, the benefit of reducing 'losses' and 'over-use' also depends on how the water saved is valued. If the size of the system remains the same, both system operators and users value saved water even more as demand increases. If demand is steady or falling, as in some northern Mediterranean countries, reducing 'losses' from mains or from end-users generates

[13] An initial approach makes no distinction between the operator and the authority responsible for the utility, even if their strategies differ.

[14] It is difficult to consider distributed volume, which is not invoiced for social and political reasons, as 'losses' because they result from deliberate policy choices.

significant extra costs for managing the water utility. On the other hand, this released water may benefit the environment or other downstream users.

At user level, the primary interest in reducing losses at the home or farmstead lies in reducing the water bill.

The findings of the cross-analysis of case studies suggest that WDM measures are worthwhile for the following reasons:

For drinking water

- When the initial yield of the system is low, the most effective solution is to reduce leaks in the distribution systems; and
- As demand on a system increases, installing equipment which uses less water is an effective solution for both user and operator.

For irrigation

Improving the existing distribution system proved just as cost-effective as changing from gravity-fed to a pressurised system. Moreover, the water volume saved by renovating/sealing leaks was significant and may account for 30% of withdrawals.

The effectiveness of measures to improve the hydraulic efficiency of the distribution system and the on-farm system depends mainly on the initial hydraulic efficiency and the irrigation methods. For example, the Ouest Hérault study found that unit cost may treble (from EUR 4000 to nearly EUR 12,000/ha) according to the type of irrigation system.

The case studies also illustrated a wide geographical variation in cost-effectiveness ratios, especially in cases of conversion to localised irrigation methods. The Syrian national programme for conversion to modern irrigation found that costs per hectare of conversion to sprinkling or enhanced gravity feed remain broadly the same from one project to the next. However, costs may double in cases of conversion to localised irrigation (Al-Azmeth 2008). In Morocco, cost per m^3 of water saved by converting plantations and market gardening to localised irrigation varied from one region to another as did the cost of developing new water resources (Fig. 11).

Box 14: Analysing cost-effectiveness of WDM measures and deployment of new water resources

In France, the aim was to develop an initiative looking ahead to 2015 and 2020 in order to economically analyse a programme of measures to manage water in western Hérault, an area fed by the Rivers Hérault and Orb and the Astien water table. The project was led by BRGM, Agence de l'Eau Rhône Méditerranée et Corse, the General Council of Hérault, and the Languedoc-Roussillon Regional Council.

A cost-effectiveness analysis considered various WDM measures as well as those aimed at developing new resources to meet the demand for drinking water. While not all water saving measures offered economic advantages (such as rainwater recovery), the four most cost-effective measures related to WDM. Implementing these measures would reduce withdrawals by more than 4 Mm^3 at peak times. This would correspond to more than half the planned increase of drinking water withdrawals. The first two measures (repair of leaks from mains and distribution of water saving devices to households) had

Continued on next page

Box 14: Analysing cost-effectiveness of WDM measures and deployment of new water resources ***Continued...***

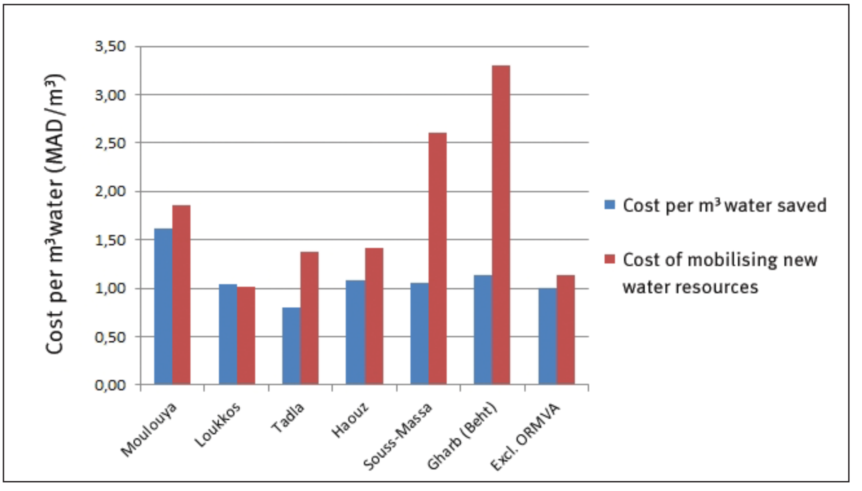
negative ratios because they dealt with population growth without the need for changing the size of the drinking water mains. They should therefore be implemented as a priority.

WDM measures or mobilisation of new resources	**Mean cost-effectiveness ratio (including indirect costs) (EUR/m^3)**
Distribution of water saving equipment to households	–1.58
Finding and repairing leaks from drinking water distribution mains	–0.03
Pricing drinking water according to peak periods	0.42
Water-saving equipment in two-star or lower hotels	0.42
Increasing support for cropping systems from the Salagou Dam	
■ Mobilisation of a volume of 3 Mm^3	0.43
■ Mobilisation of a volume of 15.5 Mm^3 for three months	0.56
Restoring the quality of alluvial groundwater (Libron catchment)	0.69
Water-saving equipment in hotels of three or more stars	0.82
Construction of a pumped supply of water from the Rhône	
■ Section 1 for drinking water supply (Bas-Languedoc)	1.14
■ Sections 1 + 2 for drinking and irrigation (River Devèze)	1.71
■ Sections 1 + 2 + 3 for drinking, irrigation and Canal du Midi	1.79
■ Sections 1 + 2 for drinking (Bas-Languedoc + Béziers region)	1.95
■ Sections 1 + 2 + 3 for drinking	2.02
Downstream desalination plant on the Hérault, capacity 30,000 m^3/d	1.55
Downstream desalination plant on the Orb, capacity 15,000 m^3/d	2.06
Reduction of leaks in residential area	6.62 to 6.70
Household recovery of rainwater (500 l drum/9 m^3 butt)	8.96 / 17.20
Water-saving measure	
Measure to mobilise new resources	

Source: Rinaudo (2008)

Agricultural water studies generally only consider financial costs and ignore external economic and financial factors. Most commonly, the only financial costs counted are those of investment: operating and maintenance costs are ignored. However, the different irrigation techniques also feature different operating and maintenance costs. These costs influence the attractiveness of a technical solution. For example, in the Guadalquivir basin, irrigators with pressurised water systems spend an average of 10% of their income on water costs compared to irrigators with gravity-fed systems who only spend around 4%. None of the evaluations took account of positive external effects such as aquifer replenishment as a benefit from irrigation system and on-farm water 'losses' from irrigation systems.

Fig. 11. Comparing costs per m³ of water saved by converting to localised irrigation with mobilising new resources in Morocco



Source: Belghiti (2008)

WDM measures may be in the irrigator's economic interest because they secure water inputs, reduce pumping costs, and even increase volumes available to agriculture. Farmers do not usually release the water they save for other uses or for the environment. The reallocation of water to other uses requires the provision of contractual incentives or enforcement in order to ensure flexibility of water rights. The results of a case study in the Amman-Zarqua basin (Jordan) suggested that strengthening the water policy may prove cost-effective. Contractual solutions would also be worth evaluating. For irrigators, WDM is also an opportunity to engage with a culture of innovation and to rethink their irrigation.

For multiple use

Findings from the studies in which water is used for multiple purposes suggest that:

- Solutions which seek more flexible use of impounded water may prove effective;
- Solutions which seek to limit diffuse pollution are effective;
- Solutions which increase supply by transfers or seawater desalination, are the least effective.

Overall project analysis

As well as evaluating individual measures, the studies also estimated the cost-effectiveness ratios of various combinations of measures, based on a target volume of available water. This water may be intended either to relieve pressures on the environment or to meet new human demands.

According to the case studies, reducing losses from mains and installing water-saving equipment are not only the most cost-effective measures, they may also contribute significantly to meeting future demand for drinking water (Box 14).

Project feasibility studies must also take several factors into account:

- Wide variability in space and time of the effectiveness of certain measures including seasonal fluctuation in supply and demand with peak periods;

- Only measures with a negative ratio are likely to be implemented spontaneously because they represent a net gain to the beneficiary. On the other hand, measures with low but positive ratios generally require collective finance from public or international agencies especially those relating to indivisible investments with high, fixed costs.

3.4 WDM in practice

Examples of WDM in practice come from national or local sector strategies, multi-sector geographical approaches, or economic strategies of trade stakeholders (as in the tourism sector). They combine different WDM tools (cf. Chapters 3.2 and 3.3) and illustrate the possibility of successful combinations of efficiency gains with the objective of resource 'sustainability'.

3.4.1 National irrigation water saving strategies

In Tunisia

Tunisia embarked on a national water saving strategy launched by the Ministry of Agriculture in 1993. This sought to mitigate the physical scarcity of the country's water resources, by giving incentives to rationalise the use of agricultural water and maximise economic profit. The underlying principles of this strategy included:

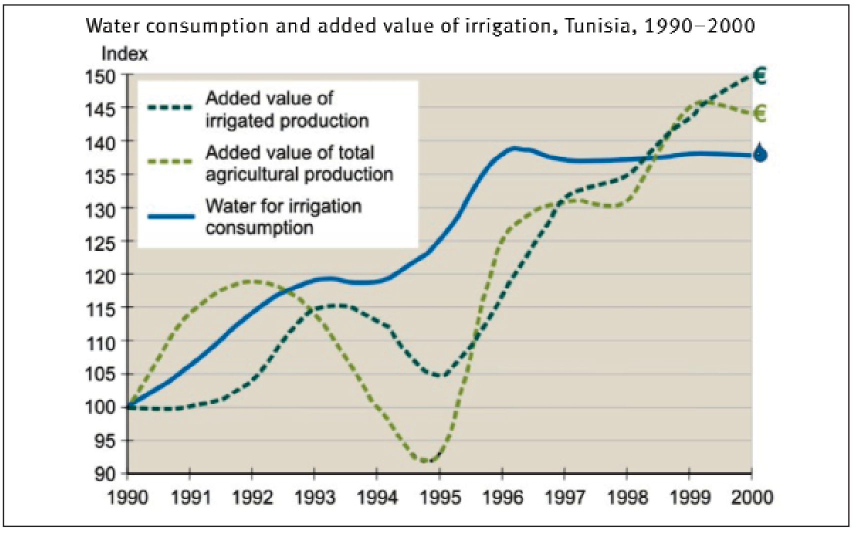
- Switching from isolated technical measures to an integrated approach;
- Progressive reforms and adaptation to local contexts;
- Decentralisation and local management of water by promoting an approach in which irrigator organisations participate and take responsibility;[15]
- Promoting water-saving equipment and technology by granting subsidies for modern irrigation systems;[16]
- Supporting farmers' incomes to provide security for investment and farm working; and
- A pricing system which combines transparency and flexibility in line with national food security objectives (cf. Box 9).

The measures taken continued the traditional 'oasis' culture of managing water sparingly, as an asset and successfully decoupled agricultural progress from the volume of water provided. Demand for irrigation water stabilised from 1996, whereas the value-added to production continued to rise (Fig. 12). Thus the demand for irrigation water fell by 23% between 1990 and 2003 while the value-added from irrigated production rose by 29% over the same period. The policy not only benefited agricultural output, but secured water needs (peak seasonal needs) for the tourist industry, a source of foreign currency and, for the towns, a source of social peace. They also progressively recouped water costs.

15 The number of agricultural development groupings for irrigation rose from 178 in 1990 to 1200 in 2007. By the latter date, the development groupings were managing 68% of public land irrigated. The groupings are self-managing, and hold full powers to provide and collectively manage their facilities.

16 Subsidies of 40, 50 and 60% for large, medium-sized and small farms, respectively. This had increased the percentage provision of modern irrigation systems from 20% of total irrigated area in 1990 to 80% in 2007. Equipment for irrigation by sprinkling and localised irrigation (trickling) served 68% of the irrigated area. The resultant improvement in irrigation efficiency is estimated at 20%. The reduction in water input to crops ranges from 9% for silviculture to over 30% for market gardening.

Fig. 12. Trend in water consumption and irrigation value-added in Tunisia, 1990–2000



Source: Hamdane (2002)

In some places, the positive balance in terms of agricultural water saving may be offset by an increase in the areas of land under irrigation. This becomes possible through the water savings achieved by improving water efficiency (as in irrigation zones with surface wells). Thus over-exploitation of the resource has not been reduced as much as originally hoped. Nevertheless, the over-exploitation of water has reduced and agricultural production has increased using the same quantity of water.

In Morocco: the Green Morocco Plan

Morocco adopted a new agricultural strategy, the "Green Morocco" Plan, in 2008. The Plan reaffirms the strategic importance of agriculture in the country's economic and social development. By 2008, the post-independence target of "one million hectares irrigated" had been met. The new Plan set a target of "one million farms," reflecting an important change in direction in national policy. The objective of the Plan is to develop plural agriculture: open to foreign markets, geographically diversified and sustainable. The Plan seeks to exploit the country's entire agricultural potential and break away from the simple, dualistic image of a modern, high-performance agricultural sector oriented towards the market, and a marginalised 'traditional' sector (food crop production).

The Plan is based on two complementary pillars and on cross-cutting initiatives and reforms aimed at removing the barriers of water and land-owning. Pillar I aims to develop agriculture with high added value, able to exist by the rules of the market. A new wave of private investment will be admitted, giving a share to small farms brought together by 'aggregation' schemes in certain areas. Pillar II is dedicated to the joint development of smallholdings in the most difficult areas (mountains, oases, plains and semi-arid plateaus). These represent the vast majority of the country's farms including the poorest. This pillar aims to achieve a substantial improvement, over 10 years, in the incomes of the most marginal farms. The aim is a combination of economic development, emergence from poverty, food security, and stability. But this will be achieved with sustainable management of the environment and natural resources which underlie the production system.

The National Programme for Saving Water in Irrigation (PNEEI) was adopted in 2007. It seeks to convert nearly 550,000 ha to localised irrigation in 15 years (Box 15). This is one of the structural cross-cutting initiatives of the Green Morocco Plan, to tackle dwindling water resources and encourage the modernisation of high value-added, irrigated agriculture. The Green Morocco Plan also follows the principle of private-public partnership (PPP) for the management of irrigation areas. This is a strategic lever to promote sustainable irrigation systems and improve performance (efficiency of systems and improvement of the water utility).

Box 15: A national programme for saving irrigation water in Morocco

In 2007, the Moroccan authorities adopted a voluntary water-saving programme (PNEEI). The aim was to convert nearly 550,000 ha to localised irrigation in 15 years. The programme's total cost was estimated at nearly MAD 37 billion (MAD 30 billion for physical investment and MAD 7 billion for institutional measures, strengthening capacity etc.) The programme's internal ROI was estimated at over 22%.
The main effects expected from PNEEI include:

- Water savings ranging from 20 to 50%, by reducing avoidable technical losses in getting the water to the farm. This will reduce the shortfalls recorded in areas supplied by the major built infrastructure known as the Grande Hydraulique. It will also save nearly 500 Mm^3/year in private irrigation zones, thereby relieving the pressure on over-exploited water tables;
- A 10 to 100% increase in water productivity, depending on crops and farms;
- An increase of over 100% in water exploitation;
- A significant increase in farmers' incomes;
- Greater national agricultural output and adjustment of the commercial food balance;
- Job creation upstream and downstream from farming.

Source: Belghiti (2008)

3.4.2 WDM in Rabat-Casablanca (Morocco)

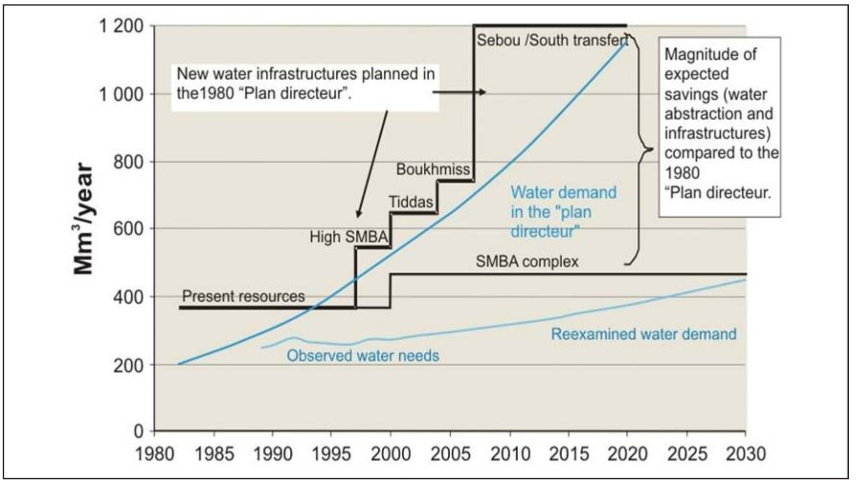
There was a marked slowdown in growth in demand for water in the Rabat-Casablanca conurbation in the 1990s despite rapid urban development. This was made possible through upgrading the mains and sealing leaks. Progressive pricing was introduced, placing the onus of responsibility on consumers (including public users but with social clauses on poverty). The water supply was systematically monitored, while users were urged to save water. These steps were facilitated by a suitable institutional framework which brought private partners together with central and local authorities in 'delegated management of the water utility' based on an inter-municipal charter.

This range of measures postponed the costly investments in the dams and transfer canals originally envisaged in the 1980 Master Plan. Such investment is so difficult to finance without further indebtedness and could prove redundant in the long term.

3.4.3 WDM in the tourism industry

The extra demand for water from tourism, over and above the needs of the settled populations of the host regions, is relatively slight over the whole year. It accounts 20% of total domestic

Fig. 13. WDM and infrastructure saved in Rabat-Casablanca



New water infrastructure envisaged in the 1980 Master Plan High-level SMBA	Southward transfer from Sebou Water demand as per Master Plan SMBA complex	Scale of savings hoped for in relation to the 1980 Master Plan (water off-take and infrastructure)
Current resources Noted water needs		Revised water needs

Source: DGH Rabat (2002)

water demand in Cyprus, 5% in Tunisia, and 5% in Malta. But there are more serious seasonal peaks in some places when population can double and in some destinations record show a five-fold increase). Tourists' daily water demand generally far exceeds that of permanent residents (500–800 l/d in luxury hotels). Tourism also stimulates service and leisure activities which use a lot of water. Golf courses consume as much water as well irrigated crops (10,000 m^3/ha/year).

Tourism-induced demand for water is problematic as it coincides with demand for irrigation water at a time when resources are at their lowest. Tourism also increases the pressure on coastal areas where infrastructure must be sufficient to cope with additional demand for both water supply and sewage treatment. Local or regional authorities have to pay for this and are only partly compensated by specific, progressive pricing. The growing tendency is to meet demand for drinking water from non-conventional sources such as desalination. This is the case in the Balearics, Cyprus, Malta, Tunisia, and on some Greek islands.

In Tunisia

Tourism is a strategic sector in Tunisia. Though it accounts for less than 1% of total national water demand, it contributes some 7% to GDP (in 2010).

Following an inter-ministerial council held in 2001, a strategic study on reducing water use in tourism was commissioned from Agence Foncière Touristique. Its purpose was to propose ways of reducing water use from 570 l/bed-night (2005) to 300 l/bed-night. Tests based on recorded water use in nearly 70 hotel units nationwide highlighted the main deficiencies in water use. In 2005, over half the water was consumed in irrigating green spaces, leaks from mains and filling swimming pools. Technical, organisational, and regulatory solutions were proposed for the short, medium and long term (Table 6). A precondition was effective enforcement of the Decree of 2002 on auditing water systems on premises of major users.

Table 6. WDM measures proposed for the tourism sector Tunisia (2005 study)

Timescale	Short term (2010)	Medium term (2015)	Long term (after 2015)
Water-saving solutions	Water system audit Training and awareness Water consumption monitoring Installation of water-saving equipment Leak detection Water system upgrading Subcontracting of laundry Swimming pool water recycling Trickle watering, etc.	Computer-aided maintenance management Subcontracting of vegetable washing Grey-water recovery and recycling Continued awareness-raising Creation of a water saving label Reinforcement of legal framework System for controlling water consumption, etc.	Use of unconventional resources (desalination, reuse of treated wastewater)
Expected results of water saving	346 l/bed-night (–39% on 2005)	201 l/bed-night (buying from SONEDE) (–25% on 2010) Actual consumption including recycled: 336 l/bed-night Water saved: 48m^3/bed/year	
Cost per m^3 water recovered		TND 0.736 to TND 5.353	

Source: Lahache Gafrej in UNEP/MAP/Plan Bleu (2007)

Actions taken by Accor hotel chain

Some operators have resolved to set up strategies for sustainable development of the tourism industry. One is the Accor hotel chain, which has decided to distribute the Hotels Environment Charter, a pillar of its Earth Guest Programme (Accor, 2005). The Charter pursues a constructive alternative to the exploitation of resources such as water and energy. It tries to demonstrate to hotel clients that other consumption patterns are possible. Accor has over 120 million customers per year worldwide. This modification of practices and raising the awareness of clients can have a positive impact on disseminating WDM principles. Early results of this policy, recorded in 2005, were convincing. Water consumption per guest room had fallen nearly 20% in two years. This was set to fall further 5% between 2005 and 2007.

The Accor Hotels Environment Charter comprises 10 types of water management action. It also contains a series of initiatives to improve the treatment, collection, and possible recycling of used

Table 7. Accor Hotels Environment Charter: action on water management

Action	Tools and resources deployed	Validation
Set consumption control targets and follow them up		
Fit flow regulators to taps and showers	Fit new equipment, more economical with water	Taps/showers fitted with 6 and 12 l/min regulators
Install lean-flush toilets		Cistern volumes < 7 l
Phase out refrigeration systems which discharge water		Replace all refrigeration systems which discharge water
Develop lean-wash laundries	Improve practices (laundry sorting, cycle selection, run fully loaded, etc.)	Water consumption reduced to less than 6 l/kg of laundry
Wash towels and sheets less often	Communicate with clients, train chambermaids	Good customer communications, effective reuse of sheets and towels
Use rainwater	Collect and treat	System set up for treating and using rainwater
Treat used water		Individual processing units set up; checked for working order. If municipal systems are used: obtain documentary evidence from local authority of processing of used water
Recycle grey-water		System set up for recycling grey-water for use in toilets and gardens

Source: Faby et al. in UNEP/MAP/Plan Bleu (2007) water (Table 7). The document reflects the chain's desire to set up systems which reduce drinking water use for unnecessary purposes (toilet flushing and green spaces), and use alternative resources (rainwater and recycled water). This initiative is in line with WDM. It not only casts the hotel chain's image in a positive light, but may also enable it to make significant savings.

3.4.4 WDM and sustainability – Upper Guadiana basin (Spain)

The efficiency gain achievable through WDM does not necessarily guarantee the 'sustainability' of the resource or of precious aquatic environments. It is therefore important to combine efficiency gains with due allowance for environmental sustainability at 'critical sites'. Where applicable, a combination of measures may be justified to achieve this objective, applied both on the supply side (developing new resources by transfers from better-endowed basins) and on the demand side. The latter entails monitoring the parties' fulfilment of the undertakings they have made, especially farmers and their trade associations. This is in line with the framework agreement recently signed for the Souss Massa water table in Morocco. The example examined in more detail below is the Upper Guadiana basin in Spain. It confirms the key importance of agriculture and the possible strategic role of agri-environmental aid. Agriculture often poses a problem but also offers the primary means to achieve a solution.

The groundwater of the Upper Guadiana basin (the western La Mancha aquifer) has traditionally been used for agriculture. In the 1980s, the irrigated area quadrupled. Annual water withdrawals for irrigation reached nearly 600 Mm^3 by the late 1980s. This exceeded the capacity for renewal and resulted in a fall of more than 20 metres in the water table. This damaged several wetland areas, including the Tablas de Daimiel, classed as a national park in 1973 and registered under the Ramsar Convention on Wetlands of National Importance since 1982. Hence the flooded area receded by 6000 ha to less than 1000 ha over 20 years.

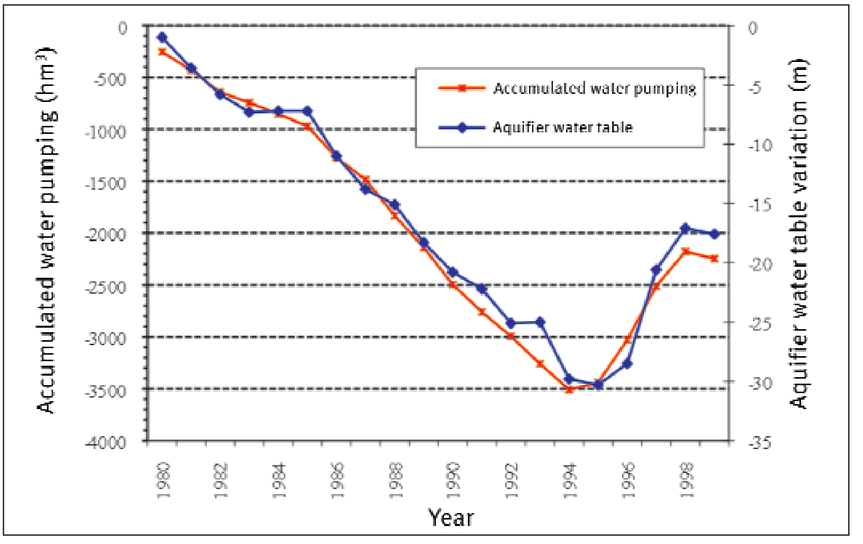
To counter this trend various measures were taken including:

- Drawing up a plan to replenish the water resources of the Daimiel water table (1984). Structural measures included reducing losses from pipes, artificially refilling the aquifer, and transferring water from the Tagus-Segura (since 1987);
- Classifying the West La Mancha and Campos de Montiel aquifers as over-exploited. This enabled the Basin Authority to draw up rules limiting water withdrawals which came into force in 1991;
- Setting up an agricultural compensation plan (1992). This was a package of economic measures (subsidies awarded by the Autonomous Community of Castilla-La Mancha and the Ministry of Agriculture) to give farmers an incentive to develop practices compatible with wetland conservation, e.g. saving irrigation water and introducing crops which consumed less water.

The Guadiana Hydrographical Confederation adopted these initiatives with the involvement of local irrigators' associations.

Since the mid-1990s, the wetlands have markedly improved and they are almost restored to their original surface area. This improvement was partly due to abundant rainfall between 1995 and 2000. Water consumption per irrigated hectare also fell by nearly 20% from 1980 to 1996. While cumulative withdrawals from the West La Mancha aquifer rose to 3500 Mm^3 between 1980 and 1995, 1500 Mm^3 was recovered between 1996 and 1999. The water table rose 10 metres during the same period (Fig. 14).

Fig. 14. Trend in cumulative withdrawals and water table in West La Mancha, 1980–2000



Source: Menéndez Prieto, CEDEX (2002)

The National Hydrological Plan for the Guadiana basin was approved in 1998. Taking account of the complex situation of the upper basin, various regulations were applied including:

- Placing aquifers linked to natural zones of ecological interest under special protection;
- Laying out protected boundaries for aquifers, wetlands, and other areas of ecological or landscape interest;
- Restricting or cancelling licences for water use in protected areas; and
- Penalties for encroaching on protected areas and policing groundwater.

3.5 Lessons, conditions, and drivers

A number of lessons were learned from the Mediterranean experience of managing water shortages and WDM, especially on the conditions and drivers for implementing WDM.

One of the main barriers to progress was a lack of understanding of the importance of the issues at stake and of the potential benefits. Too often, decision-makers rely on technology to increase supply. But they underestimate the impact of this approach on discharges, energy consumption, and the increased vulnerability to risks and they underplay the credibility of alternative options.

Systematic evaluations, such as cost/benefit or cost/effectiveness studies, comparing a number of options, are seldom carried out. By estimating the scope for feasible savings based on accurate diagnostics, and costing in the environmental impacts of the options as far as possible, these methods should increase decision-makers' awareness of the opportunities and feasibility of WDM. If conducted before investments are made, such evaluations would enable comparisons to be made with increasing supply using WDM or optimising allocations within and between sectors. In many cases WDM can be shown to be a much better option than increasing supply (cf. Chapter 3.3).

But the demand for water across all sectors must be known before the management of the water can be improved. Analysis is essential to establish where priority potential for efficiency improvements exists, or which potential is most 'profitable' to exploit. The main scope for water saving most often exists in agriculture.

Apart from the need for awareness, WDM also involves a radical change in practices, in culture, and in people's minds. This may even call methods of production and consumption into question. The aim is to take technology approaches, which emphasise the infrastructure of supply, and successfully combine them with 'societal' approaches. The latter seeks to involve all players in the action, to make the most of every cubic metre of water, and manage water collectively, sustainably, and responsibly on the right geographical scale. More generally, it involves putting people at the centre of change and involving them in the actions. This means farmers in particular, who are not only consumers of water but also 'citizens' and communities responsible for managing water as an asset.

The Mediterranean experience also shows that progress in efficiency generally necessitates the incorporation of WDM objectives into sector and local policies (agriculture, energy, industry, tourism, and towns). Given that water policies are still supply-dominated, it is primarily the dedication of ministries of agriculture, the town authorities, and of the drinking water utilities which has enabled several countries to embark on the necessary changes in water policy.

WDM should not be compartmentalised within sector policies, rather it should include an objective of efficiency between sectors. In each relevant area, it should take account of the objectives of social fairness and environmental sustainability. To overcome this difficulty and promote 'full-speed' WDM for inter-sector efficiency, some Mediterranean countries are setting up steering, liaison or arbitration authorities to facilitate diagnostics and co-ordination. At national level, these may be inter-ministerial committees on water (Algeria) or national water councils (Morocco and Tunisia). Though their role is more consultative, they raise stakeholder awareness and formulate proposals for change in the legal and regulatory framework. At local level, basin agencies and user associations may act as liaison bodies, drawing up and implementing effective measures to promote WDM.

Opposition from various stakeholders may also slow the implementation of WDM measures. Examples include officers of water authorities who have traditionally supported the construction of major public works, water utilities primarily seeking to balance their operating income, or even users seeking to minimise the immediate cost of their water supplies. But the main cause of opposition is usually ignorance of the issues and the potential for progress. It is often the case that measures which can improve the efficiency of water use also enable stakeholders to modernise their techniques and increase their income. This was observed in Tunisia in both the farming and industrial sectors.

Informing and explaining about WDM to all stakeholders is vital. Training for professionals, engineers, and technicians and the various users of water in the methods and issues of WDM can encourage the emergence of strategies which are more effective, integrated, and save more water. Innovative approaches in some Mediterranean countries have helped to develop WDM in practice (Box 16).

WDM thus consists of a combination of tools and aims. The benefits can be considerable, especially in irrigation. But to achieve them progressive approaches suited to each local situation are needed. Users must become more involved and decision-makers more aware of what is at stake. A 'cultural' change is needed. To pursue WDM and encourage it to spread across the Mediterranean countries and to other world regions requires backing at the highest level of government in order to provide a coherent strategic framework such as the national plan to improve water efficiency implemented in Israel, or the national irrigation water saving strategy in Tunisia. Such a framework is essential for co-ordinated action and persistent, long-term commitment and follow-up.

Box 16: Raising awareness and training for WDM in Cyprus and Israel

In Cyprus, public awareness campaigns are conducted by advertising, press articles, brochure handouts and posters. Weekly radio and television broadcasts by the Ministry of Agriculture address farmers and announcements about water saving have had positive results. Courses arranged by the Agriculture Department on irrigation control and planning have led to better WDM.

In Israel, the Israel Water Authority launched a national multimedia awareness campaign to inform citizens of the need to reduce their water consumption and the benefits this would have in the context of the country's water shortage. Various media were used – television, radio, newspapers and the Internet – reaching most of the population. By the end of 2009, a 10% drop in water consumption was recorded, amounting to over 75 Mm^3).

Sources: Iacovides in UNEP/MAP/Plan Bleu (2007), Rejwan (2011)

Box 17: Drivers and conditions for implementing WDM

- There needs to be strong political drive and support at the highest level of government. This provides the essential strategic framework for co-ordinated action and lasting and monitored commitment;
- Assess present and future demand for water in all sectors to identify which areas of water saving have the highest priority or are most 'profitable' to pursue;
- Conduct forecasting exercises on the relevant geographical scale, especially to analyse the relationships between water and agriculture;
- Implement WDM in geographical areas to aid understanding of the factors determining and limiting water use, hydro-social cycles, social constraints, and alternative opportunities for a given geographical area;
- Promote and embed WDM in the policies for different water using sectors such as agriculture, energy, industry, commerce, and tourism;
- Promote a cross-cutting vision and use instruments to align environmental, water, and sector policies at national and local levels;
- Use the right WDM toolkit for each situation; assign special importance to training and raising the awareness of water professionals and users to aid understanding of WDM and the potential benefits;
- Make more use of cost/benefit or cost/effectiveness analyses to compare measures aimed at increasing water supply and WDM measures and include the costs of social and environmental impacts of the various options as much as is possible;
- Draw up action plans for deploying new resources which combine technology approaches and supply infrastructure with 'societal' approaches.

4 Prospects for water-related public policies

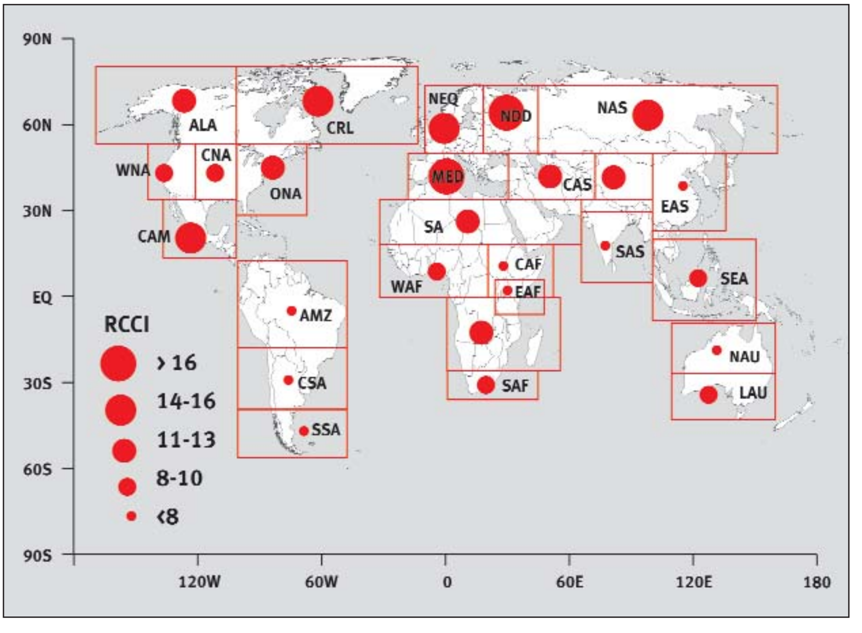
4.1 The impacts of climate change

4.1.1 The Mediterranean – a climate change hot spot

The Mediterranean region already suffers serious water stress and so climate change and a growing population will only add to the pressures on the quality and quantity of water resources.

The fourth report of the Intergovernmental Panel on Climate Change (IPCC) is unequivocal: during the 21st century the Mediterranean Basin will be one of the regions most severely affected by climate change (Fig. 15). By 2100, the region's climate is likely to see a 2–4°C rise in mean temperature, a decline in rainfall of 4–30% (Fig. 16), and sea level rises of 20–60 cm (IPCC, 2007; Plan Bleu, 2008).

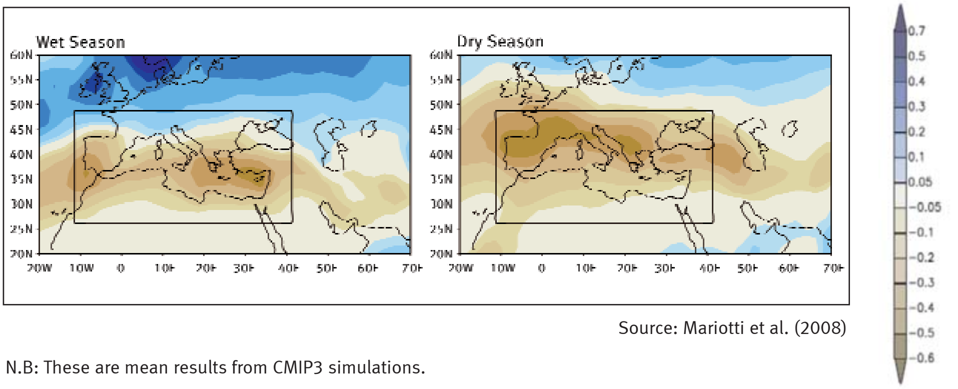
Fig. 15. Regional Climate Change Index, looking ahead to 2080–2099



Source: Giorgi (2006)

N.B: The Regional Climate Change Index (RCCI) was estimated for 26 regions of the world and calculated for 20 global models and 3 emission scenarios (A1B, A2 and B1). RCCI is estimated from the mean trend in rainfall and temperature, inter-annual temperature variability, and the relation between regional and global temperature trends, for the dry and wet seasons. The Mediterranean region and north-eastern Europe are the areas of the globe with the highest RCCI (greater than 16).

Fig. 16. Rainfall trends in the Mediterranean region (mm/d), 1950–2000 and 2070–2099



Source: Mariotti et al. (2008)

N.B: These are mean results from CMIP3 simulations.

Some local hydrological models predict significant decline in stream-flows (cf. Dankers and Feyen, 2008). Serious flow reductions are expected in the Rhône, Po, Ebro, and Upper Jordan watersheds. A warmer climate is also likely to affect water quality since higher water temperatures will impact on the self-purification capacity of water courses. Low stream-flows will result in higher concentrations of pollutants. Surface and groundwater will become more saline. If rain-fed crops are directly affected by the decline in rainfall, irrigated areas will also suffer from reduced stream flows.

The general consensus of climate change studies in the Mediterranean region is that rainfall will become more variable in place and time. This will multiply and intensify extreme events (e.g. flooding, heat-waves, and droughts) which in turn increase the risks of economic and human losses.

The parallel increase in evapotranspiration, coupled with changed rainfall and temperature patterns, is likely to increase agricultural water needs just to maintain the same output. Projections based on case studies in the Maghreb and Egypt suggest that market gardening output will vary between –30% and +5% by 2050. Increases in water demand for spring crops are projected to increase by 2–4% for maize and 6–10% for potatoes. In Morocco, the use of CropWat model (FAO, 1992) for winter cereal crops suggests yield losses of 10% in normal years and 50% in dry years by 2020. It also indicated that national cereal output could fall by 30%. Factors also likely to reduce summer crop productivity are the increased frequency of extreme events at certain key stages of crop development.

Water shortage and drought will particularly affect the SEMCs which will need more water in the next few years for people and for agriculture. Climate change will make it more essential to balance and distribute water resources among the different uses.

4.1.2 Adapting water and sector policies

Such changes are therefore likely to have serious consequences in environmental, economic, and geopolitical terms, especially in the SEMCs. Water problems therefore place a question mark over the appropriateness of current development routes and policies.

History shows that the Mediterranean countries have centuries of tradition in managing the unexpected and dealing with water shortages. There is constant concern to optimise resource use and adapt activities to climate constraints. Nevertheless, the region now faces issues on a scale which calls for an urgent review of water policies and strategies to mitigate the risks and improve resilience in order to reduce vulnerability in the short, medium, and long term. Adapting to the potential impacts of climate change on water resources implies adjustments of policies, institutions, techniques, and behaviour. A broad range of measures are needed which relate to infrastructure, such as new construction works, wastewater reuse, and maintenance of urban water mains. There must also be policies and regulations for town and country planning, tax and economic policies to better manage demand, and systems of insuring against natural risks. All these must be deployed at different levels – local, national, and regional. WDM offers key measures for adapting to climate change (Table 8).

Simonet (Plan Bleu, 2011) analysed how far seven Mediterranean countries – Albania, Egypt, Spain, France, Morocco, Tunisia, and Turkey – have responded to the need for adaptation in the

Table 8. Typology of adaptation strategies in the water sector

Type of strategy	Sample measures (including WDM)
Accept the risks and losses (do nothing)	■ Some coastal aquifers, wetlands or areas of rain-fed agriculture disappear; ■ Minor areas of flooding or erosion near rivers.
Spread risks and losses	■ Set up systems of insurance and mutualisation of the financial risks of weather and water risks; ■ Diversify sources of drinking water supply.
Anticipate and forestall the effects: technology and infrastructure (hard)	■ Increase impoundment capacity; ■ Increase transfers between basins; ■ Implement programmes to make usage more efficient*; ■ Develop systems for reusing wastewater and desalination systems; ■ Improve the efficiency of irrigation, drinking water supply and sewage systems*; ■ Modify the size of infrastructure and built works (raise the heights of dams and dykes, modify river transport infrastructure etc.); ■ Build flood-resistant buildings.
Anticipate and forestall the effects: political, regulatory and institutional responses (soft)	■ Drought management plans; ■ Programme financial incentives to save irrigation water*; ■ Modify standard sizes and operating rules for built works; ■ Rationing*; ■ Standards*; ■ Adopt new methods of decision-making, incorporating management of uncertainties.
Change/reorganise uses and activities	■ Reallocate the resource towards uses which add more value*; ■ Introduce drought-resistant/less thirsty crops*; ■ Shift businesses and dwellings away from areas prone to flooding; ■ Improve watch and alert systems.

Continued on next page

Table 8. Typology of adaptation strategies in the water sector ***Continued...***

Type of strategy	Sample measures (including WDM)
Research and exploitation of climate information	■ Improve capacities for seasonal, annual and ten-yearly modelling and weather forecasting; ■ Develop aids to decision-making and improve risk assessment methods at basin and sub-basin level (couple climate and hydro models); ■ Define suitable indicators of vulnerability and adaptation; ■ Set up early warning systems; ■ Facilitate production and provision of climate data to decision-makers, technical departments and the general public.
Boost capacity and educate	■ Expand decision-makers' planning horizons; ■ Boost the technical capacity of industry professionals to manage major risks; ■ Public awareness and education.

* Recent changes/innovations (initiated in the past few years).
Source: Simonet (2011), amending Burton (1996) and the European Environment Agency (2007)

water sector. He found that although climate change is an emerging issue in water management, little has been done in operational practice despite some advances, mainly in the EU Member States. The countries studied are presently improving their knowledge of hydrological impacts and identifying the appropriate adaptive measures plus some pilot projects and experiments, mostly backed by international co-operation. But apart from these actions most countries have yet to take account of the impacts of climate change in their water management policies.

The types of response proposed are basically 'no-regret' measures. Examples include the introduction of crops that consume less water; reducing leaks from drinking water supply systems, etc. Other responses are based on the logic of 'catching up.' These aim to reduce existing water-related pressures and vulnerabilities which are already considered problematic, regardless of the effects of climate change. Decision-makers still pay scant attention to dealing with climatic uncertainties and their implications for water management. This situation poses risks of 'maladjustment,' as the region is very prone to the effects of climate change on water runoff, resources, and demands.

Table 9 presents the main barriers and drivers to developing policies to adapt to climate change in the Mediterranean water sector. The following needs are emphasised:

- To prioritise no-regret measures in the short term, which make the water sector less vulnerable to the present pressures; to quantify the costs of 'maladjustment' in the medium to long term; to improve decision-making in the face of uncertainty; and
- To promote political, regulatory, and institutional responses by comparing their effectiveness with infrastructure measures in an uncertain future.

Regional and international co-operation has a decisive role to play in the development of strategies to adapt to climate change. Notably this can pool knowledge, expertise, and strategic reflections. Cooperation can accelerate technology transfer to the most vulnerable countries. It can also deploy the necessary finance for present and future changes in the water sector.

Table 9. Barriers and drivers for adapting policy to climate change

Barriers	Drivers
Too often, risks associated with climate change are seen only as long-term problems in relation to food and energy security issues, and economic development. These factors broadly determine current water strategies.	Better presentation and quantification of relations between climate and development issues in countries.
Lack of co-operation between sectors on adjustment; balance of power often tips in favour of the government department responsible for water (instead of the environment department, which is most often involved in UNFCCC negotiations).	Development of inter-sector co-ordination tools which can act as catalysts and promote adaptation in the various sectors.
Limited involvement at local level for water stakeholders; resource management and administrative framework are still highly centralised in many Mediterranean countries.	Development of area-based water conservancy based on local institutions with enhanced powers. Full user participation. Aim: to devise and try out more subsidiary approaches to management.
Financial, technical and human capacities not commensurate with the issues at stake; finance for adaptation competes with other short and medium-term issues.	Work harder to co-operate on upgrading the sector to meet the additional costs of adaptation.
Current water policies and management fail to include uncertainties about the geographical extent and timing of climate and hydrological changes.	Promote means and tools to take the right decisions in uncertain situations (switch from a determinist to a probabilistic approach; follow flexible management principles; combine rules of prevention and precaution in public decision-making, etc.).
General trusting attitude that existing institutional and technical tools are strong and effective to face future changes. Risk of medium to long-term 'maladjustment' (e.g. building dams to meet three or five-yearly inter-annual regulation targets)	In the short term: prioritise no-regret measures which try to make the water sector less prone to the range of current pressures. In the medium and long terms: quantify the costs of 'maladjustment' and improve decision-making in the face of uncertainty.
Priority is given to hard solutions at the expense of soft ones (e.g. legal and economic tools), ignoring the role of 'natural infrastructure' which ecosystems can play, and the services which they provide.	Promote soft responses by comparing their effectiveness with structural solutions, in the face of an uncertain future.

Source: Simonet (2011)

4.2 Addressing ecosystem water demands

The environment needs water. This demand is difficult to quantify, but countries have already legislated to enforce minimum stream-flows in watercourses for sustaining wetlands, eco-systems, and wildlife habitats[17] (Box 20). Spain has introduced an explicit water requirement for the environment; Cyprus, Israel, Morocco, and Tunisia may follow suit. The European Water Framework Directive tries to generalise and homogenise the way in which countries' deal with the environmental demand for water. The aim is to define 'hydrological regimes' with which to comply. Commonly, however, this demand for the environment is omitted from the water balance sheets. It tends to be treated as a limit on the exploitation of resources. However, maintaining minimum stream-flows also meets requirements to manage pollution by enhancing the self-purifying or dilution capacity of aquatic systems.

The policies implemented, or initiatives launched, in some Mediterranean countries (Boxes 18 and 19) have nevertheless taught a number of lessons about drivers and conditions which favour water policies that consider ecosystem water requirements[18]:

- Integrated, participatory management of water resources at catchment or sub-catchment level is necessary to meet the needs of water ecosystems. It is vital not only to consider water as a 'resource' but also to appreciate its importance to the functioning of complex ecosystems. The requisite quantity and quality of water is required to maintain their functions and the services they provide to society. Their natural dynamics must be borne in mind;
- Likewise, it is vital to encourage participation by local stakeholders in water resource management from the earliest stages of the planning process. The goal must be to establish the ecosystem water demand and include it in the planning;
- A variety of methods and tools can aid understanding of how ecosystems work. Examples include pressure analysis (developed in the EU's WFD); functional analysis; risk analysis (e.g. to climate change); eco-hydrological approaches and impact studies; remote detection to monitor plant evolution in response to fluctuating water levels; and economic tools;
- Scientific knowledge must also be embedded in clear management targets included in the planning documents and adopted by policy-makers;
- The economic evaluation of ecosystem services (e.g. wetlands) can be very useful in prioritising the provision of ecosystem water requirements;
- Local solutions based on local knowledge are necessary for sustainable integrated management and the protection of water systems;
- Regional and international co-operation can improve knowledge of how ecosystems work and favour the adoption of management approaches and tools which take account of ecosystem water needs. The practical approaches devised to implement the WFD in the EU Member States may provide inspiration for neighbouring countries.

Finally, it is for society to choose how the water demands of ecosystem services are met. It is a question of balancing between uses and cost.

[17] Thus, in France, the 1983 Fisheries Law introduced the concept of 'reserved stream-flow' (one-tenth of the inter-annual module). This exists downstream from built structures in response to fish breeding and fish farming requirements.

[18] The Zaragoza regional workshop on WDM (2007) discussed these lessons.

Box 18: Managing low water levels in the Adour-Garonne basin, France

Fragile water resources are a feature of some French catchment areas in dry years, while demand for water for irrigation remains strong. Hence water shortages recur.

In the Adour-Garonne basin, this situation has led to plans being made to manage low water levels. These apply to shortage areas as a priority. The management of water in the basin is largely organised in the context of these plans. The aim is to restore flows to rivers when water levels are low, so that they can meet domestic needs while maintaining a working aquatic environment. These flows are called "target low-level flows" and there are related to crisis flow rates.

The Low Water-Level Management Plans are contractual documents, drawn up in liaison with all the partners in a catchment area. They contain a set of rules on the management and sharing of resources. They prescribe specific action and stakeholder commitment. Joint fulfilment of these obligations is designed to achieve the aims of restoring the balance. The proposed types of action relate to the control and management of withdrawals, water saving, and optimisation of existing built structures (especially seeking agreements on the release of stored water from EDF reserves). Where applicable, new reserves are formed.

The Low Water-Level Management Plans exemplify the integration of different environmental laws with a view to a global policy of better WDM.

Source: www.eau-adour-garonne.fr

Box 19: Towards long-term management of the Ichkeul lake-lagoon system, Tunisia

Like most lagoons around the Mediterranean Basin, the lake-lagoon system of Ichkeul comes under socio-economic pressure. This environment is undergoing radical transformation mainly caused by dam construction in the upper catchment area (at Joumine-Ghézala and Sejnane). The dams will divert a large volume of water which would naturally flow towards Ichkeul. This loss of input will upset the hydrological balance of the lake/marsh system. The risks are of increasing water salinity and dwindling plant life which feeds the population of water birds.

Numerous measures were adopted to overcome this conflict between the environment and development and promote the conservation of Ichkeul:

- Construction and commissioning of the lock on the Wadi Tinja to control freshwater input and improve the management of exchanges of water with Lake Bizerte;
- Updating the Water Master Plan for the north and far north of the country to integrate the Ichkeul National Park as a consumer of water in its own right. Since 2003, 100 Mm^3 provided from the nearby barrages (Sidi El Barrak and Sejnane) has met the demand of the Ichkeul environment for water; and
- Construction of treatment plants for urban wastewater at Mateur and Menzel Bourguiba to improve the quality of Ichkeul's water supply.

Source: Hamdane in UNEP/MAP/Plan Bleu (2007)

4.3 A role for non-conventional water sources

The first response to increasing pressure on water resources is to set up WDM policies capable of reducing losses and wastage. However, an increase in supply may also be necessary in some countries and this must be organised either by better management of the available resource or by obtaining water from non-conventional sources.

Some Mediterranean countries are now developing non-conventional sources such as reuse of purified wastewater, recycling process water, reuse of domestic grey-water, and agricultural drainage flows. Some are also developing desalination of sea and brackish water.

How far this non-conventional production of freshwater progresses will depend on the related cost, trends, and especially energy needs. Another factor is technical feasibility, compared with withdrawal from existing natural resources. One limiting factor may be the impact on health and the environment and there is also the important question of public acceptance.

4.3.1 Reusing treated wastewater

The reuse of treated wastewater (RTW) offers many quantitative, qualitative, and economic benefits:

- It can substitute for withdrawals from the natural resource especially for agricultural purposes. This demand for water is dominant in arid and semi-arid regions;
- RTW also forms part of more global policies of sanitation and management of water pollution. Thus it contributes to the quality of the available water from the sanitary and environmental viewpoint, both for users and for the target environment;
- Finally, it is becoming the economic solution of choice in response to chronic or occasional shortages. This takes account of investment, operating and maintenance costs. It is usually a cheaper than desalination.[19] It also helps to reinforce the strategies for adapting agricultural and other policies to climate change.

In the Mediterranean, wastewater reuse is used mainly for irrigation. In 2000 it accounted for around 1.1 km^3 of water across the Mediterranean Basin as a whole.[20] Projects have been launched in various countries to exploit treated wastewater, directly or indirectly[21] (Box 20). In Israel, the use of treated wastewater has increased substantially over the past decade (Box 22).

Institutional and organisational constraints often delay the effective implementation of RTW projects. Cultural reluctance is another factor. Across the Mediterranean Basin, the development of re-use could also remain limited for technical and economic reasons because sewer outfall sites are often far from the places of potential reuse. Storage before reuse and reliable pre-treatment are also necessary to avoid health hazards to humans and animals and

19 The reuse of purified wastewater is a solution which costs less in energy (~1 kWh/m^3) than desalination of brackish water (~1.5 kWh/m^3) or seawater (~4 kWh/m^3).

20 In terms of all Mediterranean watersheds of the Mediterranean rim countries.

21 Direct methods of exploitation include agricultural and forestry irrigation, watering urban green spaces and golf courses, cleaning urban areas and markets, or re-cyling grey-water from a block of flats to flush toilets. This category also includes industrial uses (process and cooling water, washing, recycling etc.). The uses known as indirect are, especially, replenishment of groundwater for possible onward use in irrigation and boosting low water levels of rivers or wetlands.

Box 20: Reusing treated wastewater in the Mediterranean

In Italy water purified at Milan's new San Rocco purification plant using ultra-violet treatment is being used for irrigation. The project has reduced the amount of untreated effluent flowing into the natural environment, it keeps farms in production, and it is producing satisfactory sanitary conditions – which did not exist prior to the project. All costs are covered by the sewage charge collected from the people of Milan. The project retains the complex hydraulic organisation which has existed since the Roman era.

In Israel Shafdan purification station in Tel-Aviv provides tertiary treatment for sewage effluent which is then used to replenish the groundwater table via seven infiltration basins. Water from the aquifer is then pumped southward about 100 km and impounded in high-capacity reservoirs for irrigation of more than 4000 private farms. Most are engaged in market gardening for export. The project is justified by the scarcity of water in the region. It is also a technological benchmark in terms of aquifer replenishment. It forms part of a national policy on production of non-conventional water sources (RTW and desalination – Box 24). As such, the sector is generously subsidised (land, first start-up costs, costs of investment in storage and transfer from the centre to the south of the country).

In Tunisia treated effluent is used to water golf courses in Hammamet. Two private golf courses use the town's treated wastewater after tertiary treatment in aerated lagoons. This avoids pumping groundwater from an over-exploited aquifer. Moreover, the reuse of treated wastewater avoids the discharge of water from the purification station into the sea near tourist beaches. This PPP has created 170 jobs and helps to make Hammamet attractive as a tourist destination. Some investment and operating costs are met by the authorities who consider that this public investment contributes to tourism.

Source: AFD (2011)

soil contamination. The annual potential reuse of effluent across the Mediterranean Basin is estimated to be 6 km^3 by 2025. That would be nearly 3% of total water demand compared to 1% in 2000 (Plan Bleu, 2005). Worldwide, less than 4% of effluent is reused. In theory this represents a large unexploited source of water (AFD, 2011).

In conclusion, the main issues associated with RTW development are:

- Urban and rural sewage and the treatment of effluent must be considered national and regional priorities. They are necessary to preserve the quality of water sources and are a precondition of any reuse of wastewater. The technical choices of treatment are defined according to the intended uses of such water – direct outfall to rivers to maintain water levels; irrigating green spaces, cereal crops, tree plantations; cooling water for industry; and aquifer replenishment;
- The development of RTW depends on the degree of pressure on resources, cost, especially energy, compared with primary sources, and on the political management of the health hazards. A major issue in the development of RTW in some Mediterranean countries, and elsewhere, is the assessment of its technical and economic feasibility.

4.3.2 Desalination

Desalination is developing fast in the Mediterranean. First developments were on isolated islands (the Balearics, Cyprus, the Cyclades, Dalmatia, Malta and others), and on coastlines

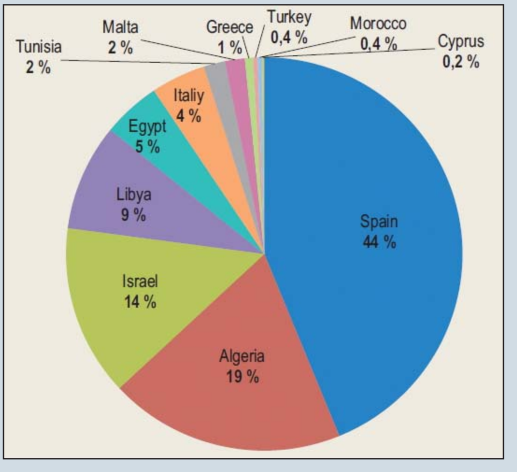
(Libya). The main aim is to meet the needs of the tourist sector characterised by high seasonal peaks. Another is to serve desert areas (Algeria). Today desalination is expanding all-round the Mediterranean. In 2010, production from the region's desalination plants amounted to 10 Mm^3/d. Worldwide production is over 55 Mm^3/d. The market for desalinated seawater should continue to grow strongly in the coming years. By 2030, the Mediterranean could triple or even quadruple its output from desalination, to 30–40 Mm^3/d.

Spain, Algeria, Israel, and Libya all have major installed desalination capacity on the shores of the Mediterranean Sea (Box 21). Freshwater from desalinating seawater accounts for 60% of Malta's drinking water supply and in Cyprus, desalination for domestic use helps to cope with repeated droughts and helps to minimise drinking water rationing.

Box 21: Examples of desalination in the Mediterranean

In Spain, with nearly 1500 working desalination plants and over 2.5 Mm^3/d of installed capacity, ranks fourth worldwide. A special feature is the generous allocation of desalinated water to the agricultural sector, for market gardening production in greenhouses to meet out of season produce for export.

Fig. 17. Desalination capacity in the Mediterranean in 2008 (10 Mm^3/d)



Source: Boyé, Plan Bleu (2008)

In Algeria energy is cheap and is used to run desalination plants which supply water to the big urban centres like Algiers, Oran, and Skikda. Between 2006 and 2009 three units were commissioned Arzew, Algiers, and Skikda. Their total capacity is 400,000 m^3/d. Algeria aims to have a total capacity of 2.5 Mm^3/d by commissioning 12 new plants in 2012.

In Israel, since 2006 the Ashkelon plant has produced 320,000 m^3/d to meet the drinking water needs of over 1.4 million people. The three utilities engaged in desalination in the country are committed to increase their drinking water production by 25% at Ashkelon, Palmachim, and Hadera plants. The country plans to increase production of desalinated water from 720 Mm^3/year in 2020 and 1550 Mm^3/year in 2050. This should meet at least 70% of domestic drinking water requirements by 2020 and 100% by 2050 (Box 24).

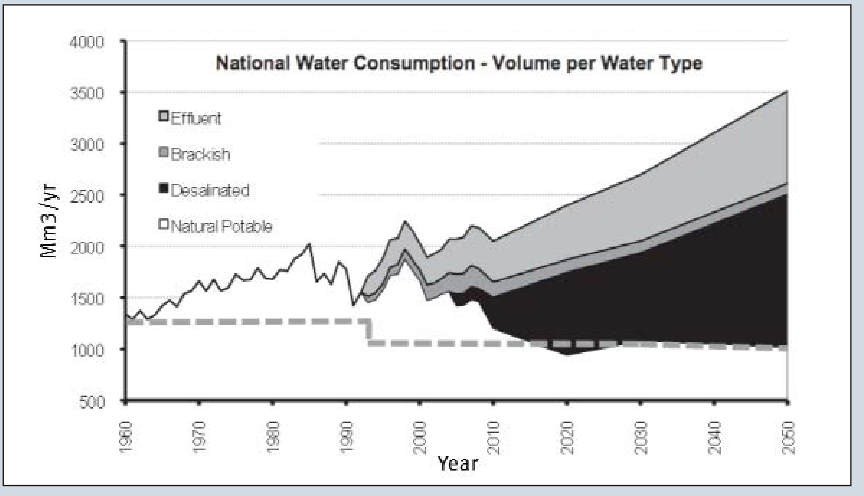
In Libya, the promising potential of 2000 km of coastline opens the way to the development of alternative solutions. The Libyan strategic plan for promoting water resources is strongly biased in favour of seawater desalination. The aim is to equip the country with total desalination capacity of 900,000 m^3/d in the near future.

Source: Boyé (2008); Blinda (2010); Israel Water Authority (2010)

Box 22: Israel's national policy on desalination

Over the past decade, Israel has developed both re-use of treated effluent for irrigation and desalination of seawater for the drinking water supply.

Fig. 18. Water consumption figures in Israel (historic, present, and projected)



Source: Israel Water Authority (2010)

NB: Volumes of water consumed (recorded up to 2010 and forecast for the period 2010–2050) (in Mm^3 per type of water: effluent, brackish, desalinated and natural potable from the coastal aquifer, the mountain aquifer and the basin of the Sea of Galilee. The dashed line represents the mean volume of water allowing renewal of natural reserves over three periods: 1960–1993 (1249 Mm^3), 1993–2015 (1155 Mm^3), and tailing off during the period 2015–2050 (down to 1020 Mm^3).

Israel's Master Plan for the water sector has set ambitious targets to pursue the development of non-conventional water resources for the period 2010–2050, and to withdrawals from natural water resources:

- By 2015, increase the use of alternative water resources (effluent, brackish, and desalinated) to meet over half the country's water needs;
- Raise desalinated water's contribution to the national drinking water supply from 20% (307 Mm^3) in 2010 to 46% (809 Mm^3) in 2020;
- By 2050, double the quantity of irrigation water produced from treated effluent;
- Reduce dependence on natural freshwater resources for irrigation.

Source: Israel Water Authority (2011))

But desalination is still an expensive option. Large-scale desalination remains an option which consumes large amounts of energy and generates greenhouse gas (GHG) emissions, especially when electricity used in desalination comes from fossil fuels. It is expensive. The cost of water produced by desalinating seawater would be of the order of EUR 0.4 to 0.6/m^3 (and EUR 0.2 to

0.3/m^3 to desalinate brackish water). These figures refer to large plants. The cost is roughly twice that of 'conventional water' and one and a half times that of treated effluent. This does not include the high initial investment. These costs are higher for small or old plants which perform less well. Of course, the costs are very sensitive to the cost of energy, which varies according to availability on the market.

Desalination can also impact the local environment. This is common where infrastructure is located on the coast,[22] but there are added problems of concentrated discharges of brine which are hot when distillation is used. Releases of highly concentrated brine into the natural environment (into the sea or injected into the ground), and insufficient dilution, may actually impoverish or destroy aquatic ecosystems. They may also degrade water quality. To limit this environmental impact, the solution adopted today is to set up diffuser systems, which control dilution of the brine with sea water and limit the size of the affected area. A balance sheet and monitoring of waste brine and chemicals used to clean the membranes must also be backed by fauna and flora monitoring on land and in the sea.

Minimising energy consumption and GHG emissions. Low CO_2 emission options are still possible with reverse osmosis plants which, combined with energy recovery systems and higher performing membranes, only need 3 to 4 kWh of electricity per m^3 of water produced.

The use of renewables for desalination (wind, photovoltaic, solar and concentrated solar thermal) is a way forward for the future, especially for the Mediterranean countries, which have strong potential for solar and wind energy. However, development remains conditional on finance and competition. Renewables can be used to supply small desalination plants at isolated sites or can be linked to conventional high-yield desalination processes, such as multiple-effect distillation with solar panels and reverse osmosis with photovoltaic batteries or wind turbines. Worldwide, about 100 desalination plants, coupled to renewable energy sources, have been built in the past 20 years, several in the Mediterranean (Algeria, Egypt, Spain, Tunisia). These low-capacity solar and wind-powered desalination plants are well designed and operated and supply sites cut off from quality water. The costs are immediately attractive.

Recourse to nuclear power is a possible medium-term option (horizon 2020). It is planned in large plants. Obstacles are the high initial investment cost and the technical and political considerations, which are still widely under discussion.

Desalination therefore appears to be an option to adapt to climate change, but it must not replace other 'sustainable' possibilities, such as rational use of water. It should also primarily produce drinking water for human consumption.

5 Summarising the Mediterranean WDM experience

5.1 Main lessons

The decision-makers and economic stakeholders are often subject to daily constraints and short-term logic. Water management, by contrast, thinks in the medium to long term. This

[22] For example: traces of heavy metal leaked from facilities, noise emissions from high-pressure pumps, and some energy recovery systems, such as turbines.

means predictive approaches play an important role. The scenarios produced by Plan Bleu since the 1980s have made it possible to quantify the imbalances between water supply and demand. They have drawn attention to the risks of shortages in the Mediterranean. Finally, by proposing ways and means of water saving, they have helped some Mediterranean countries to progress in their visions and encouraged them to follow a WDM approach.

Rather than increase available water supplies, WDM aims to promote better use of existing water supplies as an effective means of balance the equation of supply and demand. Indeed, this is an appropriate response to the situation of growing water shortages and to the vagaries and uncertainties of climate change. The Mediterranean experience has highlighted a number of lessons.

WDM consists of a combination of tools and objectives. Economic tools can be very helpful in allocating water resources in and between sectors. They also contribute to improving access to water and respond to environmental concerns. As it proves impossible to maximise all these functions at once the form of these tools is a compromise. They must prompt changes in behaviour and contribute to the essential financing of water management. Such tools make it possible to set shared objectives which all stakeholders adopt. They also genuinely promote better WDM at several levels and among different users.

Economic appraisals also suggest that WDM measures can offer cost-effective solutions. WDM can enable a better allocation of scarce funds than, say, dam building, water transfers, or desalination, in regions facing water shortage problems. An economic assessment of ecosystem services (e.g. wetlands) can also be very useful in ensuring recognition of the priority water needs of ecosystems. This underlines the value of developing the use of cost/benefit or cost/effectiveness analyses, comparing a number of water management options, such as measures seeking to increase water supply versus WDM. The analyses should take account, as far as possible, of the cost of social and environmental impacts of the various options. These tools are genuine aids to decision-making.

WDM needs progressive approaches adapted to local situations. It is almost a change of 'culture.' But to pursue and implement WDM requires support at the highest level of government in order to provide a coherent strategic framework, which is essential to co-ordinate the action, to make a steady commitment, and to pursue it in the long term.

5.2 Moving to efficiency between sectors

WDM has mainly focused on improving physical efficiency within different water uses and given the importance of agriculture the region, this has received special attention. But the idea of rational water use should not apply only to irrigated agriculture. It is worth extending to rain-fed agriculture in general, which takes the main share of natural water resources.

WDM is also about the (re-)distribution of water between uses in order to manage the stresses on the resource. Improvement of technical efficiency alone cannot guarantee genuine, significant water savings, still less an easing of stresses on the resource.

The promoters of WDM in the Mediterranean were aware of these issues from the 1990s. However, in order to respond to them, it is necessary to have an effective grip on sector policies, which broadly influence the trends and patterns of water use. WDM started with technical issues within each water use. This enabled the concept to filter into water management policies and practices and to become a key issue within them. Today, to make WDM fully effective in the management of water stresses, it is crucial to go beyond the immediate world of water and to promote tools which can influence sector policies while stimulating countries' economic and social development. The challenge is to move from technical to economic and social efficiency and from efficiency within sectors to efficiency between them. That will entail promoting a cross-cutting vision and recourse to tools which ensure cohesion between water policies and sectors, such as environmental and town and country planning policies, at both national and local levels.

5.3 Reminder – water is increasingly a global issue

It is not easy to get an over-view of water as a global issue, because its impacts and management are local. However, the factors determining how water is used are looking increasingly globalised. International trade in agricultural commodities has given rise to major virtual flows of water.[23] These are contained in the produce which various countries import and export and may have a broad bearing on local water management (cf. Annex 3). So no country can respond in isolation to water problems. These problems require consideration of the features and conditions of the international market, the interdependence of different issues such as water, energy, food security, and climate change. Together these issues imply a rethink of the approaches to international co-operation.

5.4 WDM at the service of other regions

Other regions of the world may be interested in these reflections and experiences from the Mediterranean on WDM and the process of regional co-operation on the environment and development. There are several reasons for this:

- The expected impacts of climate change will exacerbate the problems of water shortage and drought in many regions;
- Over-exploitation of groundwater is becoming a major world problem;
- There is a realisation of the need for greener growth in the interest reducing losses and wastage before deploying new resources; and
- The food crises, which are increasingly structural and internationalised, require better management of all our resources and ecosystems.

Despite the divisions and endemic conflicts, the Mediterranean has proved capable of developing regional perspectives and creating processes of co-operation, especially on environmental and sustainable development. The Strategy for Water in the Mediterranean, being drafted under the auspices of the Union for the Mediterranean, represents the latest advance. WDM is a cornerstone of this strategy.

[23] Virtual water, contained in imported or exported goods, corresponds primarily to the quantity of water consumed when those goods are produced. Trade in agricultural produce accounts for nearly 90% of virtual water traded worldwide, in this case through evapotranspiration from crops.

The Mediterranean offers other regions of the world a model of regional co-operation processes to encourage 'systemic, forward-looking' reflection and prompting the countries concerned to look ahead, to set themselves new horizons and new deliverables, to increase their self-knowledge and enrich each other through their respective experiences of water management.

Annexes

Annex 1: Five trend scenarios from Plan Bleu

The economic driver of trend scenarios is the expansion of an international market which is impacted by the economic and technological dominance of the USA and Japan. The USA's dynamism gives it a lasting lead over Europe in leading-edge technologies. In this context, Europe does not succeed in asserting itself as far as it would like, whether from the political, economic or cultural viewpoint. The same is true for the Mediterranean: individually, the northern and southern countries are more or less used to this US/Far Eastern preponderance.

T1: reference trend scenario: continuation of present trends.

T2: aggravated trend scenario: weak international economic growth, due especially to a lack of policy co-ordination (financial and macro-economic) by the dominant partners in the world economy.

T3: moderate trend scenario: better economic policy co-ordination between the European Community, the United States, and Japan, allowing relatively sustained economic growth.

As regards the environment, the three trend scenarios serve to adjust government efforts according to economic potential, which is greater in the moderate scenario (T3) than in the aggravated scenario (T2).

The alternative scenarios – The main feature of the two alternative scenarios is that the Mediterranean countries carry greater weight. This is possible through the formation of a worldwide multi-centre structure, in which western Europe, the United States, Japan, and one or two other groups of countries assert their interests. In particular, there is a stronger European political presence, though this plays a different role in the two scenarios. The two alternatives basically differ in the relations to be formed between the Mediterranean Basin countries, namely:

- **Alternative reference scenario A1** – is a pan-Mediterranean view of relations between the region's countries. The Member States of the European Community and the other Mediterranean countries, whether strongly industrialised or undergoing industrialisation, pull together to build a harmonious development area. They agree to maximise openness to trade and migration. Most Mediterranean trade runs north–south, as the European Community serves to some extent as a powerhouse;
- **Alternative scenario with aggregation A2** – is a more 'regional' view of these relations. Economic co-operation tends mainly to involve groups of countries, e.g. those of the extended European Community, the Maghreb, and the Arab Middle East. There is maximum openness to trade and migration within these groups, but some barriers remain. Some countries wish partly to shield themselves from international influences. In this scenario, the European Community plays a less marked role. The Mediterranean rim countries, which do not belong to the European Community, manage to form relatively integrated sub-sets.

Continued on next page

Annex 1: Five trend scenarios from Plan Bleu *Continued...*

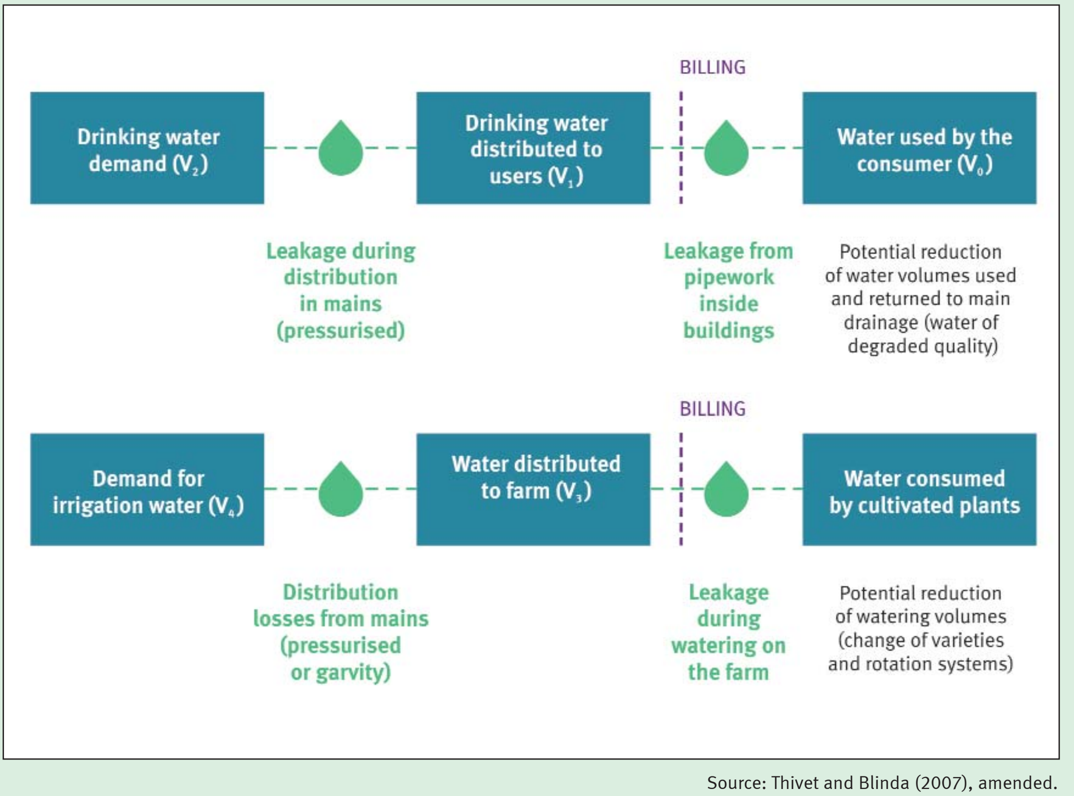
In the alternative scenarios, decision-making and development plans take better account of the environment and town and country planning. For example, they prioritise less polluting manufacturing processes, biological processes, lean methods of irrigation and 'systemic' rather than purely mechanical solutions.

Source: "Futures for the Mediterranean Basin" (Plan Bleu, 1989)

Annex 2: The Water Efficiency Index

The "hydraulic efficiency" of the water utility for domestic or farming purposes can be subdivided into: (i) efficiency of water mobilisation and distribution and (ii) efficiency of water use (Fig. 19).

Fig. 19. Efficiency of water distribution and use for domestic and agricultural consumers (blue water)



Source: Thivet and Blinda (2007), amended.

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Annex 2: The Water Efficiency Index *Continued...*

Efficient use of domestic water

The potential efficiency of drinking water distribution, as defined by Plan Bleu and used for follow-up by the MSSD, represents the portion of drinking water produced and distributed which is actually paid for by the user.

Turton and Ohlsson (1999) identify two types of water shortage: 'physical' and 'social'. A physical shortage is a lack of water resource whereas a 'social' water shortage reveals a lack of capacity to adapt and to mitigate situations of shortage. The authors proposed an index to measure countries' capacity to tackle water shortages that links the Human Development Index (HDI) based on three aspects – level of education, life expectancy, and gross national product) – with the water stress index devised by Falkenmark (1989). In this context, the HDI is used as an indirect measure of the socio-economic possibilities of adapting to eventual limits in water availability. These possibilities take the form of capacity for redistribution of jobs between sectors and redistribution of water (financial, institutional, and professional capacities measured in terms of GDP, level of education and life expectancy).

In the search for indicators the approaches which have emerged have been associated with different understandings of the 'problem' of the relations between water resources and food. The geographical and other limits of the 'problem,' the management system, and the different regulatory positions all influence the proposed solutions. An indicator helps to change the terms of the debate on strategies and policies. As it does so, the contributors to the debate borrow from it, reinterpret it and may modify it. Thus these indicators have been associated with more or less 'globalising' or 'localising' interpretations of the problem, which elicit very different proposals for action.

These different understandings confer a role of varying importance on governments, on inter-state relations and on local institutions. They will also promote the idea of a water war or, conversely, an idea that crises and shortages can generate mechanisms for co-operation. Some of these understandings are dubbed Neo-Malthusian. They offer an analysis based on models of imbalance between exponential population growth and linear growth in food production. Garrett Hardin's notion of 'carrying capacity' took up these models and associated them with an understanding that the causes of the problem were to be sought in a lack of market regulation and state structure. Sometimes these understandings rely on Falkenmark's index.

Other understandings have been based on a very different problem framing. These seek the causes rather in financial and institutional capacities for managing water shortage. Research prompted by the work of E. Ostrom (1990, 1992) has especially developed this viewpoint, in reaction to the work of Garrett Hardin (1968). This research has studied systems in which natural resources management is based on common property regimes, and the capacity of institutions to manage conflicts and deal with change. This literature can be linked to indicators such as Turton and Ohlsson's or the 'water poverty' indicator of the Centre for Ecology & Hydrology in Wallingford (Sullivan, 2002; Lawrence et al., 2002).

Source: Fernandez (2007 and 2008)

List of acronyms

ABH	Algerian River Basin Agencies
AEM	Agro-environmental measures
BRGM	Office of Geological and Mining Resources (France)
CAP	Common Agricultural Policy (EU)
CEDEX	Centre for Studies and Experimentation of Public Works (Spain)
CFR	Crisis flow rate
CIHEAM	International Centre for Advanced Mediterranean Studies
CMIP3	Phase 3 of the Coupled Model Intercomparison Project
EDF	Electricité de France (France's main generator and supplier of electricity)
EU	European Union
EUR	Euro
GHG	Greenhouse gas
GWP	Global Water Partnership
MAD	Moroccan dirham
MAP	Mediterranean Action Plan
MCSD	Mediterranean Commission on Sustainable Development
Med EUWI	Mediterranean Component of the European Union Water Initiative
MSSD	Mediterranean Strategy for Sustainable Development
NGO	Non-governmental organisation
ONEP	Office National Eau Potable (National drinking water office, Morocco)
PNEEI	Programme national d'économie d'eau en irrigation (Morocco)
RCCI	Regional Climate Change Index
RTW	Reuse of treated wastewater
SDAGE	Master Plan for Water Development and Management
SEAAL	Société des Eaux et de l'Assainissement d'Alger (Water and Sanitation, Algeria)
SEMC	Southern and Eastern Mediterranean Countries
SMBA	Sidi Mohamed Ben Abdellah (dam, Morocco)
SONEDE	Société Nationale d'Exploitation et de Distribution des Eaux (Morocco)
SWM	(Draft) Strategy for Water in the Mediterranean of the Union for the Mediterranean
TND	Tunisian dirham
UNFCCC	United Nations Framework Convention on Climate Change
WDMP	Water development and management plan
WDM	Water demand management
WFD	European Union Water Framework Directive

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