



MedWet

Conservation of Mediterranean Wetlands

Wetlands and Water resources

F. Pearce



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MedWet



The MedWet action

The Mediterranean basin is rich in wetlands of great ecological, social and economic value. Yet these important natural assets have been considerably degraded or destroyed, mainly during the 20th Century. To stop and reverse this loss, and to ensure the wise use of wetlands throughout the Mediterranean, a concerted long-term collaborative action has been initiated under the name of MedWet.

A three year preparatory project was launched in late 1992 by the European Commission, the Ramsar Convention on Wetlands of International Importance, the governments of Spain, France, Greece, Italy and Portugal, the World Wide Fund for Nature, Wetlands International and the Station Biologique de la Tour du Valat.

This project focuses on that part of the Mediterranean included within the European Union, with pilot activities in other countries such as Morocco and Tunisia. Two thirds of the funds are provided by the European Union under the ACNAT programme and the remainder by the other partners.

The concept of MedWet and its importance for the wise use of Mediterranean wetlands was unanimously endorsed by the Kushiro Conference of the Contracting Parties to the Ramsar Convention in June 1993.

The MedWet publication series

Wetlands are complex ecosystems which increasingly require to be managed in order to maintain their wide range of functions and values. The central aim of the MedWet publication series is to improve the understanding of Mediterranean wetlands and to make sound scientific and technical information available to those involved in their management.



Fred Pearce, 1996

Wetlands and water resources

Conservation of Mediterranean Wetlands - number 5

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1. Characteristics of Mediterranean wetlands
2. Functions and Values of Mediterranean wetlands
3. Aquaculture in Lagoon and Marine Environments
4. Management of nest sites for Colonial Waterbirds
5. Wetlands and Water resources

Conservation of Mediterranean Wetlands

MedWet



Wetlands and Water resources

F. Pearce

Number 5

Series editors : J. Skinner and A. J. Crivelli



Preface

The presence or absence of water, its profusion or rarity, has for centuries structured the diversity of the Mediterranean region, and the civilisations that have blossomed there. Water conditions our social and cultural associations and our economic development.

All the expert hydrologists, economists and demographers agree that the already considerable pressure on water resources will continue to grow in the coming decades.

Overusing this precious resource is to threaten its very perennity. Beyond its role as a primary resource for consumption, there is another role as a support to rich and unique ecosystems whose place in our development is poorly understood.

This is the challenge for the future – to implement an integrated management policy which reconciles economic uses with the conservation of wetland ecosystems. These two, often contradictory uses for water are often a subject for arbitration for the allocation of the resource, and wetlands usually come off worst. This ignores the hidden role played by the natural environment in sustainable development.

This publication brings a wider perspective to the challenges of integrated water resource use. It is the fruit of a collaboration between the Blue Plan Regional Activity Centre of the Mediterranean Action Plan and the MedWet programme for coordinated actions on Mediterranean wetlands, and is addressed to both water resource planners and to those involved in wetland conservation.

Our ambition is to provide the information and analyses needed to support policies and actions which will guarantee the transmission of this natural heritage to future generations.

Lucien Chabason
Coordinator of the Mediterranean Action Plan
United Nations Environment Programme



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Introduction

For generations of engineers, water pouring into a wetland or the sea was a wasted resource. Any flow not diverted into pipes and irrigation channels, or forced through the turbines of a hydroelectric dam was “running to waste”.

Today, virtually all the water in some countries is diverted for human use. Yet there is also growing concern about the damage to the ecological functions of water within rivers and wetlands. And also about the risks to future water resources being created by current overuse.

This crisis is seen at its most intense in the Mediterranean region. Here water is permanently or temporarily in short supply and arrives irregularly; water demand is soaring and peaks in the dry summer season; and surviving wet areas are a key feature of the natural landscape. Wetlands – such as marshes, river deltas and coastal lagoons – in particular harbour many of the region's species of plants and animals, and nurture many of the region's fisheries.

The purpose of this booklet is to explore the growing demand for water in the Mediterranean and the increasing pressures on the natural hydrological environment. It looks, for instance, at how natural ecosystems preserve the hydrology of river systems, storing and recycling fresh water. It asks how far our expectations for both ample water supply and environmental protection can be reconciled; how far maximising use of scarce water can be consistent with maintaining prime wetlands; and, where the two are incompatible, how to arbitrate between conflicting objectives.

It concludes that water can only be managed effectively if all the uses of water within river basins, for natural ecosystems and human use, both above and below ground, are considered as a coherent whole.

Complex methods have been developed for distributing a precious resource. At Timimoun in Algeria blocking individual outlets allows water to be sent to irrigate the different fields according to a strict allotment system.



Unequal distribution of water

The Mediterranean climate, with its hot dry summers and cool wet winters, is many people's idea of a perfect climate. But its provision of water is decidedly inconvenient. The rain falls most when it is needed least, and least when it is needed most.

The classic definition of a Mediterranean climate is one in which winter rainfall is more than three times summer rainfall¹. This is the situation throughout the geographical Mediterranean region, except north of 45 degrees latitude, where rainfall is more evenly distributed.

The seasonal contrast is most pronounced in the south and east of the region, where most of the annual rainfall may fall in a few days of torrential downpours. In parts of Tunisia, as much as 60 per cent often falls on a single day².

1 - Wigley, T.M.L. (1992)

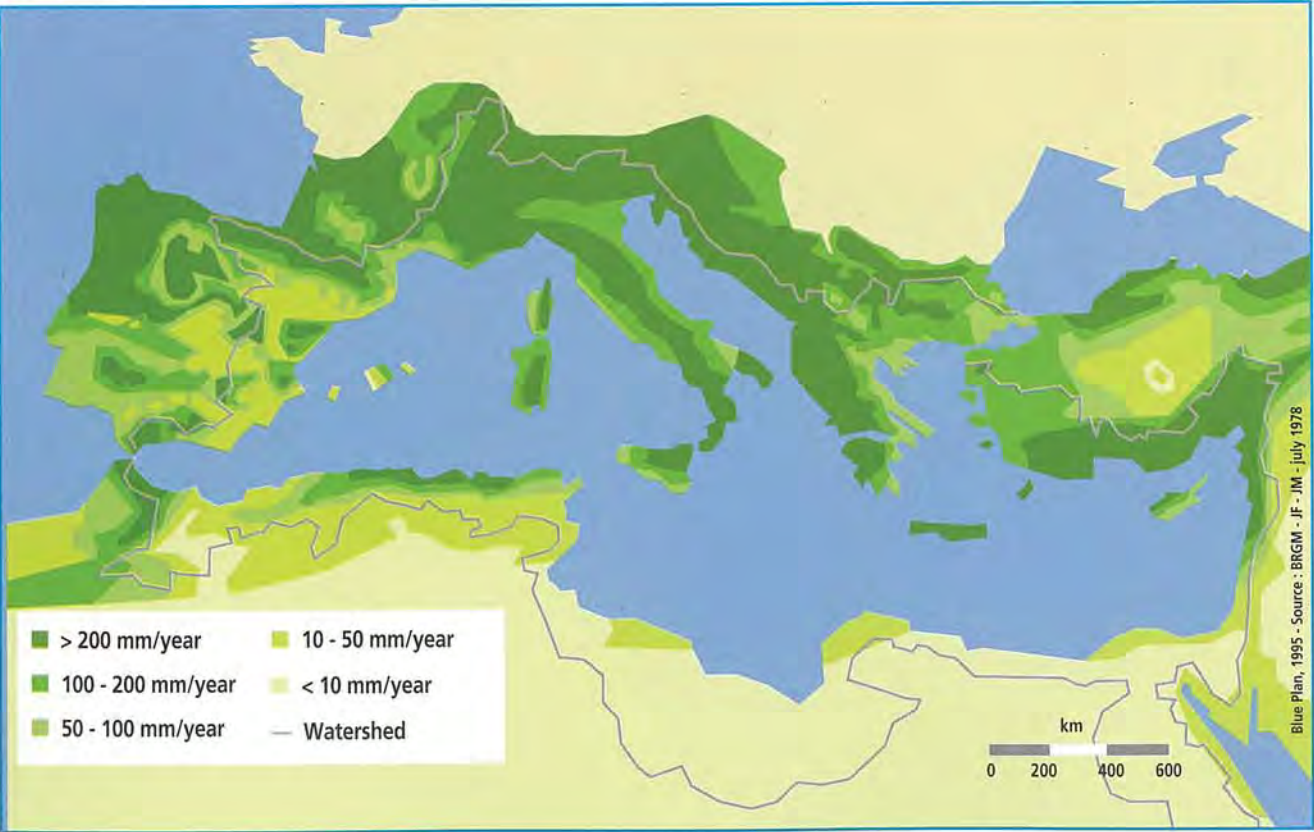
2 - Lal, R. (1990)

Average rainfall in the region ranges from around 1,500 millimetres on the east coast of the Adriatic and in the mountains of Lebanon to around 200 millimetres on the Spanish east coast, fewer than 30 millimetres in the Nile delta, and less than 10 millimetres in the Western Desert of Egypt².

But there are also local variations. In the south, the influence of the sea makes coastal areas cooler and more rainy. And mountains, such as the Alps, the Atlas ranges in north Africa, and those in former Yugoslavia, western Greece and Lebanon, receive more rain because clouds forced to rise over them release moisture.

This complex pattern of spatial and seasonal variability is exacerbated by the unpredictability of rainfall from year to year. According to the Climatic Research Unit at the University of East Anglia, the south of the region has some of the most unpredictable rainfall patterns on Earth. On the coast of Libya and Egypt, the wettest 10 per cent of years have five times more rain than the driest 10 per cent¹.

Annual runoff in the Mediterranean basin.



1 - Hulme, M. (1994)
2 - Lindb, G. (1992)

Unequal distribution of water

The water cycle

Rainfall is not automatically translated into flow in rivers. Mountains may store rainfall in the form of ice and snow until late spring, when the melt causes streams to fill downstream, often many months after the last rains.

The largest river basin in the region is drained by the Nile, which extends deep into East Africa. The other major basins, each with catchments greater than 60,000 square kilometres, are largely within the Mediterranean region. They are the Po in Italy and the Rhone in France, both draining the Alps, and in Spain the Ebro, which runs out of the Pyrennees.

Mountain rains and snows are crucial to water supplies in parts of Morocco, Algeria, Greece, Turkey and former Yugoslavia. Water may also stay for months on the land stored in soils or absorbed by vegetation, especially forests.

More water percolates from soil or river beds into porous rocks, known as aquifers*¹. These rocks can hold the water for a few days or several thousand years until it springs to the surface again or seeps into the oceans. Some of the oldest and largest water resources lie beneath the Sahara desert.

More water evaporates. In the south of the region, annual evaporation rates approach 2 metres per year, eight times precipitation. The effect of this is most visible on large bodies of water. Lake Nasser, behind the Aswan dam in Egypt, loses at least 10 cubic kilometres of water a year through evaporation.

The Euprates, photographed here near Birecik, Turkey, flows through an area of particularly low summer rainfall.



B. Pambour

* - refer to glossary, page 76



Run-off systems everywhere are influenced by evapotranspiration*. On average, only half of rainfall across the Mediterranean flows down rivers. In parts of southeastern Spain and Tunisia, only a tenth reaches rivers¹. Israel loses 60 per cent of its rainfall through evapotranspiration. Once in rivers, the water may be delayed on its way to the sea, stored in wetlands along the river, caught behind man-made reservoirs, or stored in coastal lagoons².

The water cycle* within a catchment basin is thus complex, with water moving from soil to underground reserves and rivers and then to wetlands and vegetation and back again. Human alterations to any of these features – such as chopping down trees or erecting dams, draining wetlands or straightening rivers – can have profound implications on the entire water cycle, altering the availability of water downstream in both space and time.

All these rivers interact with large underground aquifers and have substantial wetlands at their mouths. The River Nile has a delta that makes up two-thirds of Egypt's farmland. It fills aquifers in the delta area with up to 5 cubic kilometres of water a year. Egypt's total water store beneath the ground, much of it fossil water*, is 400 cubic kilometres, some three times the capacity of Lake Nasser behind the great Aswan dam upstream, but very little of this can be exploited³.

While it is sometimes convenient to categorize water supplies as either surface or groundwaters*, they are not separate, and increasing abstraction from one is likely to reduce the supply in the other.

Fossil waters

"Fossil" aquifers beneath dry lands extend almost uninterrupted beneath the Sahara from Morocco to Sinai and the Negev. The Saharan aquifers contain up to 75,000 cubic kilometres. However, only a small fraction of this water is recoverable at reasonable cost, using current technology, and annual recharge is only a few cubic kilometres⁴.

Of the three main Saharan basins containing fossil water, the largest is the Nubian basin, underlying parts of Libya, Egypt and Sudan. Estimates of how much water it contains

vary from 40,000 to 60,000 cubic kilometres. But of this, only around 180 cubic kilometres is recoverable. And the recharge rate is only around 1 cubic kilometre a year⁵.

The Sinai-Negev aquifer contains 200 cubic kilometres of water, much of it brackish* and most of it more than 20,000 years old. The Algerian-Tunisian basin receives inflows from the Atlas mountains to the north and the Erg Occidental. The oldest water, beneath the Qattara depression in western Egypt, is 25,000 years old.

1 - Lindh, G. (1992)

2 - Anonymous, *World Water* (1994)

3 - Anonymous, *Environmental Action Plan for Egypt*, (1992)

4 - Hesse, K.H. (1987)

5 - Salem, O.M. (1992)

Unequal distribution of water

Drought and climate change

Because a river system is not like a water pipe, a drought is not the same thing as turning off a tap. A short meteorological drought (in which the rains fail) may not reduce river flow by very much, provided the river is coupled to groundwaters or an artificial reservoir that will maintain the flow. However, they can provide only a temporary buffer.

The Mediterranean suffers frequently from years of low rainfall. Most of the region was hit by severe drought in 1989-90, and some countries, Spain in particular, have seen poor rains in some years since. Because countries are using their water resources with growing intensity, poor rainfall increasingly leads to national water crises as water tables* in groundwaters fall, and reservoirs, wetlands and rivers empty.

Mediterranean wetlands

The Mediterranean was once a region rich in wetlands, as rivers overflowed their banks and meandered across floodplains, coastal zones and deltas. During the 19th and 20th centuries, most wetlands, especially inland, have been drained either for agriculture or to drive out malarial mosquitoes. In recent decades, the surviving wetlands have come under threat from large water-supply projects that have dammed rivers, diverted water out of wetlands or pumped out aquifers, so depriving wetlands of their supply of water.

With many countries reaching the limits of their water supplies, the threats to wetlands are growing, even though, in theory, many are protected by their governments under the Ramsar Convention on Wetlands of International Importance.

Among the most important surviving wetlands are the deltas of major rivers that flow into the Mediterranean. They include the deltas of the Po, Ebro and Rhone, the Evros, Axios and Acheloos in Greece, the Menderes and Goksu in Turkey and the Nile in Egypt.

In the Maghreb, there are few river deltas, but several large areas of salt marshes and lakes that act as occasional drainage basins for flash floods. Usually the water forms a lake and then evaporates before the next rains. The depressions, called chotts* or sebkhet*, sprout masses of vegetation when wet, and attract large numbers of migrating birds. Thousands of flamingoes sometimes breed on the Sebkhet Sidi El Hani in Tunisia, for instance.

Damage from floods can
be considerable
- but is it sensible to build houses
in potential flood zones?



J. Jalbert

In the Sierra Nevada (Spain),
the World Alpine Skiing
Championships were
cancelled in early 1995
because, for the first time in
25 years, the slopes were
bare of snow.

Even as heavy rains caused floods in northern Europe during early 1995, Spain remained dry. Rainfall was less than a quarter of normal over south and east Spain – the fifth year of drought. Tunisia suffered severe drought from 1987-89, while Morocco has suffered continually since 1990.

There is growing debate among climatologists about whether these droughts are simply another manifestation of the notorious variability of Mediterranean rainfall – or a sign of a long-term shift in rainfall patterns, perhaps linked to global warming. There has been a decrease in rainfall throughout southern Europe and the Maghreb over the past century. In summer, rainfall is now 20 per cent less than at the end of the 19th century. In Tangiers, rainfall has dropped by 100 millimetres in 40 years and at Ifrane, in the Moyen-Atlas Mountains in Morocco, by 400 millimetres in 30 years¹.

Such changes create uncertainty. Are long-term averages of rainfall or river flow any longer valid as a basis for planning water resource use? In the mid-1990s, hydrologists in Greece were being forced to reconsider their estimates of average flows in the 220-kilometre River Acheloos, the country's longest river and scheduled for a major diversion project to irrigate fields.

Global warming could unleash further changes, further variability and further uncertainty on the region. Several computer models of climate suggest that the region will continue to become drier and hotter, with reduced rainfall and increased rates of evaporation.

1 - *Jellali, M. & A. Jebali (1994)*

Unequal distribution of water

A computer projection of possible rainfall changes if the world warms by 2°C, which climate modellers say could occur by the mid-21st century, suggested rainfall reductions through most of the Mediterranean would exceed 5 per cent over southern Spain and Morocco.



Recent droughts in Spain have dried out many reservoir.

O. Langrand / Bios

Salty tale

The majority of water inside a river catchment is usually fresh and suitable for drinking or irrigation unless it has been contaminated by sewage or other pollution. In hotter areas however, evaporation may make surface waters increasingly saline. Salts dissolved in the water become concentrated as much of the water is lost. Saline water may

concentrate in lakes in inland depressions. If the salty water percolates into aquifers, so-called groundwaters will also become saline.

Underground waters in coastal regions, such as beneath river deltas, may consist of both saltwater and freshwater aquifers lying side by side. Overpumping* of the freshwater component may cause saline water incursions into the freshwater aquifer.



Uses and abuses

The demands being placed on the Mediterranean's water supplies are growing all the time. The prime reason is demographic. But government policies towards water-hungry economic activities, from industry and agriculture to tourism, play an important part.

The way in which water resources are allocated is often based more on capturing or extracting the water and delivering it for use elsewhere, rather than allowing it also to provide multiple benefits within wetlands and coastal systems.

Wetlands provide a wide range of products, such as these reeds for thatching, which sustain local economy.

Demographic trends

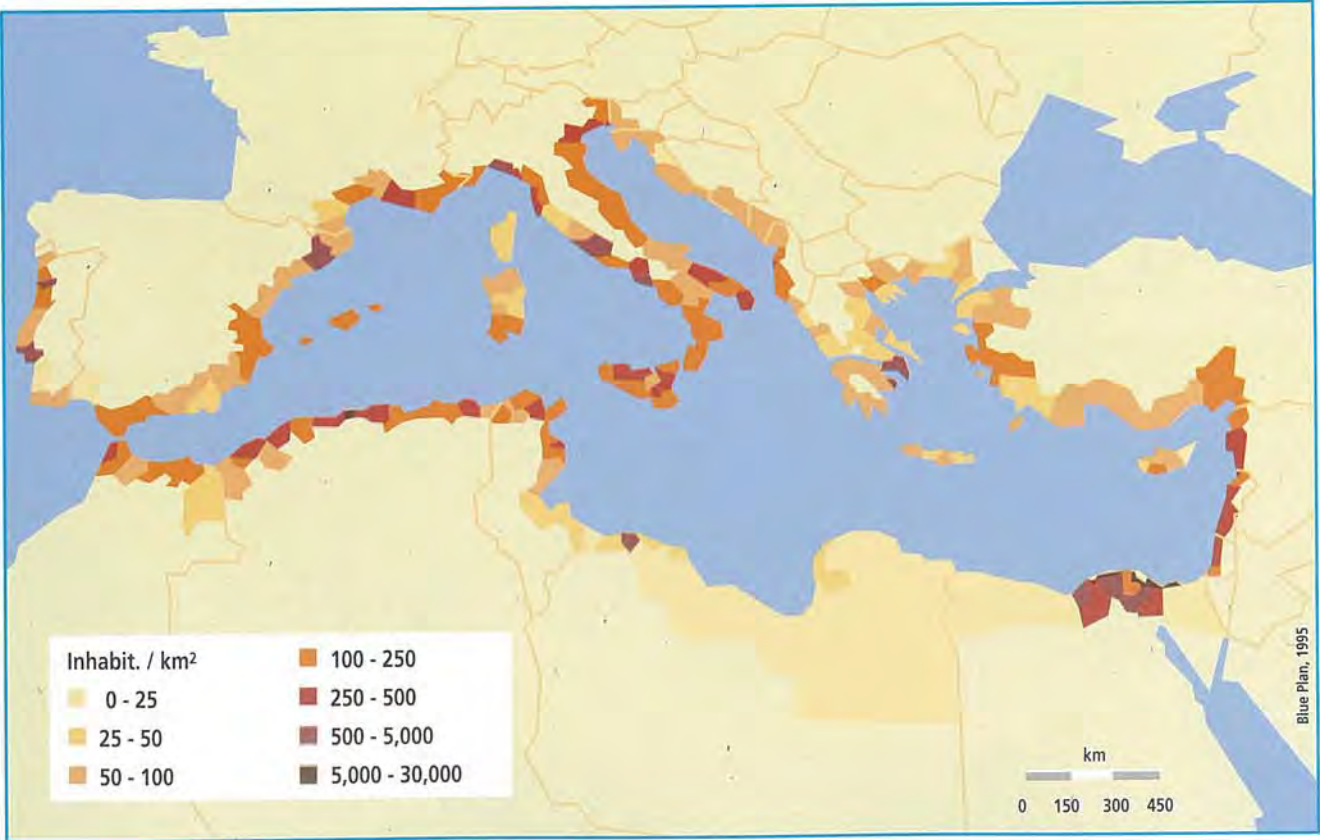
The Mediterranean is one of the most densely populated regions on Earth. More than 130 million people live in cities, towns and villages on or near the Mediterranean coast.

There are 50 coastal cities with a population of more than 100,000. The highest population densities are in the northwest of the region, exceeding 1,000 people per square kilometre along the French and Italian Rivièras.

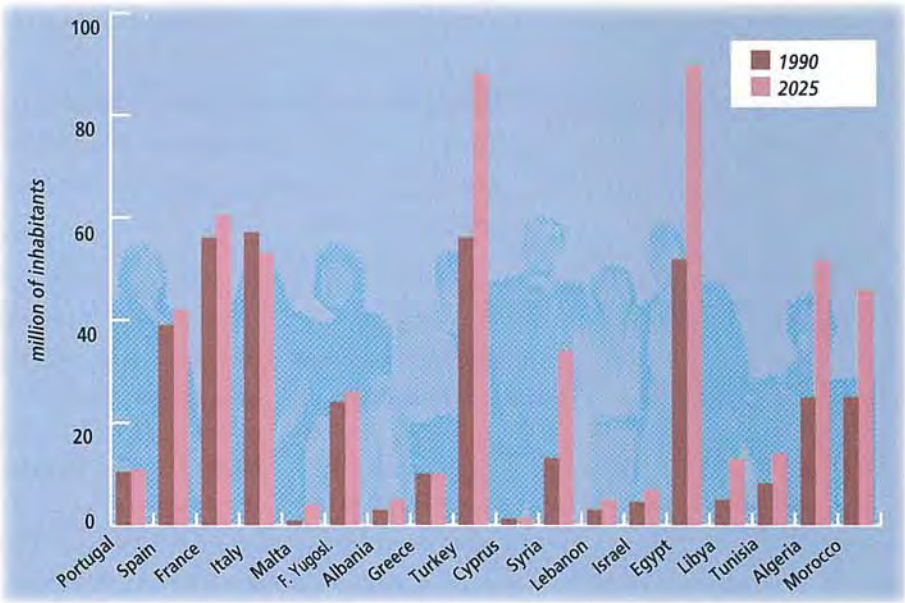
There are local “hotspots” even in the driest regions. The coast of the Levant and parts of coastal Algeria and Tunisia have more than 250 people per square kilometre. The Nile delta exceeds 500 and Gaza 2,000. The Egyptian capital, Cairo, is the largest city in the region, with a population of 16 million.

Populations in the north of the region are now relatively stable, however. Europe’s Mediterranean population is expected to rise by less than 4 million between 1990 and 2025.

Population density along the coast line.



Uses and abuses



Population projections for 2025.

Source: Commission of the European Communauty, 1992

But in the south and east of the region, the driest lands, populations are expected to rise by more than 75 per cent during the same period. Egypt's population will increase from 52 million to more than 90 million, most of them clustered along the Nile and across its delta.

Both Morocco and Algeria had fewer than 9 million people in 1950, are currently 25 million, and are expected to exceed 45 million by 2025¹.



As population levels increase effective sewage treatment systems, such as at Mèze in France, are essential to maintain environmental quality.

M. Gunther / Bios

Water demand

The potential increase in demand for water from such increases in population is self-evident. But there is also a huge, pent-up demand for water from existing populations.

In Turkey, where water demand all but doubled during the 1980s, the government estimated in 1990 that only 63 per cent of its population had access to adequate public water supplies. That left 20 million people requiring supplies¹. Demand for drinking water in the Maghreb is projected to rise sevenfold to 21 million cubic metres in the next 20 years.

Most countries are becoming increasingly urbanised. People living in cities consume more water and require more complex water supply systems to provide water for their homes. Moreover the risk of disease and pollution mean that water quality standards need to be higher in urban areas. Morocco increased the proportion of its urban residents who received adequate safe water supplies from 50 per cent in 1980 to 90 per cent by 1990, while the proportion of rural people in that position was only 20 per cent.

Irrigation of agricultural crops
account for more than 70 %
of water consumption.
Durance valley, France



1 - Kulga, D. & K. Adanali (1990)

Tourism

Many tourist developments have built or are building golf courses. Golfers demand green courses, which require constant irrigation. Yet, in Spain, for instance, where northern Europeans take about 200,000 golf holidays each year, growing water shortages have done little to douse the push to irrigate more golf courses along the Costa del Sol, the Balearic Islands and the Coto Doñana¹. Water shortages have forced bans on construction of golf courses in parts of southern France. Tunisia plans to triple its tally of golf courses to 15 by the end of the decade. In Malta and Cyprus, golf courses are still being built to attract tourists.

Around 150 million international tourists visit the region each year, more than a third of the world total of cross-border tourists.

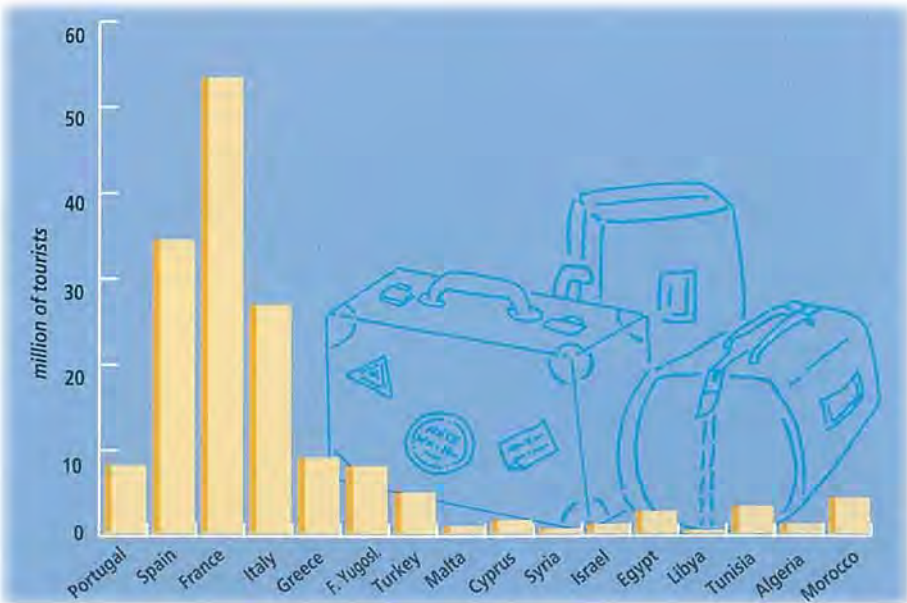
Most come during the dry summer. Around four-fifths of all tourists in the region still go to France, Italy and Spain. But many tourists are tiring of the overloaded beaches and concrete-lined coasts of the traditional destinations and are heading east and south.

Malta receives a million tourists a year, three times its national permanent population. At the height of summer, domestic water demand is more than twice the off-season average. Cuts in supply are frequent in summer outside tourist regions.

Some Turkish tourist towns increase their populations tenfold during the summer. On the Greek island of Patmos in the Dodecanese, water demand increases sevenfold in summer, at a time when water supply is at only a quarter of its winter level. The Greek navy delivers water from other islands during this period.

Visit by international tourist to Mediterranean countries.

Source : OMT, 1993



1 - Shepstone, T. (1993)

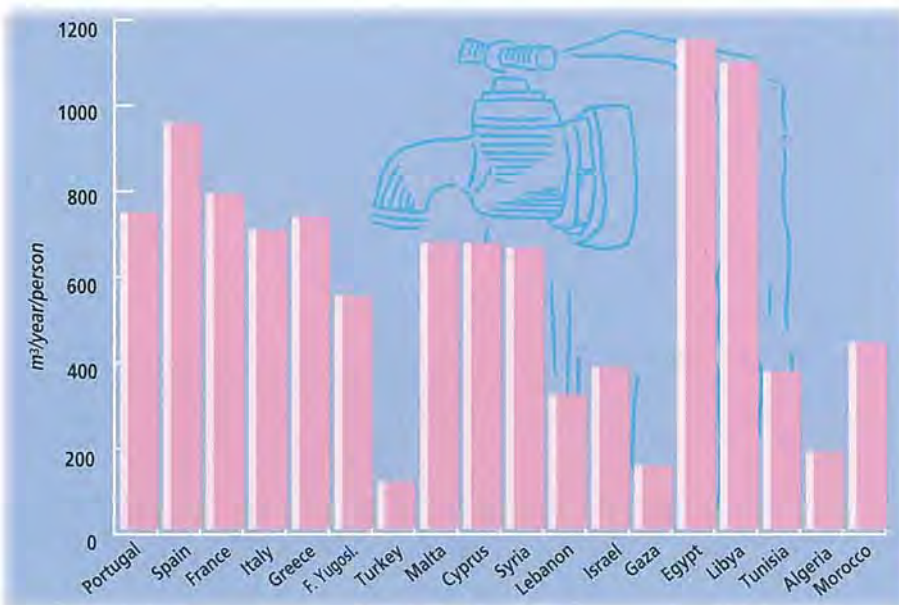


Agriculture and industry

In the Mediterranean region, 73 per cent of water consumption is for agricultural irrigation. The proportion of water demanded by irrigation exceeds 85 per cent in Libya, Morocco, Syria, Tunisia and Egypt

Even in heavily populated and industrialised nations, irrigation often dominates (Spain 70 per cent; Italy 57 per cent; Greece 89 per cent; Cyprus 88 per cent). It only dips below half in France (13 per cent) and former Yugoslavia (5 per cent), where water is not needed on such a scale for agriculture, and in Malta (1 per cent), where water is too scarce to allow much irrigated agriculture.

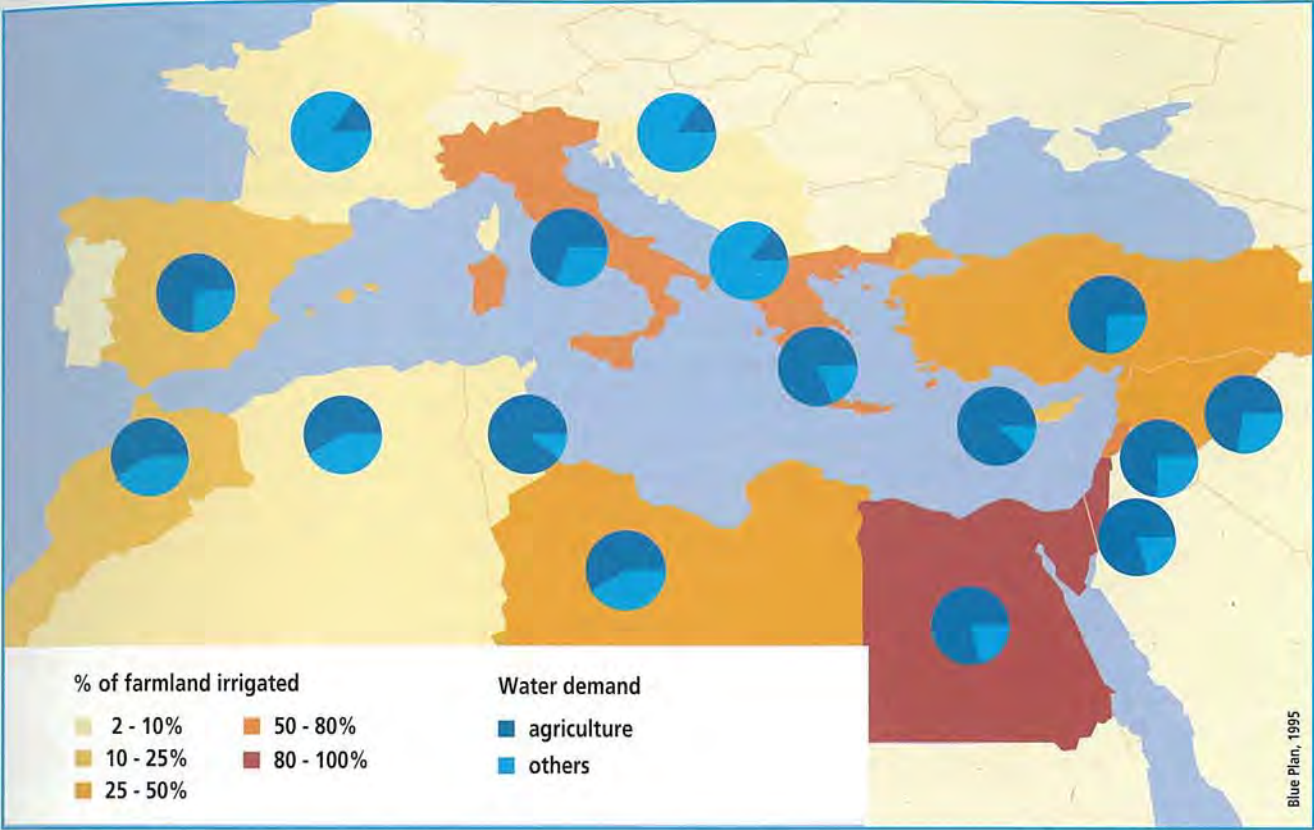
The dominant influence of irrigation means that the nations in the south of the region have some of the highest per-capita demands for water. The top three are Egypt, at more than 1,100 cubic metres, Libya at more than 1,000 cubic metres and Spain at more than 900 cubic metres.



Water demand per capita in 1990.
Source: OCDE

Many countries with little industry have been determined to secure as much self-sufficiency in food production as possible, and to irrigate water-hungry, but financially lucrative export crops such as cotton. Even so, agriculture is becoming less central to many economies. In Egypt, agriculture's share of GDP has fallen from 29 per cent in 1965, when the Aswan dam was completed, to 17 per cent in 1990. In the same period it has fallen in Morocco from 22 per cent to 16 per cent and

Uses and abuses



Percentage of cultivated land which is irrigated and percentage of water demand in Mediterranean countries.

in Tunisia from 20 per cent to 14 per cent. In Israel, the agricultural sector uses 60 per cent of its water supplies, but earns only 5 per cent of the country's GNP¹. The shortages of water can only accelerate such trends.

So, while increased water demand has been a fact of life in most of the region for many years, it is not inevitable. Israel, Spain, Cyprus and Italy all reduced their water use significantly during the 1980s.

Through most of the region, industry remains a minor user of water, though it is of increasing importance. But this demand can be hard to meet because it is concentrated. Algeria's pulp factories are major water users, for instance. One plant withdraws 30 million cubic metres annually, enough for a town of half a million people.

Many areas have ambitious plans for developing industrial uses. In Libya, the government predicts that industrial water demand will increase almost sixfold between 1990 and 2020². Sicily's new water plan envisages a fourfold increase in demand for water from industry.

1 - Starr, J.R. (1991)
2 - Salem, O.M. (1992)



Reaching the limits

To maximise the use of unpredictable water supplies, many Mediterranean countries have constructed large numbers of reservoirs to hold back the flow of rivers when they are running high.

Spain, for instance, has around a thousand large reservoirs, mostly constructed to supply water for irrigation and domestic supply. Italy has some 300.

Dam construction causes a range of environmental damage, both through the loss of farmland to the reservoir itself, and downstream through changes in river hydrology. Dams may bar the path of migrating fish such as shad and sturgeon to spawning sites upstream; trap sediment, alter river water temperature and chemical characteristics; and alter flood cycles that are essential to the life cycles of plants and animals downstream.

The burden of water surplus

Theoretical water surpluses can create their own problems, with neighbours eyeing “spare” water eagerly. Plenty of rain falls in the mountains of Lebanon. According to the Global Water Summit Initiative (a Washington water-policy think-tank), “a national water storage, engineering and management system could turn Lebanon into a lucrative Middle East water haven, were there the vision and stability to realise it”¹. One plan under discussion is to divert spare water from the River Litani in southern Lebanon to increase supplies for the Palestinians on the West Bank. But Lebanon is suspicious. Lebanon’s

National Council for Scientific Research reported in 1994 that “there is no justifiable reason for Lebanon’s neighbours to assume that they could have automatic access to some of these resources”².

Certainly, theoretical resources can take a lot of money, expertise and political stability to turn into actual water on tap. As Starr points out, rather than being flooded with water, “the country is [currently] crippled by severe water shortages in Beirut, sea-water intrusion* in the coastal aquifer, farmlands neglected by the lack of irrigation water, and pipelines and aquifers severely damaged by civil war”.

1 - Starr, J.R. (1991)

2 - Kouyoumjian, H.H. & A. Rabbat (1994)

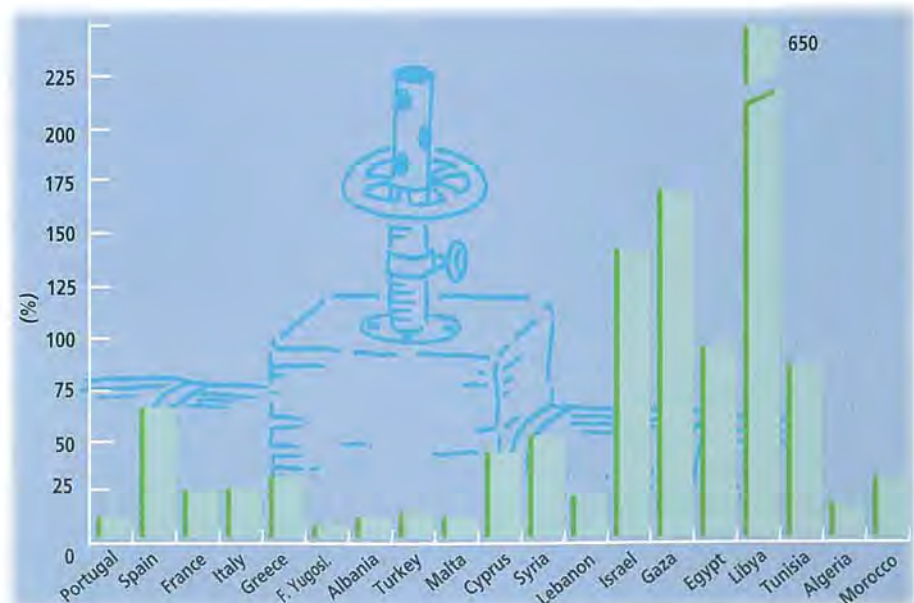
Water exploitation index

A crude measure of water stress is calculated by a national water availability index. This expresses the amount of water put into use by humans as a percentage of the theoretical total renewable water resources.

The index is only a crude guide to likely water stress. It does not take account of ecological demands on water. Nor does it allow for variability in supply and demand, either between seasons or years, or reveal local and regional shortages within countries. But it does provide a first assessment of where chronic water shortages may occur.

Let us consider the threshold for serious water stress as a 50 per cent index – that is, more than half the theoretical water resource is in use. Several countries in the Mediterranean fall into this category, for example Tunisia (83 per cent) and Egypt (92 per cent). Some countries exceed 100 per cent. Israel, which reuses sewage, has an index of 140 per cent. Gaza, by overpumping its groundwaters, has an index of 169 per cent. Libya contrives an index of a staggering 644 per cent. This arises because 84 per cent of its water comes from non-renewable fossil water from beneath the Sahara.

Some countries suffer regional stresses that are not picked up by the index. Although Greece has an exploitation index of 12 per cent, most of its water is in the west and there is serious unmet demand in the east,



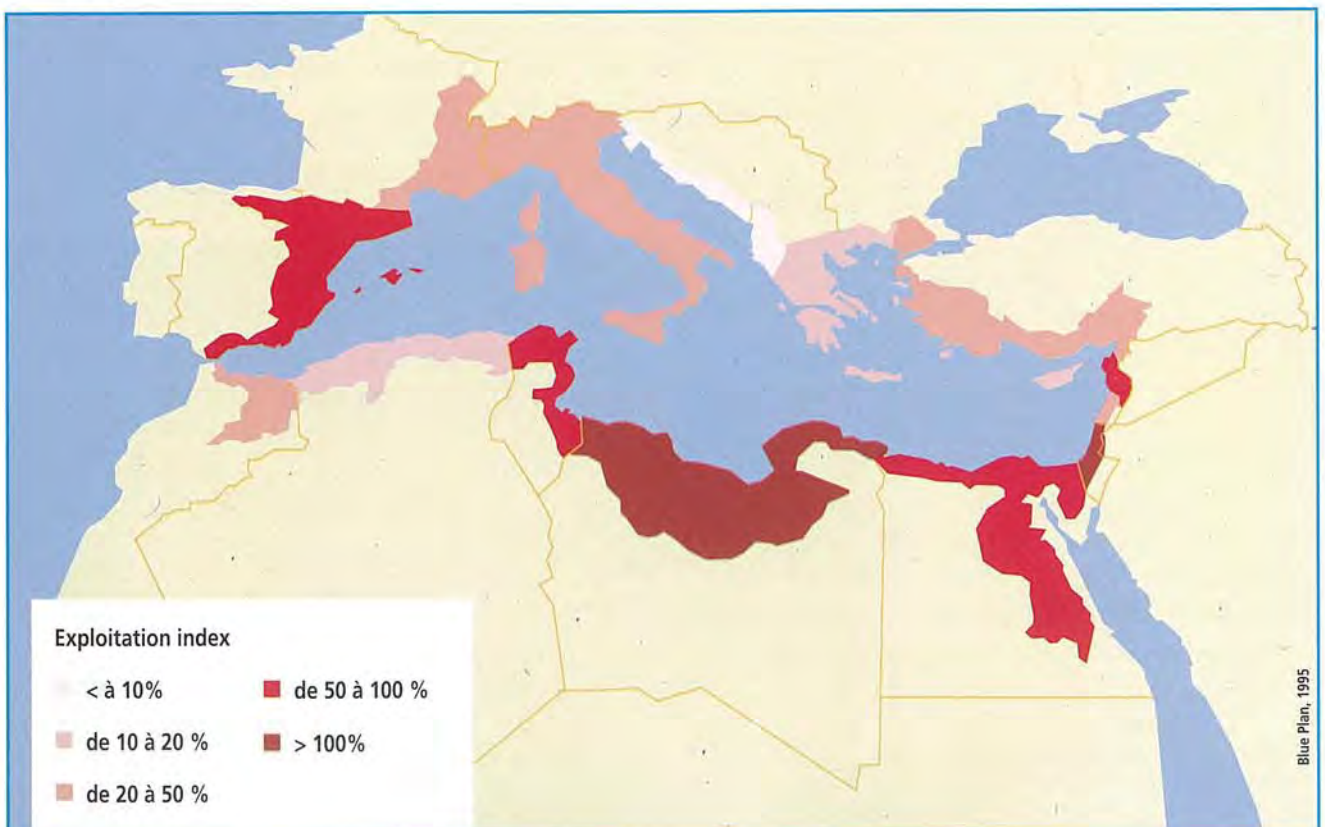
Water exploitation index within the Mediterranean watershed for 1990 (percentage of renewable annual resources).

Source: Blue Plan

including the capital, Athens, and on the islands. In Spain, the national index is only 31 per cent, but the index for the part of the country that drains to the Mediterranean is 64 per cent. Algeria and Morocco both have acute regional deficits hidden by national indices of below 40 per cent.

Countries with large water surpluses include Lebanon, dubbed the “water tower of the Levant” (index: 20 per cent), and most of former Yugoslavia (index: 2 per cent). But in both cases, there are serious problems in developing their resources because of the destruction of infrastructure caused by war.

Water exploitation index





Edwards/Still / Bios

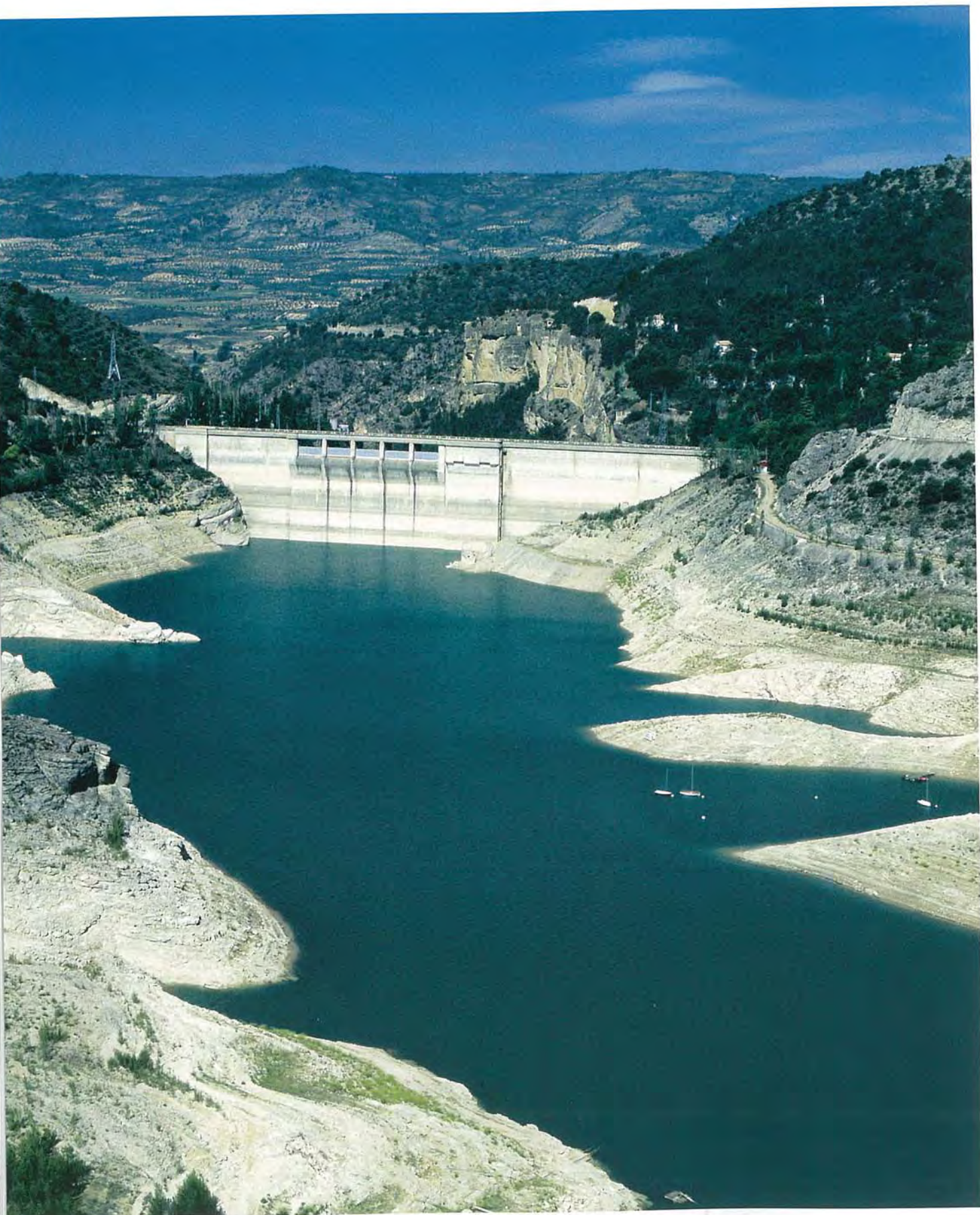
River pollution

Cities have a long history of polluting their own water supplies. Ancient Rome fouled the Tiber so severely that by the 4th century BC it could no longer use the water for drinking. Today, sewage pollution prevents water in many rivers from being abstracted downstream, and natural systems may be devastated by the pollution.

The River Po receives sewage from 16 million people and run-off from Italy's most productive farming region. The largest city in the region, Milan, discharges sewage directly into the river from its 1.5 million inhabitants mostly without any form of treatment. The pollution makes the river's water largely unfit for drinking and restricts its use for irrigation. Downstream, it also clogs the coastal lagoons with nutrients, such as nitrates and phosphates, that create beds of green algae. The result is periodical catastrophic loss of marine life in the waters of the lagoons and the wider Adriatic.

Other coastal wetlands suffer badly from pollution. They include the Lac de Tunis outside the Tunisian capital; Lake Maryut outside Alexandria, where 85 per cent of the fish have disappeared in the past 20 years; and the Manzalah lagoon in the Nile delta, which receives sewage from much of Cairo.

Many countries accept the need for new treatment works to handle sewage and industrial discharges in order to improve water quality in rivers, but find it hard to summon the political will to construct and then maintain them. According to researchers at the University of Catania, "of the 565 purification plants planned for Sicily, about 300 have been constructed, but only 38 are in operation, while the remainder have been abandoned because of a complete lack of personnel and financing". In summer, they say, raw sewage is poured onto dry river beds, from where it infiltrates into groundwaters¹.



Exploiting an irregular resource

The combination of growing populations, rising demand and uncertainties of supply are creating a growing water crisis in the region and this is bound to have consequences for the associated wetland ecosystems.

The scale and engineering sophistication of methods of water supply and transfer are increasing. But this costs money and water is now a major element in many national budgets. Costs are likely to increase dramatically in future as the remaining undeveloped water sources lie furthest from where they are needed, hence the proliferation of water transfer schemes in the region.

Dams are the preferred method for stabilising unpredictable water flows.
Buendia dam, Spain.



Ancient technologies

Since earliest recorded history, humans have created complex infrastructures to tap, transport and store scarce water in the Mediterranean lands.

The Mesopotamians built the world's first great civilisation in the desert by managing the rivers Tigris and Euphrates. The ancient Egyptians channelled the Nile floodwaters so effectively onto their fields that, in a country with virtually no rain of its own, the population density reached 180 per square kilometre in the Nile valley – double that of modern France.

More than a thousand years ago, hundreds of tunnel networks were dug into the hills of the West Bank to tap water. They watered orange groves for 2,000 years until being abandoned during the exodus of Palestinians in 1948 and 1967.

Elsewhere in the region's deserts, complex agricultural systems were built to capture occasional flash floods to water crops. A study by UNESCO has found abandoned fields and irrigation systems in the wadis of the Libyan desert, where current rainfall is less than 25 millimetres per year. Low walls diverted floodwaters to fields that grew grain, olives and vines for sale to the Roman empire. Fifteen-hundred years ago, the Nabatean kings also built walls across the Negev to capture occasional rains and divert the water onto fields outside cities such as Petra, their capital.

Even more remarkable are the long tunnels, typically 5 kilometres long, that penetrate deep into hillsides throughout the region. They captured underground waters and transported them by gravity to farms and villages.

The Persians, who invented these tunnels, called them qanats*. They still supply water in Cyprus and Egypt. In Morocco, around Marrakech and the southern pre-Saharan Rhettaras region, as well as Algerian Sahara, they are still “the mainstay of peasant agriculture” around many oases, according to Jean Bisson of the University of Tours. Hollowed-out galleries capture most of the underground water in the hills of Malta and tap water in the hills of the West Bank¹.

According to David Gilbertson, an archaeologist from Sheffield University in Britain, the frequency of ancient settlements in the semi-arid lands of North Africa “suggests that the wisdom of the ancients in managing these harsh landscapes was more substantive than our own”. But, of course, their needs were much less.

¹ - Riolo, A. (1990)

Exploiting an irregular resource

Powerful pumps extract water from aquifers.



P. Bertrand / Bios

Reservoirs, dams and pumps

The modern era of water supply has been dominated by two technological developments: boreholes and dams.

Dam construction has often been most intense on islands, which tend to have high concentrations of population and little opportunity to import water economically from less-populated areas. Cyprus did not build its first large dam until 1960, but dams now barricade most of the island's south-flowing rivers and storage now exceeds 300 million cubic metres.

Firstly, natural springs, wells and qanats have been replaced as the main method of extracting underground water supplies by boreholes using petrol-driven pumps. Cheap pumps have dramatically increased the ability of all but the very poorest farmers to extract water from beneath the ground. In Tunisia, for instance, the number of wells tripled from 20,000 to 60,000 between 1960 and 1980, and almost doubled again to 110,000 by 1990¹.

Technology has also allowed the development of boreholes that can tap water from deep underground – in some places up to a kilometre down. Such deep boreholes can provide water during periods of drought when water tables fall and shallower wells and boreholes dry up. Even so, only five countries in the region obtain the majority of their water from aquifers: Malta, Israel, Tunisia, Libya and Gaza. The rest rely principally on taking water from rivers. The second major development has been the construction of large dams that block the flow of major rivers to store water and generate hydroelectric power.

Large dams are designed to harmonise water supply with demand. Usually this means capturing water in the wet season and storing it in reservoirs for use during the long, hot summer when demand, especially for irrigation and tourism, is at its peak.

1 - Barrocu, G. & P. Puddu (1987)

Dams replace multi-functional wetlands by single-sector preoccupations.
Villefort dam, France.



The largest dam in the region is the Aswan dam on the Nile close to Egypt's border with Sudan. It has a capacity of around 150 cubic kilometres and can hold back more than a year's flow of the great river. Its purpose is to generate hydroelectricity and to capture the annual floodwater and send it downstream throughout the year, allowing year-round irrigation of the fields of the Nile valley.

On other rivers, too, a single dam has transformed the river's hydrology. The Mequinenza dam on the Ebro in Spain is one such. But often the impact is cumulative. The Rhone in France has 48 hydroelectric dams and many schemes for diverting water. The River Guadalquivir in southern Spain has 30 dams.

Today, surface water collected behind dams is the prime source of water supply in Italy, Spain, Turkey, Lebanon, Egypt and the Maghreb. Morocco has switched to dams during its heavy investment programme in water infrastructure.

Most Italian towns and cities are served by dams in the Appenines, the mountains that run the length of the country's mainland. The island of Sardinia has 35 reservoirs, the highest density in the Mediterranean, with a capacity of 1.7 billion cubic metres. It anticipates building 38 more by the year 2040¹.

1 - Lytras, C. & N. Tsiourtis (1990)

Exploiting an irregular resource

Water transfers

Whether water is taken from rivers or underground, it usually needs transporting, sometimes quite long distances, for use.

The first canals moved water around the Nile delta more than 4,000 years ago. But the Romans were the early masters of aqueducts. The city of Rome first brought clean water from springs in the hills in 312 BC. Eventually the city built 11 conduits with a total length of 500 kilometres. Roman Carthage took its water from springs at the foot of mountains 50 kilometres inland. The Pont du Gard in southern France delivered water to Nîmes from 50 kilometres away.

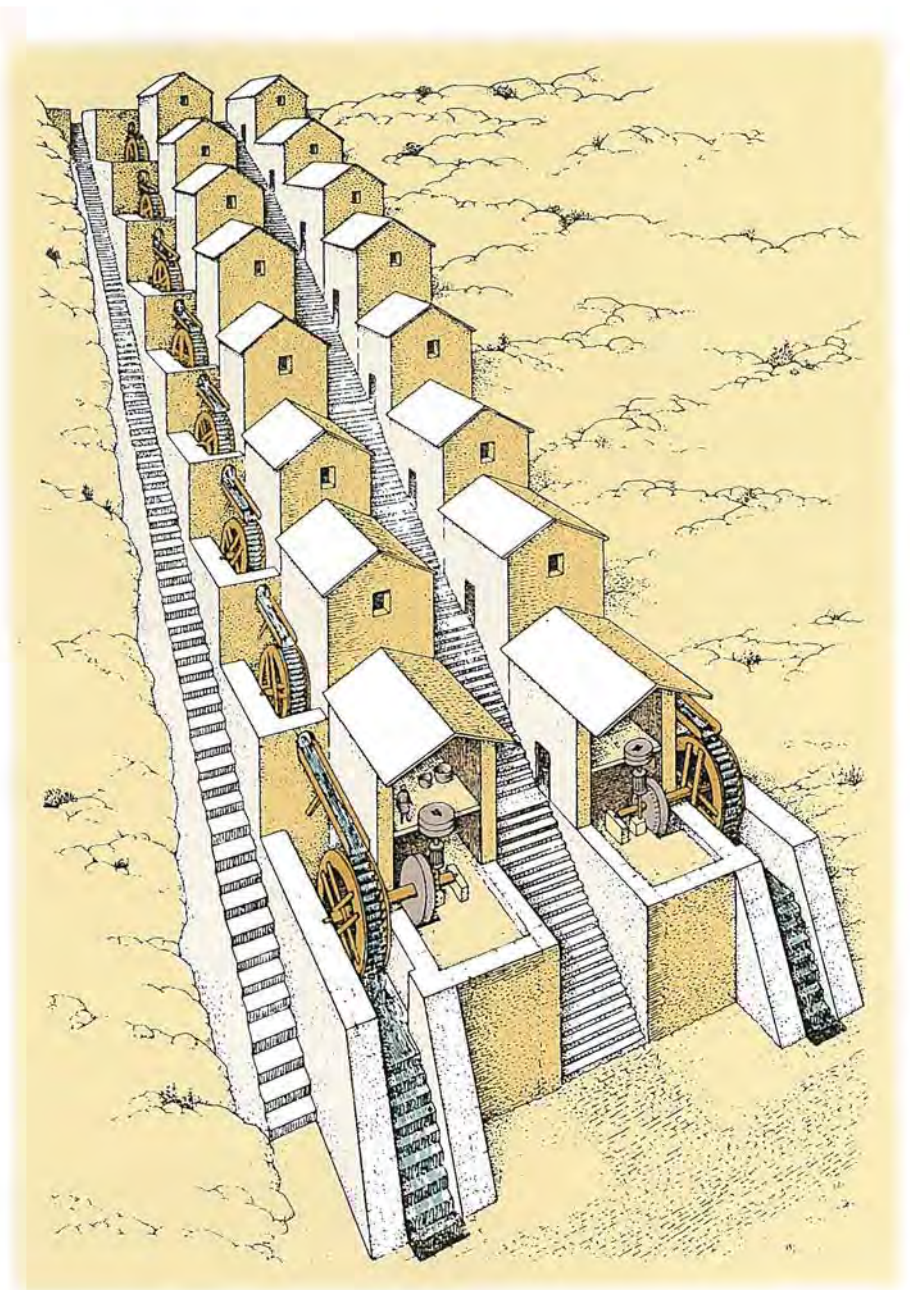
The Ancient Romans also built canals to take the waters of the River Po in northern Italy to irrigate fields. Ancient Jerusalem also used aqueducts and tunnels to supply the city from distant springs.

Great irrigation networks were established in eastern Spain in the first century BC, and extended by the Romans and again during the Moorish era. Cordoba, the capital of Moorish Spain and a city entirely dependent on irrigation to feed itself, was probably the first in the world to exceed a million inhabitants. Many of these canals and water distribution networks survived until the middle of this century¹.



Water transfers are expensive and there are substantial losses to evaporation in transit.
Aragon, Spain.

G. Lopez / Bios



Antique roman mills at Barbegal
south France.

Source: A roman factory
by A. Trevor Hodge

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Modern water transfers are often on an even larger scale. They both distribute the waters from major dams and collect water from numerous sources to supply major cities. Such transfers need not be confined to moving water within a river catchment system. Increasingly, they move water between catchments. This creates another series of hydrological and ecological problems, as river beds and wetlands run dry, and ecosystems may be upset by new species invading.

Exploiting an irregular resource

Turkey's Melen project supplies Istanbul from 180 kilometres away. In Italy recent transfers have been built from reservoirs on the rivers Fortore and Sinni¹. Tunisia's 160-kilometre Mejerdha canal supplies water for drinking in Tunis and Sfax, for irrigation in Mornag, and irrigation and tourism in Cap Bon. A single dam near Rabat in Morocco, the Bou-Regreg reservoir, provides water both for the capital and for a densely populated area stretching for 120 kilometres along the country's Atlantic coast. Water from the River Oun-Rbia feeds irrigation systems at Haouz in the south².

Israel channels most of its water through a National Water Carrier, and Spain operates the Trasvase Tago-Segura, to switch water between these two rivers, one flowing west, the other draining to the Mediterranean.

In Cyprus, the flow of most of the rivers on the south side of the island is being corralled, via dams, into the US\$ 400-million Southern Conveyor, an aqueduct that runs from west to east, almost the length of the island, supplying farms in the west, tourist developments around Famagusta in the east, and the growing demands of the capital, Nicosia.

Starting in 1996, Athens will be supplied with an extra 200 million cubic metres of water a year through a new transfer system involving four major aqueducts and a new 30-kilometre tunnel to connect the city to a 100-metre dam on the west-flowing River Evinos. Both this and another west-to-east diversion on the River Acheloos will drastically reduce flows into one of the Mediterranean's most important wetlands, the Mesolongi.

Transfers by ship

Transfers need not be by a fixed conduit. Ships are used to take water to Greek tourist islands in summer. Marseilles has recently supplied Sardinia, and Gibraltar until recently received much of its water by ship. In early 1995, the Israeli water department announced

that it hoped to agree financial terms with the Turkish government to buy 60 million cubic metres of drinking water a year. The water will be captured behind dams on Turkish rivers that flow into the Mediterranean and delivered by specially adapted tankers or giant plastic containers, called medusas.

1 - Boutayeb, N. (1992)

2 - Margat, J. (1992)

Megaprojects

More ambitious still is Libya's Great Man-Made River Project. The GMRP is an immense pipeline system that takes fossil groundwater from 450-metre deep wells in the remote Sahara desert and transports it to fields along the coast.

In the long run this supply is not sustainable. The wells will run dry, or pumping will become uneconomic. But Libya hopes to obtain water from beneath the desert a century or more before developing other sources, such as desalination*.

The first pipeline opened in 1991 from Sarir in the country's eastern desert, to the coast. The US\$ 3.3-billion pipe-laying contract for the first phase was, at the time, the largest civil engineering contract anywhere in the world. This "river" is almost as long as the River Rhine and big enough to drive a truck through. The water's journey takes nine days.

The plan is to extend it further into the desert, to the Kufra oasis, and to construct a second "river" from the Murzuq aquifer beneath the desert in the west, to Jefara. Together, at a cost estimated at US\$ 27 billion, they will transport more than 2 cubic kilometres of water a year. The two pipes may eventually be linked up along the coast.

The "great man-made river",
Libya.

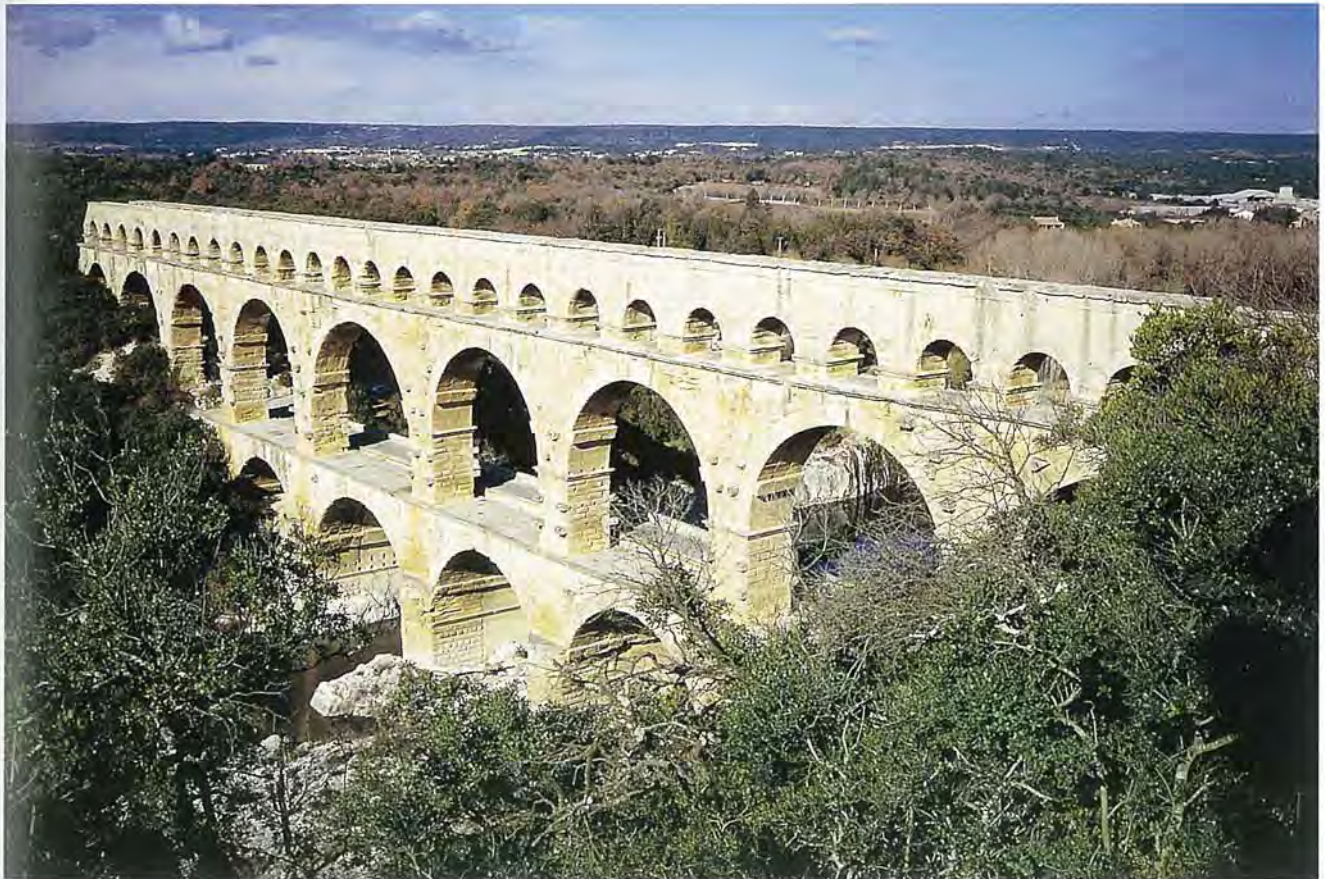


Exploiting an irregular resource

An increasing number of other “megaprojects” for transferring water around the region are being proposed. So far most have remained on the drawing board. In 1994, Libya suggested laying pipelines across the Mediterranean to carry gas and oil north and water south. Egypt’s President Sadat once proposed extending canals from the Nile across the Sinai to provide water for the Palestinians in Gaza.

In 1986, Turkey proposed a US\$ 20-billion “peace pipeline” taking water from the rivers Seyhan and Ceyhan, which both flow into the Mediterranean, on a tour of the middle east, watering everywhere from the Israeli Negev desert to the Gulf. But that has given way to the more modest idea of taking water by ship to Israel.

The Romans were experts at building water transfer schemes to supply their urban centres.
Pont du Gard, France.



J. Jalbert



Conflicts and change

Fast-rising water demand inevitably creates conflicts, especially when uses are regarded as “non-essential” or of benefiting only a few people, or of being “stolen” by neighbouring communities or countries.

In Tunisia there is growing conflict between agriculture and tourism in the Cap Bon region, where hotels containing beds for more than 100,000 tourists have been built in recent years. They are competing for water from the local aquifer, which is already seriously overpumped to meet farming needs.

Dam construction
in Rodopi, Greece.

In Morocco, both tourist and industrial developments are putting pressure on water resources currently used for irrigation around Casablanca. This has not stopped the government from formulating a national plan to increase the area of irrigated land to more than one million hectares by the end of the decade, under a programme known as the *Politique des Barrages*.

Local conflicts may develop between ecological and agricultural uses – for instance, on wetlands. Some conflicts, especially over proposed water-transfer projects, arise between regions of a country. The Spanish regional government of Aragon is angry at proposals in the country's national hydrological plan to trunk water south from its River Ebro, the country's longest river. Central government responded that the region was showing a "lack of solidarity".

In Greece, people on the west-flowing River Acheloos are fighting to retain the water in their river, for generating hydroelectricity, watering fields, and topping up the Mesolongi wetland at its mouth, opposing a plan for a US\$ 1.8-billion scheme to divert part of the flow. The government wants to send the water through a tunnel in the Pindos mountains, the spine of mainland Greece, into the east-flowing River Pinios. From there it would irrigate some 200,000 hectares of rice, cotton, tobacco and vegetable fields in the parched Thessaly plain¹.



The Ebro : a river under threat, a delta in decline.

© Institut Cartogràfic de Catalunya

1 - Anonymous, *World Water Journal* (1992)

International conflicts

Political boundaries often do not follow hydrological boundaries. Instead national boundaries sometimes run down the middle of rivers, as on the Danube; or rivers may flow from one country into another. Thus the Rhone passes from Switzerland into France; and the Jordan passes through Syrian, Israeli, Jordanian and putative Palestinian territory.

The past 30 years have seen an ongoing dispute between Israel and its neighbours over the River Jordan. In 1964, Israel diverted much of the river's flow out of the Sea of Galilee. It now passes down a "new" River Jordan, Israel's National Water Carrier, which takes water to all major Israeli cities and even the Negev desert in the far south of the country.

West Bank water

The West Bank aquifer is one of the most important water resources in Israel/Palestine. The aquifer receives its water from rain over the West Bank hills. But it extends beneath Israel and ultimately drains into the Mediterranean. So as the area becomes part of a new Palestinian state, how will the two countries jointly manage this vital resource to provide an equitable allocation?

Palestinian towns and villages currently extract water from springs and shallow wells in the hills. The Israelis extract it from deep boreholes to supply new West Bank settlements, and from boreholes on Israeli territory near the coast.

Israelis take more than 300 million cubic metres a year from the aquifer, with Palestinian villages taking much less, though

the precise amount is disputed. In any case, hydrologists say that the resource is already overpumped by at least 100 million cubic metres a year. The occupying Israeli authorities over the past 25 years have used this as a reason for not allowing Palestinian communities to sink new wells¹.

This, say Palestinian hydrologists, has resulted in a reduction of the amount of Palestinian farmland under irrigation from 27 per cent before the Occupation to 4 per cent by the early 1990s, whereas Israeli settlers on the West Bank irrigate 70 per cent of their crops. Israeli water engineers agree that in places, such as the village of Jiftlik in the Jordan valley and Bardada near Nablus, Israeli boreholes sunk deep into the aquifer have dried up shallower Arab wells, causing local disputes².

1 - Nordell, D. (1991)

2 - Pearce, F. (1991)



The first water wars were conducted between city states in Mesopotamia. Today Egypt, which uses most of the flow of the Nile, is in constant fear that upstream neighbours such as Ethiopia will begin to harness the water for their own use. Boutros Boutros Ghali, secretary-general of the UN and former foreign minister in Egypt, has frequently warned that the next war in that region will be fought over the Nile.

The River Jordan now provides 40 per cent of Israel's water. But its remaining flow south of the Sea of Galilee is only a quarter of the level in 1950, and is mostly concentrated after occasional heavy rains. The increasingly irregular and saline flow to the Dead Sea is of little use to farmers on the east bank, who once relied on it to irrigate their fields.

Jordan has attempted to replace that water by damming its one remaining surface water source, the Yarmuk, a tributary of the River Jordan. But the scheme has been held up by Israel's hostility to the proposed diversion and by Syria, which has captured much of the river's flow further upstream.

Underground aquifers also frequently cross national boundaries. If anything, the potential for conflict is even greater here. This is because an aquifer, once emptied, may take centuries or even longer to refill, and because there is greater room for dispute over the basic data of the resource: how much water it contains, what the recharge rates are, where the recharge comes from, and so on.

Conflicts about underground water can be especially acute over the exploitation by one country of non-renewable "fossil" reserves that extend beneath a neighbour. By pumping water out from the aquifer beneath its own territory, it could begin to drain forever the water beneath its neighbour's territory.

The great fossil-water aquifers beneath the Sahara are a major potential cause of future water conflict. The Eastern Erg artesian* aquifer, south of the Atlas mountains, extends from Algeria into Tunisia.

The Nubian aquifer underlies parts of Libya, Egypt and Sudan, and contains an estimated 6,000 cubic kilometres of water. Only Libya is tapping it so far – but on a massive scale, with the Great Man-Made River Project. "There is," says a World Bank study on the region, "a fear that this may reduce substantially the groundwater reserves in the two other riparian countries." There are already claims that the Libyan pumping is drying up Egyptian oases¹.

1 – Anonymous, *World Bank* (1994)

Mining aquifers

Mining of aquifers – that is, pumping out more water than nature can replenish – is widespread in the region. Such mining may destroy coastal groundwaters as a supply of freshwater by drawing in sea-waters. Such pollution can take decades or centuries to clear.



J. Roché / Bios

Low technology exploitation of aquifers has been sustainable for centuries.

Libya's Jefara valley aquifer is a classic victim. Pumping from the aquifer, largely for agriculture, increased tenfold between 1958 and 1973 and has subsequently almost doubled again. By 1987 pumping was three times the natural recharge, an annual deficit of more than 500 million cubic metres per year. Massive saline intrusion followed.

Shallow wells at Tunisia's Garaet El Haouaria wetland, which was converted to irrigated agriculture a generation ago, have now been abandoned because the lowered water table sucked in sea-water.

Islands, with their long coastlines, can be particularly vulnerable. In Malta, salt-water intrusion makes much of the country's tap water taste slightly salty. Sodium chloride concentrations are up to 150 parts per million. A recent government modelling study concluded that a 40 per cent reduction in abstraction from aquifers was necessary before salt might start to be flushed from the aquifers¹.

The whole of the Holy Land has seriously overpumped its aquifers in recent decades. Israel has overpumped the coastal and West Bank aquifers, perhaps resulting in permanent damage. In Israel, the water

Dams and hydrology

Dams completely modify the hydrological cycles of the river they bar and the wetlands and aquifers that feed off their flows. Most dramatically, the Nile's annual flood, which once rushed down the valley each May, gushing onto fields or out into the Mediterranean, has been replaced by a steady year-round flow.

Sometimes dams can be managed to conserve water for natural systems and aquifers. They can do this by slowing down fast run-off into the sea and so encouraging more water to seep into soils, wetlands and aquifers. The tendency until now has been to construct dams on impermeable substrates – perhaps the time has come to plan in favour of accentuating infiltration, rather than preventing it.

1 - Mangion, J. (1994)

Extensive pumping of aquifers around the Tablas de Daimiel in Spain threatens the integrity of the wetland.



F. Marquez / Bios

The UN Development Programme reported in 1993 that "Gaza's aquifer is being severely overexploited and salinated to the extent that wells are going out of operation and water is becoming unpalatable and in certain areas even unusable for irrigation"³.

table in the coastal aquifer, which provides 20 per cent of the country's water, has sunk from around 5 metres above sea level to, in places, below sea level. As sea-water rushes in, salt concentrations have risen to 150 parts per million, with 10 per cent of wells exceeding 250 parts per million (the limit for normal agriculture), and 50 per cent likely to exceed this level within 25 years, according to the Israeli Ministry of the Environment¹.

Many wells have been shut. Researchers at the Hebrew University in Jerusalem say that the invasion of salt water is destroying the honeycomb structure of the rocks themselves, damaging permanently the aquifer's capacity to hold water².

Israel's coastal aquifer extends beneath Gaza. Here groundwaters are already being overpumped by two-thirds, even though the area has the lowest per capita water consumption in the region.

Deprived of the waters of the River Jordan, Amman, the capital of Jordan, has turned ever more to underground water. Water tables beneath the city declined by 3 metres a year during the 1980s. Joyce Starr of the Global Water Summit Initiative estimates that "Israel, the West Bank, Gaza and Jordan are facing a combined water deficit of at least 300-400 million cubic metres per year".

The problems of water resource use in this sensitive region may be the shape of things to come in other parts of the Mediterranean if water demand continues to grow.

1 - Gabbay, S. (1994)

2 - Nativ, R. (1988)

3 - Anonymous, *World Water Journal*, (1993)

Siltation cycles disrupted

Many reservoirs are far from being permanent sources of water and hydroelectric power. Their Achilles heel is the build-up of silt behind the dam.

All rivers carry silt, eroded from the hillsides through which they have flowed. As their flow slackens on entering a reservoir, they deposit the silt, slowly taking over the space meant for storage of water. Turbines may ultimately become clogged.

Careful management of the reservoir – such as allowing the heavily silt-laden first flood to pass through without slowing – can help prolong the reservoir's life. Afforestation and other measures to reduce soil erosion will also help. Ultimately, however, most reservoirs will silt up – the only question is, how quickly.

In Morocco, some 800 million cubic metres of the country's reservoir capacity, 8 per cent of the total, had been lost to siltation* by 1990. Three reservoirs had lost more than half their capacity. Algerian dams had lost 11 per cent of their capacity by 1990, a figure predicted to rise to 24 per cent by 2010. A study of Tunisian reservoirs found that silt reduces their capacity by 1 to 2.5 per cent per year¹.



Flash floods in arid catchments can turn river brown with sediment. Morocco.

1 - Jellali, M. & A. Jebali (1994)



By capturing silt, dams also prevent its movement downstream. On floodplains and river deltas, silt is a life-giving resource providing fertility for soils and providing new material to maintain coastal features, such as deltas, sand banks and lagoons. Lose the silt and the features will be eroded away and salt-waters will invade.

This is already happening on the Nile, following the construction of the Aswan dam. The story is the same on the Ebro in Spain. Since the Mequinenza dam was closed in 1972, the amount of the river's silt that reaches its delta has fallen from 20 million tonnes a year to just 3 million. The delta, which had until then been expanding, began a retreat of up to 50 metres a year.

Silt in the Nile

For thousands of years, the silt load brought down by the Nile has been vital to the creation of its delta and the fertility of soils throughout its valley. The Nile brings down around 130 million tonnes of silt in its muddy flood. Before the construction of the Aswan dam in the 1960s, between 10 and 15 million tonnes ended up smeared onto the Nile floodplain and its delta in annual layers about a millimetre thick. But since 1964, little silt has passed the dam.

It will be hundreds of years before the capacity of the reservoir itself is seriously reduced. But the reduction in silt load downstream could prove ultimately fatal to the Nile delta, which makes up two-thirds of Egypt's farmland. According to researchers from the Smithsonian Institute in Washington DC, the delta faces "widespread erosion"¹.

Since the completion of the High Aswan, the delta's northern coast no longer receives annual

supplies of new silt to counteract the destruction caused by marine waves and currents. As a result, coastal defences built in the 1940s have been overwhelmed. The former village of Borg-el-Borellos, once at the mouth of one of the main river channels through the delta, is now 2 kilometres out to sea.

Nile sediments that escaped the delta and reached the sea once washed eastwards along the coast. They maintained the sand bars that lie in front of the delta's large lagoons. Now the bars protecting Lakes Manzalla and Burullus are eroding and face collapse. These lagoons account for about a quarter of all the surviving coastal wetland in the Mediterranean. If they disappeared, the sea-waters would invade, flooding low-lying delta farmland and filling aquifers with sea-water. All this is made increasingly likely by the prospect of sea-level rise due to global warming.

¹ - Stanley, D.J. & A.G. Warne (1993)

Impacts of water abstraction on wetland ecosystems

Wetlands rely on river flows of water and silt and high water tables to sustain their unique hydrology and profuse wildlife. Any disruption to these sources and flows can have serious consequences.

Typical is the Doñana wetland, on the delta of the River Guadalquivir south of Seville in Spain, which is rapidly drying out. There are 30 dams upstream on the River Guadalquivir. Local pumping for irrigation extracts more than 50 million cubic metres a year from beneath the wetland. Together the dams and pumps are reducing the water table in the wetland by up to 50 centimetres a year in places. Computer forecasts predict that the irrigation will desiccate much of the park, draw salty sea-water further under the park and reduce river flows onto the marshes.

The Doñana wetland is home to more than 200 bird species, over half Europe's total, include such rare specimens as the griffon vulture (*Gyps fulvus*), marbled teal (*Marmaronetta angustirostris*) and the Andalusian hemipode (*Turnix sylvatica*), a quail-like bird almost extinct in Europe. Bird numbers have dwindled drastically in recent years.

According to the country's national hydrological plans, Spain has lost 400 square kilometres of wetlands in recent years, three-quarters of which were connected to aquifers. Thus it seems that the majority of its wetland loss can be attributed to the emptying of aquifers for water supply³⁴.

Environmentalists claim that the River Acheloos diversion project in Greece could destroy the Mesolongi, an internationally important wetland on the coast of the Ionian Sea at the mouth of the river, which is protected under the EU Birds Directive.

The Mesolongi covers more than 600 square kilometres and contains two of the largest surviving lagoons in the Mediterranean region. Its lagoons, salt marshes, mudflats and woodland attract thousands of waterfowl each winter, including the globally endangered Dalmatian pelican (*Pelecanus crispus*) and slender-billed curlew (*Numenius tenuirostris*). The wetland also has important but declining commercial fisheries. The wetland is now in retreat following the construction of a new 100-metre high dam to supply Athens on the River Evros, its other main source of water.

Where river water is diverted into another watershed, the mixing of water may create its own problems. New species may be introduced into the receiving river, and chemical and flow characteristics may be changed. All can have far-reaching and largely unpredictable consequences for the receiving river and any downstream wetlands.

The Acheloos diversion plan, which could attract EU funding, has become a cause celebre, contested by environmentalists in the Greek and European courts and the subject of repeated reviews by Brussels officials.

A complex dispute has developed over how much water would be extracted from the Acheloos and its precise impact on the Mesolongi wetland. A Greek environment impact assessment published in 1989 concluded that the river's average flow was 5 cubic kilometres a year and the diversion would remove 20 per cent of that flow. Greek hydrologists said that there is no proven connection between the Acheloos and the Mesolongi wetlands.

This view was contradicted by British hydrologist Ted Hollis, brought in by the international Ramsar Convention. He argued that average flows in the late 1980s were below 3 cubic kilometres and that more than 60 per cent of the river's flow would be diverted during dry years. Though precise data was lacking on the links between the river and the wetland, he said, "it is unlikely that the river is not a major source of freshwater for the wetlands. The river appears to be in hydraulic contact with the underground water table along most of its channel".



The Acheloos river diversion plan.
Source : Pierre Heurteaux

Conflicts and change

Pressures to maximise water resources for human use are creating an increasing threat to natural ecosystems based on water, notably wetlands. In addition, supply of clean water to both humans and natural systems may be threatened by pollution. There is an urgent need to find a balance between the use of water resources, water quality and the maintenance of wetland functions.

Lake Ichkeul in Tunisia was formerly a fresh/brackish lake system with high biodiversity. Three dams constructed since 1984 have cut off most of the freshwater supply to the lake, raising salinity to above that of sea-water with catastrophic effect on the hundreds of thousands of wintering and migratory waterfowl and on the important fishery.



H. Miles

European Union approach to wetlands

The European Union places a particular value on wetland systems for their multiple benefits to society and their value as natural habitats. The Communication from the Commission to the Council and the European Parliament on "The Wise use and conservation of wetlands"¹ provides a first regional policy framework for integrating wetland concerns into wider water-use policies.

The European Council "Habitats Directive"² includes a range of wetland systems (including Mediterranean lagoons) in its list of

habitats for priority protection. More importantly it includes the obligation to undertake an environmental impact assessment for activities planned outside the site, but which are likely to have an impact on the protected habitat. This opens the door to increased consultation when upstream water management projects are likely to impinge on downstream habitats.

These measures indicate an increasing trend towards integrating development proposals with environmental concerns in order to achieve sustainable development.

1 - COM (95) 189 final
2 - 92/43/EEC



Choices

The conventional choice of water engineers and politicians to the growing water crisis in the region is: more of the same. More dams, more boreholes, more pipelines and tunnels and canals. There are clear limits to this approach, as the water exploitation index shows.

But long before the index reaches 100 per cent, the cost of extra water escalates steeply, both in financial terms and in ecological damage.

While short-term costs are readily appreciated, ecological requirements are less easy to quantify. So too is the long-term impact on sustainability, through the destruction of natural water stores such as wells and aquifers.

Untreated sewage contaminates potential water resources. Po valley, Italy.

The conventional route

Most water-supply policies in the region remain geared primarily to conventional solutions to water shortages. The pace of planned change is currently greatest in North Africa.

Algeria believes it will need another 5.5 cubic kilometres of water a year by 2010, half for irrigation and half for domestic and industrial uses. It plans 50 more dams and 10 diversion canals, and will tap non-renewable fossil water beneath the Sahara¹.

Tunisia expects by 2000 to be using 90 per cent of its surface water in the north of the country, and all of its groundwater. It will do this by building new large dams and developing a complex network of pipes and canals to transfer water between river basins. It will have the capacity to transfer through this network more than half of the water captured behind dams in the northern region.

Morocco intends to double the proportion of its river flow that is controlled by dams, and extract much more groundwater. It will build 60 large dams, sink boreholes with a total length of 100 kilometres and build 280 kilometres of water-transfer structures.

All this will be very expensive for developing countries. Water infrastructure already accounts for more than 20 per cent of public-sector investment in Morocco and Tunisia and 12 per cent in Algeria.



Floods can seriously damage badly sited infrastructures.

1 - Jellali, M. & A. Jebali (1994)

Some European countries face scarcely less serious drains on their finances if they are to meet their water demand by conventional means.

Spain, spurred by five years of serious drought, currently has the most ambitious plans, founded on more dams and dramatic schemes for trunking water round the country – from the wet north and west to the parched south and east. Such plans, as we have seen, are coming under assault, both on environmental grounds and because they appear to “steal” water from some regions in order to benefit others.

Spain's hydrological plan

In 1993, in the midst of a debilitating drought, Spain's national director-general for water, Adrian Baltanas, predicted that within 20 years his country would need 45 per cent more water in its cities, 30 per cent more for industry and 14 per cent more for agriculture. The government proposed a US\$ 30-billion national hydrological plan, with around 200 large new dams and massive new water transfers to move water from the wet north and west to the dry south and east.

The plan is currently a series of arrows on maps and rough financial projections. A central proposal, on which most of the rest hinges, is to turn the River Ebro in the north of the country into a national water highway. Water would be pumped from

ivers that flow north and west into the Atlantic and poured into the headwaters of the Ebro. Then, downstream near the river's mouth, this extra water would be pumped out again and taken south to the provinces of Segura and Jucar, and to the fast-growing metropolis of Barcelona.

Additionally, some of the water in southwest flowing rivers such as the Tagus would be dammed and also sent south into the headwaters of rivers such as the Segura. Ornithologists and hydrologists at BirdLife International estimate that Spain's National Hydrological Plan could damage more than 100 wetland bird habitats that are, in theory, protected under EU directives. Such ecological losses must be weighed beside the socio-economic costs of any policy based on total conservation¹.

¹ - Anonymous, *Plan Hidrológico Nacional Memoria* (1993)

Stretching the limits

The evidence from other places with already severely constricted water supplies is that such “supply side” solutions are possible only at greatly escalating financial or ecological cost.

Israel uses all the water available to it, including that accessed from land gained after wars with its neighbours and from overpumping aquifers. Exploitation of every last drop of water comes at a price. Israel uses a fifth of the nation's electricity on pumping water round the National Water Carrier. Its water policies have dried up rivers and drained wetlands. They have also reduced the country's long-term water resources, and those of the future Palestinian state, through overpumping of vital aquifers. And for more than two decades, access to water has been a major stumbling block to peace with its neighbours, threatening the future of the state itself¹.

Many other countries are beginning to tell similar stories. Cyprus has depleted its south-flowing rivers in pursuit of greater water supply. Malta has damaged its groundwater so seriously that it has had to switch to much more expensive desalination.

Libya is planning to spend more than US\$ 20 billion on tapping and transporting non-renewable water from beneath the Sahara to replace coastal aquifers, such as the Jefara, that have been destroyed by overpumping.



J. F. Murtza / Bios

Maintenance of water quality is an increasingly sensitive issue in the Mediterranean.

1 - Nativ, R. (1988)

Looking for new and novel water sources

Not surprisingly, there is an increasing interest in developing new technologies to exploit hitherto ignored sources of water, from brackish groundwaters to desalination.

Old ways

The World Bank is currently investigating Jordanian proposals to build a 270-kilometre canal from the Red Sea to the Dead Sea, which is 400 metres lower. The idea is to use the height difference to generate hydroelectricity to power much larger desalination works. The desalinated water could in turn irrigate large areas of desert either side of the border. However, the World Bank estimates the scheme would cost some US\$ 3 billion to build. The price of the water would probably be too high for agricultural use and industry and tourist developments in the area are more likely customers.

Ancient techniques for collecting water in the desert may hold some useful lessons. One such is rainwater harvesting* of the kind used by the Nabateans in the Negev desert. Israeli researchers have renovated Nabatean irrigation systems, and have used the system of rainwater harvesting more widely to channel water to plantations of trees in the desert. Much of this water is otherwise lost through evaporation, or percolates into saline aquifers.

Another ancient middle-eastern method undergoing a tentative revival are qanats, tunnels dug into hillsides to abstract groundwaters by gravity flow. Often in the Mediterranean region, such water otherwise disappears into the sea from underwater springs¹. Albania has recently announced plans to open a 5-kilometre tunnel into limestone hills to enlarge the flow of the Gura-Bardha spring. The water will generate hydroelectric power and help supply the capital, Tirana.

Desalination

Desalination of sea-water offers the potential of almost unlimited fresh water in coastal areas. The most usual desalination technology, reverse osmosis, essentially removes the salt by passing the water through complex filters. But, like other methods, it requires large amounts of electricity. So it is very expensive.

Libya desalinates around 100 million cubic metres of water a year from 17 plants. And there are small plants on a number of Greek islands, such as Syros in the Cyclades, and Nissiros in the Sporades.

Malta is the only country in the world without abundant cheap oil supplies for energy to opt for large-scale desalination. After degrading its major groundwaters, it has had little choice. Desalination at the country's five reverse osmosis* plants supplies more than half its water and consumes 15 per cent of the country's electricity. Malta's desalinated water costs more than one US dollar per cubic metre, three to five times the cost of tapping groundwaters².

1 - Nativ, R. & A. Issar (1988)

2 - Riolo, A. (1990)



Brackish waters

Beneath many of the most arid parts of the region are large supplies of brackish groundwaters. Most are "fossil" waters, and so their use is not sustainable in the long run. Nonetheless, they could be desalinated. Already Israel desalinates 18 million cubic metres of brackish groundwaters a year, and its current national water plan envisages increasing this to 250 million cubic metres annually within three years.

A cheaper idea may be to develop salt-tolerant crops that can be irrigated with this water, either neat or diluted with fresher supplies. Israel uses brackish groundwaters, pumped from beneath the Negev, to irrigate crops such as olives, figs, dates, celery and tomatoes. Its scientists are attempting to bioengineer these crops, inserting genes from other plants, to improve their tolerance to salt.

In-stream water use

Some uses of rivers are described as "in-stream" uses. The generation of hydroelectricity through turbines usually takes place at large dams which store water, releasing it according to electricity demand. Often such dams are also used to supply water to towns and irrigation schemes, and for risk management. Then, the operating rules require a compromise between the competing water requirements. In any event the storage and release will upset the hydrology of the river, with potential impacts on both natural and human users downstream.

In southern Europe, rivers are widely used to generate hydroelectricity. The Rhone in particular has been turned into a staircase of dams to provide electricity. Other rivers that

flow out of the Alps into Italy are similarly utilised, as are many rivers in former Yugoslavia, and the Acheloos in Greece. In Turkey, more than 30 per cent of its electricity is generated by hydroelectric dams¹. With the exception of Egypt's plant at the Aswan dam, and some Moroccan dams, hydroelectricity generation on rivers is very low in North Africa.

A second use is to provide water for cooling towers at nuclear and conventional power stations built beside the river. The water is used in very large quantities. It is returned to the river quickly but warmed, causing local ecological problems. A further "in-stream" use often ignored by water planners is the ecological functions of the water in the river and wetlands.

The alternative: reducing demand

Despite such innovations, some countries are beginning to switch their water policies towards cutting demand. Again technology can be the key.

New computer systems can monitor flow and pressure, can detect leaks and can prevent water wastage, whether in industrial plant or urban water-distribution networks. Economists also believe that savings can be encouraged by adopting a more market-oriented approach to water, using the price incentive to encourage savings. While not reducing the cost of supplying water, it will increase the services provided by the water put into supply.

Reducing leaks and evaporation

Leakage and theft of water are a constant and worsening drain on many water-supply systems. Most countries have only a vague idea of how much water is lost in this way. Few have installed the complex systems necessary to monitor the flow of water through pipes. Moreover leakages tend to worsen as systems age and pipes crack.

The World Bank warns that "unaccounted-for water" can reach as high as 60 per cent in urban delivery systems, through leaks and theft¹. A survey of 17 Greek towns at the start of the decade found average water losses of 45 per cent. In 1989, Damascus was without water most nights while an estimated 30 per cent of its resources disappeared through leaks in the distribution network.

In Malta, where 65 per cent of the water put into the country's distribution network is now produced by desalination, half of that water in 1990 was not paid for².

Plugging leaks is now a major priority in Malta and Cyprus. In Morocco, a programme of improving water mains to urban centres has saved an estimated 450 litres per second – enough to supply a city of 120,000 people³. Leaks from water mains in Israel have been cut to an estimated 10 per cent.

There is also huge potential to reduce water demand in homes, offices and factories. Israel has pioneered water-saving devices such as low-flow taps and variable-flow toilet cisterns, which are compulsory in new buildings.

Public education is a major element in any programme to reduce wastage of water. Israel's "Every drop counts" programme brought substantial savings in urban water use at the height of water scarcity in the early 1990s. Despite a 25 per cent increase in population, Jerusalem used less water in 1991 than in 1983⁴. Other countries have taken similar steps. Dramatic "Greece is running dry" stickers appeared in every hotel room in Athens in 1993.

1 - Anonymous, *World Bank*, (1994)
2 - Mangion, J. (1994)

3 - Jellali, M. & A. Jebali (1994)
4 - Daniell, Z. (1993)



Large amounts of water are also lost from reservoirs and long-distance aqueducts, through both leaks and evaporation.

According to Alicata and De Pietro of the University of Catania, Sicily suffers “enormous losses along defective conduits, waste and theft”, resulting in an unusually high rate of water use on the island. Several countries, including Algeria and Morocco, have begun projects to reduce these losses by lining aqueducts. The costs are high, but justified when water becomes scarce. Some water authorities regard such losses as inevitable, however: for example, Sicily’s current ambitious water plan assumes a continued loss of 50 per cent of water along distribution canals¹.

With evaporation rates in North Africa approaching 2 metres a year, losses from the surface of large reservoirs can be great. Lake Nasser, behind the Aswan dam, loses about 14 per cent of its water each year from evaporation. There is little that can be done about such losses, unless the reservoir itself is emptied.

British colonial engineers at the beginning of the century had already suggested that, because of the evaporation rates in Egypt, the country’s water would best be stored far upstream in the headwaters of the Nile in Ethiopia and Uganda, where the cooler and cloudier climate would substantially reduce evaporation.

Efficient irrigation

With two-thirds of the captured water in the Mediterranean region used to irrigate fields, there is great potential to save water. In traditional irrigation, water is flooded into fields. Much of it evaporates in the sun or seeps into groundwaters. Only a small proportion is taken up by the roots of plants.

In certain situations drip irrigation has the added advantage of reducing the amount of salt brought onto fields. This salt is often left behind, eventually reaching concentrations in soil that are high enough to be toxic to plants.

In much of the region, spraying of water is now standard practice, bringing some savings. But far more efficient is drip irrigation*, in which water is distributed through plastic pipes containing small holes. Water drips through the holes onto the soil, delivering small amounts of water right to the roots of plants.

When the flow of water in the pipes is controlled by sensors linked to computers, and irrigation takes place at night when evaporation is reduced, the proportion of the water reaching plant roots through drip irrigation can be as high as 95 per cent. The capital costs of such systems is high, but the savings in water are substantial. A typical system will reduce the amount of water required to grow crops by between 30 per cent and 50 per cent.

1 - Alicata, P. & R. De Pietro (1994)

More than half of all Israel's irrigated fields now use drip irrigation or similar techniques, known collectively as micro-irrigation. Jordan and Cyprus have also turned many of their fields over to drip irrigation. But other countries are far behind. Morocco, for instance, has only about 15,000 hectares (or 3 per cent of its irrigated land) under micro-irrigation.

Water conservation has massive potential to increase the use that can be made of existing water supplies, postponing by decades the day when countries run out of conventional water resources.

Recycling

The EC Directive (91/271/CEE) on waste-water treatment calls on all member states to establish sewage treatment plans for all towns with more than 15,000 inhabitants by December 2000.

Another approach is to recycle water, both from cities and farms. Morocco and Egypt already reuse substantial amounts of water, often contaminated with sewage, for irrigation of fields. Farmers even divert water from the main sewer from Cairo, the Bahr el Bakr drain, to irrigate food crops.

However, the use of untreated sewage raises health fears. Dangerous diseases may be passed on via food crops. Israelis still remember a cholera outbreak in Jerusalem in 1970, which was traced to the illegal irrigation of salad crops with raw sewage¹.

Provided treatment is adequate, there is great potential in water recycling. It provides more clean water and yields an environmental by-product in cleaner rivers. Tunisia and Libya each recycle about 100 million cubic metres of sewage, after purification. Algeria plans to do the same.

Israel is planning to reuse some two-thirds of its sewage – generally after rigorous treatment. Its current national water plan intends to boost supply from this source to 350 million cubic metres a year, representing an increase in the country's effective water supply of almost 20 per cent. The water will initially be used for irrigation, freeing more clean water for domestic use, but ultimately the country intends reusing treated sewage also for domestic use.



Defending water resources

Water resources require vigilant protection. This entails protecting the ecosystems from which waters flow. In mountain regions, where most rain falls, soils and vegetation, often combined with aquifers, store water much more cheaply than any dam.

Often the presence of forests on hill regions will also increase total rainfall – again more cheaply and effectively than “seeding” clouds to promote rainfall.

In addition, soil conservation, especially in small catchments, can dramatically reduce the amount of silt washing off hillsides and consuming the capacity of reservoirs.

Further downstream, wetlands can act as filters for pollution, again helping to safeguard supplies. Thus Israel is recreating the former Hula wetland on the River Jordan north of the Sea of Galilee. This region of lake and peat swamps once occupied 400 square kilometres, before being drained in the 1950s. Besides resuming their ecological function as a haven for rare species, the reed beds will also provide a natural filter for nutrient pollution, preventing it from reaching the Sea of Galilee, the country’s prime water source¹. In a country with one of the most severe water shortages in the region, the principle that water can have an ecological function and that wetlands have value has been established.

The Moroccan government is using dams on the River Sous in an attempt to replenish the aquifer near Agadir. These aquifers were seriously overpumped during droughts in the 1980s. The water table fell in places by 40 metres. A dam in the river’s headwaters at Aoulouz, in the foothills of the Atlas mountains, is intended to hold back flash floods after the occasional violent rains. The dam can hold roughly half the annual rainfall, and release it gradually, allowing more to percolate into the valley aquifer.

Framework of water policy

Traditional methods of water management have been based on cultural, religious and customary principles. But in recent decades many of these have been replaced by centralised decision-taking, usually in the hands of governments.

Many governments have nationalised water itself. Sometimes this was done under colonial rule. For instance, a Tunisian decree in 1885 stated that “all watercourses and their seepage areas and all varieties of spring form a part of the public domain”. More recently, independent governments have assumed control of natural resources in an effort to organise economic development.

Sometimes, centralisation has delivered the goods. A World Bank study of water in the Middle East and North Africa singled out Israel and Tunisia as examples of successful centralised management of water. But nationalisation has often resulted in the neglect of traditional water works and, equally important, traditional methods of protecting watersheds¹. The soils and forests of hillsides, once protected because they maintained local water supplies, have been left to deteriorate.

A review by the World Bank of its role in funding water projects over 40 years concluded that “institutional failure was the most frequent and persistent cause of poor performance”. The result was leaks in water mains that nobody was interested in plugging, poor maintenance and inefficient operation.

Centralised, often heavily subsidised, irrigation projects have proved not to be a catalyst for rational water planning – rather the reverse. They have led too often to widespread ecological deterioration, to the extent of destroying the resource itself.



Drainage of wetlands has not always led to the expected benefits. Menderes delta, Turkey.

M. Gunther / Bios

Bring on the market

Water around the world has, until recently, been regarded as a free resource – a birthright. Charging for water – even expensively delivered water – has often been opposed.

Certainly market pricing, with the suggestion that some people may not be able to afford water, has been opposed on ethical (and sometimes religious) grounds. But that attitude is changing.

Typical is the experience of Turkey. Until recently, irrigators and other water users were expected to pay the running costs of their water supply, but only a proportion of the often considerable capital costs. This arrangement created a disincentive to maintenance of existing facilities. It would be often cheaper for farmers to abandon maintenance and wait for the state to build afresh. But since 1988, Turkey has adopted a tougher policy, recovering more of the costs of its water projects and “disengaging” the state from water resources management¹.

A new model is emerging across the region, in which private enterprise and pricing based on the real cost of providing water are regarded as the best way to improve efficiency and encourage conservation of resources.



The right of access to clean drinking water is essential
- but who should pay ?

1 - Tekinel, O. & J. Doorenbos (1995)

Only market-based water pricing, the argument goes, will lead to rational use of water. Such policies are widely backed by Western aid agencies, including the World Bank. In the run-up to the Earth Summit in Rio de Janeiro in 1992, a UN conference of water scientists and policy-makers in Dublin took the same view. "The past failure to recognise water as an economic good has led to wasteful and economically damaging uses of the resources," it said. "Managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources."

Water pricing in Tunisia

The search for water savings has led some countries, such as Tunisia, to use a policy of gradual tariffs, hence penalising large water consumers. This policy has been developed by the SONEDE (société nationale d'exploitation et de distribution des eaux) since 1974 as a basis for reducing wastage. The different water users include households, industry and tourism, which represent respectively 64 per cent, 11 per cent and 6 per cent of water use. The tariff system has led to a decrease in demand in urban sectors of between 3 and 6 per cent, and 15 per cent of households have dropped into a lower consumption bracket. Evidence from the tourism and industrial sectors points also to reduced wastage.

One perverse effect of the measures has been to push large water users into developing their own private water supplies directly from rivers or groundwater – sources not covered by the current pricing code. These industries therefore operate outside the legal and pricing framework for water use and are difficult to monitor and control.

Pricing strategy is an integral part of the national strategy for water economy in Tunisia and applies equally to irrigation water which is more highly priced during periods of high consumption. Tariffs vary according to the region, but aim to recoup between 35 and 80 per cent of the exploitation and maintenance costs. A rise of 15 per cent in prices is foreseen if this allows farmers to maintain their revenues and continue to produce irrigated cash crops. In practice, however, recovery of irrigation fees is difficult.

The final objective of the water tariff system is to fully recover waste-water treatment costs, while government continues to subsidise the costs of supply. At present 60 per cent of expenses are covered. This approach is not sufficient to tax adequately those with their own private supply system and Tunisian experts stress that only a combination of institutional measures, sound technical means and good education can ensure the success of the dissuasive tariff policy¹.



The price mechanism is increasingly being used to manage water crises. During the drought of 1993, for instance, the city authorities in Athens raised prices to the extent that some people at certain times paid 20 times more than usual.

Increasingly, pricing is being used to reduce water demand during water shortages and to encourage farmers to invest in water conservation technology, such as drip irrigation. If farmers have to pay the true cost of their water, it will pay them to invest in water-efficient technology.

But few countries yet charge real prices for water. A World Bank study found the long-run cost of water for city dwellers in Algeria was US\$ 0.52 per cubic metre, while the average water charge was US\$ 0.12. In irrigation the difference was even more striking: US\$ 0.32 compared to US\$ 0.02.

In Morocco in 1992, irrigation water charges were likewise around US\$ 0.02 per cubic metre, a fraction of the real cost. In Egypt, urban customers pay only 15 per cent of the cost of their water.

Local control

While water markets are a sometimes attractive alternative to centralised mismanagement, it is worth remembering that much of the region's water remains in local hands, especially in rural areas. Many springs, wells and even river abstraction points in rural areas are still controlled locally, often through village committees.

In Turkey, for instance, with the exception of a few major sources, municipalities and village councils control water supplies. In much of North Africa, customary systems of water management, usually reinforced by Islamic law, persist. Detailed local knowledge usually ensures that the complex interactions between surface and underground water are well understood, in a way often ignored by modern centrally-managed water projects.

Many are also much more conservative, designed specifically to protect against irregular droughts, for instance.

Often such systems incorporate ancient water collecting techniques, such as water harvesting and qanats. Interestingly, some of these systems generate their own local water markets. For instance, most qanats are still owned by consortia of landowners, descendants of those who paid for the digging of the tunnels.

In such circumstances, where water is privately owned, or where farmers have excess water from public supplies, local water markets can develop. In Greek Cypriot villages west of Nicosia, farmers sell excess water from qanats during most summers.

Under US water law, right to water is allocated according to the “first come first served” principle. In the past, farmers have used this to claim their water entitlements. However, during the 1990s, in a series of test cases, environment bodies successfully claimed that in some circumstances, nature could claim to be the first-comer.

Some people would like to see the opening up of water markets on a wider scale. This, they argue, could unlock water resources jealously hoarded by governments. In the Levant, Lebanon’s water could be bought, just as Israel has recently agreed to buy some of Turkey’s spare water.

It could also be used to encourage conservation of water ecosystems. In the US, notably California, this system has been developed so that government-funded conservation agencies can buy up water rights in order to protect threatened rivers and wetlands.

Such ideas have yet to be tried out in the Mediterranean region, but they offer one mechanism for deciding between ecological and human rights to scarce water.

Examples of water prices for selected countries (1989)

COUNTRIES	DRINKING WATER distributed to urban areas (US\$/m ³)		IRRIGATION WATER (US\$/m ³)	
	Cost	Price*	Cost	Price*
TURKEY ¹ (Ankara and other urban areas)	0.65	0.47		0.004
CYPRUS ¹ (Nicosia, Larnaca and Limassol)	0.71	0.58	0.69	0.15
SYRIA ¹ (Whole country)		0.29		
EGYPT ^{1,2} (urban areas)	0.26	0.05		
TUNISIA ^{1,2} (Whole country)	0.44	0.81		
MAROC ^{1,2} (Casablanca and Doukala)	0.5	0.33	0.46	0.04

* Average tariffs or rents for irrigation
N. B. Some data include transport costs while other consider only treatment costs. Data are approximative.

1 - Margat, J. (1994)
2 - Blue Plan



Conclusion

The conservation of wetlands and the ecosystem functions of river systems cannot be considered in the absence of a global view of water demand and supply. The pursuit of environmental protection and sustainability for freshwater resources is requiring major shifts in policy, some already taken, but others barely contemplated yet.

Malta, driven to the point of total reliance on expensive desalination, is adopting new policies to conserve and revive its degraded groundwaters, and to control leaks and other inefficiencies in its distribution system.

Water-stressed Tunisia may contemplate whether it can really double the area of farmland under irrigation during the 1990s. Greece, likewise, is likely to reassess the water requirements of its farmers and cities in the east of the country, which demand diversion of water from west-flowing rivers such as the Acheloos and Evros. It may need to decide whether investment in water conservation is a cheaper, more sustainable and more ecologically sound option than continued investment in supply-side solutions.

The beauty of the Mediterranean coast attracts water-consuming tourists when water resources are scarest.



Spain may have similar thoughts for the south of the country. It has the highest per capita consumption of water in Europe, but the lowest rainfall. Much of the water goes to irrigate crops that are in surplus within the European Union. However great its investment in major dams and water transfer schemes, it may not want to delay demand-side management; especially if it also wishes to preserve its surviving wetlands from drying out as water tables fall and ever more water diversions are built.

Morocco faces the continued sedimentation* of its reservoirs. With the best dam sites filled with silt, every succeeding replacement dam will cost more and secure less water. Reducing the siltation of its reservoirs is likely to require radical new soil conservation policies.

Water resource needs and wetlands conservation are likely to need addressing alongside the wider policy issues. Agricultural policies have a pivotal effect. Salem¹ estimates that Libyan water demand will double within 35 years as a result of population growth and rising living standards. But if the country continues its policy of self-sufficiency in food, through irrigating more and more land, then water demand could double within 10 years.

At the end of the day, despite all measures to maximise water resources and to conserve and recycle water, many countries may have to abandon their ambitions for food self-sufficiency. Israeli hydrologist Arnon Soffer, an adviser to his country's foreign affairs department, says that Israel "must begin to allocate water according to economic rather than political priorities". Perhaps Israel should make computers rather than grow oranges, he suggests, and concede the spare water to Jordan which "has even greater water problems than us, and has no such options".

It is clear that the old notions of water as a resource available freely to those who tap it are over. Equally clearly, old notions of hydrology which deem water in rivers as "wasted" must be rethought. The model of a river as little more than a pipeline is outdated.

Water must now be regarded as a limited, often scarce, resource that must be shared in the context of policies for nature conservation and protection of other features of the water cycle. Not all of nature's water can be corralled for human use. The complex interchanges within a river basin – between rivers and groundwaters and wetlands – must be respected. So too must the requirements of the ecosystems within that basin. This requires much more sophisticated analysis of hydrological and ecological systems and their evolution over time.

1 - Salem O.M. (1992)

Wetlands in arid areas are vital staging posts migratory waterfowl.
Oued Massa, Morocco.



M. Gunther / Bios

Water must also be viewed in a social context. The paradox of water owned by the state on behalf of the people was that it too often brought inefficient use, ecological indifference and social inequity in the use of water and the sacrifice of long-term sustainability of the resource.

The most efficient available mechanism for ensuring efficient use of water may be some kind of modified market mechanism. But that will require new controls to ensure equitable distribution of water, both among human needs and between human and ecosystem requirements.

The market will not automatically make correct choices. Real policy choices still have to be made to protect water resources and ecosystems for future generations. Often they will have to be set in an international political context. In such circumstances, there must be serious efforts to ensure that data are founded on real measurements rather than political rhetoric or horse-trading. Accurate and unbiased hydrological data are especially important in a region such as the Levant, where water is a continuing source of dispute and, on occasion, armed conflict.

Moreover, agreements on international rivers will often need to cover a wide range of development and land-use issues, as well as hydrology. Recent tentative steps towards an agreement on sustainable development of the Alps, a major international watershed, could show the way.

Unchecked, the market may deplete groundwaters, pollute drinking water, dry up wetlands, undermine fisheries, sacrifice irrigation for the benefits of higher-value urban water uses. The market can be no more than a tool to achieve wider aims of sustainable development and ecological protection. Those aims have still to be set.

Such agreements should aim to be robust against change, whether political, economic and social, or hydrological and climatic. Climate change is likely to be an inevitable but unquantifiable element of water management in the 21st century. Global warming may place coastal wetlands under severe threat through rising sea levels, and so will require extra protection against inland hydrological threats.

Fresh water, because it is essential to life on Earth, and because it flows through ecosystems and interacts freely with land, atmosphere and oceans, requires integrated management more than any other resource.

River basins must be seen as a whole, with headwater activities in harmony with downstream needs. The unquantified benefits of water “lost” in wetlands or other natural ecosystems need to be better understood. Wetlands, for instance, can purify some organic pollutants in water, including sewage, as well as nurturing fisheries, buffering against saline intrusion, providing free water storage, interacting with aquifers, moderating changes in seasonal flows in rivers and protecting against floods and droughts. These free services may be best preserved through improving the efficiency of water transfer and consumption or through decreasing demand, rather than constantly searching to bring new water resources on tap when crises occur.

In particular, the feedback mechanisms between the wider water cycle and water resources for direct human use need to be understood: how aquifers interact with rivers and wetlands, and how ecosystems in rivers, soils and wetlands help to maintain hydrological systems.

Forests fires denude catchments and promote silt-laden run off.
Corsica.



M. Mastracchi / Panda photo / Bios

Conclusion

A sustainable water use policy must also address pollution issues.



J. B. Dumond / Bios

A river with stable soils and trees in its watershed and secure aquifers and wetlands in its floodplain will be more likely to flow right through the year and during droughts than one in which the forests are chopped down, aquifers overpumped, wetlands desiccated and soils erode.

All theoretical water resources cannot be used by man as minimum flows are essential for maintaining environmental quality. The level at which this minimum is established is both a technical and a political issue and a balance must be found.

Sustainable development for the Mediterranean region may well hinge upon the strategies developed for improving long-term management of this complex and dynamic system.



Glossary

Aquifer : pourous rock containing water.

Artesian aquifer : an aquifer that delivers water to the surface under pressure from below.

Brackish : slightly salty.

Chott : seasonal salt lake.

Cloud seeding : rain-making by adding particles to clouds as nuclei around which water will condense, forming droplets large enough to fall as rain.

Desalination : technology for turning salty water into freshwater.

Drip irrigation : method of applying irrigation water close to the roots of the plant, so saving water.

Evapotranspiration : return of water to the atmosphere by evaporation and from the leaves of the plants (transpiration).

Fossil water : old water within aquifer that, if removed, will not be replaced by new water from the surface.

Groundwater : water stored within an aquifer.

Overpumping : abstracting more water from an aquifer than is replaced.

Qanats : long tunnels dug into hillsides that tap aquifers, delivering water by gravity.

Reverse osmosis : method of desalination.

Salt water (or sea-water) intrusion : the invasion of freshwater reserves in coastal aquifers by sea water, often following overpumping.

Sebkhet : semi-permanent salt lake.

Sedimentation/siltation : buildup of sediment/silt from river where it is unwanted (eg. on the bottom of a reservoir).

Water cycle : circulation of water from rainfall, runoff to oceans, evaporation, formation of clouds and new rainfall.

Water exploitation index : measure of water used by human activity as a percentage of total renewable water resource.

Water harvesting : collecting surface drainage water by training it into reservoirs or directly to soils, often using low walls.

Water table : level within porous rocks below which the rocks are saturated.

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The Station Biologique de la Tour du Valat was established in the Camargue (France) in 1954 by Dr. Luc Hoffmann as a private research institute, primarily for field ornithological studies. The 2500 ha estate is one of the few in the eastern Camargue on which extensive areas of near-natural landscapes have survived the post-war expansion of arable agriculture.

The scientific programme of the Station has evolved over the years, and has included programmes on the management of vegetation using domestic herbivores, fish ecology, optimal foraging strategies, behavioural studies, and migration and breeding success of colonial waterbirds.

This programme has provided the Station with a fundamental understanding of Mediterranean wetland ecology which can be applied to wetland management problems in the region.



The Blue Plan Regional Activity Centre for the Mediterranean (BP/RAC), established in Sophia Antipolis (France) is one of the centres of the Mediterranean Action Plan-UNEP. Its task is to analyse and evaluate current situations before exploring the possible evolutions of relationships between environment and development in the Mediterranean Basin, in order to provide relevant and reliable information to decision-makers for sustainable development strategies.

BP/RAC works in cooperation with a network of institutions, national observatories, experts and scientists counterparts in the Mediterranean countries and internationally.

Its work programme includes strategic studies (situations and perspectives) for the Mediterranean level and at local level within Coastal Management programmes and thematic environment/development synthesis (statistical synthesis, indicators sets, information briefs and institutional profiles).

From the outset, Blue Plan made water a priority subject within its systemic and prospective studies and published already a deepen analysis of this issue through its publication serie "*fascicules du Plan Bleu*".



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