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Drought in the Mediterranean: WWF Policy Proposals

A WWF Report, July 2006

© WWF-Canon / Roger Le Guen - Dried-up brackish swamp, Camargue, France

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1 Introduction

In the last few years, several regions in Europe have been affected by drought. The drought of 2005 was the worst for large parts of the continent but was especially bad in the Mediterranean region (see **figure 1**). In 2006, drought affects the major part of Spain and Portugal and large parts of the United Kingdom, Italy and France.

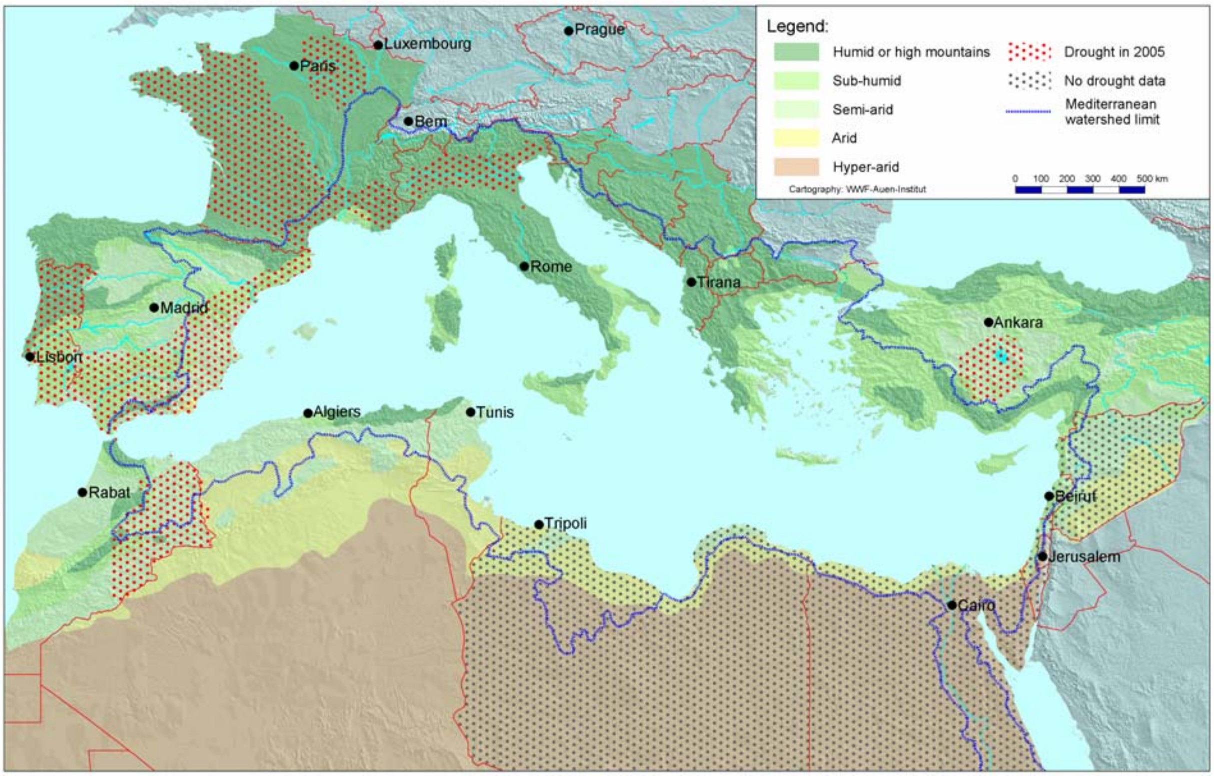


Figure 1: Drought areas of the Mediterranean region [70]

Droughts are estimated to become worse and more frequent in the light of global climate change. Therefore, essential shifts in policy are required to be prepared for drought events and prevent situations of chronic water scarcity.

Current management response however, calls for the building of more dams and desalinization plants and the drilling of more boreholes in order to guarantee water supply for an ever increasing demand. This results in an unsustainable over-exploitation of natural resources and ultimately these responses do not solve the problem.

This report intends to make clear the urgent need of good water management practices in the Mediterranean in light of increasing drought. It compiles key available data and gives an overview over the situation of Mediterranean countries concerning the water resource situation and trends. The report covers the Mediterranean as wide as possible yet may not always reflect the whole region due to limited data availability. Most data is taken from the countries where the WWF is active.

The different chapters will give general information further illustrated by country-specific data. In addition, case studies from different countries are presented to illustrate examples of good and bad water resources management.

WWF’s four key messages

1. Drought is a natural phenomenon and will appear more frequently.
2. If water is not managed wisely, both in rainy and in dry years, drought will become 'chronic' (water scarcity) and its impacts will increase
3. Key examples of unwise water management are the increased irrigation in agriculture due to subsidies in EU countries, while for non-EU countries the low efficiency in irrigation.
4. To avoid drought becoming chronic, governments have to engage in a three fold approach: manage demand, increase efficiency, and apply integrated and sustainable water management. Increasing water supply is not an option.

© WWF, M. Gunther **Drought leaves the land parched in Tunisia**

2 Definition of drought

2.1 Conceptual definition

Drought is a normal, recurrent feature of climate, although often erroneously considered an unexpected and extraordinary event. The origin of every drought is a reduced precipitation over an extended period, usually one season or more. As a consequence of climate change, rising temperatures and decreasing precipitation in many parts of the world are increasing the frequency and severity of drought events.

Drought is a natural hazard that differs from other events in that it has a slow onset, evolves over months or even years and affects a large spatial region. Its onset and conclusion, and the severity of drought are often difficult to determine [(1)]. Drought typically causes substantial economic, environmental, and social impacts in large regions or entire countries. It occurs in virtually all climatic zones, but the vulnerability of the area and the grade of impact vary significantly from one region to another [(2)].

	Natural regime	Influenced regime [1]
Temporal situation	Drought	Cyclical Deficit
Permanent situation	Aridity	Water Scarcity

Figure 2: Differentiation between drought and related terms [(3)]

Drought has to be differentiated from other terms related to situations of water deficit. It is a temporary aberration of natural variability. Nonetheless, usually 'droughts' in the Mediterranean region are technically 'cyclical water deficits' as the major part of the Mediterranean is strongly influenced by humans. In this sense, WWF uses the term 'drought' in this report as a synonym to 'cyclical deficit'. Aridity, in contrast, is a permanent characteristic of regions with low rainfall. Water scarcity is also a permanent characteristic but is a result of human water demand and activities (see **figure 2**).

Human activities such as over-exploitation of aquifers, loss of soil covers or vegetation due to inadequate land use may aggravate effects of drought. Both together may further accelerate processes of desertification. According to Art 1a) of the International Convention to Combat Desertification "desertification" means land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities [(56)].

2.2 Operational definitions

There are operational definitions that help to identify a drought's beginning, end, and degree of severity [(4)]. The various types of drought are listed below and their relations shown in **figure 3**.

Meteorological drought

Meteorological drought is defined on the basis of precipitation or the degree of dryness, in comparison to a normal or average amount of rainfall, and the duration of the dry period. Definitions of meteorological drought must be region-specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable. Hence, there is a huge variety of meteorological definitions according to different countries or regions.

Agricultural drought

Agricultural drought links various characteristics of meteorological drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapo-transpiration, soil-water deficits, reduced groundwater or reservoir levels, to name a few. Plant water demand depends on prevailing weather conditions, biological characteristics of the specific plant, the stage of growth, and the physical and biological properties of the soil.

Hydrological drought

Hydrological drought refers to a persistently low discharge and/or volume of water in streams and reservoirs, lasting months or years. Hydrological drought is a natural phenomenon, but it may be exacerbated by human activities. Hydrological droughts are usually related to meteorological droughts, and their recurrence interval varies accordingly. Changes in land use and land degradation can further

[1] Anthropogenic influence in terms of infrastructure, water use etc

affect the magnitude and frequency of hydrological droughts.

Socio-economic drought

Socio-economic definitions of drought associate the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought. It differs from the other types of drought in that its occurrence is influenced by human activities and depends on the processes of supply and demand. Socio-economic drought occurs when the demand for an economic good such as water, forage, food grains, fish or hydroelectric power, exceeds the available water quantity as a result of a weather-related shortfall in water supply, causing social and economical impacts.

Drought in this paper is used in the sense of socio-economic drought if not referred to differently.

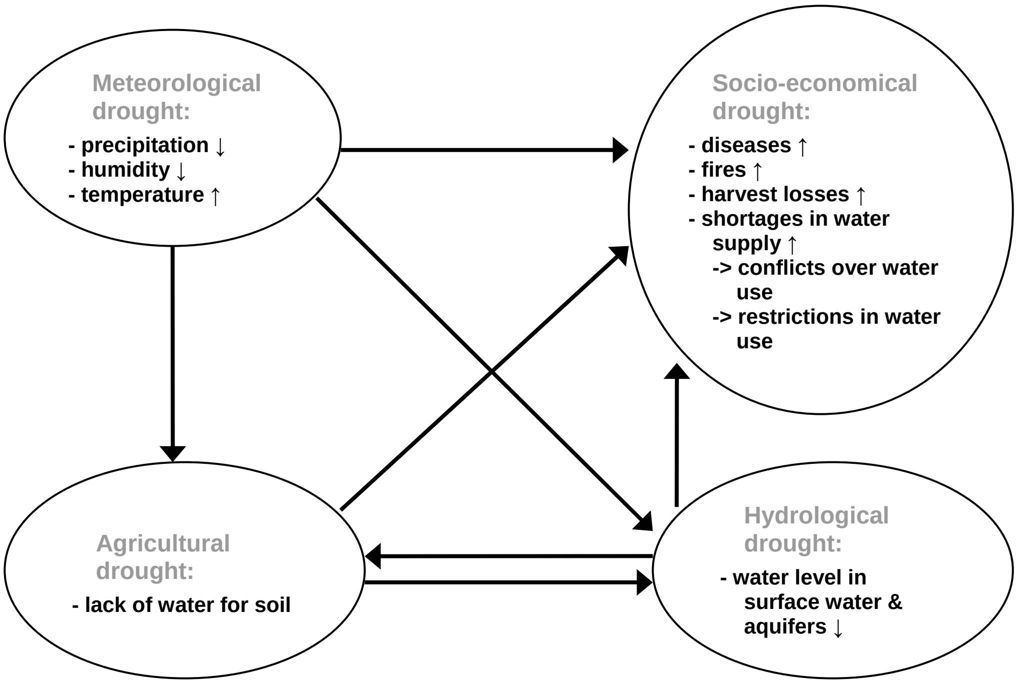


Figure 3: Gradation of drought severity and persistence

3 Freshwater availability in the Mediterranean

A lot of data regarding the freshwater availability in the Mediterranean region is strongly distorted as it reflects national data that includes different climate areas than the Mediterranean. This is especially relevant for Northern Portugal and Spain, the major part of France, some Balkan areas, and the Southern parts of the African countries that border the Mediterranean.

Overall availability

Despite immense disparities between and within countries, the total natural renewable freshwater resource in the Mediterranean region is quite low at about 1,200,000 hm^3 [(5) (11)]. The region holds 3% of the World's Freshwater resources and 50% of the World's 'water poor' [2] population. The Mediterranean countries

[2] 'water poor' = less than 1,000 m^3 water per capita and year [(5)]

differ considerably in their availability of water.

© WWF, M. Gunther Illusory safety of wetland in Algeria

© WWF, S. Cervello Drought effects in Spain

Turkey is one of the most water rich countries of the Mediterranean, but due to an enormous population increase from 28 million in the 1960s to 68 million in 2000 the availability of water resources has already decreased from around 4,000 m³ to 1,500 m³ per capita/per year today (6).

The North-African countries are among the region's water scarcest: The average potential water resource of Tunisia is 500 m³ per year/per capita (7) despite the North's relative water abundance with around 1,850 m³ available per year/per capita. The South however only counts on 180 m³ per capita (8). Algeria is also considered a 'water poor' country with 700 m³ per year/per capita (9). In Morocco, the water potential has already declined from 1,271 m³ per year/per capita in 1971 to about 1,000 m³ per year/per capita in the early 1980s[10] and is estimated to drop down to 720 m³ per year/per capita by 2020 (8).

Precipitation

Precipitation in the Mediterranean countries is distributed very unequally, both spatially and temporally. The total rainfall for the Mediterranean region is estimated at 1,000 km³ per year of which two thirds is concentrated over one fifth of the surface area (11). The annual rainfall varies considerably between and particularly within the Mediterranean countries. Also, it is typical in regions with low rainfall that evapo-transpiration is very high. Both combined with a possibly high surface run-off, depending on the soil and land cover, this leaves a relatively low effective precipitation across the region.

Some regions in the Mediterranean count with comparably abundant rainfall (e.g. Northern parts of Spain, Portugal, Morocco and Tunisia, and the Western and mountain areas of Greece can exceed 2,000 mm as well as North-East of Italy (Julian Pre-Alps) where precipitation can exceed 3.000 mm (58)) whereas others are rather water scarce (e.g. Southern parts of Spain, Portugal, Morocco and Tunisia, and the Greek islands can receive less than 200mm) (see **table 1**).

Trends in precipitation are presented in paragraph 4.2.1 entitled 'climate change' in this paper.

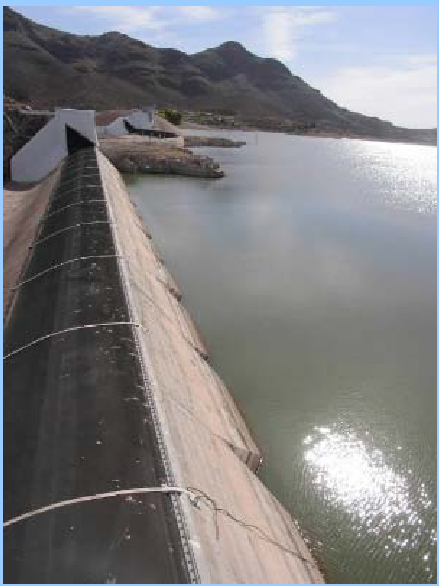
Table 1: Average rainfall in Mediterranean countries

Country	Precipitation		
	Precipitation in 2002 (12)	Minimum (13 if not specified differently)	Maximum (12 if not specified differently)
Algeria	257 mm		
France	818 mm		
Greece	748 mm	200 mm e.g. on islands (14)	2,150 mm in mountain areas (14)
Italy	932 mm	750 mm in Sardinia	> 3,000 mm in the Julian Pre-Alps (58)
Morocco	340 mm 220 mm (10)	<30 mm in the South (8)	> 1,000 mm in the North (8)
Portugal	1,039 mm	<700 mm in the Guadiana basin	1,800 mm in the North
Spain	645 mm	380 mm in the Segura Basin	1,315 mm in Northern Spain
Tunisia	355 mm	100 – 200 mm in the South (15)	400 – 900 mm in the North (15)
Turkey	643 mm	250 mm around Lake Tuz (6)	2,500 mm in mountainous coastal areas (6)

Surface water

In the whole Mediterranean region, water reservoirs play a major role for the supply of water, partly due to the high temporal irregularity of precipitation.

Spain, France, Turkey, and Italy hold the largest number of large dams (>10 hm³) in the Mediterranean. Spain has the highest number of dams per inhabitant worldwide at a total of around 1300 dams with a capacity of some 50,000 hm³ (10). Their storage rate has been at an average of 61.3% of the overall capacity over the last decade (1995-2005).



© WWF, J. Zapata **Large dams pull the plug on downstream river**

In Italy, there are 549 large dams of which 498 are currently in operation, including those in the initial as well as controlled filling stage. 31 dams are in various stages of construction and 18 out of service (57).

In Portugal, there are 151 large dams, more than half of which are for irrigation purposes. The biggest one is the multipurpose dam of Alqueva at the Guadiana with a maximum height of 152m (65).

In Morocco, the construction of dams began in the 1960s. Since then, the stockage rate in reservoirs has increased from 2,000 hm³ in 1961 up to around 16,000 hm³ in 2004, allowing the mobilization of approximately 67% of the surface water resources via 113 multipurpose large dams (10)(16). Algeria's large dams are mainly used for irrigation (17). Characteristic for Tunisia are little reservoirs in the mountains of which there are several hundred (18).

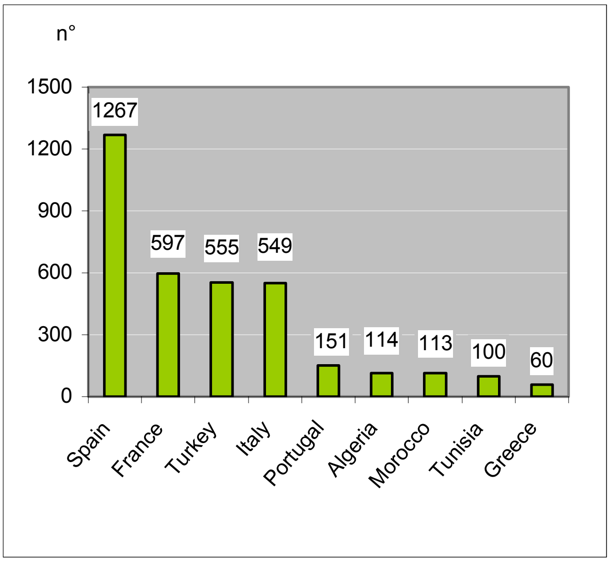


Figure 4: Number of large dams in Mediterranean countries [65]

Ground water

The aquifers in the Mediterranean countries account for 20% of the average withdrawal of renewable resources [5] though possibly more, depending on the country. In Greece, for instance, the share of ground water for the total water withdrawal was much higher at 42% in 1997 [19].

The dimensions and resilience of ground water to exploitation differ within and between countries. Some areas count on large aquifers that can regenerate every year via precipitation and others constitute of non-renewable water bodies.

In Greece, the amount of stored ground water is estimated at 10,300 hm³/a [14]. The total ground water potential of Turkey is estimated to be 13,660 hm³/a, and 37% of this potential is allocated for agricultural water use [8]. Portugal shows a low annual recharge of aquifers with a total of 3,200 hm³ [12].The aquifers in Northern Africa have big differences in their spatial distribution:

In Tunisia, 72% of the total ground water resources are located in the South [7]. In Northern Algeria, 2,000 hm³ are available per year which is renewable via precipitation. This is a different situation in the South of the country where 5,000 hm³ non-renewable resources are stored [20]. The renewable ground water reserves in Morocco mount up to 9,000 hm³/a out of which 4,000 hm³/a are available and about 67.5% of these actually used [8].

4 Causes of drought in the Mediterranean

As mentioned earlier in this paper, the identification of the factors responsible for drought and its impacts in the following paragraphs refer to the phenomenon of socio-economic drought.

4.1 Natural causes

Since most inland water resources are sustained by precipitation, a temporal decrease in rainfall generally is the major initial cause of drought. The hydrological year of 2004-2005 in Spain for instance, was the driest year ever recorded by the National Meteorological Institute since 1947; in 2005, only 459 mm of precipitation fell compared to the historical average of 669 mm. Precipitation anomalies however, are a naturally recurring feature of the global climate [2].

Empirical studies in the last century have shown that a meteorological drought has never been the result of a single cause, but of many often synergetic causes [2]. Factors that play a role in the development and characterization of drought besides precipitation for example are temperature and humidity, the evapo-transpiration (ET), wind velocity and pressure, geography of the region and vegetation. All of these factors determine the efficiency of precipitation and the severity of drought. Those areas in the Mediterranean vulnerable to drought typically have a high ET potential, e.g. Northern Africa and Southern Spain.

4.2 Man-made aggravations

Beyond the natural factors determining droughts, anthropogenic often set the pace and dimension of drought and severely aggravate its effects. Many of the causes are inter-related and are not easily distinguishable. The human variables in the phenomenon of droughts are the actions contributing to climate change, the current sector policies of water, agriculture and energy, the ways to secure the water supply and actual water consumption. Droughts may further develop cumulative effects from one year to the next, depending on the precipitation and also on water demand and consumption.

4.2.1 Global climate change

The worldwide percentage of terrestrial area affected by serious drought more than doubled from the 1970s to the early 2000s according to an analysis by scientists at the National Center for Atmospheric Research in the US. Climate change has been singled out as the key factor [21].

Human activities, basically emissions of CO_2 and other greenhouse gases, are the reason for the ongoing changes in the global climate with consequent influence on temperature, precipitation and extreme weather related events.

Temperature

The global average temperature rose by 0.6ºC during the 20th century while Europe’s average rose by 0.95ºC [22]. For the Mediterranean, the future developments are possibly worse than for the worldwide average: With a global warming forecast of 1°C by 2025, the temperature in the Mediterranean region is likely to increase 0.7-1.6° implying less harsh winters and hotter summers [23]. As **figure 5** shows, some areas will experience summers with increases in temperature of up to five degrees.

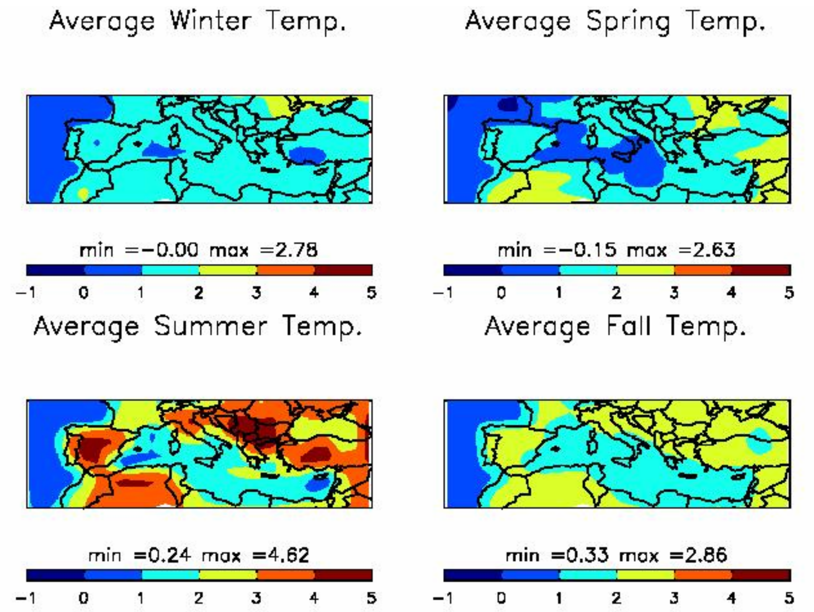


Figure 5: Changes in average temperatures in the Mediterranean at global warming of 2°C [23]

With an increased rise in temperature, dry summers will become more frequent. Tin *et al.* [23] developed climate change scenarios that forecast that duration of dry summers (<1mm precipitation) will increase by 2-4 weeks for the South of Italy, the Peloponnesian region in Greece and from the South of the Iberian Peninsula to Morocco. The start and conclusion of dry summer periods are also likely to shift. In the South of France and Central Spain, dry summers are expected to start three weeks earlier and end two weeks earlier which would mean a shift of the dry season toward spring [23].

Precipitation

In Southern Europe, most of the Mediterranean basin has already experienced a reduction of up to 20% of the rainfall in some areas during the last century [2] leading to increased aridity in the Mediterranean. In Italy, the number of wet days decreased by an average of about 12% over the period 1880-2002 [63].

The projections for the 21st century show further decreases in precipitation. Contrary to Northern Europe, there is a marked difference between the seasons: Except for the Balkans and Turkey, precipitation in Southern Europe will augment in winter while summer precipitation is projected to decrease by up to 5% per decade [2]. The overall amount of rainfall is likely to diminish in the whole Mediterranean area.

4.2.2 Policy impacts

In many Mediterranean countries environmental policy and water resources and drought policies have been badly structured and organized and continue to negatively impact the water resources situation in most countries. In the European Union, the Water Framework Directive (WFD) sets the general framework for water management in member states and requires “good ecological status” to be achieved in EU waters by 2015. It promotes the integrated management of water resources to support sustainable water use and reduce problems associated with excessive water abstraction, pollution, floods and droughts.

Water demand in the Mediterranean region has been stimulated by a number of factors. These include inadequate pricing systems that do not recover the costs of providing users with water nor stimulate water savings, lack of compliance with water related legislation as well as lack of control by the competent River Basin Authorities. Also, agricultural subsidies that support production and/or the development of irrigation systems, regardless of water availability.

This becomes especially evident in the agricultural sector, where the **EU Common Agricultural Policy** (CAP) has led to increased water consumption through subsidies which provoked a shift of traditional rain fed crops to irrigated cultivation, e.g. maize and sugar beet. In Spain, olive production for instance has traditionally been a rain fed crop and is nowadays the main water consumer in the Guadalquivir region in Andalusia (69).

Additionally, EU Rural Development funds are used to enlarge irrigation areas or to support crops that are high in water demand with agro-environmental schemes such as cotton. This enhancing of irrigated agriculture furthermore stimulates the policy of water transfers and the construction of dams.

Although the CAP reforms in the last few years have introduced some regulations (CE 1782/2003, CE 796/2004, CE 1698/2005) towards new approaches for EU agricultural funding (decoupling, compliance), in practice national implementations are weakening these changes. It is still to be seen if and how the regulations will be implemented by the member states over the long run. Current compliance application in Spain for example is not impeding illegal water users from benefiting from CAP funds (69).

In non-EU Mediterranean countries, the construction of dams and irrigated agriculture are also often highly subsidized, for instance the production of sugar beet in Morocco (10).

Prices for water in the Mediterranean countries are generally low compared to the European average; especially those for agricultural use. For the EU member states, the WFD foresees cost recovery and **water pricing** policies that give incentives for a rational water use, to be introduced by 2010. However, the directive leaves space for exceptions for particular situations. In May 2006, Spanish irrigators claimed to be a generic exception to the user-pays principle since a third of irrigated Spanish farmland would become uneconomic if the principle is introduced (67). **Table 2** gives an overview over current urban water prices in some Mediterranean countries.

Table 2: Water prices in some Mediterranean countries

Country	Water pricing
Algeria	Industry: from € cent[3] 1.1/m³ in 1985 to € cent 4/m³ in 1997. For irrigation there is a dual system both elements of which show increasing prices: A) from € cent 0.13-0.18/m³ in 1985 to € cent 1.1-1.3/m³ in 1995, and B) from € 1.7–2.2/ha in 1985 to € 2.8–4.4/ha in 1995 (9).
France	€ 1.15/m³ on the average according to the NUS Consulting Group (24),€ 2.8/m³ in whole France and € 2.52/m³ for the Mediterranean region in 2001 (43). However, the water prices differ according to the region. Agricultural water charges correspond to procurement and consumption. Irrigation is highly subsidized and is commonly priced by a two-part tariff method which consists of a combination of a volumetric (€ 0.04–0.1/m³) and a flat rate (€ 0.07–0.12/m³) (25) (68).
Greece	Water prices rose after drought in the 90s (26). Water fees in general depend on extraction costs (25). Water pricing is politically influenced and not based on water cost, leading to inadequate finances for the funding of further infrastructure (14). Per area charges in irrigation are common.
Italy	€ 0.78/m³ (24)
Portugal	Since 1999, all licensed water is subject to water taxes, depending on the amount of used water and

[3] converted from Algerian Dinar (1 Euro = approx. 90 Dinars)

	the region's relative water scarcity [25].
Spain	There is a huge range of urban water prices in Spain: INE reports an average of € 0.86/m³ in 2003 (min. € 0.53 -> max. € 1.68) [27]. Prices for irrigation are also highly variable and are sometimes still fixed per area, not per volume consumed [25].
Turkey	All types of users have to pay for water, but the water pricing system should be revised especially for agricultural sector [28].

4.2.3 Water consumption

Water consumption in the Mediterranean area is high, especially in the hot and dry regions where less water is available. The agricultural sector constitutes the highest consumption of water but tourism also produces huge problems in peak seasons in specific, mostly coastal, areas. In summer, pressure on water resources escalates when the demand for water from tourists and agriculture is at its peak. Drinking water has priority for water use in all Mediterranean countries.

Overall water consumption

Despite the overall high water consumption in the Mediterranean, there are big differences among the regions in terms of water consumption, varying from around 500 to 1000 m³ per capita/per year (see **figure 6**).

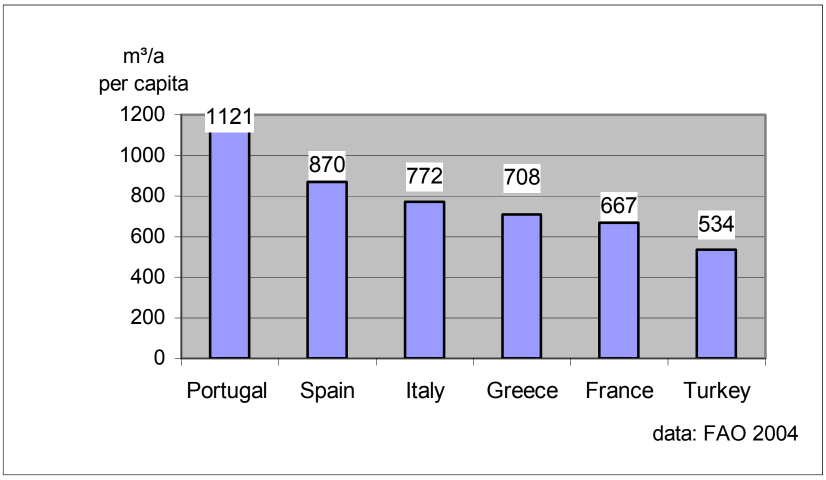


Figure 6: Average water consumption in the Mediterranean countries 1998-2002 [4]

Water demand in Mediterranean countries has doubled in the second half of the last century and has now reached about 290 km³ per year [5]. The countries experiencing the greatest growth (more than 2% per year) are Turkey, Syria and France [5]. Italy is among the few Mediterranean countries that reduced their water consumption over the past decade. However, it had already reached one of the top levels of water consumption in the Mediterranean (see **figure 7**). The overall water demand in the Mediterranean region continues to increase, even more in the light of the effects of climate change (see paragraph 4.2.1 'climate change').

[4] no data available for Algeria, Morocco and Tunisia
[5] In France, there are great differences within the country. Mostly concerned by high water consumption and water shortage problems are the Western and Southern regions.

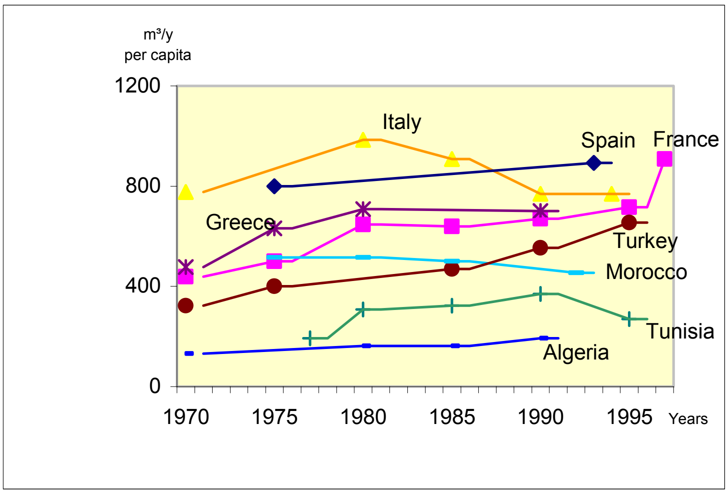
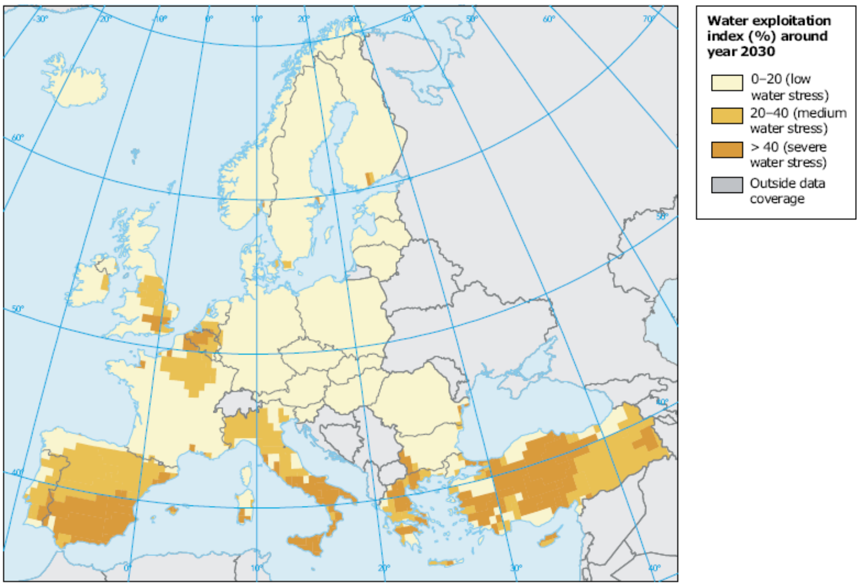


Figure 7: Development of water demand per capita for all uses in the Mediterranean countries [adapted from Plan Bleu 2004] [6]

Future estimations forecast a rise of consumption by 25% by 2025 in the Southern and Eastern Mediterranean, particularly in Turkey, Syria and Egypt [(5)]. Turkey expects a severe decline in the available amount of water per year/per capita due to population growth [(6)]. In terms of water stress the Mediterranean region is and will remain the most affected in Europe (see **figure 8**).



Source: EEA, 2005.

Figure 8: Water stress scenario for Europe [(75)]

With an average of 65% [(5)], irrigated agriculture constitutes the biggest bulk of water consumption in the Mediterranean, except for France and the Eastern Adriatic countries. However, the range of water consumption in agriculture is wide, reaching from around 14% of the total water extracted in France [7] [(29)] to more than 80% in most of the South-European countries as well as in Northern Africa [(30)]. Spain has climbed three steps on the drought scale [(2)] from light to extreme hydrological drought in only one year (2005) mainly due to agricultural water use. Water demand for irrigation is likely to go on increasing with

[6] No data available for Portugal. No data available either for a general overview over the last few years.

[7] Note that in large parts of France there is no irrigation at all whereas in regions such as the Mediterranean the percentage is very high. 14% is the average share of water for agricultural purposes with regard to the total extracted amount of water in the country. The agricultural share of water consumption, that is the water that is not returned to the water cycle close to the place where extracted, is similarly high in France at 65%, same as in most of the rest of the Mediterranean.

the rise of temperature.

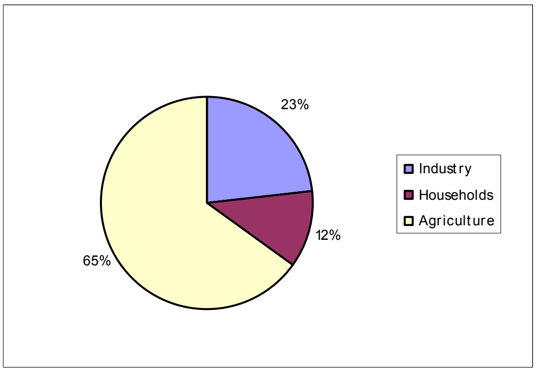


Figure 9: Average water consumption in the Mediterranean by sector[8]

The share of households in water consumption is similar in all Mediterranean countries with 9 to 15%. In the Northern Mediterranean region, this trend appears to be stabilizing. This trend is different to the North African countries where urban water demand is expected to continue increasing [(10)].

In the industrial sector there are again huge differences: France shows the highest water use with around 70%, the biggest problem being a sufficient amount of water to cool power plants. Spain, Portugal and Turkey show much lower industrial shares with around 15%, and almost negligible are Greece, Morocco and Tunisia with around 2% [Ø 1998-2002 [(13)]].

Water demand for tourism is clearly increasing. In Tunisia, for instance, tourist water demand has doubled between 1977 and 1996. On the Balearic Islands, tourist water consumption likewise multiplied 15 times between 1980 and 1995 [(10)].

Agriculture

In the Mediterranean, agriculture is the main water user, with an average of 65%. While this has always been the traditionally biggest user of water in the region, consumption continues to increase for various reasons. Among these is the fact that the surface of irrigated land is increasing (see **figure 10**). Irrigated area in the Mediterranean has doubled in 40 years, accounting for 20.5 million ha in 2000 compared to 11 million ha in 1961. The biggest increases in absolute terms have occurred in Turkey (3.2 million ha) and Spain (1.7 million ha) [(5)]. Most of the countries' water supply projects, mainly constructions of dams or ground water exploitation, are for irrigation purposes. Some countries however, show a different development. Italy for example has reduced its irrigated area over the last twenty years [(61)].

[8] Average calculated on basis of different sources [(5)], [(12)], [(19)], [(25)] and [(37)]


© WWF, M. Gunther **Wasteful irrigation - sunflowers grown in semi-arid areas**

Another issue besides the amount of irrigated area is the actual irrigation techniques used. In Turkey, the main problem in agricultural water use is related to the efficiency of irrigation methods: 88.5% of the total irrigation area is irrigated through flood irrigation, 8.5% is spring irrigation and only 3% is drip irrigation [(28)]. This makes average irrigation efficiencies at only 45% [(30)].

In principle, it is possible to calculate the required amount of water needed according to the crop water requirements and the local climatic and soil conditions. But due to a low level of understanding by

SPAIN - Saving water in agriculture to better manage droughts

Information about the amount and time of irrigation is one of the key factors to achieve water saving in irrigation. The efficient use of water in agriculture regarding the daily practice first of all requires a well trained farmer. He needs to know about the different methods to estimate the water needs of the different crops and about the right moment and the method of irrigation.

In current practice, however, there is a huge discrepancy between what should be irrigated following the various guidance systems for irrigation, e.g. the one from FAO based on the evapo-transpiration of the crops, and what is actually irrigated. Applying the FAO system, an average of 10% of water could be saved compared with the current actual practice.

The **project LIFE HAGAR** (www.life-hagar.com) in which WWF/Adena Spain participated 2002-2005 shows that even more water could be saved by exactly calculating the real water demand of the crops. LIFE HAGAR facilitates decision-making in irrigation with the help of microclimatic sensors and sensors for soil humidity generating values on-site and in real time.

The HAGAR project which was carried out in an over-exploited aquifer in Spain has demonstrated the possibility to save water from 6% in vineyard cultivation (one of the socio-economically most important crops in the study area) up to 36% for onion cultivation. With other highly water demanding crops like maize or beetroot the results have been also significant with around 20-30% of water savings compared to the habitual practice.

farmers, too much water is used in irrigation even where adequate (water-saving) techniques exist.

Farmers grow a lot of "thirsty crops"[9], particularly cotton, sugar and rice, as well as many greenhouse crops, mainly fruit and horticulture produce and principally in the Mediterranean arc.

[9] that is crops that require a lot of water, e.g. 1kg of cotton requires up to 20,000 litres of water for its production [(51)]

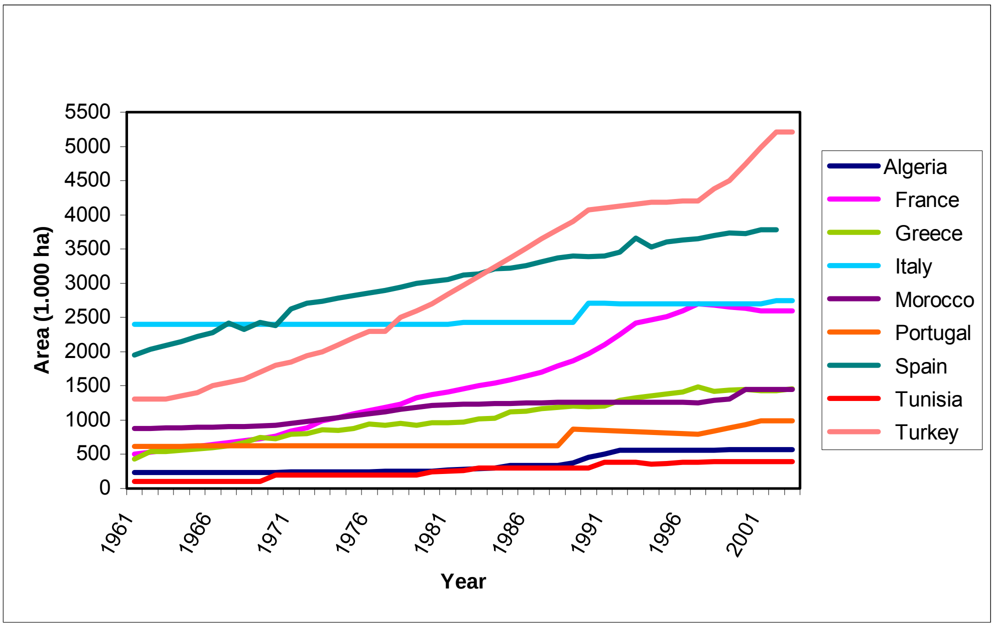


Figure 10: Development of irrigated areas in Mediterranean countries [(55)]

GREECE - Subsidized cotton production puts water availability at risk

All in all, pressure on quantities of water resources is moderate in Greece, but there are severe water shortage problems, especially during the irrigation season, when about 87% of total freshwater withdrawal is consumed by agriculture, particularly for cotton production.

Cotton is a crop that needs a lot of water. In Greece, 100% of the production is irrigated and mostly with inefficient techniques. With flooding, cotton production requires up to 20,000 liters per kilogram due to high surface run-off and evaporation. With drip-irrigation, water consumption could be reduced to 7,000 liters per kilogram. However, this is still seven times higher than the water need for the production of one kilo of wheat. The regions in Greece where cotton is cultivated show bad quality in ground and drinking water.

Greece and Spain are the only producers of cotton in Europe. Greece holds the larger production with 390,000 tons of cotton lint in 2004/5 (maximum producer world wide is China with around 6.3 million tons), principally grown in Thessaly and Macedonia.

© WWF, M.Gunther **Water wastage through cotton cultivation**

Domestic support for European cotton growers is high. Subsidies are three to four times higher than for maize and oilseeds and up to eight times higher than for cereals. Due to this enormous subsidization Greece and Spain could expand their cotton production to more than 50% since 1990. European cotton production is the most expensive world wide. The subsidies paid from 2003 to 2005 were € Million 872, 858, and 937 respectively.

Before the CAP (Common Agricultural Policy) reform, the aid regime was based on a direct aid per ton of unginned cotton. Since January 2006, the systems shifted towards decoupling and single farm payments. However, 35% will continue as direct aid in the form of an area payment. The remaining 65% will be provided as a single farm payment. The total amount of both payments adds up to € 695.8 million annually from 2006 on.

Urban use

Rapid expansion in urbanization and the construction of tourist complexes mainly along the Mediterranean coast signify huge environmental impacts. Vulnerability to drought increases and its impacts are aggravated due to increases in water demand.

There is little comparable data concerning water household consumption in the Mediterranean. Sources differ considerably with respect to years and related countries (see **table 3**). The Blue Plan [(10)] estimates the average household consumption in the Mediterranean to be about 100-200 liters per day. Different to the Northern Mediterranean region, the North African countries are expected to further increase their water consumption.

Table 3: Urban water use (per inhabitant) in some Mediterranean countries

Country	Water use	Year
France	165 l/d	1998 (37)
Italy	297 l/d	2002 (62)
Morocco	100 l/d [10]	1983-1989 (10)
Portugal	184 l/d	1998 (37)
Spain	167 l/d	2003 (28)
Turkey	68 l/d	1996 (37)

Tourism

Water use in the tourism sector is generally higher than water use by residents: A tourist in the Mediterranean consumes between 300 and 800 liters per day. In extreme cases, water demand can be up to 5-10 times higher in peak season, as for example in the Greek islands (38). On the Balearic Islands tourist water consumption during peak months may reach up to 20% of that used by the local population in a whole year (38).

© WWF, M. Gunther **Huge tourist complexes dominate the Mediterranean coast**

Increasing golf tourism exacerbates the stress on water resources in the mostly already water scarce Mediterranean tourist areas. In Spain, for instance, 276 golf courses already exist and 150 new ones are planned, each requiring an average equivalent to the water consumption of a city of 15,000 inhabitants (38).

The impact of tourism on water quantity depends on water availability in relation to the timing and location of the water demand from tourism and on the capability of the water supply system to meet peak demands (2). This capability is often low on islands and overstrained in coastal regions where the pressure from tourism is usually very high. **Table 4** sums up the main reasons for stress on water resources through urbanization and tourism.

Table 4: Stress on water resources through urbanization and tourism

Water consumption	
	High urban water use: wet street cleaning, irrigation of public green, private water consumption in households and gardens
	High tourist water consumption, golf courses
Water loss	
	Loss through defective water pipes
	Increased surface run-off due to sealing of soil for urban constructions

10 70 l/d in the water scarce and 230 l/d in the water rich areas (1990-1993) (10)

5 Impacts of drought in the Mediterranean

5.1 Hydrologic - On water availability

As a short-term impact of drought events, water availability temporarily diminishes. Coupled with an increased demand, particularly for human needs, this leads to a substantial water stress for humans and ecological systems. Over the long run, groundwater resources and reservoirs will not be able to recover from over-exploitation, and will be exacerbated by times of drought, turning towards a situation of water scarcity. Moreover, an increase in droughts due to climate change effects via reduced precipitation and increased temperatures will lead to a further decline in water availability. Future scenarios affirm recent events and experiences of most Mediterranean countries.

In Morocco, the water potential per capita/per year is declining: The 2,500 m^3 of water available in 1980 is reduced to 1,000 m^3 in 2006: a decrease down to 500-720 m^3 is calculated for the year 2020 [10] [8].

The exploitable water in Tunisia which currently is at 4,040 hm^3 is expected to increase until 2010 but then decline to 3,133 hm^3/a by 2030 [7].

In Algeria, a 1°C rise in mean annual temperature would lead to decreases in precipitation of 15% and influx of surface waters of 30%. Subsequently, water demand would exceed available water resources by 800 hm^3 [40].

Groundwater availability

Excessive water withdrawal for industrial and agricultural purposes has led to widespread over-exploitation of the aquifers in most of Mediterranean countries. Principally, in coastal areas the ground water has dropped below sea level. When this happens the intrusion of sea water in the aquifer is likely to happen increasing the salinity of water. This may results in increased water treatment cost for drinking water, low water quality for irrigation and sometimes even unsuitability of aquifer for water supply (both for drinking and irrigation purposes). Hence, the aquifers have become more and more vulnerable to drought effects.

In Italy for instance, over-exploitation of the Po River in the region of the Milan aquifer has led to 25 m (even up to 40 m) decrease of ground water levels over the last 80 years [5].

In Spain, more than half of the abstracted groundwater volume is obtained from units facing over-exploitation problems [76].

In Tunisia, 54 out of 196 aquifers are over-exploited and in many coastal areas ground water has fallen below sea level [5].

Morocco has plans to increase ground water exploitation by 3,000 hm^3/a until the year 2020 which means a considerable increase compared to the current exploitation rate of 2,670 hm^3/a out of the 4,000 hm^3/a available [5][21].

Storage rate of reservoirs

Over the last few years, reduced precipitation has led to lower levels in many reservoirs with dramatic consequences for the water supply of human as well as ecological needs.

The capacity of the Spanish reservoirs has been at 61.3% of the total between 1995 and 2005. During the drought of 2005 however, the water level declined considerably to an average of 40%. The consequences have been much more severe in some places, like in the Segura basin which was left at 12% of its capacity in autumn 2005. By March 2006, the reservoirs had reached a level of 56.9% again (30,284 hm^3) thanks to winter precipitation. Still the overall situation remains critical because precipitation has not been sufficient in all the Spanish territory to recover from the previous very dry year. Moreover, even if the human uses are ensured by the stored water, rivers and natural lands are not receiving enough water from dams and rains.

In Portugal, 12 out of 57 reservoirs were at less than 40% of their total capacity in 2005 and 10 showed a storage volume of more than 80% of the total volume (42).

5.2 Environmental - On aquatic ecosystems

The impacts of dry spells on the environment are multiple. To some extent, Mediterranean ecosystems are designed to cope with periodic droughts. However, droughts often have severe impacts because the ecosystems already show signs of degradation (see **table 5**) and hence much more vulnerable to drought impacts.

© WWF, M. Harvey **Flamingos need wetlands**

The main impacts on the environment caused by drought involve aquatic systems, such as fresh and ground water and coastal systems.

Drought has a direct impact on landscape quality, provoking accelerated soil erosion, increased number and extension of forest fires, damage to flora and fauna and impacts on air and water quality. Some of these effects are short-term and may return to normal after the end of the drought. Other environmental effects last for some time and may even become permanent [(4)].

Table 5: Drought causes, aggravations and environmental impacts

Causes	Impacts	Intermediate consequences	Long term consequences
Reduced precipitation	➢ Reduced flows in surface waters ➢ Reduced infiltration for ground water recharge	➢ Reduced water availability ➢ Higher concentration of pollution and toxics ➢ Warming of water bodies ➢ Boost in nutrients in the water bodies ➢ Reduced ground water levels ➢ Salinization of aquifers ➢ Saline intrusion in coastal areas ➢ Stress on (ground) water dependent eco-systems ➢ Spread of invasive species ➢ Loss of sedimentation for deltas and estuaries	**Decline in biodiversity:** ➢ **Loss of aquatic eco-systems** ➢ **Severe changes in the coastal eco-systems** ➢ **Regression of dunes and deltas** ➢ **Loss of species in flora and fauna** ➢ **Shift of species with increase of thermophiles**
Aggravations			
Climate change	➢ Increase in temperature ➢ Reduced precipitation ➢ Increase of extreme weather events		
Bad water use planning	➢ Reduced flows in rivers ➢ Non compliance with ecological flow regime ➢ Water pollution ➢ Over-exploitation of aquifers		

Drought can lead to the loss of whole freshwater ecosystems[11]. Reduced precipitation leads to lower water levels in rivers, reservoirs and aquifers. In times of dry spells, this provokes a higher concentration of toxics and pollution in surface water which results in inferior water quality. Warming of water bodies is a further consequence which in turn produces changes in the water layers and thus in the whole ecosystem, gravely affecting the performance of species, particularly those living downstream of dams in an already disturbed ecosystem. These processes and effects are exacerbated by ongoing climate change.

© WWF, M. Gunther **Wetlands in danger of drying out**

Bad water use planning further aggravates the impacts of drought. Water withdrawals and water infrastructures lead to reduced flow in rivers which in turn can result in reduced ground water levels as well as salinization of aquifers [(5)(2)]. Over-exploitation of aquifers in turn imposes stress on ground water dependant ecosystems and may lead to drying up of wetlands. This implies problems for migratory birds as well as for the breeding habits of certain species.

Dams often have severe ecological impacts that contribute to increasing the vulnerability of ecosystems to drought. The construction of water reservoirs leads to drastic changes in the hydrological regime of

[11] compare WWF Living Planet report 2004

certain ecosystems. This causes numerous cumulative long-term consequences: Flow systems in surface waters are altered, environmental flow regimes in rivers downstream are often not guaranteed, the river as well as the fauna population is fragmented, the reservoirs often silt up and sediment fails to reach estuaries and deltas.

As a combination of decreased rainfall, increased drought and dam construction, less and less water reaches the Mediterranean Sea. The consequences include severe changes in coastal ecosystems, regression of dunes and deltas and saline intrusion in coastal areas.

The ecosystems changes have negative impacts on corresponding species. The warming of water bodies entails a boost in water temperature and nutrients. This leads to migration of species to cooler northern waters or to mountainous regions (when migration is not impeded by impenetrable infrastructures) with the result of a general increase in thermophile species. It possibly leads to eradication of whole populations, threatens non-adaptive species with extinction and gives room for invasive ones to thrive. In the summer of 1999, France reported a massive mortality rate of gorgonians (*Eunicella singularis*) and sponges [50].

© WWF, D.M. Garces **Will the water bird find a place to breed next summer?**

The drought of 2005 caused fish mortalities in Spain and Portugal. New species that have already been introduced in France due to the warming of water are for instance the slipper lobster (*Scyllarides latus*) and ornate wrasse (*Thalassoma pavo*).

5.3 Economic - On water uses

Droughts are different to other natural hazards and can take a long time to evolve yet leave severe and costly damage. It has been calculated that the economic impact of the drought in 2003 in Europe was about € 11 billion [2]. The biggest economic impact in the Mediterranean usually concerns agriculture since it is the most water dependent sector, but other sectors are also affected.

Agriculture, Fishery & Forestry

The economic impacts on agriculture, fishery and forestry from drought are severe because of the reliance of these sectors on surface and subsurface water supplies.

The lack of precipitation is reflected in water deficit for irrigation and harvest losses for both irrigated and rain fed crops, although the impacts for the latter are much worse.

In the summer of 2005, Portugal lost around 60% of its wheat production (Spain 50%) and 80% of the maize production was destroyed. In France in the same year, the harvest of maize, the crop that covers the main part of the irrigated area, was reported to be 20% less than in 2004.

In Spain, the loss in agriculture and livestock production amounted for a total of € 2 to € 3 billion in 2005.

In the future, a general reduction in crop yield is expected as a consequence of climate change. The expected negative responses of climate change on crop yield would require up to 40% more water for irrigation. The likelihood of this to be achieved can be highly doubted since the current water demand already exceeds supply in many regions, especially in times of drought [(23)]. The forecasts for Morocco estimate the reduction of yield in cereals to reach 50% in a dry year and 10% in a normal one by 2020. These developments jeopardize the livelihoods of farmers. In addition to obvious losses in yields in crop and livestock production, drought is associated with increases of insect infestations, plant diseases and wind erosion [(4)].

© WWF, N. Dickinson **Drought kills fish**

Tons of dead fish were found in the reservoirs in Portugal and Spain after the drought of 2005: In Spain, 6,000 dead fish and invertebrates were counted in San Roque Guadiaro, in the Guadalquivir river basin: Two major fish mortalities were registered in October 2005 in the rivers Corbones (500 kg of dead fish) and Guadalete (more than 1000 fish) [(22)].

In Portugal, 12 tons of dead fish were removed from the reservoir of Monte da Rocha (Ourique) and 9.4 tons in Bravura (Algarve) just to mention a few [(44)].

Reduced water level in the surface waters and reservoirs entails a boost in water temperature and nutrients which may cause fish populations to diminish or migrate and even species to disappear when they are not able to adapt to new environmental conditions.

Higher temperatures and related reduced humidity also significantly increases the risk of fires. The Southern Mediterranean is expected to be at risk of forest fires all year round by the middle of the century whereas on the Iberian Peninsula and in Northern Italy the period of extreme fire risk will lengthen notably [(23)]. Fires imply a loss of forest biomass and furthermore require financial resources for fire extinction. In Spain, the designated budget for prevention and extinction of fires for 2006 is triple the one of 2005. In France, some 150 million Euros per year are invested in fire prevention and extinction.

Tourism

Typically, tourism in the Mediterranean is highly water consumptive so that in times of drought the necessities for hotels, swimming pools, and golf courses for example may not be met or lead to conflicts with other water needs.

The consequences of climate change, such as reduced water availability combined with increased temperatures in the long run may lead to spatial and seasonal shifts of tourist flows, that is, from the South to the North and from summer to spring and autumn [(23)].

Energy

During drought, hydropower production may be notably curtailed due to reduced water levels in reservoirs. But also conventional power plants are affected because they need water for cooling and for driving turbines [(4)] [(23)]. The latter is of huge concern in France due to the country's large number of nuclear power plants, many of which are cooled with water from rivers. Moreover, the additional energy supply of hydropower plants for meeting peak demands in the morning and evening hours can not be guaranteed during dry spells since the turbines can not be run.

In Spain, the production of hydropower in 2005 was 39.3% less than in 2004 due to lower water level in reservoirs [(45)(46)] and in Portugal, hydropower production in 2005 was reported to be 54% lower than the average and 37% lower than in 2004 [(47)].

In Morocco, the average hydropower production in the last 20 years was of 1000 million KWh, which is half the previous amount as a result of high fluctuations in water availability. Hydropower has no priority in energy production in Morroco. As a consequence, no dams for hydropower are planned for the next 20 years. Hydropower production can only take place in times of water excess since the water availability in Morocco is usually quite low [(10)].

Beyond reduced hydropower production, energy consumption for cooling machines (freezer, air condition etc) increases during heat waves which was estimated at 5-6% in Portugal and Spain in 2005 [(23)].

Navigation

Reduced water supply impairs the navigability of rivers and causes the increase of transportation costs because goods must be transported by rail or truck [(4)].

The Po River in Italy became no longer navigable in summer 2005 when the water level was several meters lower than normal and the water of the river was laden with sediment [(48)]. Temporary closure of rivers and canals in France, e.g. the river Rhone or the Canal du Midi, is a familiar problem in hot summers possibly becoming more severe as droughts turn more frequent and drastic.

5.4 Social - On quality of life

Social impacts involve a reduced quality of life and health, conflicts between water users, and inequities in the distribution of impacts and disaster relief. Many of the economic and environmental impacts have social components as well [(4)]. Under conditions of resource scarcity like during drought, economically and politically disadvantaged social groups usually meet difficulties in sustaining their livelihoods and their quality of life [(2)].

These difficulties are exacerbated by actions that aggravate the conflicts about water, such as water transfers from abundant into scarce regions. These transfers do not increase the overall amount of water but merely displace the problem, entailing new environmental and social impacts. Water transfers often create conflicts between the regions and countries that are involved. The Tagus-Segura transfer in Spain, for instance, resulted in conflicts between the autonomous communities of Castilla-La Mancha and Murcia and also created tensions between Spain and Portugal concerning the flow regime which was then regulated by the Convention of Albufeira of 1998.

Farmers are the most affected group in terms of income loss. Moreover, a reduction in farming community wealth has consequences for other businesses which rely on the trade and patronage of farmers.

Heat waves especially affect old and fragile people. High temperatures and the elevated ozone levels in the air lead to increased morbidity and mortality rates. The record-breaking summer of 2003 claimed around 40,000 lives, half of them in Italy alone [31]. Common causes of death include respiratory and cardiovascular diseases, as well as heat strokes and dehydration [(22)].

People that are in good health may suffer though from restrictions in leisure activities as a consequence of decreased water level in rivers and lakes and related deteriorated water quality. Water sports like sailing and surfing may be restricted, and also swimming may not be possible or advisable when bathing water quality is not secured. As for non-aquatic leisure, forests are more prone to fires in times of drought and loose aesthetic and leisure value when burnt.

6 Business-as-usual management response to droughts

6.1 Drought policy

Reactions to drought have typically been seasonal and reactive. When the water supply situation gets critical and drought impacts become obvious, emergency alleviating plans are launched and drought effects are attempted to be palliated by financial compensation. Ad-hoc policy and emergency “solutions” prevail over long-term strategic approaches. Increase in supply continues to be a paradigm, and plans for generating even more water resources are launched.

During the past decade, widespread and severe droughts in Europe have resulted in an increased awareness of nations continuing vulnerability to this creeping natural hazard. This experience has resulted in initiatives by governments to improve the timeliness and effectiveness of response efforts. Particular emphasis has been placed so far on the improvement of forecasting instruments. Drought plans are being developed but implementation is lacking because ultimately, each water-use sector insists on its share of water not being curtailed.

Hence, although some progress has been made, much remains to be done. Comprehensive, long-term drought preparedness policies and plans of actions that may significantly reduce the risks and vulnerabilities to extreme weather events are yet to be developed and to take root in most parts of the Mediterranean region [(2)]. In most countries, governments continue to deal with drought in a reactive rather than proactive mode.

FRANCE - Establishment of a national drought monitoring committee

After the severe drought that affected the whole country in summer 2003 together with a heat wave that left behind thousands of dead in August, the French government decided to anticipate future water shortages and set up a series of measures. A drought monitoring committee was established and collaboration with the Ministry of Agriculture was improved. Local governments and water agencies were asked to contribute to evaluating the effects and risks of present and possible future droughts.

Subsequent to 2003, the hydrological year of 2004-2005 was especially dry in autumn and winter with up to 33% less precipitation than usual at the end of March 2005. Especially the Central-West coast and a part of the South-East area were affected. In summer 2005, approximately 3,800 km of dry river sections were recorded at national level entailing harmful effects on aquatic ecosystems with the fear that 2006 will lack migratory fish spawning. Although the situation was quite difficult in the summer of 2005, almost no drinking water shortage occurred. This good result stems from several measures started in February 2005, amongst other recommendations for farmers to plant less thirsty water cultures (particularly not maize!) especially during the hot season. As a consequence, an average of 8% less of maize was planted whereas the reduction of plantation in the water shortage concerned areas reached 20%. Parallel, in 75 (out of 95) Departments the prefects issued orders to limit water consumption in certain periods and areas. In 30 Departments, irrigation was completely prohibited. In addition, other measures were taken in the industry and energy sectors summing up to a total of 600 orders to adapt to the situation.

An evaluation of all measures was conducted in September 2005 concerning the way of establishment of the measures, the time of application, implementation and the effects. All in all, the measures were quite effective and improved considerably in comparison with 2004. Yet, there is still potential for improvement. The measures primarily addressed the agriculture sector with overall good results. However, out of approximately 660,000 farms cultivating 27.8 millions ha, only 25,000 farms (that is 3.8% of the total number and 25% of those that irrigate) and 540,000 ha of irrigated land (approximately 33% of the total) were actually concerned by the restrictive measures.

6.2 Water supply

The traditional approaches to manage water resources are supply-based. That means that policies focus rather on an increase in water supply than on a decrease in water demand in order to meet the current and future need for water. Increased water supply is meant to be secured via water transfers to provide dry regions with the vital resource, by intensified ground water exploitation and construction of additional dams to achieve a higher storage capacity. However, the logic of new dams and reservoirs is highly questionable since the hitherto policy of increasing water supply via dams has not proved to solve problems [(32)]. Dams may be a necessary means for water supply, particularly in developing countries, but should then be based on a strategic planning looking for the less impacting solutions.

MOROCCO – Dams

In Morocco, water availability is a critical issue. In normal years (in terms of precipitation) in five out of eight river basins water demand exceeds the water resources available by 396 million m^3 [71]. During drought events in 1980-85 and 1990-95 the demand registered exceeded availability in all eight basins.

To address the problem of drought as well as to accommodate the increased demand for water the Moroccan government has attempted to guarantee and increase the water supply by building reservoirs. The royal decision "One Dam per Year" in 1986 resulted in a boost of construction of dams. The water stocking capacity has increased from 2 million m^3 in 1920 to 16 billion m^3 in 2004, and still more dams are planned.

Nevertheless, dams are no ultimate solution, neither to drought nor to the increasing water demand. One huge problem is the high rate at which they fill with sediments and consequently lose water storage capacity. It is estimated that some dams (e.g. the dam Allal Fassi in the Sebou basin) can have a life span of 42 years [72] and that, considering all the dams, 65 million m^3/a of water are lost due to siltation (comparable to one dam lost per year)[73]. To face the problem on a long-term basis, the government has launched a plan to fight deforestation. Over the short term they have dredged some reservoirs to remove sediments and raised the height of four dams.

Dams furthermore have an impact on communities living nearby as well as the ones downstream. In the case of Morocco's biggest dam (Al Wahda on the river Ouergha, Sebou Basin) the nearby communities do not get any benefits from the dam (in terms of water supply, electricity or tourism) but suffer the consequences of its construction (increased humidity affecting both human health and the olive sector, decreased tourism due to impeded access to the area due to the dam, displacement of 20,000 people, sudden water level hike that caused drowning of people and livestock, and no appropriate compensation). The downstream communities benefit from flood protection but face serious problems when it comes to water for irrigation. They cannot afford the water, even although the price is quite low. In the end, although more water is available thanks to the dam, their income decreased after the construction of the dam.

Ground water extraction

Although they mostly share a relatively low rate of the total water supply, aquifers in the Mediterranean are mostly over-exploited - that is, more water is extracted per year than can be regenerated. Some aquifers, like the ground water tables in Southern Algeria, which are not renewable, are at increased risk of depletion by augmenting extraction. Illegal water extraction is a severe problem in many parts of the Mediterranean.

© WWF Turkey **Illegal ground water extraction is a huge problem**

The estimated number of illegal boreholes far exceeds legal ones in many regions in Spain. The Spanish Ministry for the Environment estimates that there are approximately 510,000 illegal wells. It is estimated that around 3,600 hm^3/a are being extracted illegally; this means that at least 45% of the annual subterranean water abstraction in Spain is illegal and supplies 1/6 of the irrigation areas [(32)].

In Italy, the estimates are of about 1.5 million illegal wells (*Contratto Mondiale dell'Acqua*). In eight regions (Abruzzo, Molise, Puglia, Campania, Basilicata, Calabria, Sicilia e Sardegna), about 830,000 ha are irrigated legally while the total of irrigated area reaches about 1.6 million ha [(59)]. Alone in the Puglia region, 300,000 illegal wells are estimated which provide for one third of the total irrigated area in that region [(60)].

In Turkey, illegal ground water extraction constitutes a severe problem. In Central Anatolia, specifically in the Konya Closed Basin, half of the 50,000 wells are said to be illegal and groundwater levels are decreasing 2-3 meters annually [(28)]. Morocco also reports serious problems in illegal water extraction, yet no official figures are available [(10)].

Large water infrastructure

Construction of dams to store water is still one of the most popular means to meet increasing water demand. Despite the negative impacts of dams, particularly in the social and ecological ambit, some countries adhere to their plans of increasing the number and storage capacity of dams, mainly in order to gain water for irrigation.

In Turkey, 86 large dams (above 15m) and 124 small dams are currently under construction or planned. The aim is to increase the area under irrigation by 58% and hydropower generation by 36%, as well as domestic and industrial water supply by 27% [(33)].

In Spain, more than 110 new dams storing 25,000 hm^3 were envisaged in the Spanish National Water Plan of 2001 [(5)]. No major review of dams has been made in the reform of that infrastructure plan that derogated the Ebro water transfer in 2004.

In France there are three dams under construction since 2001 and 20 more planned [(34)].

In Greece, the Mesochora dam which is already built but not yet filled, will store 228 hm^3 of water. The Greek Ministry of Environment, Planning and Public Works and the National Electrical Company favor building another dam at Sikias. Additionally, the Ministry of Agriculture has an extensive program for the creation of reservoirs and dams [(26)].

In Algeria, the national water plan is expected to exploit an additional 5,400 hm^3 between now and 2020, of which 3,100 hm^3 will be from surface water, in particular by building 50 additional dams [(5)].

In Tunisia, according to the National plan (2002-2011) 1,000 small dams are planned as well as 3,000 structures to recharge aquifers and 1,500 diversion structures for water harvesting [(2)]. Storage capacity of dams is planned to increase from 1,480 hm^3 in 2000 to 1,900 hm^3 by 2010 [(5)].

In Morocco, there is a trend towards the construction of smaller dams but still large dam construction has great weight: 50 new large dams are planned within the next 20 years plus 1,000 smaller reservoirs until 2050 [(64)].

Water transfers

Water transfers are a frequent means for inter-basin equilibrium in the Mediterranean catchment areas that often differ considerably in their availability of water. Hence, there are many transfers moving water from water rich regions to water scarce ones, principally for irrigation purposes.

Water transfers are no long-term solution to water scarcity

In Spain, the Tagus-Segura water transfer began in 1978 and allows a transfer to Murcia of up to 600 hm^3/a for urban water supply and irrigation. It is a clear example of severe impacts in the donor and receiving basin and shows how the increased water supply has led to even more increasing water demands, increasing the risk of water-dependency. In drought years, this transfer is at risk not to provide all the expected water.

Furthermore, the Spanish Government is currently constructing the Júcar-Vinalopó water transfer, in order to support an additional supply of up to 70 hm^3/a from Valencia to the overexploited Alicante area. The 1,050 hm^3/a-Ebro transfer project was derogated in 2004 due to the increasing doubts and criticism from wider parts of society and the European Commission as well as due to a change in Spanish Government.

In Greece, water transfers increased after the drought of the 1990s. There are several water transfers from rain-laden western Greece to the metropolitan area of Athens. The project of diverting around 1,000 hm^3/a from the river Acheloos, the second largest river in Greece, to the plain of Thessaly, an important farming area, was stopped by the State Council in April 2005 due to lack of planning [26].

In Italy, there are two aqueduct projects under discussion for the Puglia region: one is an undersea aqueduct of 80 km, connecting the Adriatic Sea shores of Albania and Puglia, and the other one is an aqueduct planned to transfer about 200-300 hm^3/a water from the Abruzzo to the Puglia region. The Puglia region today already gets water from Basilicata, Molise, Campania, and Calabria regions while new dams are under construction [61].

In Morocco, two new water transfers are planned: One for region between Rabat and Casablanca of 700 hm^3/a of which 300 hm^3 are earmarked for irrigation and another project to transfer the 400 hm^3/a water surplus of the West to the dryer East of the country [35].

In Turkey, the largest water transfer project is the Blue Tunnel Project: 10% of the Göksu River will be transferred to the Konya Plain to irrigate a total area of 230,000 ha through a 17km tunnel and three hydropower stations. The project will start in late 2006 [(28)].

Rather small water transfers, which are very common in the Mediterranean are those from the continent to the islands, e.g. Cyprus or the Balearics. These transfers are by boat and principally serve to satisfy the water demand of tourists during the summer.

Recently, there are increasing efforts for more sophisticated ways of water procurement such as desalinization or re-use of water. Albeit being maybe ecologically more suitable, these measures still address only the supply side. Questioning and addressing the extent and distribution of water demand and the water pricing policies is still avoided. The result is that water supply increases, water prices are kept low, principally in the Mediterranean area and principally for agriculture.

7 WWF proposals for drought prevention and mitigation

7.1 Proposals & recommendations

For effectively preventing droughts and increase resilience to its impacts it is indispensable to achieve a rational use of water, even in rainy years.

Despite the necessity to improve individual water consumption patterns, policies need to be adapted since they have a much greater effect on water savings. **WWF proposes for both EU and non EU countries a major shift for European and National policies towards the management of water demands, increasing the efficiency in the water use, and applying integrated and sustainable water management**. Increasing water supply is not an option, and supply investments should be ranked with lower priority and funding.

It is worth mentioning that a better management of water resources and demand is listed as the first among seven priorities identified by the Mediterranean Strategy for Sustainable Development (MSSD) finalized in 2005 and adopted by the 21 Mediterranean countries and the European Union in the framework of the Barcelona Convention.

The management of water demands requires changes in the use of subsidies, mainly for agriculture and cohesion/ public works funds. **Agricultural subsidies**, e.g. the EU funds via the Common Agricultural Policy need to be based on realistic strategies for irrigation agriculture that take into account water availability and climate change impacts. A particularly worrying aspect is the planned support of bio-energy crops that might increase even more the requests for water. Agriculture policy also needs to ensure effective compliance, excluding for instance illegal water users from the list of beneficiaries. Despite several new EU mechanisms such as decoupling, cross-compliance and the new Rural Development regulations, the National and Regional implementations of the CAP continue promoting similar policies as before.

EU Structural or Cohesion Funds and different National funding schemes still continue subsidizing the construction of **major dams and other infrastructures**, although these degrade the status of water bodies and do not provide solutions for the ever-increasing water demand. Many actions to save water and manage water demand are potentially eligible for EU Structural or Cohesion Funds. Nevertheless, the inclusion of these measures in programming and actual spending is an option, not an obligation for the individual EU member states. No matter how many opportunities are included in the EU regulations, it will depend largely on decisions made at national and sub-national levels on programming for the use of these funds. Therefore member states should ensure their national strategic framework and operational programmes reflect these opportunities.

WWF strongly supports policies that ensure a major **efficiency in the use of water**, particularly for agriculture. In many Mediterranean countries, irrigation schemes require investments in the networks and in the plot itself in order to save water. Innovative technologies can provide farmers and water managers with additional climate, soil and plant data to further reduce water losses. To ensure the application of these measures, training of farmers is crucial.

Efforts towards water savings and increased efficiency alone will not solve drought problems in the Mediterranean, as often 'saved water' is used to support further enlargements of irrigation areas or to cultivate crops with more water needs. **Integrated and sustainable water management** needs to ensure adequate water planning that takes into account environmental objectives and ensures a long-term framework. In Europe, the Water Framework Directive (WFD) provides this framework to improve water management even under drought and water scarcity situations. Its proper implementation should "*contribute to mitigating the effects of (…) droughts*" (article 1 WFD [74]) and water scarcity cannot be used as an argument/excuse for the straightforward application of a derogation from achieving the WFD objectives. The WFD provides a framework for managing waters in a way that all water uses (domestic, agricultural, industrial and ecological) and water availability are taken into account. Moreover, it allows member states flexibility to adapt their measures according to the problems faced. In non EU countries the Water Framework Directive should be regarded as a model to adopt for improving water management and tackle water scarcity and drought.

Furthermore, water scarcity needs to be on the top of the priorities in bi- and multilateral relations among Mediterranean countries, as river basins often **cross borders**. The EU should ensure that water scarcity is on top of the priorities of the European Neighborhood Policy (ENP) regional strategy for the Mediterranean region. Funding for water scarcity and drought under the ENP Regional Strategy for the Mediterranean should be tied to cross compliance with environmental criteria and the wise use of water resources.

7.2 What does WWF do?

WWF is active in the Mediterranean region with numerous projects which contribute directly or indirectly to the prevention of droughts and the mitigation of its effects. These projects embrace various issues, from the promotion of rational water use in agriculture to dialogue with governments and local authorities for improving political commitment and sound environmental legislation (see **table 6**).

Table 6: WWF activities for drought prevention and palliation in the different sectors

Water resources management
➢ Implementation of the EU Water Framework Directive (http://www.panda.org/about_wwf/where_we_work/europe/what_we_do/epo/initiatives/freshwater/wfd_seminars/index.cfm) ➢ Collaboration with water authorities ➢ Capacity building of stakeholders (e.g. WWF Across the Waters http://www.panda.org/about_wwf/where_we_work/mediterranean/about/capacity_building/index.cfm) ➢ Dams initiative (http://www.panda.org/about_wwf/what_we_do/freshwater/our_solutions/policies_practices/removing_barriers/dams_initiative/index.cfm) ➢ Capacity building on IRBM and EU legislations for governmental and non-governmental organizations, Turkey
Conservation of wetlands
➢ Conservation of the Doñana region in Southern Spain (http://www.wwf.es/aguas_continentales/juntos_donana.php) ➢ Conservation of Salt Lake and Beyşehir Lake in Konya Closed Basin, Turkey ➢ Conservation of Uluabat Lake (Ramsar Site) in Marmara region in Turkey ➢ Conservation of Merja Zerga lagoon in Morocco
Urbanization & Tourism
➢ Enhancing of rational water use and promotion of water-saving measures (project Alconbendas in Spain http://www.adena.es/casadelagua/) ➢ Promotion of water recycling (http://www.panda.org/news_facts/education/high_school/homework_help/project_ideas/index.cfm?pjid=4) ➢ Assessment of tourism impact on freshwater resources
Agriculture
➢ WWF actions for EU sugar policy reform (http://www.panda.org/about_wwf/what_we_do/freshwater/problems/agriculture/sugar/index.cfm) ➢ Modernization of irrigation with the objective to reduce the total amount of water consumed (project LIFE Hagar in Spain http://www.life-hagar.com/) ➢ CAP reform process - revision of the agricultural subsidies and orientating them towards water saving practices, favoring rain fed crops over irrigated ones (http://www.panda.org/about_wwf/where_we_work/europe/what_we_do/epo/initiatives/agriculture/common_ag_policy/cap/index.cfm) ➢ Water use control, certification of the legal use of water and identification and closure of illegal wells (http://www.wwf.es/aguas_continentales/gestion_agua.php) ➢ Capacity building of farmers for adequate irrigation (project LIFE Hagar in Spain) ➢ Drip irrigation and organic agriculture demonstration projects in sugar beet fields near Salt Lake, Konya Closed Basin, Turkey ➢ Capacity building for farmers in modern irrigation techniques and organic agriculture in Konya Closed Basin, Turkey
Forests
➢ Change in forest management: reduction of monocultures to minimize the risk of forest fires ➢ Capacity building of farmers and awareness raising in general about risks of expansion of fires

Climate change
➢ Power Switch campaign (http://powerswitch.panda.org/) ➢ Assessment of climate change impact in the Mediterranean (http://www.wwf.es/descarga/descarga_genetsis/medreportfinal.pdf)
Capacity Building
➢ Exchange programs, trainings and small grants (ATW WWF MedPO) ➢ Freshwater NGOs network

8 Abbreviations

CAP	Common Agricultural Policy (EU)
CO_2	Carbon dioxide
DSI	General Directorate of State Hydraulic Works Turkey
EEA	European Environment Agency
EFP	European Freshwater Program
ENP	European Neighborhood Policy
EPTRI	Environment Protection Training and Research Institute
ET	Evapo-transpiration
et al.	*et alii*
EU	European Union
EUWI	EU Water Initiative
FAO	Food and Agriculture Organization
ICOLD	International Commission on Large Dams
IFEN	Institut Français de l'Environnement – French Environmental Institute
IJHP	International Journal of Hydropower & Dams
INAT	Institut National Agronomique Tunisie – National Agronomic Institute Tunisia
INE	Instituto Nacional de Estadística – National Statistics Institute Spain
IRBM	Integrated River Basin Management
IUCN	World Conservation Union
kWh	Kilowatt hour
MATE	Ministère de l'Aménagement du Territoire et de l'Environnement – Ministry for Spatial Planning and Environment Algeria
MedPO	WWF Mediterranean Program
MRE	Ministère des Ressources en Eau – Water Resources Ministry Algeria
NCAR	National Center for Atmospheric Research USA
NDMC	National Drought Mitigation Center USA
NO	National Organization
ONAGRI	Observatoire National de l'Agriculture – National Agriculture Observatory Tunisia
ONEP	Office National de l'Eau Potable – National Drinking Water Office Morocco
ONSA	Office National des Statistiques Algérie – National Statistics Office Algeria
PHG	Portugiesisch-Hanseatische Gesellschaft
SDSU	San Diego State University
UCAR	University Corporation for Atmospheric Research USA
USA	United States of America
WCD	World Commission on Dams
WFD	EU Water Framework Directive
WWF	World Wide Fund for Nature

9 Glossary

Agricultural drought [12]	Deficit in soil humidity as a consequence of meteorological drought which produces negative impacts on the harvest and the growth of the natural vegetation (operational definition)
Alternative sources	Water resources of "non-natural" origin that is, recycled or desalinated water
Aquifer	A subsurface water bearing stratum of permeable rock, sand or gravel
Aridity	Permanent structural natural situation of very low annual or seasonal precipitation of a certain region
Climate	The normal or average state of the atmosphere for a given period within a year and a given geographical position
Cyclical deficit	Temporal water deficit in a certain region due to man-made causes. Nonetheless, in this report, the term "drought" is used for expressing a cyclical deficit.
Desertification	Land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (36)
Drought	Temporal natural recurrent climatic anomaly of water deficit (conceptual definition). Nonetheless, in this report, drought is used in the scientific understanding of "cyclical deficit".
Environmental flow regime	Environmental demand of water for the functioning of the aquatic ecosystems (mainly used for rivers)
Evapo-transpiration	The amount of water from precipitation that evaporates form the surface and through transpiration of plants
Ground water	Water that is stored in aquifers
hm^3	hecto cubic meter (1 million m^3)
Hydrological drought	As a consequence of meteorological drought the amount of water in streams, reservoirs and aquifers is reduced over months or years, reducing the availability of water for ecological and human requirements (operational definition)
km^3	kilo cubic meter (1 billion m^3)
Meteorological drought	Water deficit defined on the basis of the degree of dryness in comparison to a normal or average amount of precipitation of a certain region and the duration of the dry period (operational definition)
Mitigation	Structural and non-structural measures to limit aversive impacts

[12] all definitions based on (53) and (54)

Prevention	Anticipatory measures and activities in order to reduce potential risks and uncertainties
Renewable water resources	Volume of fresh water that is provided naturally in the hydrological cycle (per year)
Reservoir	Basin for water storage behind dams
Socio-economic drought	As a consequence of meteorological, hydrological, and agricultural drought the human demand for water can not be met, implying severe social and economical impacts. Socio-economical drought affects the water supply for the municipalities, the production of hydro-electricity, agriculture, industry etc (operational definition)
Surface water	All waters above the surface (rivers, lakes, canals, reservoirs etc)
Water demand	Amount of water that is required to fulfil the ecological and/or human needs for the different uses
Water scarcity	Permanent water deficit regarding the water demand in a certain region, either due to natural or man-made causes
Water supply	Aggregation of all water resources that may be used for different ecological and human needs, including precipitation, surface and ground water and alternative sources

10 Internet links of interest

	Issue/ entity	Link	Language [13]
General	**WWF**	**www.panda.org**	**EN**
Environment	Regional Activity Centre - Environment & Development in the Mediterranean	http://www.planbleu.org/	FR, EN
	European Environment Agency	http://www.eea.eu.int/main_html	
	World Resources Institute – The Environmental Information Portal	http://earthtrends.wri.org/	
Drought	US National Drought Mitigation Center	http://drought.unl.edu/	EN
	ARID Cluster	http://www.arid-research.net/	EN
Water	AQUASTAT FAO's global information system of water and agriculture developed by the Land and Water Development Division of FAO	http://www.fao.org/ag/agl/aglw/aquastat/main/index.stm	EN, FR, ES
Forests	Global Fire Monitoring Centre	http://www.gfmc.org/	EN
ALGERIA			
Water	Water Resources Ministry Algeria	http://www.mre.gov.dz/eau/ressources_mre.htm	FR, EN
	Meteorological National Office	http://www.meteo.dz/	FR,
	Euro-Mediterranean Information System on the know-how in the Water Sector, Algeria	http://www.semide.dz/	FR, EN
FRANCE	**WWF**	**www.wwf.fr**	**FR**
	National Statistic Institute France	http://www.insee.fr	FR, EN
Environment	Ministère de l'écologie e du développement durable	http://www.ecologie.gouv.fr	FR
	Institut Français de l'Environnement	http://www.ifen.fr/	FR
Water	Euro-Mediterranean Information System on the know-how in the Water Sector, France	http://semide.oieau.fr/	FR, EN
	Water Agency Rhone, Mediterranean and Corsica	http://www.eaurmc.fr/	FR
	Water Agencies	http://www.lesagencesdeleau.fr/	FR, EN
	Water infos of Ministère de l'écologie e du développement durable (Actualité -> Bulletin!)	http://www.eaufrance.fr/	FR
	Institut Français de l'Environnement – water use data	http://www.ifen.fr/dee2003/ressourceseau/ressourceseau5.htm	FR
	Water documentation portal	http://eaudoc.oieau.fr/sie/gedoieau.asp	FR
Hydro-power	Electricity Supply France	http://www.edf.fr/	FR, EN
Agriculture	French National Institute for Agricultural Research	http://www.inra.fr/ , http://www.international.inra.fr/	FR, EN
Forests	Data bank about fires in the French Mediterranean	http://www.promethee.com	FR
Climate Change	Meteorological info about France	http://www.meteofrance.com	FR
	Climate change infos of Ministère de l'écologie e du développement durable	http://www.effet-de-serre.gouv.fr	FR
GREECE	**WWF**	**www.wwf.gr**	**GR**
Water	Euro-Mediterranean Information System on the know-how in the Water Sector, Greece	http://kronos.minenv.gr/emwis/	GR, (FR), (EN)
ITALY	**WWF**	**www.wwf.it**	**IT, EN**

[13] Languages: AR = Arab, D= German, EN = English, ES = Spanish, FR = French, GR = Greek, IT = Italian, PT = Portuguese, TR = Turkish

Water	Euro-Mediterranean Information System on the know-how in the Water Sector, Italy	http://www.semide-it.org	IT, EN, FR
MOROCCO	**WWF MedPO**	**www.panda.org/mediterranean**	**EN**
Water	Euro-Mediterranean Information System on the know-how in the Water Sector, Morocco	http://www.water.gov.ma	FR, EN
	Office National de l'Eau Potable	http://www.onep.ma/transfer.htm	FR
	World Commission on Dams	http://www.dams.org/kbase/submissions/showsub.php?rec=opt063	EN, FR
	Ministry of Land Management and Water	http://www.matee.gov.ma/index.asp	FR
	50 years of Human Development - Outlook	http://www.rdh50.ma/fr/atlas07.asp	FR, EN, AR
	Euro-Mediterranean Information System on the know-how in the Water Sector	http://www.water.gov.ma/semide/fr/page%20principale1.htm	EN, FR
Climate Change	Report of the Ministère de l'Aménagement du Territoire, de l'Urbanisme, de l'Habitat et de l'Environnement [2001]: "Communication Nationale Initiale à la Convention Cadre des Nations Unies sur les changements climatiques"	http://www.bdix.net/sdnbd_org/nationa_communication_not_in_annex1/Morocco_1.pdf	FR
PORTUGAL	**LPN**	**www.lpn.pt**	**PT, EN**
Water	Euro-Mediterranean Information System on the know-how in the Water Sector, Portugal	http://snirh.inag.pt	PT, EN
SPAIN	**WWF**	**www.wwf.es**	**ES**
Environment			
	National Environment Ministry	www.mma.es	ES, EN, FR
Drought	Observatorio Nacional de Sequía	http://www.mma.es/rec_hid/sequia/htm/que.htm	ES
	Junta de Andalucía, Consejería de Medio Ambiente	http://www.juntadeandalucia.es/medioambiente/Infosequia/index.html	ES
Water	Euro-Mediterranean Information System on the know-how in the Water Sector, Spain; Sistema Español de Información sobre el agua	http://hispagua.cedex.es/	ES
Forests	Fires	www.incendiosforestales.org	ES
Climate Change	National Ministry of Meteorology	http://www.inm.es/	ES
TUNISIA	**WWF MedPO**	**www.panda.org/mediterranean**	**EN**
Water	Euro-Mediterranean Information System on the know-how in the Water Sector, Tunisia	http://www.semide.tn	EN, FR, AR
Agriculture	L'Observatoire National de l'Agriculture	http://www.onagri.nat.tn/apropos.htm	FR, AR
TURKEY	**WWF**	**www.wwf.org.tr**	**TR, EN**
	State Planning Organization Turkey	http://www.dpt.gov.tr/ing/	TR, EN
Water	Euro-Mediterranean Information System on the know-how in the Water Sector, Turkey	http://212.174.165.253/english.htm	TR, EN
	General Directorate of State Hydraulic Works	http://www.dsi.gov.tr	TR, EN
	Southeastern Anatolia Project Regional Development Administration	http://www.gap.gov.tr	TR, EN
Agriculture	Ministry of Agriculture and Rural Affairs	http://tarim.gov.tr	TR, EN
Climate Change	Ministry of Environment and Forestry, General Directorate of State Meteorological Works	www.meteor.gov.tr	TR, EN, D
	State Planning Organization, 8th National Development Plan climate change Commission Report	http://ekutup.dpt.gov.tr/cevre/oik548.pdf	

11 References

([1]) Medroplan [2006]: http://www.iamz.ciheam.org/medroplan/

([2]) WFD/EUWI [2006]: Mediterranean Joint Process WFD/EUWI, Water Scarcity Drafting Group, Tool Box (Best practices) on water scarcity, Draft Version Number 9, to be modified, 13th February 2006

([3]) ONS [2006]: Observatorio Nacional de Sequía, http://www.mma.es/rec_hid/sequia/htm/que.htm

([4]) SDSU [2006]: San Diego State University, http://threeissues.sdsu.edu/three_issues_droughtfacts01.html

([5]) Blue Plan [2005]: A sustainable future for the Mediterranean - The Blue Plan's Environment & Development Outlook, edited by Giullaume Benoit & Aline Comeau, Earthscan, London 2005

([6]) DSI [2006]: General Directorate of State Hydraulic Works, Land and Water Resources, Turkey, http://www.dsi.gov.tr/english/topraksue.htm

([7]) Treyer [2000]: Analyse des Stratégies et prospectives de l´eau en Tunisie - Rapport I Monographie de l'eau en Tunisie, Plan Bleu, Centre d'activités régionales, texts by Sébastien Treyer (ENGREF), January 2000

([8]) Bzioui [2004]: Rapport National 2004 sur les ressources en eau au Maroc, UN Water-Africa

([9]) MATE [2000]: Rapport sur l'Etat et l'Avenir de l'Environnement, Ministère de l'Aménagement du Territoire et de l'Environnement, République Algérienne Démocratique et Populaire

([10]) Mohammed Yacoubi Soussane [1999] : Les ressources en eau du Maroc: bilan, perspectives et plan d'action. Institut Mediterranéen de l'Eau.

([11]) Plan Bleu [2004]: L'eau des Méditerranéens – Situation et perspectives, Programme des Nations Unies pour l'Environnement & Plan d'action pour la Méditerranée, Jean Margat, Athens

([12]) FAO [2004]: FAO Statistical Yearbook 2004, Table A.5 Water use and national rainfall indices, http://www.fao.org/es/ess/yearbook/vol_1_1/site_en.asp?page=resources

([13]) EEA [1996]: European Topic Centre of Inland Waters, Water resources problems in Southern Europe, Topic report No 15/1996, http://reports.eea.eu.int/92-9167-056-1/en/page003.html

([14]) NTUA [2006]: National Technical University Athens, School of Chemical Engineering, http://environ.chemeng.ntua.gr/wsm/Newsletters/Issue2/CircumstancesInGreece.htm

([15]) INAT [2003]: Water & Wetland Index [2nd Phase], National report Tunisia, Institut National Agronomique de Tunisie, by Mohamed Salah Romdhane & Islem Ben Ayed, 01.10.2003

([16]) WCD [2006]: Large Dams in Morocco: Experience and Perspectives for the Future, World Commission on Dams, http://www.dams.org/kbase/submissions/showsub.php?rec=opt063

([17]) ONSA [2006]: National Statistics Office Algeria, http://www.ons.dz/

([18]) ONAGRI [2006]: ONAGRI, L'Observatoire National de l'Agriculture, http://www.onagri.nat.tn/chiffres_ResHalieu.htm

([19]) WWF EFP [2001]: WWF European Freshwater Programme, Water and Wetland Index, Assessment of 16 European Countries Phase 1 Results, April 2001, http://assets.panda.org/downloads/WWI-report-en.pdf

([20]) MRE [2006]: Ministère des Ressources en Eau Algérie, http://www.mre.gov.dz/eau/ressources_mre.htm

([21]) NCAR/UCAR [2005]: National Center for Atmospheric Research & University Corporation for Atmospheric Research, http://www.ucar.edu/news/releases/2005/drought_research.shtml

([22]) WWF [2005a]: PowerSwitch! Campaign, Europe feels the heat – the power sector and the extreme weather

([23]) WWF [2005b]: Climate change impacts in the Mediterranean resulting form a 2°C global temperature rise, a report for WWF, by C. Giannakopoulos, M. Bindi, M. Moriondo, T. Tin, July 2005

([24]) NUS Consulting [2003/2004]: Annual Water Cost Survey

([25]) EEA [2001]: Sustainable water use in Europe, Part 2 – Demand Management, European Environment Agency, Belgium

([26]) WWF Greece (2006)

([27]) INE [2005]: Encuestas del agua 2003 - “El consumo medio de agua aumenta un 1.8% durante el año 2003 y se sitúa en 167 litros por habitante y día”, press release 3 August 2005, Instituto Nacional de Estadística

([28]) WWF Turkey 2005

([29]) IFEN [2006]: Institut Français de l'Environnement, http://www.ifen.fr/dee2003/ressourceseau/ressourceseau4.htm

([30]) EarthTrends [2006]: http://earthtrends.wri.org/country_profiles/index.php?theme=2, respective country data from differing years

([36]) IUCN [2004]: Assessment and Provision of Environmental Flows in Mediterranean Watercourses – concepts, methods and emerging practices, Mediterranean Resource Kit, World Conservation Union

([37]) Eurostat [2003]: „Wasserverbrauch und Abwasserbehandlung in der EU und in den Beitrittsländern“, Ulrich Wieland, Statistik kurz gefasst, Umwelt und Energie, Thema 8 - 13/2003, http://www.eds-destatis.de/de/downloads/sif/nq_03_13.pdf

([38]) WWF [2004]: Freshwater and tourism in the Mediterranean, Lucia de Stefano, June 2004

([39]) Rodriguez *et al.* [2005]: A preliminary assessment of the impacts in Spain due to the effects of climate change, Ministry of the Environment, Government of Spain

([40]) MATE [2001]: Elaboration de la stratégie et du plan d’action national des changements climatiques, Ministère de l’Aménagement du Territoire et de l’Environnement, Direction Générale de l’Environnement, République Algérienne Démocratique et Populaire

([41]) Le Monde [15-02-2006]: “La France risque de subir une troisième année de sécheresse”, http://www.lemonde.fr/web/article/0,1-0@2-3228,36-741498@51-725020,0.html

([42]) Journal Correio da Manha 08-03-2006

([43]) WWF France 2006

([44]) Journal Correio da Manha 13-07-2005

([45]) estimations MMA

([46]) Journal La Razón 23-01-2006

([47]) Journal Publico 06-07-2005

([48]) Journal Le Figaro 04-07-2005

([49]) Corriere della Sera 29-07-2005

([50]) WWF France [2004]: Les impacts du changement climatique sur la biodiversité en France (métropolitaine et Outre-mer), Synthèse et priorités d'actions pour le WWF France, Cécile Querleu, September 2004, internal doc WWF France

([51]) WWF Deutschland [2005]: Hintergrundinformation Baumwollanbau. Kampf ums „weiße Gold“: EU- und US-Subventionen gegen Baumwolle aus Afrika., Dezember 2005

([52]) WWF/Adena (2006)

([53]) MIMAM [2006]: Spanish Environmental Ministry, http://www.mma.es/rec_hid/sequia/pdf/que/glosario.pdf

([54]) FAO [2006]: FAO glossary, http://www.fao.org/ag/agl/aglw/aquastat/glossary/index.jsp

([55]) Different sources: The Environmental Impacts of Irrigation in the European Union", a report to the Environment Directorate of the European Commission, Institute of European Environmental Policy (IEEP), London; INE report from June 2001

([56]) UNCCD [1994]: International Convention to Combat Desertification in countries experiencing serious drought and/or desertification, particularly in Africa

([57]) IJHP [2005]: International Journal of Hydropower & Dams, World Atlas & Industry Guide 2005

([58]) Tockner, K. *et al.* [2003]: The Tagliamento River: A model ecosystem of European importance. Aquatic Sci.65: 239-253

([59]) Istituto Nazionale di Economia Agraria, www.inea.it

([60]) David Belfiore [2005]: Italian research on environmental impact of tomato production at national and local level. WWF Italia.

([61]) WWF Italy (2006)

([62]) Comitato per la Vigilanza sull'Uso delle Risorse Idriche [2003]: "Relazione al Parlamento sullo stato dei servizi idrici, anno 2002", July 2003

([63]) CNR [2006]: Consiglio Nazionale delle Ricerche, Trend in daily precipitation intensity and in the frequency of extreme precipitation events in Italy in the last 120 years, by Brunetti M., Maugeri M., Nanni T., http://www.cnr.it/istituti/FocusByN_eng.html?cds=075&nfocus=3

([64]) Government of Morocco, http://www.water.gov.ma/03programmes/prog-barrages.htm

([65]) ICOLD [2006]: International Commission on Large Dams, http://www.icold-cigb.org/

([66]) Gleick [1995]: “Human Population and Water: To the Limits in the 21st Century”, President of the Pacific Institute for Studies in Development, Environment, and Security, Oakland, California, http://www.aaas.org/international/ehn/fisheries/gleick.htm

([67])Environmental Data Services Limited (ENDS), Spanish farmer claim water pricing exception, 17 May 2006, http://www.endseuropedaily.com/articles/index.cfm?action=search&searchtext=spain+irrigation

([68]) Etat de lieux du bassin du Rhône et des cours d'eau côtiers méditerranéens, Caractérisation du district et registre des zones protégées, Document adopté par le Comité de Bassin du 4 mars 2005

([69]) WWF/Adena [2005]: Los excedentes agrícolas “se beben” el agua de 16 millones de españoles: Un análisis de la sobreproducción en el regadío. http://assets.panda.org/downloads/consumoaguaporexcedentesagricolasfinal.pdf

([70]) WWF Auen-Institut, Germany

([71]) Yacoubi- Soussane M. [1999] : Les ressources en eau au Maroc. Bilan, perspectives et plan d’action. Institut Méditerranéen de l’eau

([72]) Snoussi M., Haida S. and Imassi S. [2002]: Effects of the construction of dams on the Moulouya and the Sebou rivers (Morocco). Reg. Environ. Change, Vol.3, N° 1-3 Dec. 2002., Springer-Verlag. p 5-12

([73]) Mokhtar Bzioui [2004]: Rapport national 2004 sur les ressources en eau au Maroc. UN Water-Africa

([74]) Water Framework Directive (2000/60/EC), www.euwfd.com

([31]) ISTAT [2004]: Bilancio demografico nazionale 22004. Comunicato Stampa 27 Giugno 2005.

([75]) EEA [2005]: The European environment, state and outlook 2005, http://dataservice.eea.europa.eu/atlas/viewdata/viewpub.asp?id=1718

([76]) Libro Blanco del Agua en España, MIMAM, 2000, page 164

([32]) WWF/Adena [2006]: Uso ilegal del agua en España – Causas, efectos y soluciones. May 2006

([33]) DSI [2005]: General Directorate of State Hydraulic Works 1954-2005

([34]) WWF France [2003]: Encore plus de grands barrages?, Martin Arnould, WWF France, 23-10-2003

([35]) ONEP [2006]: Office National de l'Eau Potable, http://www.onep.ma/transfer.htm

Comment: For information cited as WWF offices of the year 2006, please contact staff of the relative office for the respective information