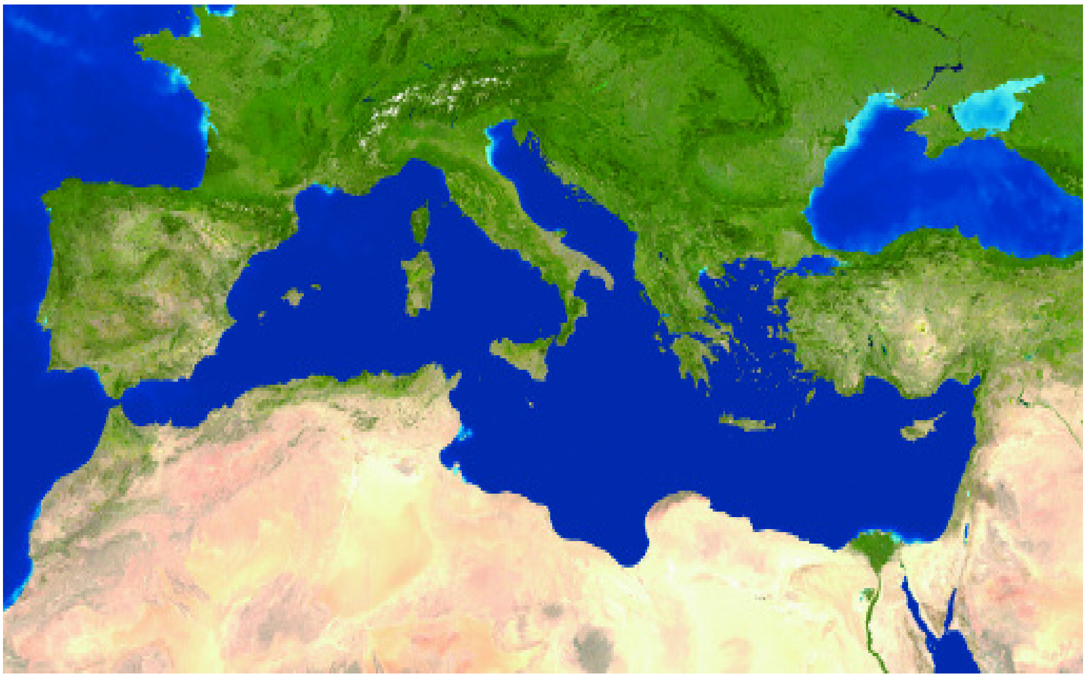
JOINT MEDITERRANEAN EUWI/WFD PROCESS



Mediterranean Water Scarcity and Drought Report

Technical report on water scarcity and drought management in the Mediterranean and the Water Framework Directive

(Draft Version 28 October 2006)

Produced by the

MEDITERRANEAN WATER SCARCITY & DROUGHT WORKING GROUP (MED WS&D WG)

PREFACE

Because of the increased frequency of drought events over recent years, the informal meeting of Water Directors of the European Union (EU) held in Roma (Italy) in November 2003, agreed to take an initiative on water scarcity issues. A core group led by France and Italy - the Water Scarcity drafting group of the Common Implementation Strategy of the Water Framework Directive (WFD) - prepared a technical document on drought management and long-term imbalances issues which was presented to the EU Water Directors in June 2006. The EU Water Directors took note of the technical document and endorsed the Policy summary[1].

The Mediterranean report is based on the EU document produced in June 2006. It has been prepared by the Mediterranean Water Scarcity & Drought Working Group, in the framework of the MED-EU Water Initiative / Water Framework Directive Joint Process.

The first phase of the Mediterranean Joint Process was initiated in September 2004, thanks to a Mediterranean Workshop gathering Mediterranean Pilot River Basins from EU Member States and representatives of partner countries[2]. Three topics were selected as a first basis of common interest. Three Mediterranean thematic Working groups were set up to address these issues, including the Water Scarcity & Drought (WS&D) one. This group is led by France and the European Commission. Two Mediterranean Focal Points were invited to joint the EU group on the same issue, Egypt and Tunisia. The Focal Points participated in two workshop/conference organised in the framework of a research project: Palermo, Italy Oct.2004 and Cyprus, May 2005 and in EU meetings on Water scarcity held in Rome, January 2005, Paris, September 2005, Rome October 2005 and Madrid, February 2006. Finally, meeting of the plenary Mediterranean Working Group on Water Scarcity & Droughts was organised in Brussels on 27 September 2006 where the preparation of this report was discussed.

The current document is the **draft report on Mediterranean Water Scarcity & Drought. It is being completed by supplementary contributions. Conclusions are preliminary at this stage and may be subject to revision.**

The document consists of five parts. The introduction presents the situation of water scarcity and droughts in the Mediterranean and the

[1] Water Scarcity Drafting Group – Water scarcity management in the context of the Water Framework Directive, June 2006; document and Appendix (121 p.& 33 p.) and Policy summary (6p.)

[2] Workshop – "The PRB Mediterranean dimension", Back-to-back with the Workshop – "Linking rural development and land degradation mitigation into river basin management plans"., 22-24 September 2004 Brindisi, Italy organised by DG JRC and DG Environment of the European Commission and the Italian Ministry of Environment, APAT and the Regione Puglia

linkages between the Water Framework Directive and Water scarcity. In chapter I, the definitions and assessments of the different phenomena are described. Chapter II reports on planning and management of drought events. Chapter III deals with long-term imbalances in supply and demand. The conclusions and recommendations are presented in Chapter IV.
The main objective of this report is to present the Mediterranean specificities regarding water scarcity situations and droughts events and the role of the Water Framework Directive. Examples of strategies and measures taken in the Mediterranean region for addressing Water Scarcity and Drought illustrate the different sections of the reports. In addition, the specificities of the WFD implementation related to Water scarcity and drought are identified for non-EU countries.

Co-Authors:

Mohamed Blinda, Plan Bleu
Mohamed Boufaraoua, Ministry of Agriculture, Tunisia
Natasha Carmi, Palestinian Hydrologic Group
Thierry Davy, Agences de l'eau, France
Sylvie Detoc, European Commission, DG Environment
Jochen Froebrich, University of Hanover, Germany (with contributions from Prof. M. Kirkby, Prof. I. Ribarova, Prof. M. G. Tournoud, Prof. P. Kondouri, Prof. E.A. Nuppenau, Dr. Huchzermeyer, Prof. R. Maja, Prof. M. Salgot, and Prof. R. Kanwar)
Abdul-Latif Khalid, Palestinian Hydrologic Group, Palestine Authority
Essam Khalifa, Ministry of Water Resources and irrigation, Egypt
Jean Margat, Plan Bleu
Zach Tagar, Friends of the Earth Middle-East

To Be Completed

Coordinated by **Sylvie Detoc**, European Commission, DG Environment

This work was supported by the **Mediterranean Water Scarcity & Drought Working Group (MED WS&D WG).**

CONTENTS

INTRODUCTION

1. What is water scarcity? How is it evaluated and measured?

In general, all situations of shortage (scarcity) mean an imbalance: an excessive demand for excess compared to the supply, which is thus partly dissatisfied.

Water scarcity corresponds to the mismatch between demands (for all uses) and supply, which can be considered as water resources, or, more strictly, their exploitable part which is in particular offered by water operators; therefore water scarcity can be considered as the *imbalance between water requirements and water supply*.

Water scarcity can be then structural, due to the scarcity of the average resources compared to increasing demands, or random, determined by failures of natural resource (drought) or mobilization system, or because of temporary increase of demands. It can be physical, due to excessive demand compared to natural resources, or socio-economic, because of structural or random insufficiency of system means of use (poverty, defect or technical accident), even because of excessive demands compared to the needs.

To evaluate a situation of water shortage implies a space-time definition and a relevant analysis of the resource system and reference use, for the comparison between resources (or water productions) and demands, which it acts present or projected situation, based then known prospective of supply and demand.

The measurement of the gravity degree of a situation of water shortage rests primarily on the difference between demand and resource, its duration and the extent of the affected territory, but also on its socio-economic consequences.

Two macro-economic indicators, secured by significant conventional thresholds, are commonly used to reveal and characterize the shortage situations, in particular in a regional group:

- **water resources per capita,** tension index ("water stress") with less than 1000 m³ per year and shortage ("water scarcity") with less than 500 m³ per year, while referring to the renewable natural water resources in average year.

Proposed by Mr. Falkenmark, the threshold values of this indicator are adapted with the countries where the irrigation takes part largely at the water demands and where a part only of the natural resources is exploitable in practice (what is thus well adapted to the Mediterranean).

- **the resources exploitation index,** ratio withdrawals/resources of renewable natural water (%), indicates a presumption of tension (with local or random shortages) above 50%, and structural general shortage to the approaches and above 100%.

In short:

Indicators	Situations	
	Tension (water stress)	Structural shortage
Resources per capita	1000-500 m³/year	<500 m³/ year
Exploitation index	50 à ~ 100%	>100%

The estimates according to these two indicators are naturally very correlated, in particular in the Mediterranean area.

These indicators have however two defects which can make the evaluations too optimistic:

- National calculations, by whole country, level intern regional inequalities and can mask tension situations or local shortage. In the same way the reference to the average resources is unaware the random shortages related to the climate risks.
- the references to the natural resources thus do not take enough account of the interannual variations of the random shortages presumptions ascribable with the droughts.

One and the other lend itself to the prospective while being based on demographic projections and the future water demands estimated according to various scenarios.

2. Current situations of water scarcity and outlook

In the Mediterranean the situations or the risks of water shortage are generally ascribable at the high level and the growth of the demands face to limited renewable water resources- and mainly irregular and unequal qualities- thus with availabilities which rarefy.

Because of the diversified distributions of the water resources and uses as a whole of the Mediterranean area, it is by comparing the respective geographies of the ones and others, by means of the above-mentioned indicators, that one can highlight tension situations or present or future shortage, while proceeding initially, more conveniently, by country (Figures 1 and 2), in spite of the reserves indicated.

Figure 1 :

Renewable natural resources per capita per year in Mediterranean countries, 2000-2025

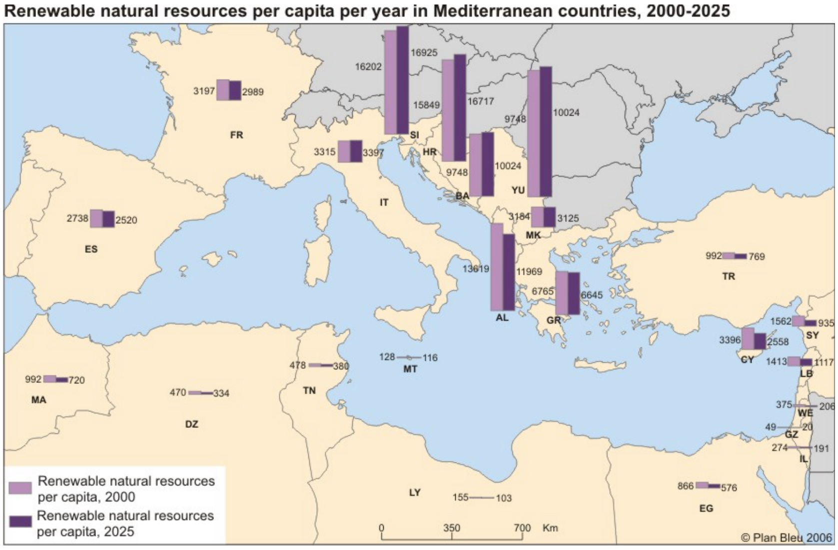
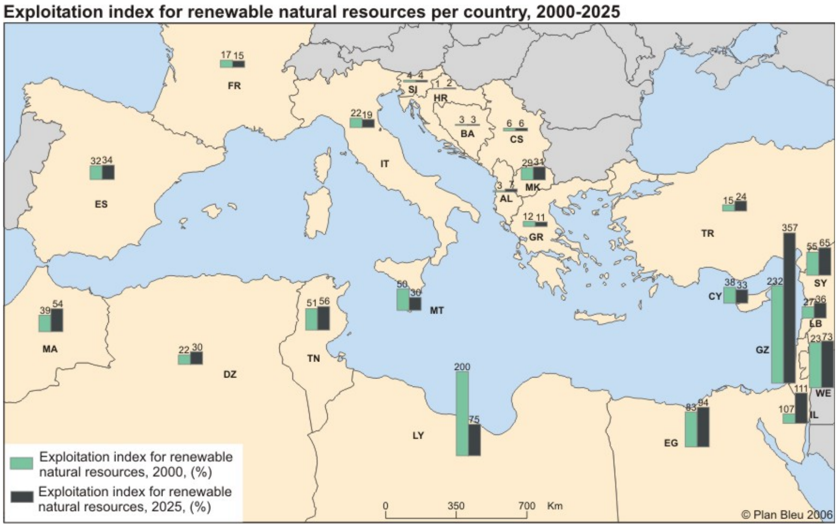


Figure 2 :

Exploitation index for renewable natural resources per country, 2000-2025



Figures are presented in appendix (table 1), which makes it possible to compare the situations of each Mediterranean country in 2000 and 2025 (according to population projections "variable medium" of the United Nations (2003) and following demands trend projections) on the constancy assumption of the reference renewable natural water resources.

The same exploitation index of the renewable natural resources calculated for the Mediterranean catchment basin for 2000 and 2025 as shown in figure 3 highlights the variety of situation:

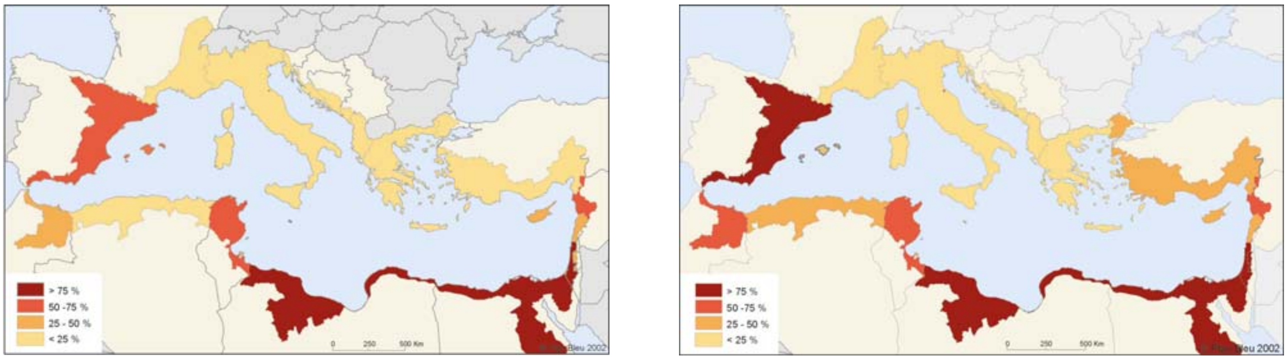
- A first group of countries, where water withdrawals are close to or exceed the average annual volume of renewable natural resources (exploitation index equal to or greater than 75 per cent), i.e. in 2000 Egypt, Israel and Libya, to be joined by 2025 by the Palestinian Territories and Spain's Mediterranean basins. The natural resources in all these countries are already in very highly stressed and they will have to meet a growing part of their demand from other "unconventional" sources.

- A second group of countries where total demand represents a growing share of the average annual volume of renewable natural resources, but where the exploitation index will stay between 50 and 75 per cent until 2025: Malta, Syria and Tunisia.

- A third group of countries, where the exploitation index lies between 25 and 50 per cent, may nevertheless experience local or exceptional stress: Lebanon, Cyprus, Morocco, joined by Turkey and Algeria by 2025.

- A fourth group of countries where the exploitation index is less than 25 per cent: Greece and the Eastern Adriatic, France and Italy, where total demand is dropping.

Figure 3 Exploitation indices per basin, 2000-2025



2000 **2025**

☹ Pressure on water is growing in the South and East; ☺ Pressure is decreasing in the north, except in Spain

The good agreement of these indicators in the Mediterranean area, because of the general irrigation predominance in water demands, consolidates these analyses. Groundwater overexploitations which explain current exploitation indices >100% in some countries are with the obviousness of shortages symptoms. The high exploitation indices can as presume as water demands cannot be entirely covered any more by the conventional resources exploitation and must partly use to non-renewable resources or with non-conventional supply sources (wastewater re-use, desalination).

Almost all the Mediterranean countries of the South and the Middle East are right now in tension situation or shortage according to these national indicators. In 2025, the tension situation would have occurred in Syria and Egypt would approach the shortage situation. A finer regionalization reveals moreover situations of more local shortage present in several countries of the South (Algeria, Morocco) or North (Mediterranean Spain, South Italy, Greece, Turkey).

It is more difficult to regionalise water resources projections per capita deduced from the population projections (2025) - and minored by potential reductions due to climate change, especially in the South - and forecast evolutions of water demands in baseline scenarios. However these projections foresee shortage extensions and aggravations in several countries, in Maghreb and Middle East.

In 2025, the populations in water stress situation or water shortage, according to the indicator "resources per capita", will rise to 244 million, 44% of the total population of the Mediterranean countries on this date, in average projection (without counting certain local situations in country of North).

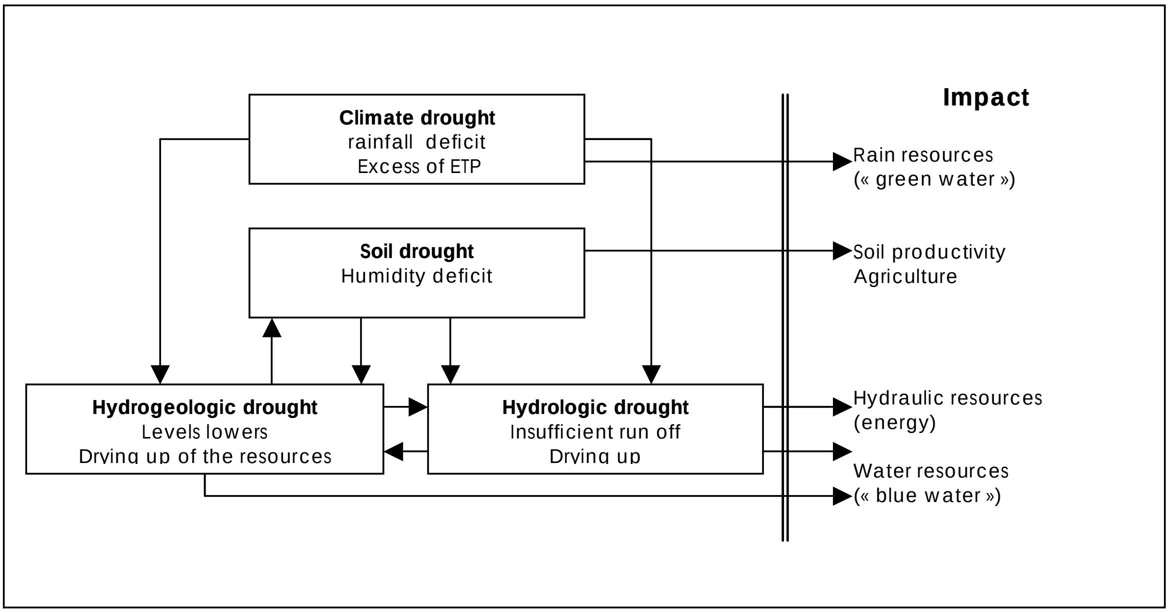
Can one assess the future water shortages by considering the "deficits" estimated: surpluses of the projected demands, in baseline scenarios, on the exploitable renewable resources? Calculations of differences between demands and resources overall by country are significant only in the countries where the system of resources and uses is unified, either by nature (Egypt), or by water projects (Israel, Libya); elsewhere these national comparisons can mask local deficits (Maghreb, Syria).

In the whole of the South and the Middle East countries, the deficits could be in 2025 about 50 km3/year (including 30 in Egypt, 7 in Libya, 1 in Israel).

3. Droughts and water scarcity in the Mediterranean

Climate risks (rainfall deficiencies compared to the annual or seasonal averages) with hydrological consequences, therefore on the renewable water resources, the droughts are naturally the principal cause of random shortage per failure of resource everywhere where the water demands border, in quantity, the annual average resources in "blue water", but moreover because "the green water" deficits (soil humidity) make grow the irrigation water demands: the drought at the same time reduced and makes request more the natural water resources.

The droughts typology and their impacts can be summarized by the diagram below:



Mediterranean, where the climate is characterized already by a normal dry season (summer), an "annual" drought can consist:

- in contribution deficit (effective rainfall) of winter and spring, with especially hydrological consequences, therefore on the resources, more especially as the regimes are irregular;
- and/or in stressing of the summer drought (fuller and longer) with immediate consequences on the soils and the vegetation, and for differed hydrological effects, which rather impact on the water demands (in particular of additional irrigation), but indirectly on the resources by their increased exploitation.

Locally, the severity of a seasonal or annual drought can be characterized several manners (either by the fuller of the difference to the average of the period, measured in standard deviation; or by a frequency of conventional occurrence compared to a median), which also makes it possible to draw up statistics. For example:

- Marseilles, between 1840 and 1975, 73 dry years occurred, including 41 with moderate drought (less than 1 standard deviation), 29 with strong drought (1 to 2 standard deviation) and 3 with very strong drought (> 2 standard deviation).
- Tunis, over 110 years, including 55 with insufficient rainfall (lower than the average), 32 moderate droughts and 23 strong droughts, were counted according to the same criterion (Benzarti, 1990).
- Athens, over 132 years, one knew 12 "severe" droughts (> 1,5 standard deviation) (Baloutsos, 1993).

- Oujda (Morocco), between 1932 and 1996, 21 dry years (with rainfall lower than those of decile 3) out of 65 were counted.

The space extension of the droughts is naturally a multiplying factor: they can affect vast areas, indeed whole countries, defraying the chronicle of the media and preoccupying the political authorities.

The droughts succession several consecutive years is not rare and worsens the situations, by supporting the drying up of soil and subsoil reserves.

To evaluate the intensity and the gravity of a drought must be based at the same time on various variables of natural state (duration, geographical extension, variation with the averages known as "normal") and on the socio-economic estimate of the consequences. Various indicators were proposed, like the Palmer index (1995), but were not still applied to the Mediterranean droughts classification.

The renewable natural water resources are unequally sensitive or "resistant" to the annual or multi annual droughts, according to the regulating capacities either of the aquifers, or of the possible developments (dams), very variously divided into Mediterranean.

To lessen the impact for the random shortages ascribable the droughts then must, in the measurements varied, to combine water storages by water developments, indeed of the transfers between basins, food reserves storages, and the guarantied procedures.

4. Link between the EU Water Framework Directive and Water Scarcity issues

There is a Europe-wide awareness of the full range of values water offers for the population's well-being, from livelihoods to recreational, aesthetic and cultural points of view. This recognition is clearly reflected in the Water Framework Directive, adopted on 23 October 2000[3]. WFD defines a European framework for water management and protection at each hydrological basin level. Aiming to preserve and restore good water status to both surface and groundwater sources by 2015, the WFD gives priority to environment conservation through participatory and consultative programs. It raises the issue of water floods and droughts in its article 1 which emphasizes the need to :

- prevent further deterioration (articles 1.a and 4)
- promote sustainable water use based on a long-term protection of available water resources (article 1.b)
- contribute to mitigating the effects of floods and droughts (article 1.e)
- contribute to the provision of the sufficient supply of good quality surface water and groundwater as needed for sustainable balanced and equitable water use

In addition, the WFD requires that "good quantitative status" of groundwater bodies (balancing abstractions with recharge) is attained, thus supporting sustainable water

[3] "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy" http://ec.europa.eu/environment/water/water-framework/index_en.html

abstraction regimes, even in water stress and shortage situations. Furthermore, groundwater levels should not be subject to anthropogenic alterations that might have impacts on surface waters. Water quantity can have a strong impact on water quality and therefore on the achievement of the ecological status.

It will also be essential to encourage participatory ecosystem-based management, to provide the minimum flow of water to ecosystems for conservation and protection and to ensure sustainable use of water resources.

In conformity with WFD regulations, member states are responsible for protecting, enhancing and restoring all bodies of surface water to achieve good status. In practice, this is carried out through the implementation of monitoring programs (article 8) which cover :

- the volume and water level or rate of flow to the relevant extent for ecological and chemical status and ecological potential.
- the ecological and chemical status and ecological potential properly speaking.

For groundwater, monitoring programs relate to chemical and quantitative status.

As regards groundwater, a Groundwater Daughter Directive will define the requirement under article 17.1 to "prevent and control groundwater pollution". While it is important in this regard to derive criteria to assess groundwater status and identify significant upward trends, this should not preclude the early adoption of simple pragmatic measures to protect groundwater quality. This is even more valid considering that a groundwater protection regime against pollution is already mandatory under the directive 80/68/EEC.

By adopting the WFD, the EU has thoroughly restructured its water protection policy. The directive requires that integrated management plans be developed for each river basin in order to achieve good ecological and chemical status. Although the WFD will contribute to the mitigation of the effects of droughts, it is not one of its principal objectives. In most cases, droughts are identified too late and emergency measures are undertaken in a hasty way. The latter are not, in general, sufficiently effective. Clear and consistent criteria for an early detection and warning of drought situations need therefore to be established. Such criteria would allow sufficient time, before and at the beginning of a drought event, to look for suitable responses in the management of a water resource system.
The WFD additionally considers that prolonged droughts "cannot reasonably have been foreseen" (article 4.6). Prolonged droughts are therefore "grounds for exemptions from the requirement to prevent further deterioration or to achieve good status" (Preamble (32)) where "additional measures are not practicable" (article 11.5). The measures that directly relate to drought mitigation are left as optional supplementary measures (WFD Annex VI, Part 5).

Chapter I: Definitions and assessment of the different phenomena

**********************************TO BE COMPLETED***

Characterization of drought/drought definition - Palestinian hydrologic Group
The past few years have witnessed annual precipitations below the average in Palestine. In 1998/99, the rainfall record in the winter was the minimum in the past 100 year long history of rainfall records. This drought has led to water quality deterioration, drop in the groundwater levels and decline in spring discharge. Accordingly, water shortage has become very acute and available supply falls short in meeting demand. Under the foreseeable future scenarios of population growth and development needs, this water shortage is expected to intensify. The average population growth rate is estimated at 4%, which, means that the population is expected to double in the coming two decades. (Rabi et.al, 2003a). In an attempt to quantify the characteristics of the 1998–1999 droughts and assesses its hydrologic impact on the Eastern groundwater basin in the West Bank/Palestine, hydrologic droughts were defined as the decrease in spring discharge and the drop in water levels. Most of the springs in the West Bank are affected by seasonal changes in rainfall quantities. When the relationship between the rainfall depths and spring discharge was investigated further, it was found that the adjusted correlation improves once rainfall of the previous years is taken into consideration. This means that the amount of spring discharge in any particular year is a function of rainfall during the same year, as well as that of the past years. The best correlation was found to be a three-year model. The analysis of groundwater level–rainfall depth relationship showed that the best correlation was a one-year model. However, in order to recommend drought management plans, further monitoring and hydrologic modeling is required. In another attempt to conduct drought analysis in the West Bank and to assess the impact of climate change, a physically based model has been used to assess the water balance components along with possible climatic scenarios (Carmi et al, 2004). The possible increased rainfall intensity coupled with an increase in extreme events, and an overall reduction in precipitation will lead to the increased soil erosion, runoff and salinization. This in turn will cause loss of biodiversity and increase desertification. Palestine already suffers from water shortage and if the available quantities are polluted the situation will be more critical and will likely cause a rise in the incidence of water borne diseases. On another level, the increased water stress will increase the likelihood for water resource conflicts in the region. This will also increase abstraction from groundwater and will deplete the storage. Although, assessments have been made in relation to the particular climate scenario used, yet they are expected to serve as a guideline for future research only. The development of non-conventional water resources for agriculture and artificial recharge and sustainable use of water, along with water conservation practices are among the possible adaptation measures adopted.

Chapter II: Drought Planning and Management

**********************************TO BE COMPLETED**

1. DROUGHT PLANNING EXAMPLES IN DIFFERENT COUNTRIES

1.1. Singular non conventional management measures for water conservation, Cyprus

Water scarcity is a reality in Cyprus. Presently, water demand for various uses exceeds the amount of water available, while in recent years, the problem has been exacerbated due to the observed prolonged periods of reduced precipitations.
In order to achieve minor water scarcity deficit, the Government of Cyprus has adopted novel actions for water conservation using second quality water or “grey waters”: establishment of subsidies for saving good quality domestic water through the connexion of private boreholes to toilet tanks or for the installation of grey water recycling systems in houses, schools, for watering gardens and toilet flushing, etc (see Appendix 2). Lightly polluted or “grey water” from baths, showers, hand or wash-basins and washing machines is kept separated from heavily polluted or “black water” from WC and kitchens. As a result, it is relatively easy to intercept each type of wastewater at household level for subsequent treatment and reuse. With this scheme, cypriots have achieved a drinking water conservation of 30 % to 65 %.

1.2. Drainage water reuse as a mean of fighting water scarcity, Egypt

To properly assess the future status of water resources in Egypt, the national water resources plan is considered as a model example document towards development of the integrated water resources management. The document focuses on the physical improvements necessary to satisfy the supply-demand imbalance. The totality in the approach to water resources/agricultural/urban water management is significantly expressed throughout the plan. The national plan emphasizes the coordination between ministries, stakeholders, NGOs and civil societies to ensure the successful implementation and sustainability for the integrated management of the water resources. Institutional reform, financial and privatization, planning and cooperation, and gender issues were also considered in the plan.

The Ministry of Water Resources and Irrigation of Egypt was entrusted to carry out a long-term monitoring program to give answers to decision and policy makers about the quantity and quality of drainage water and its locations. A monitoring network of 90 measuring locations on the main drains in the Nile Delta and Fayoum was established in the early 1980’s, providing daily measurements of drainage flow and bi-weekly salinity and other chemical components. Since then, the network has been continuously maintained and upgraded to furnish reliable measurements. The current monitoring network in the Nile Delta and Fayoum consists of 140 sites for monitoring the quantity and quality of drainage water in the main and branch drains with a monthly frequency. The number of parameters is increased to 31 parameters, taking into consideration toxicological, microbiological, oxygen budget related and extended ions, metals and trace elements as well as the classic parameters.

The field measurements and laboratory analysis are regularly stored in an interactive database, continuously maintained and finally linked with a Geographical Information System (GIS). The monitoring results are routinely published in yearbooks and disseminated to all concerned decision makers. Historical data is now available about drainage water quantity and quality in the Nile Delta for the last 15 years. Many important decisions regarding the existing and future plans of drainage water reuse were taken on the basis of this information. The monitoring program clearly reveals that the drainage water quantity changes with time, depending on water use policies and the management of the main supply system. The variations occur from month to month, season to season, and year to year. The average drainage water discharged annually to the sea is 12.5 bcm. The measured drain discharges to the sea are not entirely excess irrigation water. They include brackish groundwater, sea water and M&I wastewater discharges.

The results of monitoring and experimental areas were used to develop guidelines for using drainage water in irrigation on environmentally sound basis. The guidelines enable the user to rate salinity hazard factors and suggest irrigation and crop management practices to overcome hazards, forming a decision support system for use of drainage water irrigation for sustainable crop production. The guidelines are intended for use on currently cultivated lands as well as on new land being brought into production by reclamation. They are meant to be applied to a specific crop or to a crop rotation that is to be irrigated with a water of known quality under particular soil salinity and hydrologic conditions. The guidelines contain three matrices organized in categories of crops: salt tolerant, moderately salt tolerant, and salt sensitive crops. The matrices are designed to identify and compare the relative potential hazard of crop yield reduction and soil salinization when using various types of irrigation water.

Three major effects are considered in the organization of each matrix: the direct impact of irrigation water quality on crop yield via irrigation water salinity and sodicity hazard; irrigation water management related to consumptive use and leaching requirement of the crop; and soil quality. This last factor rates the potential of the soil to remain a suitable medium for plant growth related to soil salinity and sodicity. The guidelines also include criteria for environmental protection and public health preservation. Additionally, they rate the degree of socio-economic vulnerability of the farmers involved in the use of drainage water, and list institutional measures indicated to mitigate the risks.

Faced with the future challenges, the Ministry of Water Resources and Irrigation started an integrated management approach that combines all available resources (freshwater canals, drainage water reuse and groundwater) to meet the water demands of different users. The approach requires full coordination between government institutions at all levels, and active participation of water users in planning, managing and operating irrigation and drainage systems. The main pillars of the vision are Making the best agricultural, social and environmental use of the available water resources by means of irrigation improvement and changing crop patterns, Applying Integrated Water Resources Management approach through developing governmental and non-governmental Institutions as well as enforcement of laws and legislations, Allocating different conventional and non-conventional water resources, Supporting and effectuating the private sector role and Countering pollution as well as preserving water resources. This could be accomplished through cooperation with various stakeholders and institutional reform by means of merging different sectors as well as purging incompetent ones to cope with the potential changes.

1.3. Water allocation during drought, France

A common way to face water allocation during drought is the French model. The French Water Act of 1992 seeks to guarantee a balanced management of water resources, allowing prefects to share these resources in case of crisis. Several tools are used to limit the impact of crisis situations when they occur: in the event of a proven crisis, i.e. as soon as the low flow-rate limits are exceeded, various measures may be taken to temporarily limit or suspend uses of water.

Framework decrees have been drawn up for watersheds, enabling the rules and thresholds for triggering restriction measures to be defined in advance. This approach greatly facilitates the exercising of regulations during crisis periods. It also makes possible to have greater transparency and better cooperation.

The document drawn up by the prefects indicates the warning levels (which may be gradual) and the measures to take when they are passed : uses to be suspended or scaled down, priority uses to be maintained – a definition of the priority of uses should ideally be drafted. The implementation of these measures if thresholds are passed is stipulated in a decree. Several incompressible needs have been identified and will need to be guaranteed for civil security, public health and national defense : regulated nuclear facilities, hospitals, fire-fighting facilities, etc.

The measures taken by the prefect must be appropriate. They must be sufficient in light of the severity of the situation and be in proportion. The prefects are also setting up contingency management offices with a view to organizing cooperation between users. They may bring together the various categories of users directly concerned as well as the fishing federations, nature protection associations and local water commissions when relevant.

Cooperation is the watchword for any water management system. Indeed, the law hallows it in the process of drawing up "Schéma Directeurs d'Aménagement et de Gestion de l'eau" (SDAGE), bringing together the water field players for development phases and monitoring.

The public authorities assess what measures need to be taken to combat drought in light of local circumstances (weakness of flow-rates for tables and watercourses, scale of withdrawals on the resource). Drinking water supplies remain a priority use, but it is also essential to protect and reconcile economic uses of water with efforts to safeguard aquatic environments.

Measures to limit uses of water may concern : the use of water for agricultural needs, the use of water for washing private vehicles or filling private swimming pools, the watering of public and private garden areas, the filling of man-made lakes, etc.

As water is a common resource, each person is responsible for preserving it. If they fail to comply with the restriction measures defined in the prefectoral decrees, they may be fined up to 1500 euros or even 3000 euros for repeating offenders.

1.4. Drought Mitigation Measures, Palestine

Background

In the Middle East in general and in Palestine in particular, integrated water resources management is hindered by the complex hydro-political situation, which is characterized by natural water scarcity, shared nature of water resources, conflicting demands, and intensive development and use of resources. The foremost significant uncertainty is the one related to climate change in general and to drought in particular.

Palestine enjoys typical Mediterranean climate conditions. It has two distinctive seasons; a wet winter, which lasts 5 months (November-March) and a dry summer, which nearly lasts for seven months (May-October). Rabi (1999) demonstrated that the number of rainy days is limited and rarely exceeds 60 days a year. Rainfall depth has a non-uniform distribution and exhibits high spatial and temporal variability.

Currently, 31% of the Palestinian communities are not connected to water networks. In general, local springs and rainfall collection cisterns are the major sources of water supply for domestic and agricultural use in many Palestinian communities. Therefore, the livelihood of these communities is always threatened since these sources are directly affected by rainfall and drought incidence. Rainwater harvesting supplies approximately 6.6 mcm per year. In most cases, cisterns collect water from rooftops during the rainy season, which is then stored in subsurface containers, usually ranging in size from 60-100 cubic meters. A large percentage of water collected in cisterns is used for domestic purposes. In addition, there are 297 natural springs in the West Bank which provide approximately 60 mcm per year, the majority of which comes from 114 major springs. However, it is estimated that there are actually more than 400 small and large springs throughout the West Bank. Given that recharge levels of the water table are dependent on rainfall quantities, the yield from springs varies across the years. In terms of usage, the majority of springs meet agricultural needs. However, it is worth noting that springs, particularly given the severity of the current water situation, often serve a dual purpose. (PHG, 2005)

The Palestinian Hydrology Group-PHG- has implemented in cooperation with the Palestinian Ministry of Agriculture and ACDI/VOCA, a 1.5 year Drought Preparedness and Mitigation Program in the north of the West Bank. The main goal was to support food security and economic development of poor and risk communities as a result of drought. The objectives of the program were to alleviate existing and future droughts problems through the build up of water resources; increase fresh water supply through rainwater harvesting and conveyance; develop and strengthen the agricultural sector in the local community; raise community awareness and capacity to respond to drought situations; and demonstrate practical cooperation with MoA and assist to build capacity and responsiveness to drought situation.
In total 10 communities were targeted and 8500 inhabitants benefited from the program activities. The target areas make up the food basket of Palestine, where agriculture is the main source of income and the drought season is hard due to the poor water resources infrastructure; springs are neglected, groundwater wells have old equipment and low efficiencies, water network losses are high, storage systems are absent, and soil canals are needed. In addition, public awareness about water resources is low.

The following activities were implemented in order to meet the objectives of the program:

- Construction of 17,071 meters of soil canals
- Rehabilitation of 3 groundwater wells, increasing well discharge by 65 m3/hr
- Rehabilitation of 3 springs, increasing spring discharge by 83 m3/hr
- Construction of 81 water harvesting pools, making available 33,100 m3 of water
- Construction of 46 water harvesting cisterns, making available 3,216 m3 of water
- Construction of 331.6 m2 of retaining walls
- Production of 1500 copies of posters on water harvesting, kids' story written by students on water resources protection and management, and 200 copies of a brochure on mitigation of drought.
- Conduct training for farmers, students and women in water resources management, water resources protection, water conservation, water harvesting, irrigation techniques, cost recovery, financial management, environmental campaigns, and computer skills.

This program has assisted in solving the water shortage problem and in providing additional water resources for domestic and agricultural use, making the area better equipped to deal with future drought conditions. In addition, it has increased the land area – an additional 244 dunums- and encouraged land reclamation, use of green houses and improved irrigation techniques.

1.5. Drought planning legal framework, Spain

It is interesting, for instance, to have a look to the Spanish legal framework which specifically refers to drought in a planning process. The Spanish legal framework determines the way to face the problem for Public Administration and stakeholders. In the past, exceptional measures were applied during a crisis but few of them were dealing with preparedness, mitigation and previous planning. By the way, the former Water Act (1985) gave certain powers to Reservoir Committees of River Basin Authorities in case of water shortage, in agreement with water rights. Reservoir Committee submitted proposals to the Basin Authority Chairman with regard to filling and emptying reservoirs and aquifers, according to the rights of the different users and the current hydrological situation. In circumstances of unusual drought, the Government may adopt exceptional measures in order to address the situation, even if concessions (rights of water use under certain conditions) have been granted. Such measures may include the building of emergency infrastructures. Water Act also described a water use priority list, from first to last in order of importance: water supply in urban areas, irrigation, industrial uses for power generation, other industrial uses, fish farming, recreational uses and navigation.
The experience acquired during the last droughts suffered in the country have showed how this concept was inappropriate and demonstrated the necessity of new regulations and adequate drought risk management.
The new legal framework deals with drought planning and management through modifications introduced in the Water Act. For instance, Government may authorize the River Basin Authority to set up Water Interchange Centers (Water Bank) to enable user rights to be waved by voluntary agreement (Water Act, article 71). Specific legislation related to drought can be found in National Water Plan Act (Act 10/2001,

article 27 "Droughts management"), which establishes that Ministry of Environment must establish a global Hydrological Indicators System (HIS), and River Basin Authorities (Confederaciones Hidrográficas) must prepare Special Plans submit them to respective River Basin Councils and Environment Ministry for approval. A Special Plan includes water supply (for more than 20000 inhabitants) directives in case of drought or drought warning.
The process is as follows : River Basin Authority declares state of Drought or Drought Warning, according to the HIS threshold, initiating the measures included in the Special Plan. The institutions responsible for water supply (for more than 20000 inhabitants) have to draw up a Drought Emergency Plan and implement it when the state of drought or warning has been declared by the River Basin Authority.
The Water Directorate will have prepared a Guide in order to facilitate and coordinate de process with the River Basin Authorities. The process goes as in the following figure xx :

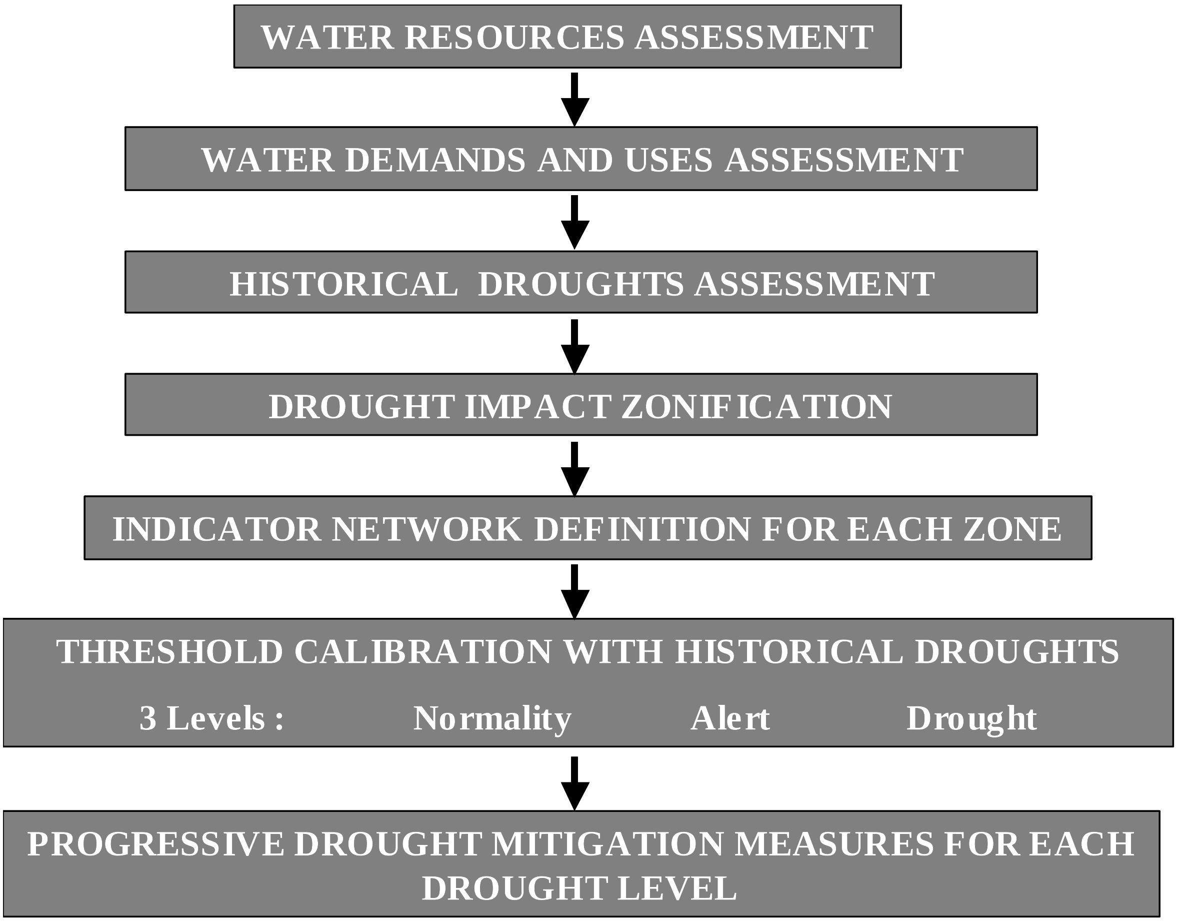


Figure xx : Drought Special Plan drawing up Guide (Spanish Ministry of Environment)

1.6. Strategy of soil and water conservation, Tunisia

A major critical problem of agriculture in much of Tunisia is the recurring deficiency of soil moisture for crops and range production. The central farming regions (200-400 mm) and the intermountain plains (400-550mm) in the north-western part of country are particularly affected. Because of non-uniformity of precipitation patterns, many sub-humid region areas (400-550 mm) are also influenced by moisture shortage during certain periods in the growing season.

The enormity of the problem is particularly evident in the annual variation of cereal yields. The total national production fluctuates commonly in a ratio of 1 to 5 depending on the amount and timing of rainfall. The soil moisture during the planting season affects also the hectares used for cereals.

Water resources Problems:
There is an estimate that about 29 billion m3 of the rainfall is lost by evaporation and transpiration and 0,5 billion of m3 lost to the sea and to salty lakes. This water could be retained to improve the over-exploited water table. Furthermore some 10.000 hectares of arable land are sterilised annually in these reservoirs. Consequently, the dams lose this same volume of their storage capacity.

Strategy of Soil and Water Conservation:
A long-term strategy stressing the necessity to conserve the national soil resources and to protect the existing infrastructure was set up. A national programme to invest in soil and water conservation was established, and an estimated budget of almost 500 million dinars was used to cover the cost of all needed interventions from 1991 to the year 2002. The introduction of new farming policies based on the use of technology and adequate water harvesting practices are adopted.
This national wide project gave the opportunity to manage one million hectares and to maintain and rehabilitate 440000 ha in watersheds and cereal production regions. It has permit also to construct 580 mountain lakes (small dams with an average of capacity of 100000 m3), 2000 small check dams to trap sediments and 2000 diversion dams for water harvesting.
After the evaluation and the success of this program, A new national plan was established for the period 2002-2011. An estimated budget of 780 million dinars was proposed to manage and maintain 1,5 million hectares in watersheds and to construct 1000 small dams, 3000 structures to recharge aquifers, 1500 diversion structures for water harvesting, 5500 protective structures for water ways and the management of 15000 ha by traditional techniques of soil and water conservation. The objectives of soil and water conservation plan are:

1- To reduce the loss arable land estimated to 10.000 ha/year.
2- To maintain soil fertility in order to avoid the decrease in soil productivity.
3- To retain the 500 million cubic meters of run-off water (which are actually lost in the sea and salty lakes), by carrying out water and soil conservation works.
4- To recover arable land by establishing structures (jessours) in the south of Tunisia.
5- To improve the life span of dams, which are threatened by sedimentation at the rate of 25.8 million cubic meter/year.
6- To reduce damages caused in valleys and plains by floods.
7- To implement a new farming policy, which aims at utilizing anti erosion works in order to increase production?
8- To create job opportunities and to improve revenues of rural population in the marginal areas.

The water harvesting interventions, as planned for in the management plan have covered different regions and proposed to reach an ambitious objective, particularity due to the fact that the anti-erosive interventions call not only for

mechanical and physical measures such as (bank construction, waterway lying, drop structures, farm ponds...) but also agricultural developing interventions (fruit tree planting, forage crop, range management, change in crop production) with an effective farmer's participation .
Water and soil conservation division in collaboration with other technical institutions is aiming at increasing production to reach food self sufficiency, improving revenues and standards of living of the rural population, creating job opportunities and reducing the rural urban migration.

An Integrated water and Conservation Approach:
In order to reach the objectives of an adequate land management, an integrated approach, based on a methodological study and a planning, which permit to find practical and rational solutions to the problems encountered in water scarcity, will be adopted
The approach is to protect the downstream of watersheds from sedimentation, and floods, and to improve revenues of farmers and livestock herders established in the upper parts of the watersheds. The integrated conservation management will be considered at three levels:

- Technical and environmental: It is fundamental to define guidelines to help prevent and fight against water scarcity, and to consider the watershed management techniques which aim at maintaining the fertility of the soil in the watershed and reducing the transport of sediment to the dam reservoirs taking in care environmental aspects.

- Economical: In order to make the best micro and macro economical return of the conservation work, it is crucially important to count on the participation of the land-user. It is not expected that this one will change his usual practices unless he perceives that the change is directed towards his interests, that it will minimise his risks and increase his income.
At the macro level, the aim consists of meeting the government objectives of controlling the critical soil erosion situation, moving towards food self sufficiency, and ensuring the best global ratio cost-benefit of the government's investments.

- Social level: concern must be given to the support of the local population, as the objective is not only to fight against soil erosion and promote economic growth but is also related to the improvement of the public's conditions especially in the most seriously affected areas where misery, unemployment and under-development are present.

Successful land resource management involves the introduction of changes in farmers' behavioural patterns. Therefore the principal benefit of this approach is to give small and medium scale farmers the opportunity to breakout of the vicious circle of abusive cereal cultivation which decline production yields and accelerate soil erosion by adopting an improved farming system based on animal production.

CASE STUDY Tul Karem / Emek Hefer
Title: Tul Karem / Emek Hefer
Type of case study: local example
Objective of case study – Given ongoing regional water scarcity in the Middle East, efforts to protect existing resources from pollution are particularly important. Unfortunately, in the context of Israeli-Palestinian relations, these efforts are often hampered by the conflict and lack of cooperation. Owing to the trans boundary nature of local water resources, their protection cannot be achieved without cooperative action. This case study demonstrates an innovative way to overcome difficulties associated with the conflict when it comes to protecting shared water resources through unique cooperation between local municipalities, supported by civil society groups from both sides.
Contribution … Friends of the Earth Middle East
Characterisation The Palestinian city of Tul Karem is located in the north western West Bank, adjacent to the green line: the 1967 cease-fire line representing the boundary between Israel and the West Bank. Across that line is the Israeli Regional Council of Emek Hefer. In recent years, a separation barrier, consisting in part of a concrete wall and in other parts of a system of fences, was established between Palestinian and Israeli populations, completely preventing passage of people and vehicles. However, sewage from the West Bank city of Tul Karem flows westward, across the green line and underneath the separation barrier, into the Israeli municipality of Emek Hefer. In the past, the sewage polluted the Alexander River, which flows through Emek Hefer Regional Council on its way to the Mediterranean Sea. Alarmingly, the untreated sewage also contaminated scarce, valuable groundwater resources which are shared by Israelis and Palestinians.
Experiences gained - Conclusions - Recommendations Addressing this issue, the Mayors of both municipalities signed in 1996 a Treaty of Intentions outlining their mutual interest and initial plans for regional sewage solutions. The local level initiative complemented activities by national governments and their water authorities. Israeli-Palestinian cooperation encountered a significant blow with the outbreak of hostilities in 2000. Government level cooperation continued to take place around water issues, however it was insufficient to solve the sewage pollution. An emergency facility was built unilaterally by Israel, funded by tax revenue owed by Israel to the Palestinian Authority. However, the treatment provided was insufficient and required additional components. Ties between both mayors were also initially severed, but were soon reinstated with the help and initiative of Friends of the Earth Middle East (an NGO) and another (Israeli-Arab) neighboring Mayor. The two mayors succeeded in transcending the new reality, and facilitate the establishment of pretreatment facilities for Tul Karem sewage despite the conflict conditions, with funding provided by the German Development Cooperation. The Tul Karem pre-treatment plant was launched on February 2005, easing the treatment burden in the Israeli side. Among the guests attending the opening ceremony were members of both communities. This project could only be facilitated through the cooperative effort of the local municipality, German assistance and the neighboring Israeli community of Emek Hefer. The ties established between the two mayors and their mutual interest to find solutions for the pollution threat resulted in a close working relationship that was crucial for successful project implementation. Many conflict related difficulties encountered by donor countries operating in the West Bank could be alleviated through Israeli-Palestinian municipal cooperation, such as coordination with the military, the Foreign Ministry and the Israeli Water Commission which partially controls all water projects in the West Bank. Experience on similar projects during the period of conflict shows that without local level cooperation, progress has been prohibitively slow. The cooperation between the municipalities is supported by community groups from both sides,

through the Good Water Neighbours project carried out by Friends of the Earth Middle East since 2001. As part of the project, youth groups and adult volunteers from both communities carry out educational and practical activities related the water realities in both sides and addressing common concerns of water conservation and protection.

The close cooperation continues to date, with both mayors cooperating to seek additional funding for other additional sewage solution projects. The successful implementation of this project served as an impetus for the continuation of German supported sewage infrastructure in other West Bank cities, hitherto on hold due to the conflict situation.

This case study demonstrates the nee for local level cooperation on transboundary water management, particularly in conflict situations where national level cooperation is often inadequate. It further demonstrates the need for international development funding for protecting scarce water resources from pollution. In addition, it highlights the contribution of community groups and NGO's from both sides of a conflict divide to the protection of scarce water resources.

Outlook - Next steps – Accessibility of results

The continuation of both conflict conditions and water scarcity in the Middle East are a matter of fact for the near future. In fact, cooperation between governments in the region has significantly deteriorated. Sustainable management of water resources under scarcity, an issue traditionally in the domain of national governments, requires the involvement of local actors, at the municipal and community level.

Chapter III: Long term imbalances in supply and demand

1. Introduction

The following chapter deals with long term imbalances. This chapter allows to share knowledge on different instruments on demand side (water saving, water reuse, reduction of leakages,...) and on supply side (reservoirs, dams, water transfer,...). The EU water directors have clearly expressed the priority on demand side instruments before to create new resources. This document reflects also the direction promoted by the WFD: the integrated river basin management (IRBM). It is clear that if the WFD is not directly transferable in Mediterranean some tools and instruments of it could transposed with benefits to these countries. The integrated vision of water management, the building of programme of measures and associated river basin management plans dealing at the same time with quantitative and qualitative issues could be of added value for Mediterranean non EU countries. This chapter could be improved by examples on measures for demand and supply side coming from Mediterranean non EU countries. In these countries a special attention to social affordability of proposed measures should be given. Social and economic impact of scarcity for household and agriculture could be highlighted with example in the future.

For instance the following topics could be further developed and illustrated with examples, within this chapter:

- water reuse for agriculture
- rainfalls storage
- desalinization
- reduction of leakages for agricultural channels and urban networks
- new techniques of irrigations
- water storage (dams, aquifers, reservoir,)
- aquifer recharges
- social impacts of scarcity for households and farmers
- Impacts of the development of the tourism
- transboundary issues (when existing)
- impact of scarcity on water quality (specially for drinking water)

In water stressed areas, the limited availability of water resources (depletion of some resources and loss of others due to pollution) and increased water demands (greater variety of uses and users) are the main causes of water scarcity problem. Remedial measures used to be based on the development of new water resources to offset the increasing demand. However, the ever increasing abstraction of the limited resource, in order to deal with a growing scope of multi-disciplinary uses and avert global heating hazards, have stimulated a new management strategy mainly economizing water rather than working out new water resources. To reach the goal of a sustainable water management, balance has to be achieved between abstractive uses of water (e.g. abstraction for public water supply, irrigation and industrials uses), in-stream uses (e.g. recreation, ecosystem maintenance), discharge of effluents and impact of diffuse sources.

This new concept is defined as an Integrated Water Resource Management (IWRM) approach that promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Global Water Partnership, 2004). This approach is not only about "managing physical resources" but also "reforming human systems to enable people to benefit from the resources".

Within the EU territory, WFD is a good first step towards this approach in terms of quantitative management of water. Throughout the program for the monitoring of surface water and groundwater status and protected areas (article 8) and throughout the programme of measures (article 11), WFD proposes an IWRM approach. Moreover, quantitative aspects are mentioned several times in these articles. WFD gives a framework for long-term changes on quantitative management in order to deal with long-term imbalances between supply and demand, recalling that "all practical steps are taken to prevent further deterioration in status" (article 4a).

These practical steps can be divided into two types of measures:

- Measures for fulfilling demands using available water
- Supply side measures

2. Type of Management Measures for balancing Demands Using Available Water

The relationship between water abstraction and water availability has turned into a major stress factor in the exploitation of water resources in Europe. Therefore, it is logical that investigation on sustainable water use in application of WFD is now reoriented on the possibilities of influencing water demand in a favourable way for aquatic environment.

Integrated Water Management (IWM) is the new paradigm for a wish of efficient, sustainable and safe supply of water. IWM usually means inter alia the use of the best water quality for each demand, so different uses can be supplied with different qualities of water and consequently, and water have to be collected from different sources and retorted to their end-users as efficiently as possible. Nevertheless, in order to get real IWM from the demand side, it is also necessary to consider the Shadow Water (SW), the water that, as a consequence of best practices, we don't need to use. The water we don't have to produce, the water we prevent from leaking from the network, the water we avoid using and that we don't have to clean is Shadow Water, the best water we can achieve for our safe supply, for our environment and also for our economy.

Probably, many of these assertions would be discussed on a short-term and economic basis, but in a global and long-term prospect, they are unquestionable. Action towards a sustainable future has to be founded on the use of IWM based on raising the offer of SW versus Real Water. In fact, ratio between these two types of water is an indicator of the water supply quality.

Many experiences already exist in the "production" of SW. Some of them have been quantified in different situations and we are able to consider some of its advantages and difficulties. Cost estimations are time dependent, as many of them could be considered as long-term investments which clearly overcome company budgets.

2.1 - Demand-side measures

Demand-side management is already well developed in other economic sectors like electricity, gas or oil. Efficiency standards, product labelling and advice services to users are good examples of actions set up. For example, household appliances are now stamped by the EU Energy Label that rates appliances from A (most efficient) to G (least efficient). However, economic incentives are usually more efficient than these actions. They can enter into account:

- On the price of a good. From example, in France, the electricity provider EDF (Electricité de France) proposes 3 different options : 1st option, a minimum subscription and a fixed price per kWh ; 2nd option, a higher subscription and a reduced price per kWh during 8 hours per day (usually at night) ; and finally 3rd option, the same as the 2nd one with a variability of the reduced price per kWh depending on the period of the year (higher in winter).
- On technology development financing. For example, in France, FIDEME (Fond d'Investissement de l'Environnement et de la Maîtrise de l'Energie) is a € 45 millions fund to promote and facilitate the financing of energy saving as well as control and waste improvement projects. The fund is used by subscribing bonds issued by enterprises that develop projects eligible to the fund.

The Plan of Implementation approved at the World Summit on Sustainable Development (WSSD), held in Johannesburg in 2002, included a specific directive calling for all countries to develop integrated water resources management (IWRM) and water efficiency plans by 2005. As Global Water Partnership technical committee stressed in a first version (April 2004) Paper on Guidance in preparing a national IWRM plan, advancing the WSSD plan of implementation inherent in an IWRM approach is the recognition that truly sustainable water resources management involves managing demand, not just supply.

2.1.1 - Technological approaches

Water usages can be prioritized according to their ability to answer to human and aquatic environments' needs following the "human basic needs" or the "aquatic environments survival needs" to the "human being needs" or the "aquatic environments best conditions for life". Thus resource waters should be classified over periods of time referring to this prioritization. For example, groundwater, which is usually of high quality, should be reserved for drinking water or more generally for hygiene usages. Surface water collected by dams during winter should at least be used to maintain life conditions (temperature, oxygen,…) during summer and, at best, permit the good functioning of aquatic life cycle like fish migration or access to reproduction zone for example. Thus inter-usage water transfer can intervene in order to answer to this prioritization.

2.1.1.1 - Water saving devices

Water planning, efficiency of uses, quality of the supply, storm water and reuse of water are keystones to improve IWM (defined at the beginning of paragraph B). Many of the mistakes of any type of water management come from the non linear pressures on water demand: droughts are medium and long-term unpredictable events. For that reason, water supply pops up in the media just a few months from when a new shortage starts. Consequently, questions and promises of new investments just arise at this time. Many of them drive to quick answers that surely do not constitute the best possibilities for dealing with water scarcity.

Water planning has to be ready for these circumstances, defining what has been done and what is to do in each case by the appropriate person. The reality will probably be different whenever a new case comes up, but we avoid a lot of mistakes and save a lot of water and money if we put on top of the table different previously deemed possibilities.

Efficiency is not only a water manager question. Most people could expend less water just thinking about this objective. Moreover, we are able to use less water just by changing some of our habits while maintaining our standard of living. Water saving campaigns must inform citizens about how to use water and which level of efficiency we could obtain through already available technology. Pricing of water has to converge towards this objective: above the minimum of needed water, and for a normal standard of living (between 110 and 130 liter per person per day), the price of water has to achieve its full cost for industrial users and to be overtaxed for sumptuary users. Total recoveries have to reach the total cost of the water including external factors like the price we have to pay for aquatic system recovering.

Quality of the supply should agree with well-known standards and guarantee information to consumers. No supply could remain without metering: establishing an account with a minimum of reliability is an absolute requirement. Transparency is the key for a service that is considered as a monopoly for the consumer. In order to increase the quality of the supply, blame and shame policy, as well as an adequate financing, are necessary. A public water board must be considered to audit these services in a consistent way.

Storm water has a promising future as a urban supply complement. Like in the past, collecting water from the roof is a very good practice, especially in residential areas of the cities where family houses are easily prepared for this collection. New technologies for filtering and storing storm water will help end-users to implement these catchments.

Although urban water represents a small percentage of the water consumption around the world, regions that periodically suffer from drought episodes have developed different strategies to deal with supply shortages. Many of them come from the supply side but, as new sources of water become scarce and more expensive year after year, demand policies gain their place in the centre of the debate.

Reuse of water is a common practice in dry regions of the world (figure 14). Europe reuses over 700 million m3/year. The reuse is considered, in many cases, as the future trend. Indeed, we need to consider different qualities for different uses and to choose the best cleaning process for each purpose. Second quality water has the greatest possibilities for urban supply. A lack of infrastructures is usually a threshold for its development, but we need to establish standards for water reuse in order to include them to new developments. **A special focus on water reuse for Mediterranean regions should be given in the future in order to better evaluate the potential of this type of measures.**

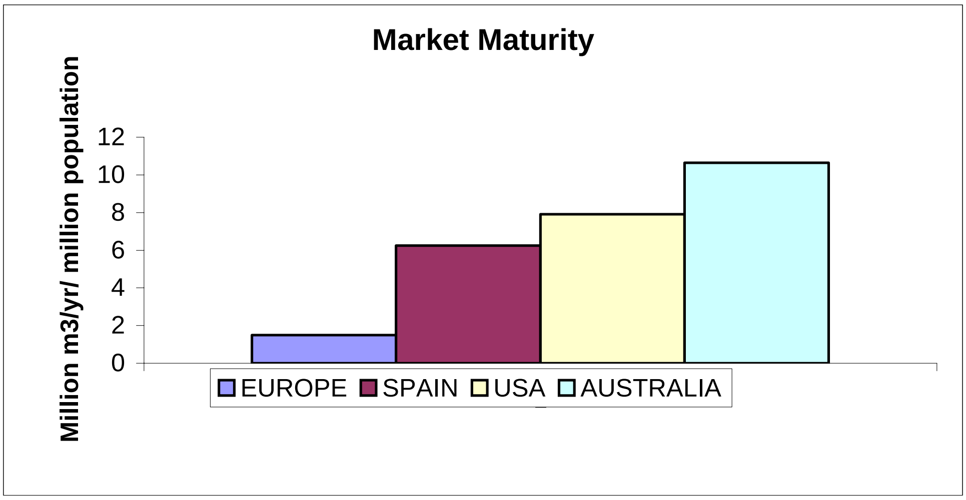


Figure 14: Actual 2002 water reuse installed capacity vs population. European values include Spain. Australian values are for Mediterranean climate States only. Eureau water reuse working group, www.eureau.org

Water saving devices are often easily usable technologies in households, companies, farms and governmental communities:

- Air devices aim at saving water by pressuring it enough to use less water for the same result (high pressure coach cleaning or high pressure firemen device).
- Thermostats allow to avoid water losses to adjust temperature.
- Double command mechanisms permit to choose the amount of water necessary (double-command toilet, dishwasher cleaning options).
- Timed length of flow regulation system enables water saving with the same efficiency (drop by drop watering).

Water saving devices impact on water demand varies depending on the importance of water consumption of the activity sector considered. In agriculture, developing water saving devices can strongly impact water consumption especially during irrigation periods. In households, implementing water saving device would help developing people awareness of the necessity of considering water as a scarce resource. However, the impact on water scarcity problems would not be very significant for two reasons:

- Household consumption is usually not the biggest part of water consumption of a country where water scarcity problems occur specialy in Mediterranean context.
- Because of the cost of these not widely spread technologies and the slow turnover of home appliances, water saving devices often have difficulties to penetrate the market. Long campaigns of information on their availability and advantages are required. Thus, water saving device should be seen as a solution to help economizing water but not as the main action of a management plan.

2.1.1.2 - Water metering

Metering water can be the first step towards a succession of actions to reduce water consumption.

- Metering water at waterworks and households permits to localize leakages in the distribution network.
- Because price is often related to the consumed volume when water metering is introduced, water metering is a good way to develop people awareness in order to make them economize water resource.

However, it is difficult to estimate the effect of water metering on the decrease of consumption. A 10 to 25 % reduction is estimated as immediate savings from the introduction of water metering (Lallana et al., 2001). This effect certainly depends on the consumer's activity. Householders may not be very regardful whereas irrigants may surely pay attention because of the relative importance of this charge in its spending. This effect depends as well on the mode of pricing. Living standards must be taken into account otherwise numerous and low income families would have to pay more than wealthy families for the same volume per person and might try to economize that much that they would reduce their hygiene whereas high income family would not be aware of the necessity of saving water.

The impact of the introduction of metering of water consumption is difficult to separate from other factors effect, particularly the water charges applied. It is also essential to have a correct balance between real water consumption and unaccounted water. Water losses are better measured if a meter is installed at the waterworks as well as at the consumer's home.

However, immediate savings from the introduction of revenue-neutral metering are estimated to be about 10-25% of the consumption, because of the effects of information, publicity and leakage repair, as well as the non zero marginal pricing. Savings are also sustainable over time (waterstrategyman – 2005, Guidelines for integrated water management).

The introduction of metering, as part of water demand management, is usually accompanied by a revised charging system and regulation on leakage.

Water meters have usually been used to determine water consumption, but in some countries, such as Denmark, meter readings will be used to calculate a pollution tax, on the basis that water consumption indicates the discharge to the sewage treatment plant.

Introducing water metering to new regions would lead to effects to take into account (effects on socially disadvantaged households which are more vulnerable to water metering and pricing – large family, medical conditions ; waterstrategyman – 2005, Guidelines for integrated water management).

2.1.1.3 - Leakage reduction in distribution networks

The quantity of water lost is an important indicator of the positive or negative evolution of water distribution efficiency, both in individual years and as a trend over a period of years. High and increasing annual volumes of water losses, which are an indicator of ineffective planning and construction, and low operational maintenance activities, should be the trigger for initiating an active leakage control programme. However, a leak-free network is not a realisable technical or economic objective, and a low level of water losses cannot be avoided, even in the best operated and maintained systems, where water suppliers pay a lot of attention to water loss control. Particular problems and unnecessary misunderstandings arise because of differences in the definitions used by individual countries for describing and calculating losses (IWA, 2000).

The problems of water and revenue losses are:

-Technical : not all the water supplied by a water utility reaches the customer.

- Financial and economic : not all the water supplied is paid for.
- Terminology : lack of standardized definitions of water and revenue losses.

Leakages are difficult to calculate. They can be involved in consumption that is sometimes defined as the abstracted volume of water not restored to water cycle. They cannot be calculated from the invoiced water because volume of invoiced water involves leakages at the consumers' place. They cannot be assumed as equal to losses because losses are not always due to leakages (evaporation in industrial water cooling for example).

Losses in the water distribution network can reach high percentages of the volume introduced. Leakage covers different aspects: losses in the network because of deficient sealing, losses in users' installations before the water is metered and sometimes the consumption differences between used (measured) and not measured quantities are also counted as losses. Leakage figures from different countries not only indicate the different aspects included in the calculations (e.g. Albania up to 75 %, Croatia 30-60 %, Czech Republic 20-30 %, France 30 %, and Spain 24-34 %).

It is possible to use different indices to express the efficiency of a distribution network. Many suppliers argue that a large number of factors should be taken into account in leakage performance and that the indicators described may not be comparable. IWA recommends the use of the Unavoidable Average Real Losses (UARL) index which recognizes separate influences of Real Losses from length of mains, number of service connections, total length of service connections from the edge of the street to customer meters and average pressure when the system is pressurized. In order to evaluate the maximum potential for further savings in Real Losses when the system is pressurised, the difference between the Technical Indicator for Real Losses (TIRL - to be intended as annual volume of real losses divided by the number of service connections) and the UARL must be calculated.

Anyway, network meters are generally considered as necessary to enable good network management.

In most rural municipalities, distribution network maintenance is not a priority (lack of regular monitoring, networks plans). This situation coincides with a lower price of water than the national average and a lack of a general use of domestic meters.

Tracing and repairing leakage can be very expensive. Increasing water production to feed leaks may prove cheaper in some systems. The consequence is that local authorities may decide not to trace leakage despite low efficiency ratios but continue their wasteful use of water (Waterstrategyman, 2005).

Even the systematic use of acoustic instruments such as "correlators" has its limitations too. The solution could be found in the application of the minimum optimum rehabilitation methods, in which the performance of the network is assessed according to standard of service requirements. Experience has shown that the most efficient and effective way of controlling leakage is to divide the network into a number of permanent districts by closing selected line valves and installing flow meters on the few remaining key supplying mains. In this way, leakage can be continuously monitored and the presence of a new leak identified immediately. In large and complex systems, the division of a network into districts represents quite a delicate operation which, if not undertaken with care, can create low pressure and water quality problems. In order to overcome such difficulties, a fully calibrated network analysis model should be constructed, allowing the design of the districts to be evaluated and optimized before the system is constructed in the field.

Despite the difficulties to identify the most effective measures for leakage reduction, these issues must be considered as a priority among demand-side interventions to be individuated in the programme of measures. Furthermore, the leakage reduction must support the achievement of the water balance at river basin scale.

2.1.1.4 - New technologies and changing processes in industry

Until now, a lot of emphasis has been put on reducing energy use in the industrial sector to reduce costs. It was only during the 1990's that improving water efficiency also began to be considered as a way of cutting costs. Actions to improve water efficiency are focused on the process and on the discharges.
In a study carried out between 1992 and 1997 in the industrial sector of Catalonia, the Institute of Energy (Catalonia, Spain) found that about 35 % of the proposed cost-saving measures were implemented in areas of management and control, 32 % in the process and only 18 % in the reuse of effluents. By implementing water saving measures, the amount of water saved varies depending on the industrial sector. Following a study carried out by the same institute in 1999, the range of potential water saving is 25 % to more than 50 %. The main findings for industry are as follows:

- The introduction of water saving technologies in the industrial sector is basically focused on the most common processes: cooling and washing.
- Water substitution means immediate savings for an industry (cost savings correspond to the drop in water charges, especially if the substitution did not imply additional investment).
- Improving the control of process conditions can reduce water consumption by about 50 %.
- Work in closed circuits can reduce water use by about 90 %.
- A reduction in the cost of the existing water saving technologies could encourage further extension to small industries.
- Better communication between industries with high water consumption may help to disseminate pilot project results on water saving technologies.

2.1.1.5 - New technologies and changing processes in agriculture (examples of irrigation methods in some countries)

Irrigation permits to increase culture production on one hand and partly prevent from climatic hazards on the other hand, obtaining a more stable output and a better quality. It also allows decreasing risks on agricultural income. Water withdrawals for agricultural irrigation have clearly increased since 50 years in southern Europe countries and mostly happen in summer (low water period) when water is not very available. They are thus conducive to create or enhance water shortage harmful for the other resource users and natural systems.
A reduction of agricultural withdrawals can be achieved through :

- A reasoning of irrigation with a precise adaptation of the amounts of supplied water: launching of irrigation from an irrigation balance, estimation of the existing cultivations needs, irrigation recording book, etc.
- Leakage limitation by drain, infiltration, evaporation or drift : gravity irrigation suppression, localized irrigation development (drop by drop)

when possible, equipment adjustment, no irrigation during maximum sunshine or when wind blows over 7 km/h.
- Collective management of disposable resource for agriculture.
- Changing the type of crops : less consuming or differently distributed in time (winter cultivations instead of spring ones).

2.1.1.5.1 - Better control of irrigation

In order to achieve a balanced water resource management and a better knowledge of the pressures, removed water counting is necessary. It is an essential tool to pilot the irrigation and permits to know the actual amounts of withdrawals and consequently allows :
- An adaptation of water supplies according to actual needs for cultivations and soil specificities.
- The control of the good functioning of irrigation devices (leak spotting for example).
- To give the opportunity to local stakeholders to set up a planed and umpired management of the resource for all users.
- To make money savings by diminishing the removed volume.

But it is advisable to insure an as precise as possible counting, by means of maintenance and regular standardization of the counting devices.

Over the last decades, major efforts have also been made to adapt water consumption of irrigation to water needs of the crops, in relation to its variety and lifecycle. Traditionally, the UN FAO methodology was calculating the theoretical crop evapotranspiration. But water efficiency technologies have significantly improved over the last years and current methods are more precise to determine water requirements of the crop via analyzing soil humidity, plant and climate. Strategically placed control sensors measure humidity in the upper soil layers and the trunk at a high frequency. These data are transmitted to a central control station and combined to meteorological data from a climate station close to the plot.

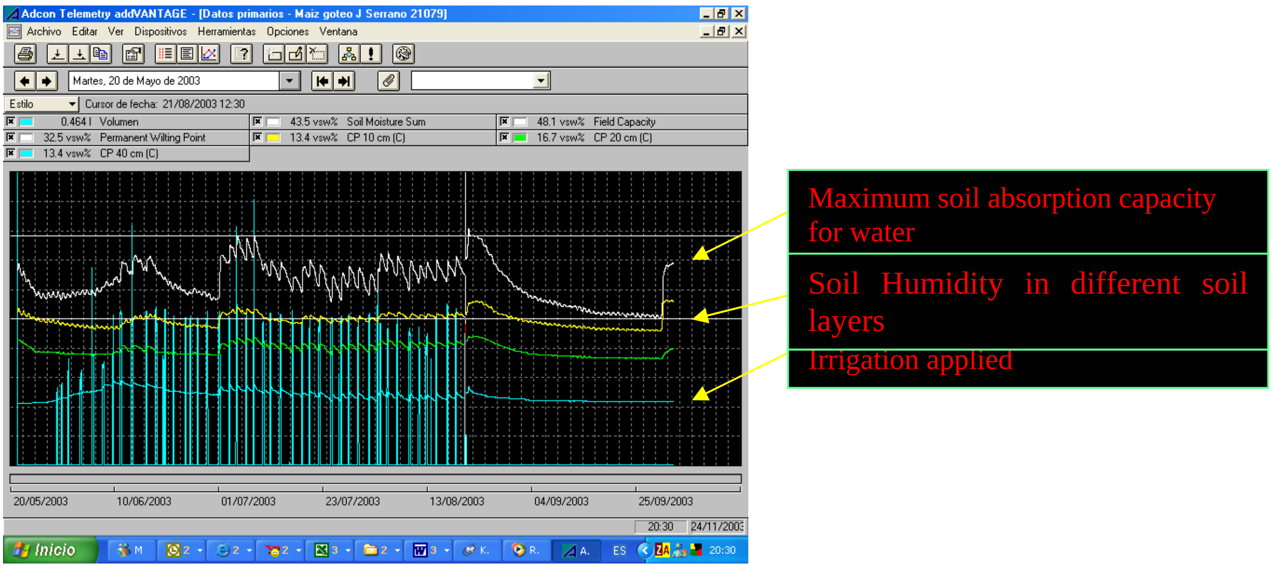


Figure 15 : Example of a register of irigation and soil humidity (WWF & Acciones Integradasde Desarrollo, 2005 : Proyecto LIFE Hagar. Madrid).

The resulting graphs show soil humidity and water absorption by the crop, facilitating the establishment of very adjusted irrigation recommendations (figure 15). The frequency of irrigation can permit to avoid water losses by infiltration and ensure that the soil is always partially humid. This control of the plant access to water is an ideal way to develop production objectives regarding a certain crop quality.
This method has been applied in different projects. In EU LIFE pilot project (www.life-hagar.com) in Castilla La Mancha (Spain), 12 plots of vineyard, onion, alfalfa, sugar beet and melon crops have been studied with soil humidity sensors (C-probes FDR), irrigation control, water meters, precise dendrometers and climate stations. The average water saving is 14 %, with a range of 4 to 30 % according to the crops. These savings are significant in an area with constant overexploitation (total deficit of 5500 Hm^3) and high water pumping costs. In the orange and mandarin Los Mimbrales estate (Huelva, Spain) immediately upstream the Doñana National Park, 30 % of water have been saved.

B.1.1.5.2 - Improvement of irrigation technologies: switching from gravity to pressurized irrigation and other technologies

The irrigation industry is rapidly developing new technologies to make irrigation more efficient. It is important to keep in mind that there is no one best irrigation method for all conditions. Any method can work efficiently if it is appropriate to the circumstances, well designed, and diligently maintained. In all cases, the proper application amount equals the water required by the crop, plus the water needed to prevent the build-up of harmful minerals in the soil through a process called leaching. It helps prevent waste, minimize run-off and lessens the effect of drought. "Smart" technologies, like systems with flow-control nozzles, climate-based controllers and automatic shutoffs are beneficial and even required for irrigation systems in some areas. More and more communities are moving toward rewarding or requiring new irrigation systems to include more water-wise features with irrigation systems that deliver exactly the right amount of water at the right time. The benefits of an automatic irrigation system include:

- reduced labour for watering
- convenience
- full landscape coverage
- easy control over irrigation timing for overnight or early-morning watering
- added value to home or business property
- minimized plant loss during drought

Traditional irrigation system controllers are really just timers. They turn the water on and off when they are told, regardless of weather conditions. Smart irrigation controllers, on the other hand, monitor and use information about environmental conditions for a specific location and landscape -information such as soil moisture, rain, wind, the plants evaporation and transpiration rates, and, in some cases, plant type and more - to decide for themselves when to water, and when not to, providing exactly the right amount of water to maintain lush, healthy growing conditions. Because smart irrigation controllers are more efficient than traditional, timer-based controllers, they also reduce overall water usage, typically by 30 %.
Gravity flow surface irrigation is the spreading of water over a basin or along furrows by gravity flow. Earthen borders check the spread. There may be pumps at the tail end of the field to recycle excess water (if there is any). Fields should

be prepared so they are level or slightly and evenly sloped. A farmer can calculate the amount of water to apply (irrigation scheduling) by noting the field dimensions, crop, stage of growth, climate conditions, and soil dryness. The objective is to minimize the water lost beyond the reach of plant roots and the excess water pumped from the tail end of sloped fields. Farmers close to rivers can drain their excess tail water to the natural channel or let extra water percolate below the plant roots underground back to the river, thus helping to replenish the quantity of the river flow. However, the return water carries sediment, soil salts, chemicals and fertilizer, all of which diminish the water quality in the receiving stream. Careful water scheduling benefits the environment by reducing both diversions and runoff. Since less water is diverted, less power is required to pump water to the fields.
Pressurized sprinkler irrigation is the distribution of drops of water over the crop, imitating rain. For permanent installations, pipes can be laid on the ground or buried (solid set). For mobile installations, pipes may be moved by hand or supported by wheel structures that advance the sprinklers along a field (linear moves, wheel lines). Center pivot systems, similar to linear moves, rotate about well heads that supply water from underground rather than from canals. Sprinkler systems are well suited for uneven terrain. These systems apply water most uniformly when there is little wind ; windy conditions can spoil the application pattern. Careful monitoring and water scheduling reduce over-watering. For linear moves, downward oriented drop tubes deliver water closer to the crop with less wind scatter. The objective is to match the application rate to the infiltration rate, so that the soil is wetted without water pooling upon the surface where it evaporates or runs off the end of the field. Sprinkler irrigation can serve many purposes : frost protection, seed germination, leaf canopy cooling, delivery of agricultural chemicals mixed with the irrigation water and replenishing soil moisture during the off-season. But pressurized, elevated pipes also require expensive electrically powered pumping. The degree of application uniformity determines the efficiency of a sprinkler system. When water is unevenly distributed, supplying sufficient water to the least watered areas means that everywhere else is over-watered. Compared to surface irrigation methods, sprinklers permit better control over application amounts. Low pressure micro-irrigation delivers water drop-by-drop right to the root zone so the plants take up water gradually from their roots. Low pressure tubes allow water to seep through tiny perforations (emitters). Drip tapes and rigid drip tubes are rolled out over the surface, or buried under the soil surface. Mist sprayers are used to apply fine droplets beneath the leaf canopy, directly upon the soil. This method can be the most efficient crop watering method when the system is designed for :

- even application across the irrigated area
- careful timing to prevent over-watering
- water filtration to keep the emitters clean

The high cost of installing and maintaining a micro-system is justified for permanent high value crops such as vineyards and orchards. As technological innovation reduces the cost and as water prices rise, micro methods will find further application.

2.1.1.5.3 - Quota control

The water quota system is used to define the limit on water use or establishes how much to use, when, by whom, and for what purpose water can be augmented and used. When users' behaviour is not very responsive to price changes, because of rigid price elasticity, or when uncertainty is involved in the computation of marginal cost and benefit, quota regulation is suggested as one of the measures for controlling water use (Tsur and Dinar, 1997; Mohamed and Sevenije, 2000). The difference between the quota and pricing system is that in the former case, the marginal social costs associated to each unit of abstraction are assumed to be minimal through the setting of some standards. Likewise, the basic difference between a quota and right allocation is that the former may have various attributes, including a pre-determined price, and be subject to modifications, based on external conditions and number of users, or participants (Tiwari and Dinar, 2001).

2.1.1.6 - Water reuse

Reclaimed water is an alternative water resource (see reuse European project, www.aquarec.org). Water reuse can be a tool in managing scarce water resources. Recycled water is being used as substitute for many traditional non potable uses and for sources that provide raw water for drinking water production (table 4). Such use can help conserving drinking water by replacing it or the water taken from drinking water sources, and by enhancing sources such as reservoirs and groundwater. The improvements in treatment of wastewater have opened new possibilities to reuse treated wastewater. Hence, the indirect recycling of water used in many parts of the world has been largely practiced for many years.
There are no formal european wide guidelines, best practice or regulations for water recycling and reuse other than the Urban Wastewater Directive which requires that “treated wastewater shall be reused whenever appropriate”. Disposal routes shall minimize the adverse effects on the environment” (article 12). The EU needs suitable guidelines and definition of “whenever appropriate”. This should however be seen in the light of the objectives of the directive (article 1) : “…to protect the environment from the adverse effects of waste water discharges”. Significant progress has been made through initiatives in some member states. To maintain the momentum gained, the valuable initiatives in Cyprus, Belgium, France, Spain, UK and other countries should be used as a base to develop water recycling and reuse guidelines and codes of best practice.

Table 4 : Water recycling and reuse definitions

	Definition
Reclaimed water	Treated wastewater suitable for beneficial purposes such as irrigation
Reuse	Utilization of appropriately treated wastewater (reclaimed water) for some further beneficial purpose
Recycling	Reuse of treated wastewater
Potable substitution	Reuse of appropriately treated reclaimed water instead of potable water for non potable applications
Non-potable reuse	Use of reclaimed water for other than drinking water, for example, irrigation
Indirect recycling or indirect potable reuse	Use of reclaimed water for potable supplies after a period of storage in surface or a groundwater
Direct potable reuse	conversion of wastewater directly into drinking water without any intermediate storage

The potential of reuse in Europe is high, especially in Spain, Italy, and to a lesser extent in France, Portugal, Greece, Poland and Belgium. For example in Spain, a maximum water reuse of 2000 Mm^3/year could be reached (Hochstrat et al., 2005).

2.1.1.6.1 - Applications

Although treated wastewater has been an important mean of replenishing river flows in many countries and the subsequent use of such water for a range of purposes (figure 16) constitutes indirect reuse of wastewater, it is becoming increasingly attractive to use reclaimed or treated wastewater more directly. In addition, reclamation of wastewater is attractive in terms of sustainability since wastewater requires disposal if it is not to be reclaimed (UKWIR et al., 2004).

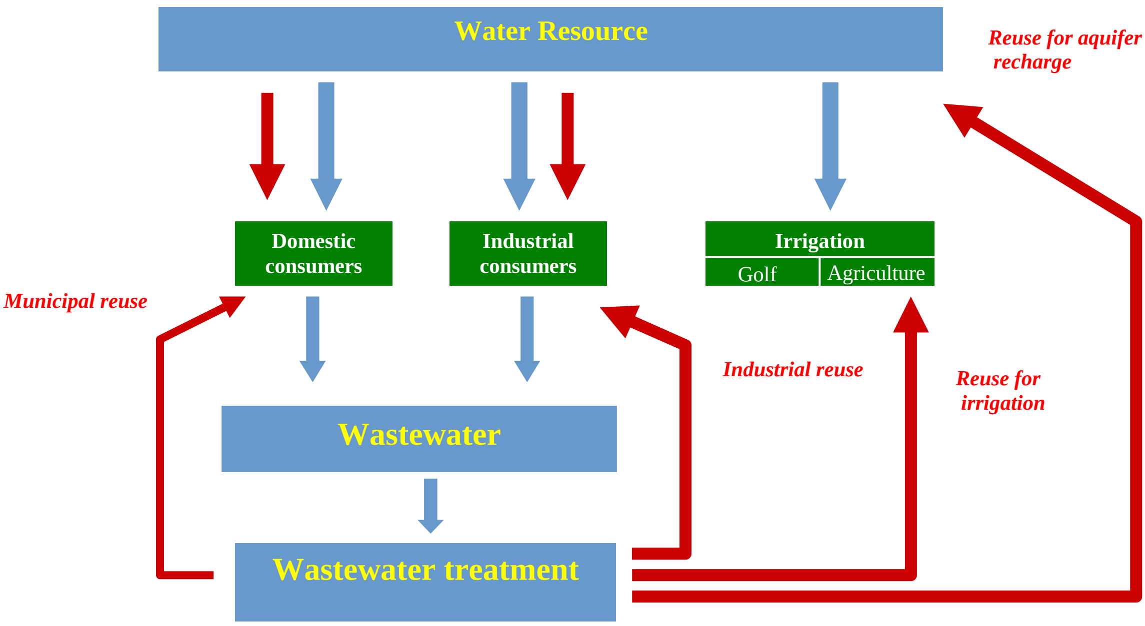


Figure 16 : Different applications of reuse

Treated wastewater may be used as an alternative source of water for agricultural irrigation. Agriculture represents up to 60 % of the global water demand while the requirements arising from increasing urbanization such as watering urban recreational landscapes and sports facilities, also creates a high demand: water scarcity in Mediterranean countries historically led these countries to appropriately use treated wastewater in agriculture, irrigation of golf courses and other green spaces, including those used for recreation in which individuals may come into contact with the ground. It can be used to supplement artificially created recreational waters and for reclamation and maintenance of wetlands for which there can be a significant ecological benefit and a subsequent sense of profit to the community (see example of Costa Brava, Appendix 3). Concerns related to the reuse of treated wastewater are similar to the reuse of sludge, in particular the risks of contamination. Treatment plants are typically only equipped for biological treatment which does not eliminate the chemical substances in the waste water.

In urban environments, treated wastewater may also be used for fire-fighting purposes or street cleaning. In industry, the use of recycled or reclaimed water has extensively developed since the 1970's, for the dual purpose of decreasing the purchase of water and avoiding the discharge of treated wastewater under increasingly stringent emission regulations. This trend started with wash-water recycling but now incorporates the treatment of all types of process waters. Virtually, all industrial sectors are now recycling water, with examples in pulp and paper, oil refinery, etc. Consequently, together with overall shifts in the industrial sector, a 30 % reduction of industrial water consumption has been achieved in some European countries (website ref 1). Where water is scarce, industries also use reclaimed municipal water to reduce their production costs.
An additional use may be the direct supplementation of drinking water resources through groundwater infiltration and by adding it to surface water, with examples in northern Europe where several cities rely on indirect potable reuse for 70 % of their potable resource during dry summer conditions. It is even technically possible to use reclaimed water as a direct drinking water source, although acceptability of the public may not be achievable yet.
The first priority to consider, with regards to the benefit and the public acceptance, is the recharge of surface and groundwater bodies. This form of indirect reuse is a common practice : artificial recharge of groundwater for saline ingress control, or potable resource enhancement, such as in Flanders. Potable substitution is the second priority for any non potable application such as :

1. reclaimed water for industry (for cooling water make up, process water to reduce manufacturing costs
2. agricultural and urban irrigation, to increase productivity and increase the value of amenities such as parks, sports fields, golf courses as well as domestic gardens on new developments, and finally agriculture itself.

2.1.1.6.2 - Public health and environment protection

The protection of public health is the key issue associated to water reuse. In addition to public health risks, insufficiently treated effluent may have detrimental effects on the ability to grow irrigated crops. The main risk associated to reuse in irrigation is a short-term hazard associated to the presence of pathogens in the water. The World Health Organisation (WHO) has set guidelines for water reuse in irrigation, mainly based on fecal coliforms and helminth eggs counts, with quota adapted to the use for crops.
In Europe, a few member states (where reuse is necessary for irrigation, like in Spain, Belgium, Italy and France) had to overcome the absence of european guidelines or regulation by creating their own national regulation. These standards are based on the WHO guidelines and necessary conservative assumptions, the later leaving room for extremely severe requirements. It is worth noting that, in contrast with some other standards such as the Californian Title 22, member states standards for reused water are not based on technology.
For direct or indirect drinking water supply, the Directive 98/83 is applied with very strict standards for pathogens and chemical contaminants, therefore offering a high level of public health protection. There is however some concern that the current standards and guidelines were not designed to deal with the mixture and individual contaminants that are unique to wastewater sources and water catchments recharged with treated wastewater. Endocrine disruptors, pharmaceuticals, disinfection byproducts and pathogenic bacteria, viruses and

parasites, and genetically engineered products might be present at levels relevant to public health.
Hence, beyond the strict legal requirements for compliance with maxima designed for various types of uses, there is a shift towards water safety plans which are based on a risk assessment of the entire water cycle from source to final user. This incorporates a thorough analysis of the raw water quality parameters and protection measures, the individual treatment steps, their capability to remove the targeted pollutants, and the distribution system up to the point of use. This methodology uses the Hazard Analysis and Critical Control Points (HACCP) approach where the multiple barriers appear as the preferred approach to minimize risks to an acceptable level, in addition to the complementary water quality control.
The opportunities for water reuse should also avoid or minimize environmental impacts to biological, hydrogeological and cultural resources, and to land use due to the construction or operation of reuse facilities.

2.1.1.6.3 - Technologies

All types of technologies are used to reclaim wastewater, depending on the initial pollutant type and concentration, and treated water quality to be achieved. Stringent control of water quality and operational reliability are the main requirements which drive the technological choices. The most well-known example of reuse in Europe is the supply of drinking water through bank filtration, where the local geology (soil aquifer treatment) and land protection regimes authorize the use of surface water situated downstream of wastewater treatment plants. In such cases, the natural processes taking place in the bank safely remove the pollutants and pathogens. Whenever needed, these natural processes may be complemented by filtration on granular activated carbon for pesticides and ozonation for micro-pollutants removal.
One third of the water reclamation schemes relie on secondary treatment of municipal sewage. This level of treatment usually fulfils the requirement of cooling water in the industry, or irrigation water where the food crops are consumed after cooking. One has to mention the possibility offered by membrane bioreactors, which can replace the secondary treatment, while enabling to meet disinfection requirements. Other advanced treatment may replace traditional secondary treatment for reuse purposes.
More often, some kind of tertiary treatment is required to meet the industry or irrigation standards, especially in the later case where disinfection is needed. Disinfection may be achieved by oxidation with chlorine, ozone, or more recently ultraviolet irradiation. Granular activated carbon is used where micro-pollutants are likely to be present.
The last case involves a quaternary treatment with membranes. The most common processes involve either microfiltration (pore size of 0,1 µm) or ultrafiltation (pore size of 0,01 µm), which also removes viruses. These treatments are the favorite technologies on sewage for the removal of suspended solids, particles, bacteria and parasites. In addition, nanofiltration (pore size of 0,001 µm) or reverse osmose membranes (pore size of 0,0001 µm) are used when soluble materials such as salts or dissolved organic matter have to be removed, in order to achieve drinking water quality or ultra pure water quality for industry.
A combination or hybridization of different centralized or decentralized technical solutions is needed to reach the specific objectives when considering the local

water cycle. The issue is not the availability of technology but the vision, experience and institutional infrastructure needed to recognize and implement reuse solutions. These needs to build on the synergy between natural and technological solutions that protect public health and the environment, reduce costs and energy demand to treat and transport water.
In the interest of managing both known and unknown risks, advanced water treatment processes are increasingly being deployed in recycled water projects to provide added assurance that unknown risks are mitigated.

2.1.1.6.4 - Water reuse benefits

Water reuse benefits all segments of the anthropogenic water cycle and should be considered as an horizontal application that pulls together the normally segregated disciplines of potable water and wastewater treatment for economic development, public health and environmental protection. Water reuse reduces the competition for water between agriculture, public and industrial supplies by increasing the available water resource and can be used as an effective cohesion tool across Europe. Water reuse benefits are :
1 - Decrease of net water demand and value addition to water
2 - Potable substitution: keep potable water for drinking and reclaimed water for non potable use
3 - Lower energy costs compared to deep groundwater, importation or desalinization
4 - Reduction of manufacturing industries costs by using high quality reclaimed water
5 - Valuable and drought proof alternative water for industry and irrigation
6 - Reduction of nutrient removal costs to protect the surface waters through irrigation
7 - Reduction of nutrient discharge to the environment and loss of freshwater to the sea
8 - Increase of land value when developing brown field sites and with drought proof irrigation
9 - Increase of local ecological benefits, flood protection and tourism through the creation of wetlands, urban irrigation, bathing beach protection and reduction of the need and cost of long sea outfalls
10 - Control of the problems of over-abstraction of surface and groundwater
11 - Management of the recharge of surface and groundwaters to optimize quality and quantity
12 - Integration of all parts of the anthropogenic water cycle to enable cohesion between all regulators and industries across Europe.

2.1.1.6.5 - Enabling the growth of water recycling and reuse

It is essential that the development of water recycling and reuse in agriculture and other sectors be based on scientific evidence of effects on environment and public health. The EU needs a regulatory and institutional framework tailored to suit local needs to take advantage of the water recycling and reuse opportunities, and to help overcome the water shortage problems regarding cost-effectiveness. These regulatory principles could be transfer with some adaptations to Mediteranean non EU countries It appears necessary to provide a comprehensive guidance document to ensure that any risk is minimized and that valuable knowledge is available for any organisation considering the implementation of a water reuse project.

In line with the Water Framework Directive 2000/60/EC, the civil society and the stakeholders must be involved so that they understand and fully contribute to the decisions. The consultation required by directive 2000/60/EC creates a momentum for a better understanding of water cycle, upon which local projects should be built. For any project, the safety of the product and the systems has to be proven, and the solutions must be justified and sustainable from environmental, economic and social point of view. This can be achieved by the publication of clear and accurate documents on the anthropogenic water cycle to overcome the lack of understanding of drinking water, wastewater, water resource planners, environmental fraternities, politicians and the public.

The promotion of water reuse would benefit from clear guidance and best practice documents from the European Union authorities (Durham et al., 2005).

DG Environment of the European Commission recognizes that wastewater reuse has a potential role to play in the efficient and integrated use of water resources and is one of the actions that need to be undertaken for a more effective water management. A preliminary discussion on this issue took place at the EU Water Directors' meeting in Luxembourg (June 2005).

Several research projects[4] (UKWIR, 2004) provide the initial material for such a work, and workshops[5] have already been organized in Europe on the various aspects earlier described in this document. In the drafting of the guidelines, several points need to be precisely addressed. Beyond an accurate description of the anthropogenic water cycle, the benefits and risks of water reuse for different purposes need to be clearly explained. Moreover, the guidelines should provide a framework for new projects implementation, since local authorities and stakeholders normally do not have the experience to handle the various tasks involved. Consideration should also be given as to some new legal requirements or financial incentives to allow Water Districts to encourage or favour water reuse projects.

In addition to the appreciable amount of experience gained in Europe, the realizations and institutional set-up in other water stressed regions of the world such as the USA, Australia and Singapore, could provide some useful complementary concepts. As an example in Australia, an achievable target of 20 % reuse of wastewater by 2012 has been set in some territories to highlight the importance of reuse and focus regional strategies (Durham et al., 2005).

Finally, water scarcity solutions need to include economically justifiable water saving and demand management techniques rather than immediately searching for new water resources. Water reuse is one of a large number of alternative solutions but is important when considering the objectives of the Water Framework Directive as water reuse is proven to increase water availability and reduces surface water eutrophication. Agenda 21 and the widely agreed need to recycle waste materials are dynamically being promoted and implemented across Europe. It can be argued that water recycling has a higher impact on european sustainability than paper, glass and metals recycling and Europe does not have guidelines yet to help innovators to sustain recycle water.

See example of Cyprus and Sogesid case study (the reuse of treated urban wastewater: case studies in southern Italy), Appendix 3.

---

[4] In particular: AQUAREC, CORETECH, MEDWATER

[5] By UKWIR, EUREAU, AEAS Spain among others.

2.1.2 - Economic approaches

Demand-side management efficiency is rather due to economic actions (research financing, subsidies for efficient products, regulatory price controls, price incentives) and legal obligation than to public awareness actions. Economic actions are often the result of public intervention in the sector and public intervention policy depends on the sector and the country. Thus, the mode of intervention, direct incentives (taxes) or indirect incentives (fiscal instruments), must be adapted.
Economic actions are often a way of promoting one technology more than another. Distortion in prices, taxes or subsidies leads to competitive advantage of a service or a product to the detriment of another one. The consequences for non beneficiary companies have to be foreseen. These incentives can be proposed not only for alternative technologies but, as well, for programs that could be developed by non beneficiary companies to reduce their clients' consumption, for process evolution or for activity diversification of these same companies. Attention must be paid on the choice of the technology that receives economic help because the cost of a technology is often difficult to estimate and some technologies are already helped through indirect incentives.

2.1.2.1 - Impact of agricultural policies

The increased water demand in agriculture has been stimulated by numerous causes, including farmers' response to market demands or in certain cases agricultural subsidies - often under the CAP frame - that support certain production.
The EU and National agricultural policies orientate water consumption in several ways :

- by differentiating subsidies for irrigated and non-irrigated crops
- by investing into irrigation systems through rural development funds
- by paying export subsidies, often used as means to deal with European over-production, and often in sectors in which volumes of production are directly linked to irrigation (e.g. tomatoes)

There have been CAP reforms in the past few years, and these have -in part- diminished the direct link between subsidies and volume of production (and therefore irrigation). The direct payments for arable areas are now fully decoupled except for only two member states (France and Spain), which have decided to keep these payments coupled at the level of 25 % allowed by the Community framework. Indeed majority of MS didn't follow fully the Commission's ideas on de-coupling.
In order to reduce the effects of droughts and water scarcity, measures to promote adapted agricultural production such as low water requiring crops (WFD appendix VI) are needed. Furthermore, and in order to minimise drought impacts on water bodies, the cross-compliance review in 2007 must include WFD standards as a baseline for cross-compliance.
Furthermore, some of the water-demanding agricultures still have to be reformed within the framework of CAP, including the wine and horticultural sector. Reform proposals will be tabled in due course. Although there are no direct subsidies in the Fruits & Vegetables sector, there are payments to help producer organisations operate and also to place products on the market, as well as export

subsidies (but there are many other measures possible, e.g. similar to agri-environment). The planned reforms should take into account the effects of the agricultural subsidies on water consumption, especially in water-stressed areas. Here again the issue of respect of water (abstraction) standards comes in.

2.1.2.2 - Examples of pricing methods for irrigation in different countries

Irrigation has a different purpose in different geographic and climatic areas of Europe. In southern European countries, irrigation is necessary to secure crop growth each year, whereas, in central and western Europe, it is used to maintain production during dry summers. These different roles are important when analyzing water pricing policies in the agricultural sector because these policies are often derived from more general policies (economic and social development in rural areas). This difference is also important when comparing agricultural pricing policies between countries or regions (see Table A, Appendix 3).
The situation regarding water tariffs for irrigation is often very different from other sectors :
• irrigation tariffs can be extremely low and there is significant lobbying pressure to resist any increase
• water use in the sector has been subsidized in most of the countries (subsidies as a tool for developing irrigation for food production and/or social development)
• tariffs can be based on forfeits
• meters may not be installed on many abstractions or uses
• public pressure concerning the environmental image of agriculture is much less than for industry for example

Most agricultural water prices distinguish between charges for water resources and charges to cover part or all of the cost of water supply for irrigation. The aim of the former component is to ration water use (especially if it is scarce), while that of the latter is to guarantee that the supply system is financially self-sufficient. Nevertheless, it is only in the regions where water is scarce, and as a consequence is a tradable good, that water prices tend to reflect their scarcity values, as distinct from supply cost (OECD, 1999). The cost of irrigation water supply consists of the variable costs of processing and delivering the water to end-users and of the fixed cost of capital depreciation, operation and maintenance. Variable costs depend on the amount of water delivered, while fixed costs do not. In most countries, fixed costs are heavily subsidized (UN, 1980).
The method by which irrigation water is delivered affects the variable cost, as well as the irrigation technology applied and the feasible pricing schemes. The irrigation water in a region is often delivered by more than one method, depending on tradition, physical conditions, water facilities and institutions (UN, 1980). The most common pricing methods for irrigation are described in Table B (Appendix 3). The most common system for irrigation charges is based on the irrigated surface, followed by a combination of per unit area and volume used.
The adoption of more efficient irrigation technologies is accelerated by higher water charges but also other factors such as land quality, well depths, and agricultural prices, are just as important, if not more so, than the price effect of water itself.
Subsidies for the rehabilitation of irrigation districts and for new irrigation technologies might end up increasing farm water consumption. Although water

productivity could increase, total water consumption at the level of the basin might also increase, unless allocations are simultaneously revised downwards.

Examples of pricing methods for irrigation
Cyprus: Water for irrigation purposes is supplied through government and non-government schemes. Irrigation water in government schemes is delivered directly to individual farmers (retail supplies) and in isolated cases is also provided on a bulk basis to irrigation divisions. Non – government schemes consist of small irrigation schemes, which are managed by committees chaired by the District Officer. For irrigation provision through the government schemes, charges are established on a volumetric basis and are uniform for all schemes covering a high proportion of the total financial cost.
England and Wales: Multi-rate volumetric pricing is common. Water authorities greatly vary in the complexity of their charging systems. For example, in 1984/85, the Wessex Water Authority had
9 different rates and the Yorkshire Water Authority 45 rates (OECD, 1987).
France: Irrigation water is commonly priced by a two-part tariff method, which consists of a combination of a volumetric and a flat rate. In 1970, the Société du Canal de Provence et d'Aménagement de la Région Provencale, which supplies 60000 ha of farmland and nearly 120 communes, introduced a pricing scheme in which rates vary between peak demand and off-peak periods. The peak period rate is set to cover long-run capital and operating costs. The off-peak rate
is set to cover only the operating costs of water delivery. About 50 % of total supply costs (variable
and fixed) are subsidized by the State (OECD, 1987).
Greece: Per area charges are common. The proceeds usually cover only the administrative costs of
the irrigation network. The irrigation projects are categorized as of basic, local and private importance and the project areas are also classified as areas of national, public or private interest.
The proportions of the capital costs of an irrigation project paid by farmers are 30, 50, and 40 % for projects classified as of national, public and private interest, respectively (Gole et al., 1977).
Spain: The water charges are established per agricultural area and not per volume consumed. This
means that the user pays the same amount despite the amount of water used and there is no real incentive for saving water (MMA, 1998).

In general, the amount of water used for irrigation moderately responds to water price levels but is more influenced by factors such as climate variations, agricultural policies, product prices or structural factors. Cross-sectional studies of irrigation districts, at both national and international levels, have found conflicting evidence of the influence of water price levels on water management efficiencies (OECD, 1999).

2.1.2.3 - Economic incentives/fines

Essential elements of water demand management programmes in the urban context are measures dealing with economic incentives. Price structures are generally fixed at municipal level and can widely vary within a country. The differences, in general, take into account different types of users (e.g. domestic, industrial and agricultural) and tend to reflect differences in cost structures.

There is a huge variety in the types of metered tariff which can be used (Pezzey and Mill, 1998). The main types of tariff structure (excluding the initial connexion charge) are :

- flat-rate tariff
- uniform volumetric tariff
- two-part or binomial tariff (sum of a flat-rate tariff and a uniform volumetric tariff)
- block tariffs, which also usually incorporate a flat-rate charge, plus declining block tariffs and rising block tariffs

Frequently, tariffs include a basic allowance (charged at zero or a low rate) to allow equity concerns. A minimum charge for a volume consumed can also be applied. The same or different tariffs may apply to different types of users. Rates and thresholds may vary over time, according to customer characteristics (property value or income) or location. Two-part, rising block and declining block tariffs are widespread. The two former types are gaining ground due to a general shift of opinion away from consideration of water supply as a public service to its use as a commodity with a correct price. Seasonal tariffs (summer/winter) are uncommon, but are becoming more widespread. Peak tariffs (hourly or daily) have only been tested in experiments.

Tariffs may be designed with several aims, which may in some cases be in conflict:

- efficiency (maximum net benefit for society)
- raising revenue to cover the costs of supply in a fair and equitable way
- reducing environmental costs (abstraction and pollution)
- understandable for customers and applicable for administration purposes

In fact, improving the fairness or efficiency of a tariff often makes it more complex and more difficult to understand.

Economic incentives (water charges and taxes) have mainly been introduced with the aim of generating revenue to partially cover the cost of supplies.

Maximum economic efficiency is attained when the price is set at the level where marginal costs equal marginal benefits. Volumetric pricing is a mechanism through which tariffs can be designed to achieve efficiency and to account for equity (access of the poor) without involving high transaction costs due to monitoring, measuring and collecting water charges. The effectiveness of direct water charges on volumetric basis in changing the users' behaviour will mainly depend on the price elasticity of demand. Pricing of water can also reflect the quality of water. The higher the amount used, the higher the price per unit. Users, both residential and agricultural, will adjust their use behaviour to the structure of the tariff, and respond by improving their water use practices. One caveat is that in many countries, and especially in the case of irrigation water, the effectiveness of price increase is affected by the difference between the value of unit of water to the user (the shadow price of water) and the actual price charged per unit of water. In many countries, that difference is so big that for any price increase to be effective, it has to be so high, that political considerations may arise that will prohibit it from happening.

Irrigation water can also be priced on the basis of output per area, i.e. irrigators pay a certain water fee for each unit of output they produce. The basic concept is that farmers should pay the charge according to the crop productivity or the value of output, or the marginal value product of water per unit of water used.

Subsidies can be provided either directly to users of water or for a water use technology. The adoption of subsidy measures for promoting efficient water use is often practiced for promoting environmentally friendly technologies, but it is

also used to promote water savings, from which society as a whole may benefit. Different types of subsidies such as grants or payments to farmers, budgetary subsidies (e.g. tax credits), provision of extension services, preference loans, debt relief, etc, could be implemented depending on their effectiveness and suitability to a particular country.
Tax incentives are designed to modify behaviour by encouraging particular groups or activities, and could be implemented in the form of preferential tax treatment to certain producers or residential consumers through tax credits, exemption or deductions, or through tax benefits provided to investors. Taxes are relevant in the case of negative externalities resulting from water use. For example, the excess pumping of groundwater lowers the water table, increases salinity of the aquifer and creates negative regional externalities. The excess withdrawal of water also results in degradation of ecosystems because the minimum water requirement of the ecosystem is not met due to the lowering of the water table and the reduction of the regional water balance. A tax incentive, equal to the marginal environmental damage cost, could be designed and implemented so that the water charge also addresses these ecological concerns. Indirectly, environmental taxes can also be imposed on the water-related inputs such as energy inputs and chemical fertilizers, which also partly influence the level of water use and the level of externality. Energy usually used in water abstraction is highly subsidized and encourages farmers to use more water at a relatively lower cost of extraction (Tiwari and Dinar A., 2001). Such taxes can be designed so that individuals internalize the externalities by improving water use efficiency and gradually adopt efficiency measures.

2.1.2.4 - Water banks and markets

Water banks or markets are mechanisms to sell or rent water use rights. They exist in the USA, Chile, Canada and Australia. In Europe, water banks are a new concept and the only fully developed experience is the one of the Canary Islands in Spain (Aguilera-Klink et al., 2000). In order to tackle water scarcity problems, the Spanish government is currently implementing “Centers for the Exchange of Water Rights” in the Segura, Júcar and Guadiana river basins and developing legal regulations for water banks.
Water bank regulations have to ensure a difficult balance that stimulates the exchange of water rights and, at the same time, protects the environment and every water user.
Water banks offer several opportunities to tackle drought problems : as water user acquires a “value”, current water users save water in order to sell their rights on the unused amount of water. At the same time, new water users (e.g. tourism) in water stressed areas with limited water permit to have a legal way of acquiring water rights and would not illegally abstract it. Water banks can furthermore support the establishment of environmental stream flows in certain river stretches, either by establishing a percentage of sold water for environmental purposes or by acquiring water rights. This measure can directly support the establishment of a good ecological status, as requested by WFD.
However, water banks have some inherent risks:

3. Upstream concentration of water rights can reduce stream flows in river stretches.
4. Changes in water use can produce higher pollution.
5. In water stressed areas, “virtual” water might be sold because legally established water rights might exceed the existing resources.

6 If a public water bank does not work adequately, a “black” water market might appear.

For all these reasons, it seems appropriate to introduce water banks in a step-by-step approach, avoiding illegal water sellings and fixing a baseline water price that ensures that resource and environmental costs are taken into account.

2.1.3 - Social approach

2.1.3.1 - Users education and information

Dialogue with users and participation of citizens is essential for an efficient water management, permitting a demand regulation and a better use of amenities. Information and educational campaigns in all sectors are always part of a wider plan to use water more efficiently by encouraging more rational water use and changing habits. For this purpose, public awareness has to be motivated. As a user, the citizen gives financial support (taxes) to mobilize and distribute the resource as well as rectifying quality and quantity variations. Civic pressure has to be as constructive as possible, so it is necessary to inform people about roles and means of water managers. Information campaigns as well as promoting water-saving devices, raising prices to pay for leakages, are important initiatives.
In the agricultural sector for instance, farmers must be helped to optimize irrigation by means of training (on irrigation techniques), regular information on climatic conditions, adaptation of the irrigation volume and period according to the type of crop, rainfall level and type of soil.
In the industrial sector, water savings are just part of a wider programme which includes measures to reduce water pollution and implement environmental management systems.
It is difficult to quantify the effect of a public educational campaign because it is always part of a wider water-saving programme which includes other measures.

2.1.3.2 - Institutional aspects : conflict resolution and administrative settings

The administrative setting of river basin authorities is a key factor to adequately implement drought mitigation measures, especially those regarding law enforcement. Two recent NGO reports (WWF, 2003a ; WWF and EEB, 2005) show that administrative setting of competent authorities for water management and implementation of the WFD are still a pending issue in many EU countries.
“Unpopularity” or concern for social consequences of drastic alleviating measures such as the closure of illegal boreholes, make their practical application very rare. This fact does not help respect the corresponding law and also explains why, for example, the Guadalquivir river basin authority (Spain) waited 18 years to start mapping illegal boreholes in the Doñana National Park, finding 100 % of completely or partially illegal water users in the first studies (CHG, 2003).
Lack of incentives to comply with the law is also due to the fact that suiting infringements through administrative and legal procedures takes years and frauds can even expire before the suiting process is completed.
In other cases, the existing legislative text is the result of a long negotiation which has weakened and altered the original objective of the law. For instance, the Spanish 1985 Water Act converted water from private to public good, with the objective of improving the manageability of this resource. However, during the negotiation of the legislative text, it was decided to maintain property rights for all those that could prove to be water users before the entrance into force of

the act. This has caused a huge administrative overload. 20 years after, the filing of all the application forms for the recognition of private rights is still unfinished. Frauds still exist, for example in the hydrogeological unit 04.04 of the Guadiana river basin, the water volume associated to registered rights currently doubles the unit renewable water resources. It becomes practically impossible for some river basin authorities to manage this public good. In the Alicante province, on the Mediterranean coast, almost 80 % of water rights are private.
A part of these shortcomings is due to a lack of human resources in water administration, both in terms of staff number technical competences needed to deal with increasingly complex legal requirements. Water policy actions should strengthen river basin authorities role and the capacity to enforce the existing law. Moreover, the speeding up of judicial procedures against frauds would help making the river basin authorities' control action more effective than it is for the moment.

2.1.3.3 - Wider user participation

To keep a permanent dialogue, the user must be associated to the decision process and participate at the most upstream level as possible to the different steps of the establishment of fixtures. The adaptation of fittings to the demand is the condition for their acceptance by the public.
The place given to users in water management has been increasing with the passing of years. Water services are developed for users but they have only been beneficiaries of those services for a long time. Their places have gradually been recognized by the mean of organisations such as consultative commissions of local public services where users are represented and can officially share their positions.
A lot of associations have developed in water sector. Many of them deal with environmental protection. They provide information to the public, education, actions in law, environmental maintenance and management of specific systems. Recently, a new type of (often local) associations is developing in water services management and sanitation (management modes, price of water, etc) in connexion with specialized consumers' associations.
In France, a particular water services management have been developed: delegation of services. A city gives to an enterprise (after a call for tender) the service exploitation and eventually the investments charge. They are linked by a contract. Since the middle of the 19^{th} century, this device have permitted the development of big industrial groups, or to smaller groups have risen these last years, often at a regional scale.

2.1.3.4 - Education and awareness campaigns

The financing of educational and sensitisation campaigns must not be considered as a brake for action but as a tool for promotion and profitability of this action. The message has to be adapted to specific publics according to their interests. The size of the operative organism (global or local), the width of the action zone and the level of information determine the accomplishment of the actions vis-à-vis users and beneficiaries of a given project. A big organism will provide information at a large scale about comprehension of the water cycle, the fragility of the resource and the impact of the problems on health and daily life. This kind of information sets general public's sight. A local operator, directly concerned by a specific project in a reduced perimeter of action, will explain the advantage of

the project to the users, the correct and efficient utilization and the importance of maintaining this fixture. The users targeted are the direct users and beneficiaries of the installation.
Useful information has to be selected in order to sensitize users and point their behavior toward a better use of water and get their endorsement for the projects they are concerned with. The acting informators must be aware of the needs and demands of the target public (as well as his link with water) and use the field knowledge in order to be more efficient.
Dialogue and participation of the users can be achieved by two means :

- Meetings of different users categories and beneficiaries as well as their representatives
- Moderators visiting users for a more direct and individual contact

2.1.4 - Conclusion : integrated water management approaches on demand side measures

The management of water is very different across Europe and on the Mediterranean area. A range of regional and decentralized policies is already existing. The WFD is an important step towards integrated management of water resources at a river basin scale and towards harmonisation of water policies among member states. These integrated water management approaches and the tools of the WFD could be used for Mediterranean non EU countries in order to facilitate a better management of the demand side in these countries.

1.7. 2.2 - Supply-side measures

2.2.1 - Natural catchment storage

Water naturally stored in catchments as lakes, rivers, aquifers and wetlands is globally abundant in Europe with seasonal and regional variability.
Wetlands are usually considered as patches in catchments, isolated from other functional elements. Hydrologically spoken, wetlands are discharge areas with many economic, social, natural, environmental values and services as a source of drinking water, water for irrigation, fishing, wildlife, biodiversity, etc. However, wetlands can behave like recharge areas to aquifers in many parts of the world, generally in arid and semiarid zones. Streambeds in the catchments and floodplains usually recharge aquifers during periods of floods or when high discharges occur. It is especially important in arid and semiarid areas where rainfalls are usually scarce and successions of dry years are unpredictable.
Although the relationship between groundwater and wetlands is very complicated and not well known, it is accepted that aquifers are the best manner to store water in these semiarid regions where evapotranspiration exceeds the rainfalls and water deficit may be significant during many months along the year. Moreover, storage water in aquifers decreases seasonally following the characteristic natural variability of water resources in arid and semiarid regions, not suffering from drought impacts as dams do (website ref 2). Some aspects regarding the role of wetlands in the water cycle at river basin scale are tackled in the CIS Guidance Document N°12 “The role of wetlands in the Water Framework Directive”.
Some experiences show us the importance of good management of natural storage water in catchments during drought periods. For example, in Messana

Valley in Crete, about 50 % of recharge to the aquifer occur through catchments streambeds. During a wet year, the aquifer can store 19 million m^3 of water. Each year, about 22 million m^3 are withdrawn to irrigate olive trees and vines. In southeast of Spain, an alluvial aquifer (Sinclinal de Calasparra) is used during drought periods to supply drinking water to 76 Segura river basin villages. Sebkhet Kelbia, located in central Tunisia, is a big flood-plain wetlands of 1 300 ha and one of the 16 Natural Reserves of Tunisia, designated for strict nature protection. It receives water from three rivers (Nebhana, Merguellil and Zeroud) that rise in the near mountains (website ref 3). During floods, these rivers recharge alluvial aquifers although outside this period the rivers are dry. Water from aquifer is then used for irrigation (websites ref 4 and 5).

The ecological integrity of wetlands maintenance, especially for those located in arid and semiarid regions, is not a simple technical question, but increases the supply of groundwater that may be essential for many human activities survival during drought years.

2.2.2 - Aquifer recharge

Natural aquifer recharge (from rain or surface water infiltration) is vital in order to maintain the groundwater and to replenish the discharges from the aquifer with a good quality water resource, but in many cases is quite impossible to grant a sustainable groundwater level only considering natural recharge.

In many areas of the world, aquifers that supply drinking-water are being used faster than they recharge. Not only does this represent a water supply problem, it may also have serious health implications. Moreover, in coastal areas, aquifers containing potable water can become contaminated with saline water if water is withdrawn faster than it can naturally be replaced. The increasing salinity makes the water unfit for drinking and often also renders it unfit for irrigation.

To remedy these problems, some authorities have chosen to recharge aquifers artificially with treated wastewater, using either infiltration or injection. Aquifers may also be passively recharged (intentionally or unintentionally) by septic tanks, wastewater applied to irrigation and other means.

Artificial recharge is the planned, human activity of augmenting the amount of groundwater available through works designed to increase the natural replenishment or percolation of surface waters into the groundwater aquifers, resulting in a corresponding increase in the amount of groundwater available for abstraction. Before deciding on aquifer recharge as a measure to solve water scarcity problems, an analysis needs to be undertaken if and how it affects other water bodies, such as surface, transitional or coastal waters. Aquifer recharge cannot be made independently from an understanding of the whole water cycle. Furthermore, previous to aquifer recharge, it is necessary to identify the water services that benefit from this measure and how and in which proportion they would be required to recover the costs of the measure. In this sense, artificial aquifer recharge must be considered as part of a wider approach to water resource management which addresses demand and quality issues as well as supply aspects. Although the primary objective of this technology is to preserve or enhance groundwater resources, artificial recharge has been used for many other beneficial purposes. Some of these purposes include conservation or disposal of floodwaters, control of saltwater intrusion, storage of water to reduce pumping and piping costs, temporary regulation of groundwater abstraction, and water quality improvement by removal of suspended solids by filtration through the ground or by dilution by mixing with naturally-occurring groundwaters

(Asano, 1985). Artificial recharge also has application in wastewater disposal, waste treatment, secondary oil recovery, prevention of land subsidence, storage of freshwater within saline aquifers, crop development, and streamflow augmentation (Oaksford, 1985).
Aquifer recharge with treated wastewater is likely to increase in future because it can :

- restore depleted groundwater levels
- provide a barrier to saline intrusion in coastal zones
- facilitate water storage during times of high water availability.

If aquifer recharge is haphazard or poorly planned, chemical or microbial contaminants in the water could harm the health of consumers, particularly when reclaimed water is being used. Wastewater may contain numerous contaminants (many of them poorly characterized) that could have health implications if introduced to drinking-water sources. Ensuring that the use of treated wastewater for aquifer recharge does not result in adverse health effects, a systematic science-based approach is needed, designed around critical control points, as used in the hazard analysis critical control point (HACCP) approach. Such an approach to potable aquifer recharge requires a thorough evaluation of the best practices that will protect public health, and consideration of environmental and sociocultural concerns.
A variety of methods have been developed and applied to artificially recharge groundwater reservoirs in various parts of the world. The methods may be generally classified in the following four categories (Oaksford, 1985) :

- Direct Surface Recharge Technique (Asano, 1985).
- Direct Subsurface Recharge Technique.
- Combination surface-subsurface methods, including subsurface drainage (collectors with wells), basins with pits, shafts, and wells.
- Indirect Recharge Techniques.

Direct surface recharge techniques are among the simplest and most widely applied methods. In this method, water moves from the land surface to the aquifer by means of percolation through the soil. Most of the existing large scale artificial recharge schemes in western countries make use of this technique which typically employs infiltration basins to enhance the natural percolation of water into the subsurface. Field studies of spreading techniques have shown that, of the many factors governing the amount of water that will enter the aquifer, the area of recharge and length of time that water is in contact with soil are the most important (Todd, 1980). In general, these methods have relatively low construction costs and are easy to operate and maintain. Direct subsurface recharge techniques convey water directly into an aquifer. In all the methods of subsurface recharge, the quality of the recharged water is of primary concern. Recharged water enters the aquifer without the filtration and oxidation that occurs when water percolates naturally through the unsaturated zone.
Direct subsurface recharge methods access deeper aquifers and require less land than the direct surface recharge methods, but are more expensive to construct and maintain. Recharge wells, commonly called injection wells, are generally used to replenish groundwater when aquifers are deep and separated from the land surface by materials of low permeability. All the subsurface methods are susceptible to clogging by suspended solids, biological activity or chemical impurities.
Combinations of several direct surface and subsurface techniques can be used in conjunction with one another to meet specific recharge needs.

Indirect methods of artificial recharge include the installation of groundwater pumping facilities or infiltration galleries near hydraulically-connected surface waterbodies (such as streams or lakes) to lower groundwater levels and induce infiltration elsewhere in the drainage basin, and modification of aquifers or construction of new aquifers to enhance or create groundwater reserves. The effectiveness of the former, induced recharge method depends upon the number and proximity of surface waterbodies, the hydraulic conductivity of the aquifer, the area and permeability of the streambed or lake bottom, and the hydraulic gradient created by pumping. Using the latter technique, aquifers can be modified by structures that impede groundwater outflow or that create additional storage capacity. Indirect methods generally provide less control over the quantity and quality of the water than do the direct methods.
For example, Managed Aquifer Recharge (MAR) is a method of adding a water source such as recycled water to underground aquifers under controlled conditions using infiltration galleries. Treated effluent flows via an inflow pipe, then flows down through a chamber into covered galleries (engineered trenches that facilitate the infiltration of water into the ground and consisting of parallel slotted pipes containing either gravel or open plastic structures). The top and sides of the galleries are covered in geotextile material to prevent topsoil from entering the galleries, while the base is open to the in situ soil. The trenches are about 10 metres above the water table to allow water quality improvements to occur in the in situ soil before recharging the aquifer. As the treated water infiltrates the soil natural biological, chemical and physical processes occur to remove pathogens, chemicals and nutrients from the water. This “filtering” process continues whilst the water infiltrates and resides in the aquifer. The following water quality improvements occur during the process : removal of nutrients such as phosphates and organics, degradation of chemicals such as disinfection by-products, pathogen die-off. This significantly reduces the health and environmental risks that may be associated with secondary treated wastewater, leaving the reclaimed water in similar quality to that of the surrounding groundwater. This method costs less to treat and use reclaimed water using MAR than desalination ; however should high quality water be required the reclaimed water may still need to be desalinated. As there is much less salt in reclaimed water than seawater, significantly less energy is required to desalinate reclaimed water. (websites ref 6 to 8)

2.2.3 - Dams

Reservoirs play an important role in public water supply, irrigation and industrial uses. The construction of dams, however, can have serious implications for the functioning of freshwater ecosystems in a river basin and ultimately impact livelihoods.
Dams disconnect rivers from their floodplains and wetlands and reduce river flows. They act on the migratory patterns of fish and flood riparian habitats, such as waterfalls, rapids, riverbanks and wetlands, which are essential feeding and breeding areas for many aquatic and terrestrial species. Dams also disrupt the ecosystem services provided by rivers and wetlands, such as water purification. By slowing the movement of water, dams prevent from natural downstream movement of sediments to deltas, estuaries, flooded forests, wetlands, and inland seas, affecting species composition and productivity.
The World Commission on Dams found that the technical and economic performance of many water supply dams, both irrigation and bulk water supply,

have failed to reach the intended targets. The survey showed that, except 29 dams with a water supply component (excluding irrigation), 70 % of dams did not reach their targets over time, and a quarter of dams delivered less than 50 % of the target. Equally, irrigation components of large dams studied by the WCD fell short on targets, including the areas irrigated. However, dams with heights inferior to 30 m and reservoirs of less than 10 km^2 tended to be closer to predicted targets (World Commission on Dams, 2000).
When considering dams as a structural solution to water scarcity, the decision making process must be realistic about the dam technical and economic performance, as well as about the environmental and economic cost associated to the disturbance and loss of ecosystems and the services they provide.
The construction of new water supply dams and the management of existing dams in Europe are subject to EU legislation, especially WFD, which aims to ensure the environmental quality of water bodies. The directive applies to all surface waters (rivers, lakes and coastal waters) and groundwater in a river basin. Its objective is to achieve at least a “good ecological and chemical status” of all waters by 2015, as well as preventing from the deterioration of current status. Volume of water flow is included in the definition of ecological status. This is of particular relevance to dams which tend to interrupt streamflow. This has implications on new dams construction, which inevitably modify water bodies status. According to article 4 (7) derogation provision, WFD allows the development of new water infrastructure, even if it prevents from reaching good status. However, this provision comes with a number of strict conditions, including :

- conditions for mitigation measures
- proof that there are no better alternative options in environmental terms
- condition that the project is either of “overriding public interest” or that the provision of benefits to human health and safety (e.g. flood control) or sustainable development outweight the benefits of achieving the directive environmental objectives. Furthermore, articles 4.8 and 4.9 are mandatory as conditions for these derogations.

WFD implications for existing dams depend on whether or not the water body is classified as heavily modified, fulfilling article 4.3 criteria and respecting those of articles 4.8 and 4.9. In other cases, dam sites may be subject to extensive mitigation measures implementation in order to reach good ecological potential, particularly regarding minimum flow regimes, aquatic fauna migration and sediment management. In addition, the fact that these water bodies also need to reach good chemical status should be taken into account (Barreira, 2004).

2.2.4 - Use of basin-external water resources

2.2.4.1 – Alternative sources

DESALINIZATION
This technic is used when technically and economically feasible. There are more than 7500 desalting plants in operation worldwide producing several billion gallons of water per day. 57 % are in the Middle East and 12 % of the world capacity is produced in the Americas, with most of the plants located in the Caribbean and Florida regions. However, as drought conditions continue and concerns over water availability increase, desalinization projects are being proposed at numerous locations.

A number of technologies have been developed for desalinization which include distillation, reverse osmosis, electrodialysis, and vacuum freezing. Two of these technologies, distillation and reverse osmosis, are being considered by municipalities, water districts and private companies for the development of sea water desalinization (website ref 9).

Desalinization costs are very sensitive to the salinity of the feed water. Desalinization of brackish waters and waters that are mildly saline can be economically justified for some high valued uses. Seawater desalinization remains enormously expensive when all costs are fairly accounted for. There is a tendency to promote seawater conversion projects that are joint with power plants. The resulting costs are almost always understated because the power is subsidized and all of the joint costs are allocated to power production. Seawater conversion is unlikely to be the solution to water problems except in a few instances where there are no alternative sources of supply and there is considerable wealth to defray the costs of seawater desalinization (Vaux H. Jr., 2004).

Water treatment costs vary by the amount of salt removal, cost of energy, size of plant, as well as the type of treatment technology. Desalinization costs are dominated by capital investment, energy and maintenance costs. Reverse osmosis systems, which utilize membrane technology for water treatment, have the lowest cost of operations, especially in areas with high power cost. While membrane technology advances have resulted in significant cost reductions, energy still accounts for up to 60 % of the operating cost. Further improvements in energy efficiency will deliver sustainable reductions in operating cost. Along with improvements in energy efficiency, improvements in membrane performance and membrane life through integrated treatment systems can reduce capital cost and life cycle cost. Membrane-based treatment solutions are essential to create new water sources such as brackish water aquifers, seawater, and even wastewater. Membrane-based desalinization and reuse is a proven solution, but a broader application of these technologies to create meaningful new water sources requires investment to further reduce the energy consumption associated to the operation of membrane systems. The long-term, sustainable solution to produce economical sources of new water lies in developing more advanced, energy-efficient technologies to treat multiple water sources. As a practical matter, substantial incremental funding for research and development would significantly accelerate the development of economical sources of new water (website ref 10).

RAIN WATER HARVESTING

To help meet water demand, rainwater harvesting and grey water practices are commonly used in several European countries. Traditional regulatory practices prohibiting rainwater harvesting or grey water reuse as substitutes for potable water supply are changing. Applications of these practices are supported by commercially available technologies. Where these practices and technologies are encouraged by regulations, they are increasingly being used. The incentive may be a lack of alternative water supply, or where available water is not an issue, the cost of publicly supplied water may be encouraging acceptance (website ref 11).

Rainwater harvesting involves the use of captured rainwater, usually from a roof catchment, which otherwise would have soaked into the ground, evaporated or entered the drainage system. Once captured, the water can be drawn on for a variety of uses from irrigating crops or gardens, as toilet flush water, in water features and occasionally as a source of drinking water. Watering a garden with rainwater collected in a water butt is a rudimentary form of rainwater harvesting. Where there is negligible potential human contact, the rainwater will usually only require coarse filtration to prevent leaf litter, debris and small animals entering the system. If the rainwater is to provide a potable water supply, thorough treatment is required, which makes this use uncommon.

During rainfall events, the first flush of water usually has the lowest water quality due to contamination from leaf litter, bird droppings and wind-blown pollutants that have adhered to the roof surface or guttering. For this reason, many rainwater harvesting systems divert the first flush of water so that it is not used.

The amount of rainwater that can be harvested is a function of the rainfall received and plan roof area. For example, in Northern Ireland, where 2004 annual rainfalls were just over 1000 mm/year, a home with a 100m^2 plan roof area could harvest 60 m^3 of rainwater, assuming that 60 % of rain that falls on a roof catchment is collected and used.

Legislation in France permits the use of rainwater for certain purposes and under certain conditions. Untreated, the water can only be used for external utilisations such as irrigation and automobile washing, or where there is suitable plumbing construction preventing cross-contamination or cross-connexions, it can be used inside homes for toilet flushing. A number of experimental buildings that incorporate rainwater harvesting systems have been constructed in France. Studies have unequivocally demonstrated that such systems can be designed, constructed and implemented with due regard to public and environmental health. It is claimed that an average residential rainwater harvesting system can be fully amortized in less than three years.

National legislation in Belgium requires all new constructions to have rainwater harvesting systems for the purposes of flushing toilets and external water uses. The aim of this legislation is twofold : 1) to reduce demand for treated water and the expansion of the water supply infrastructure ; and 2) to collect and use rainwater instead of surcharging stormwater management systems.

DOMESTIC GREY WATER REUSE

Conventional toilet flush water is supplied water unnecessarily treated to drinking water quality standard, an expensive and energy intensive process. Greywater recycling is an innovative alternative whereby treated greywater is principally used for toilet flushing but also for gardens watering. Greywater is wastewater from showers, baths, wash basins, washing machines and kitchen sinks although for recycling purposes kitchen sink and washing machine water is normally excluded because it is too greasy and/or contains too many detergents to allow cost effective treatment (website ref 12).

Unlike rainwater, greywater requires filtration to remove hair, skin and soap products from the water and chemical or biological treatment prior to reuse. The potential level of human contact with the water in its end use will determine what level of treatment is required. For example, greywater used for hosing down vehicles will require a high water quality because the risk of human contact with the water is greater in highly pressurized systems. Similarly, black water (toilet effluent diluted by flushing water) is not recycled because of the even higher level of treatment needed before it is safe for human contact. Public acceptance is also a major barrier here.

Perhaps the two biggest barriers to widespread uptake of greywater recycling are public concern about the risk to health and system maintenance requirements. The health concerns are twofold : firstly the health risk from contact with

greywater in the normal operation of the system and secondly the health risk posed by the breakdown or ineffective operation of the treatment system. Greywater recycling systems are designed for minimal user contact with the greywater. Aerosols from toilet flushing are the only potential contact most users will have with the water and this is unlikely to have health implications if the water has been properly treated. It can be minimized even further by closing the toilet lid prior to flushing.
There is a health risk however where treatment systems have broken down or not been maintained correctly so that untreated water (which may have been stored for long periods) comes into contact with users. Where untreated greywater has a long residence time in the system, the risk is greater. If there are pathogens such as enteric viruses, giardia, cryptosporidium, salmonella and campylobacter present in the wastewater from affected individuals, lengthy periods of poor storage could result in the water turning septic and posing a health risk. The untreated greywater awaiting treatment should instead be stored in a dark, cool container and continually stirred to prevent anaerobic conditions.
Despite these risks, there are numerous safeguards which together diminish the health risks almost completely :
• Ultraviolet, chemical and/or biological disinfection
• Periodic inspection and cleaning of the system to ensure the water is being adequately disinfected
• Clear identification of pipes which are carrying greywater and incompatibility with main pipework
• Pale colouring added to the recycled water to differentiate it from potable water
• User training covering how the system works and good practice to adopt to minimise potential risks
• A manual “divert” option whereby excessively contaminated water does not have to enter the recycling system
• Multi-occupancy buildings are likely to have greater water circulation ensuring the greywater used is fresh rather than having had a long storage residence time in the system.

USE OF ALTERNATIVE WATER RESOURCES IN INDUSTRIAL CYCLE
Industry is one of the largest consumers of water. Water is used for processes as diverse as mixing, cooling, boiler feed and plant wash-down as well as for washrooms and other sanitary uses.
Unlike most residential properties, industry and business in the UK are subject to compulsory metering. With the cost of mains water, sewerage and trade effluent rising, businesses are increasingly conscious of the substantial water, and therefore cost, savings that water reuse and water conservation can achieve. For example the five finalists in the Industry category of the 2005 Water Efficiency Awards were able to cut water consumption by between 25 and 98 % by adopting a combination of water reuse and conservation strategies. Enhanced Capital Allowances, a UK Government initiative, promotes this sustainable solution and provides tax incentives for water saving and rainwater devices and water reuse with membranes as well from September 2005 (website ref 13). In addition to these water cost savings other potential benefits to industry include (website ref 14) :

- avoiding water restrictions imposed during periods of drought
- reduced energy and chemical costs through recycling
- removing the need for discharge consents
- good publicity opportunity

- improved company image and reputation amongst the public, customers and own workforce
- helping to achieve certified environmental accreditation (e.g. ISO 14001)
- fulfilling corporate social responsibility commitments

Sustainable Drainage Systems

Sustainable Drainage Systems (SUDS) is an approach to drainage which seeks to decrease the amount of surface runoff, decrease the velocity of surface runoff, or divert it for other useful purposes, thereby reducing the contribution it makes to sewer discharge and flooding.

As well as controlling the quantity of runoff, SUDS can also improve the quality of runoff, preventing pollutants from entering the drainage system. SUDS will also “green” the urban environment and should provide landscape, amenity and biodiversity benefits too.

Techniques that come under the SUDS umbrella vary enormously but usually involve some of the following components :

- Permeable and porous surfaces to reduce surface runoff
- Ponds/basins for temporary storage during high magnitude rainfall events (detention basins) or longer term storage (retention basins)
- Pipes and channels to divert water from undesirable locations
- Structures that increase the lag between a rainfall event and discharge of water to the drainage system by increasing infiltration.

The SUDS approach is particularly valuable in urban areas where high density development and impermeable surfaces mean surface runoff can easily cause flooding, either directly or indirectly through sewer flooding (website ref 15).

Direct and Indirect potable reuse

Direct potable reuse (i.e. treated wastewater directly reused for drinking water) is very rare because of the increased potential risk to public health and the negative public perception. Even though the technology is well proven, direct potable reuse is only justifiable when there is no other option for example in the desert or outer space. Currently, the only place where direct potable reuse takes place on a municipal scale is in Windhoek, Namibia where treated wastewater combined with surface runoff is treated to provide potable water. Direct reuse is common practice for non potable applications in industry and irrigation.

Indirect potable reuse can be planned or unplanned. Conventional water treatment in many countries involves unplanned indirect potable reuse of treated wastewater. Water abstracted from rivers to provide drinking water includes treated wastewater that has been discharged upstream. It is unplanned in the sense that it is not an intentional part of the wastewater discharge policy that the water will be reused downstream for potable water supply. The abstracted water will still need to meet potable water standards if it is to supply drinking water. River water may go through several abstraction/treatment/use/treatment/discharge cycles before reaching the sea. The pursuit of economies of scale has led to a tendency for large down-catchment wastewater treatment plants. Planned use by relocating treatment and shortening the use/reuse cycle could increase water availability for both environmental and other purposes.

The reason why indirect water reuse is not considered to pose a health risk is that the treated wastewater benefits from natural treatment from storage in surface water and aquifers and is diluted with “ordinary” river/ground water before abstraction to ensure good drinking water quality (part of a multi-barrier approach in the water safety plan). The storage time provides a valuable buffer to measure and control quality. Direct potable reuse, however, is almost a closed loop system with limited storage and a shorter buffer time therefore increasing the risk (website ref 16).

use of alternative water resources for Irrigation

Irrigation is the artificial application of water to the ground surface in addition to what falls naturally as rainfall. Unlike energy production that gives back the majority of the removed water to the environment, irrigation consumes half the water deducted from the environment because of absorption and evapotranspiration (website ref 17).

Since the mid-1990's, irrigation has consistently been the largest use for freshwater globally. In France, a 66 % increase of the irrigated surface has been observed between 1988 and 1997. The use of recycled water for irrigation is widespread because water quality standards are less stringent where water is not for potable use or direct human contact. Irrigating land uses extensive amounts of water so there may be cost savings associated to using recycled water too. The two main irrigated environments are agricultural land (horticulture, crop production and grazing pasture for livestock) and amenity/recreation areas (e.g. golf courses, public parks, and commercial landscaped gardens). The quality of water required for irrigation of agricultural land will depend on the crop type and whether the crop is eaten raw or cooked (website ref 18).

2.2.4.2 - Increasing availability of water resources

The creation of new resources is rarely a sustainable solution for environmental management, considering the heavy cost and the impact on natural systems. But the creation of a new resource, when ecologically feasible and within rational economic conditions, is conceivable, when the imbalance is so great that other imaginable management measures seem to be insufficient. But this approach mustn't become an escape ahead. For that reason, withdrawals have to be stabilized in order to keep the advantage of the resource creation in terms of restoration, because an increase can contribute to the imbalance. For this purpose, collective commitments for withdrawals limitation have to be made, leading to results with the height of the stakes, by the mean of existing collective structures or creating organisms that gather the concerned irrigators when they do not exist.

Nevertheless and generally, the cost in capital of collective infrastructures for storage and transfer is not affordable for the majority of the irrigators. These collective infrastructures have mostly been funded by public cities within development planning general policy. The Water Framework Directive compels to take into account the cost recovery from beneficiaries.

Therefore, it seems important for new resources projects to be preliminary analyzed on a macroeconomic basis, so all merchant and non-merchant users can think in terms of cost/advantages and notably taking into account the perspectives evolution of water demand in agricultural sector.

In the strong imbalance zones, a solution can be seen in the creation of small water dams of substitution of which the filling is made during winter with little impact on natural systems and under the same conditions as cited before. In France for instance, the development of irrigation since the 60's has led to a

correlative development of this kind of dams at a superior rate than the constitution of multi-usage and structuring resources.
The generally private status and the importance of those small dams deserve to be the object of an environmental examination. Indeed, the cumulative impact of these reservoirs at a basin scale has to be taken into account and can be equivalent or even superior to the impact of a big unique work.

2.2.4.3 - Inter-basin water transfers

The main objective of inter-basin water transfer is water security. In some arid regions, this transfer is not a question of choice but a necessary act. Inter-basin water transfers are often seen as a fast and easy solution to face drought and water stress situations. Transfers require a specific derogation and justification adjusted to the criteria established in WFD articles 4.7, 4.8 and 4.9. If these criteria are met, transfers can be considered as the "last option" to address water problems. They often provoke social and political conflicts between donor and receiving basins.
In their initial planning stages, expectations towards water transfers have often been overestimated, as shown by a recent review of three different transfer projects in Spain (Tagus-Segura - WWF, 2003b- Ebro and Júcar-Vinalopó). Some particular aspects require special attention :

- water availability in donor basin, including water consumption expectations in the proper basin and variations in rainfalls and evaporation due to climate changes.
- environmental and social effects of the transfer on the donor basin.
- effects of the transfer on the receiving basin.
- costs of water transfer projects.
- respect of the derogation criteria established in WFD articles 4.7, 4.8 and 4.9.

Considering water availability, the initial Júcar-Vinalopó transfer project studies demonstrated that there were enough available resources. Nonetheless, after reviewing streamflows and environmental needs of the Júcar basin, current plans for the Vinalopó transfer consider the pumping of up to 62 Hm^3/y of groundwater from the Valencia aquifer.
Regarding the environmental effects, transfers usually worsen water bodies ecological status. For example, transfers from the Tagus basin suppose a significant reduction of stream flows in the Middle Tagus so the river currently has problems to dissolve urban and industrial pollution. Furthermore, ecological processes dynamics such as erosion/sedimentation are crucial for the maintenance of downstream ecosystems, as observed in the Ebro delta, and of the coastal waters nutritional chains (Ibáñez et al., 1999).
In receiving basins, inter-basin water transfers often promote an increased land-use and stimulate the increase of long-term water demand, as seen in the Segura basin for instance. The difference of water quality between the basins can affect freshwater ecosystems and even provoke inadequacy for potential water users, as the Ebro transfer project analysis have shown. Furthermore, aquatic species translocation is an additional risk of transfers : the Tagus-Segura transfer has transported four fish species (Carassius auratus, Gobio gobio, Chondrostoma polylepis and Rutilus arcasii) between basins and promoted hybridizing with Chondrostoma arrigonis in the Júcar basin (Oró, 2003).
The costs of water transfer projects do not often fully reflect all the transfer and associated works, infringing WFD cost recovery obligations. During the Ebro

transfer project, different economic reviews of the initial studies doubled the expected price of water from 0,31€/m^3 up to 0,72€/m^3 (WWF, 2003c).
Considering the upcoming new data, the Spanish Government is currently reviewing all major transfer projects. The lessons learnt from this process should be taken into account in future projects in all countries at an early planning stage, additionally to WFD mandatory requirements, an option assessment, including non-constructive alternatives, is highly recommended.

2.2.5 - Conclusion : integrated water management approaches on supply side measures

Water Conservation and water demand management in Emilia-Romagna is a good case study to illustrate integrated water management approach. Emilia-Romagna (44° latitude) is situated in northern Italy in the valley of the Po river, bounded by Apennine Mountains to the south and the Adriatic Sea to the east. The climatic conditions of the region are related to the climatic general conditions of the Po valley (surrounded by the Alps and the Apennine) and are mostly influenced by the mountains and the sea, leading to a high spatial variability of the precipitation fields. For the region, but also for the Mediterranean zone, the water uses for irrigation are generally predominant. In December 2005, the Regional Legislative Assembly approved the Regional Water Protection Plan anticipating the WFD someway. The Water Saving and Conservation Programme is an integral part of the Water Protection Plan. The Region, together with Basin Authorities, has established the Plan objectives for each drainage basin with reference to the WFD. By 2016, every significant surface and ground water body must reach the “good” ecological quality status. In order to assure the fulfilment of this objective, each classified surface water body, or a portion of it, must acquire at least the requisites of “sufficient” status by 31st December 2008. For quantitative aspects, priority objectives are eliminating water deficit in groundwater and maintaining a minimum flow in rivers.

- water saving and conservation program

The structure of such a program is presented in figure 21.
In Emilia-Romagna, the withdrawals (in million m^3) in the 70’s, the 80’s and in year 2000 were estimated as presented in tables 5, 6 and 7 .

Table 5 : Total withdrawals in the middle of the 70’s.

	Civil Uses	Industrial Uses	Agriculture Uses	Total
Groundwater	350	240	150	740
Surface water	negligible	290	852	1142
Total	350	530	1002	1882

Table 6 : Total withdrawals in the middle of the 80’s.

	Civil Uses	Industrial Uses	Agriculture Uses	Total
Groundwater	310	227	193	730
Surface water	170	337	681	1188
Total	480	564	874	1918

Table 7 : Total withdrawals in the year 2000.

	Civil Uses	Industrial Uses	Agriculture Uses	Total
Groundwater	282	171	222	675
Surface water	205	62	1183	1450
Total	487	233	1405	2125

There is a modest increase of the total withdrawals, with a strong replacement from the industrial uses to the irrigation uses and, partially, to the civil uses. An important decrease in the groundwater withdrawals is observed. It is also interesting to note that the civil withdrawals are stable since the 80's. The increase in surface water withdrawals depends on the regional policies developed to answer the subsidence problems posed by the unsustainable uses of groundwater in the south-eastern part of the region (Bologna, Ravenna and the coastal zone), using a canal (Canale Emiliano Romagnolo, CER), which can take about 60 m^3/sec from the Po river for agricultural uses, the Ridracoli Dam builded at the end of the 80's for civil uses and a stronger regulation of groundwater withdrawals. Nowadays the groundwater annual deficit is estimated to be around 25 Mm^3/y, with the worst problems in Bologna and also in Parma. Considering the surface water, the estimated deficit due to the future application of the Minimum Flow (MF) is around 47 Mm^3/y. The average regional consumption for domestic uses is 170 L/capita/day (L/c/d). The estimated overall (real and apparent) leakage from the civil networks is 123 Mm^3/y, which means about 26 % of the civil withdrawals.
The application of MF is the most demanding task. The need to keep a higher volume of water in the rivers impacts the actual use of resources with particular significance during summer when the water flow is low while the water demand is at the highest level. In most of the cases, it is needed to revise "historical" water withdrawal, that were already present in the last centuries for irrigation and old mills, and in the 20th century for drinking purposes. The level of the conflicts is therefore pretty high.
The regional strategy is based on a twin track approach and, considering the regional situation and water balance, is firstly based on the development of new regional policies for water conservation and the demand management, not forgetting the infrastructural development where necessary (for instance the local connexions with the Canale Emiliano Romagnolo. The Conservation Program also includes a need to define a Regional Drought Contingency Programme. The main Conservation Program actions are as shown in figure 17.

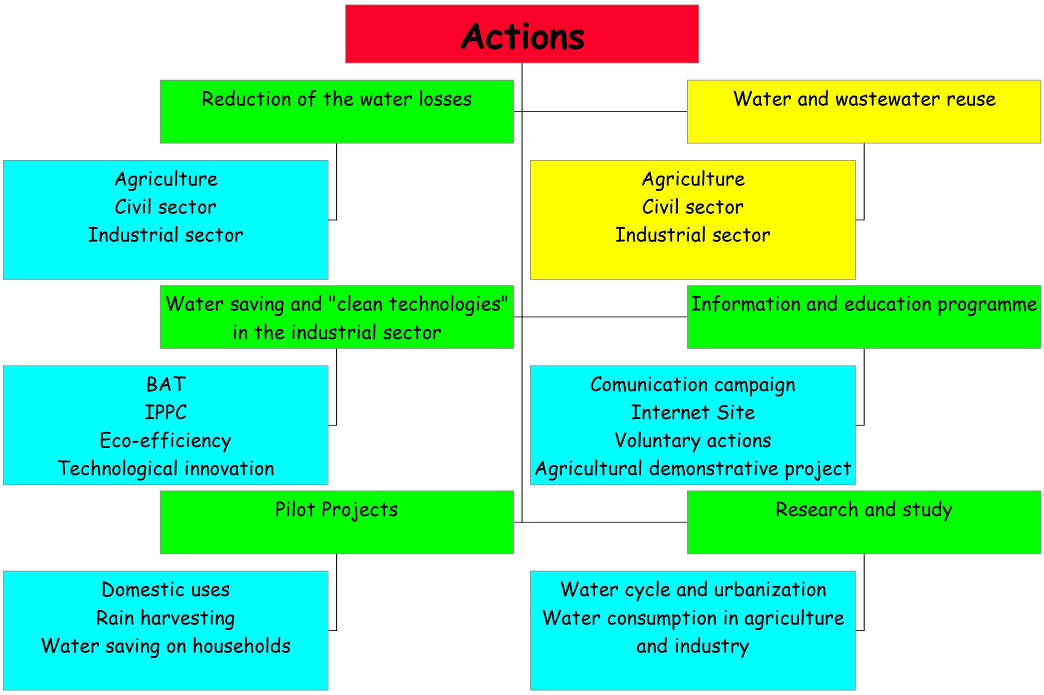


Figure 17 : Water saving and conservation program.

- water and energy saving

Energy production and use are responsible for the bulk of greenhouse gas emissions. Europe has committed itself in the Kyoto Protocol to reduce those emissions which come from fossil fuels burning, mainly coal, oil and gas. In its 2005 Green Paper on energy efficiency "Doing more with less", the European Commission set out a strategy to improve energy efficiency and to encourage greater use of new, renewable sources of energy. The total final energy consumption in the EU in 1997 was about 930 Mtoe. A simplified breakdown of this demand shows the importance of buildings in this context: 40,7 % of total energy demand is used in the residential and tertiary sectors, most of it for building-related energy services. Space heating is by far the largest energy end-use of households in member states (57 %), followed by water heating (25 %). The planned water savings in Emilia-Romagna will directly bring an energy saving for the domestic water heating of about 12 %, which means 3 % of all the energy needed in the residential sector (2,7 Mtoe/year in Emilia-Romagna region), which is about 1/6 of Kyoto commitment in the residential sector of the region.

- results of the regional conservation planning

The demand scenarios "business as usual" show an 8 % population growth for civil water uses, stability in the unitary consumption and a "natural" reduction of water losses (26 to 20 %). The industry is declining since the 70's. For agriculture, irrigated surface is still growing, but technological efficiency at the field is increasing with an almost stable demand (no clear indication from CAP). With the above conservation measures and assumptions, which must lead to a reduction of domestic consumption of 170 L/capita/day (L/c/d) to 150 L/c/d by 2016, plan measures would allow, in 2016, groundwater abstraction levels essentially depending on recharge capacity, also enabling to progressively offset current piezometric anomalies. As for surface waters, critical aspects are linked to irrigation uses of Apennine waters ; plan measures will foster resource deficit reduction in view of MF application.

- regional Plan for drought management

The plan also outlines the first elements pertaining to the Regional Plan for Drought Management. The report presented by IPCC predicts changes in the regional distribution of precipitations, leading to drought and floods, changes in the occurrence frequency of climatic extreme events, particularly heat events. Climate changes that were observed during the last decades in the region seem to be consistent with the predictions and have social impacts even at a local scale. The Water Regional Plan takes care about those aspects in order to define, for the first time in the Emilia-Romagna region, a Drought Contingency Program at the regional and local scales. Studies realized for the planning, using indicators like Standard Precipitation Index (SPI), showed that the last 15-20 years were years of growing drought. Anyway this specific risk must be afforded as in other sectors (floods, etc) with a planning strategy which shall be implemented after the plan adoption and asking the local actors to define their Contingency Programs following the regional guidelines within 2006.

3 – LONG-TERM IMBALANCES IMPLICATIONS

1.8. 3.1 - Environmental concerns (quantitative aspects in the WFD)

The Water Framework Directive establishes that member states, in implementing the program of measures specified in the River Basin Management Plans (RBMP), shall protect, enhance and restore all surface water bodies and groundwater bodies with the aim of achieving good ecological status (good ecological potential for artificial and heavily modified water bodies) within 2015. Good status is defined, for surface water bodies, according to the ecological and chemical status, while, as regards groundwaters, the good status refers to the quantitative and chemical status. So for surface waters, the Directive is more focused on quality aspects than on quantitative ones; nevertheless, quantitative aspects are addressed through an indirect approach.
Drought Management Plan at national level is linked to RBMP at river basin scale by the fact that there is a need of coherence between actions per basin. National strategy and instruments constitute the doctrine whereas measures are the actions at river basin level.
Moreover, RBMP must be linked to other land management plans (town-planning, public roads), especially soils management plans, in order to take into account the other management and planning instruments that can influence the quantitative management, notably in arid environments .

3.1.1 - Integration of qualitative and quantitative aspects

Quantitative protection of water resources is closely linked to qualitative aspects. Reaching the objectives for good ecological status would be very difficult or nearly impossible without properly considering quantitative aspects. On one hand, quantitative actions are essential in order to guarantee ecosystems (typical habitats, dilution, prevention of extreme situations) and on the other hand, pollution diminishes available resources creating imbalances within the hydrological cycle and causing conditions of water stress

1.9. 3.2 - Social concerns

3.2.1 - Socio-natural dynamics in the context of water scarcity

Under conditions of any type of resource scarcity, economically and politically disadvantaged social groups usually meet difficulties to sustain their livelihoods, their quality of life, and even their very existence. The objective of this section of the document is to explore the undesirable social impacts of water scarcity and the effect of its mitigation on our communities. By inference, this specification embraces the concept of livelihoods as well as lives and therefore includes threats to the economic viability of individuals and communities.
The number of citizens exposed to drought within the European Union is increasing. The same evaluation of people impacted by scarcity could be done for Mediterranean countries.

Figure 18 shows the relevant data for 2002.

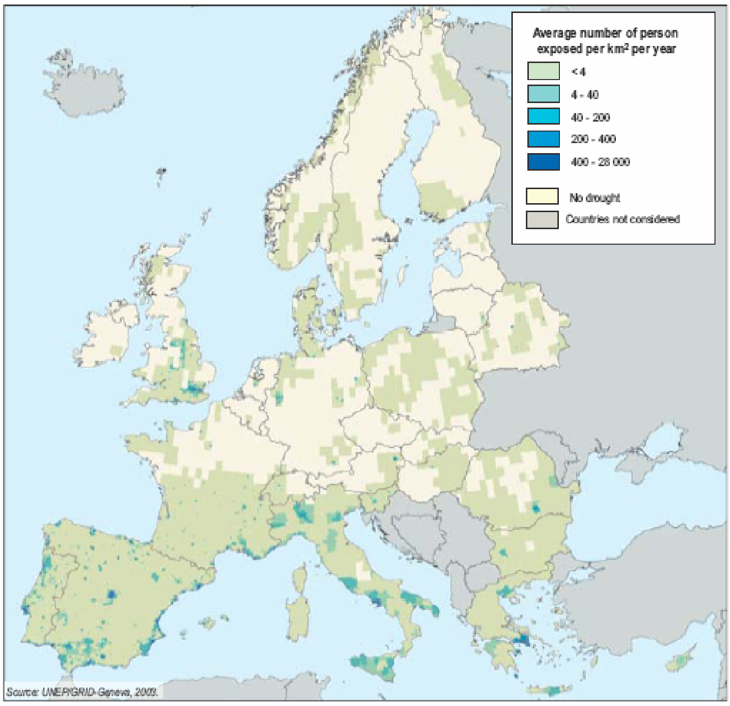


Figure 18: Average number of people per km exposed to drought (UNEP)

Scarcity of water resources can affect a wide range of social indicators, perhaps the most significant of which are:

- the affordability of water
- the public health
- the community cohesion

Recent and current EC funded research on the human and social dimensions to water stress and water management is represented by the projects (many of which are members of the Human Dimensions Cluster coordinated by the Harmoni-COP project) listed in the end of chapter III references.

3.2.1.1 - Affordability of water

As resource managers seek to raise extra-capital for investment in new supply sources or improve the efficiency of current systems, the delivered price of water can dramatically rise. The issue of affordability, whilst of obvious concern to those working in the developing nations, has latterly attracted increasing interest in Europe and the developed world (OECD, 2003). The literature on the affordability of water in the context of privatisation (Rodriguez, 2004) and willingness/ability to pay (Merrett, 2002) has been full of lively deliberations in recent years and has also prompted a wider debate on the human right to water (Bluemel, 2005).
Tariff structures in the developed world tend to reflect a desire that the basic human needs of water and sanitation should be accessible to all members of society regardless of financial circumstances. Where government has detached itself from influence over water pricing, or has set other performance criteria above this social imperative, affordability is under threat and needs to be regularly monitored although the phenomenon is not exclusively a problem for the water sector as it is also clearly related to low incomes. The social affordability, which is even a more sensitive topic in non EU Mediterranean could be investigated more in depth.

3.2.1.2 - Public health

Where water scarcity is driven by climate change, there can be significant impacts on human health. Warmer, sunnier climates also encourage more recreational water use, leading to the increased exposure of leisure users to waterborne pathogens. The additional risks to human health from water stress mainly results from changes in the spread and activity patterns of pathogens and their intermediate hosts. For example, drought can induce malaria outbreaks following drought years (Chase et al., 2002) and recent research suggests that hemorrhagic fever may probably be associated to drought events (Acuña-Soto et al., 2005).

3.2.1.3 - The community cohesion

At higher scales of social organization, water stress can give rise to economic disruption and mass migration as agricultural systems fail. Loss of income (due either to the increased costs of securing access to water or of lower crop prices) and loss of land value (perhaps due to desertification) are obvious consequences of increasing water stress. However, this reduction in farming community wealth has consequences for other businesses which rely on the trade and patronage of farmers. The social, and often psychological, damage caused to farming families may well take several years to materialize as they struggle to adapt to changing climatic, environmental and production pressures. Working longer hours, delaying investment, selling stock, and taking on extra work off the farm (sometimes leading to the involuntary separation of families), are all well recognized adaptation mechanisms.
Scarcity conditions are also likely to raise new, or exacerbate existing, social tensions. Young people develop very negative impressions of farming as a livelihood. The strain placed on farming communities by water scarcity is often

long-term and the end of a drought period rarely presages a sudden return to full production and the restoration of income levels.

3.2.3.4 - Educational category

The education of water users through different contact routes and media is largely utilized to modify water use behaviour and encourage voluntary water conservation actions. Often seen as the core instrument for use in long-term conservation strategies (Grisham et al., 1989), educational programmes make use of printed, video, and audio media as well as face-to-face methods. Developments in the fields of participative planning and social learning have influenced the design and execution of this type of water policy instrument as more consensual and community informed approaches to water management have been developed. Indeed, although the term “education” has traditionally been used to characterize this form of water policy instrument, there is increasing impetus to use a term which better reflects the collaborative nature of the process (e.g. “communication”, or “dialogue”; the latter of which being the preferred term here).
Dialogue, as noted above, is an instrument which encourages behavioural change. Consequently its effectiveness is posited on the assumption that beliefs determine values, values determine attitudes, and attitudes determine behaviour. However, the ability of attitudes to predict behavioural intentions and overt behaviour continues to be a major focus of theory and research in psychology and it is now generally recognized that although attitudes are relevant for understanding and predicting social behaviour, many important questions remain unanswered. Indeed, many studies, such as that conducted with specific reference to the water sector by De Oliver (1999) tell us that none of these links can be taken for granted, and that measuring the causal process is itself a non-trivial activity. These limitations to managing water use behaviour through dialogue have led to calls for more targeted campaigns, greater public participation during the early stages of programme design, best practice exemplarity to demonstrate the benefits of conservation and programmes which generate a commitment to act.

Conclusions and recommendations

To be Completed************************************

Future research and action priorities for supporting water scarcity mitigation in Mediterranean basins :

Water scarcity and data scarcity on water related issues are strongly correlated and limit the sustainable management of water resources in semi-arid areas. While there is substantial work on specific hydrological issues on the process level, and also extended knowledge on irrigation techniques, aspects of IWRM or basin management in general are suffering from a missing deeper understanding of how water resources are deteriorated over time and space, and therefore how future changes may even worsen the situation.

In particular, this is related to a limited understanding of how pollution and water quality aspects are affecting the availability of safe water resources, and where the deterioration of water quality requires a wider consideration within basin management plans and the implementation of the EU Water Framework Directive.

Missing information about the critical role of water quality is superposed by a strong competition on limited water resources, resulting in a strong role of stakeholders with particular interests. The more the water resources are already limited, the more the regional population is felt directly depending on water as a rare good, often resulting in many objections which limit the flexibility to explore alternative approaches.

So, basically, there are two main domains affecting sustainable planning a) the knowledge on water resources and b) the social economic component. While this appears trivial and well known, it is often ignored in the public discussion that both aspects are interconnected, and limited knowledge may also prohibit any rational sustainable planning or public participation. Even worse, there is still a lack of methodology to be used for an integrated risk assessment and the organisation of adaptive risk management strategies.

In this context risk management in dry land basins has to address both

a) the temporary and/or recurring onset of droughts due to a limited water availability, and
b) the water stress by periodical or unforeseen overexploitation or pollution hazards.

The risk management needs to address both the set up of strategic frameworks as well as the implementation of concrete technical and non-technical options.

Consequently, for dry land basins the implementation of integrated basin management plans, including drought management issues, appears much more difficult than in basins of the northern hemisphere.

One of the specificities of water in the Mediterranean countries (apart from the problem of water scarcity) is the fact that coastal zones show high densities of population and concentrate quite all of the domestic, agricultural and industrial activities. A significant proportion of the wastewater production is concentrated along the coast and has a significant impact on the water quality of the Mediterranean Sea. Being of major importance for the local economy, including aquacultures and tourism, a good ecological status has to be maintained also during droughts and increasing water scarcity.

In the MENA region, as well as in water scarce regions of Africa and Asia, a sufficient water availability to meet the growing need of increasing world population is going to be a major challenge. This includes all water related sectors, as needs for humans, agriculture to produce more food, concentrated animal industry to meet the growing need of the society for meat proteins, and other industrial and recreation uses.

The following paragraph will introduce a number of themes, which are considered as critical key issues to improve the integrated water resources management and water stress mitigation in dry lands. Water scarcity is perhaps the over-arching issue, and most of the other issues arise from it.

Hydrological inventory/monitoring
Inventory of catchment areas, and (seasonal) outflows from Mediterranean catchments needs to be extended. At present, dryland catchments and smaller catchments, though representing a significant contribution to the total area, are not well represented within published literature or the Water Framework Directive.

Independently of any research or planning of management options, the database has to be improved by the set up of monitoring stations and adapted sampling campaigns. It is of specific need to gather detailed water quality information during the initial part of floods.

Pollution dynamics
The fate of chemicals (all forms of nitrogen, phosphorus, etc), point and non-point sources in dependence on soil moisture or duration of the dry period need to be better understood.
This should include:

- Investigation of pollutant accumulation on agricultural lands (fertilizers, agrochemicals, adsorbed metals) during the dry period and its impact on remobilisation.
- Toxic pollutants such as pesticides and heavy metals.
- Impacts of storms and floods on pollutant remobilization from agricultural lands and municipalities.
- Securing water supply by mitigating toxic algae blooms in reservoirs.

Desertification and land transformation
Dryland priorities interlock with issues of desertification, fire management, and the conservation of both wetland and dryland areas of scientific (geological and ecological) interest.

Interactions between desertification mechanisms and water security still need further attention. This is especially the case for the ongoing soil salinization and ineffective irrigation schemes.

Here, a vast gradient of knowledge and practice within MENA countries and the European Mediterranean countries still exists, and information/experience exchange still needs highest attention.

Of particular interest are the applicability of biodrainage and low cost remediation practices.

Treatment options
In many cases, countries and communities lack financial means for treating wastewater as required. At times, raw sewage and direct effluents from industry and animal production systems are directly discharged to water bodies.

To reduce water quality deterioration, there is a need to extend the use of adapted wastewater treatment for manufactures and small industries, in particular in the MENA region. Focus must be on simple, safe, and cheap technologies for wastewater treatment and reclamation.

Risk/Vulnerability assessment
Basically, Risk Assessment as issued by the WHO needs to be extensively implemented into practice, especially for tap and reclaimed water to extend the limited experience and lack of practical data (i.e. analytical data).

Increased effort on the vulnerability assessment will support a justifiable selection of urgent action areas as well as the identification of non-monetary benefits related to the implementation of mitigation options.

Risk and vulnerability are not only related to the sensitivity of the water resources under use, but also to climate conditions and human behaviour determining the consumption. This is related both to unpredicted short-term events, as well as to long-term predictions of climate change effects.
It is important to refine our prediction methods to be able to understand how people behave when faced with risk and uncertainty. Methods are required that enable the characterisation of people's risk preferences and to integrate these risk preferences in policy making. Without such integration, any policy that aims to improve dryland water management will fail, as it will not be compatible with human behaviour.

Results of the vulnerability and risk assessment have to be used in the determination of Water Safety Plans.

Methods should be provided to overcome restrictions of existing simulation models and to enable a more comprehensive assessment of the predicted effect of management options.

Risk management - Strategic frameworks

Dryland areas lack an overall plan for sustainable future planning, at regional, national, and international scales. This includes strong interactions between the domestic water consumption imposed by growing urban areas along the coasts, waste disposal loads and agricultural water needs.

There is a need to envisage an efficient development of sustained Droughts Early Warning Systems, which include also the enhanced accompaniment of drought effects over the existent water uses, and the prediction of overexploitation.

The coordinated drought management needs to be adapted in particular for transboundary river basins, with the countries involved contributing with compatible information, in order to set up the necessary drought management instruments (like drought plans) at river basin scale.

Apart from it, the use of non-conventional resources (reclaimed water, stormwater...) is not really being applied, up to now. Here, a commonly agreed rule/regulation on reclaimed water quality must appear in the Mediterranean (the same water quality for the north and the south of the Mediterranean), because of the crop products movement from south to north.

Enhanced operation of water infrastructure and dams

Even if dams and canals are classical approaches to redistribute the hydrological availability of water in dry lands, their optimised use has, in most cases, not exploited fully.

This may be related to adapted strategic reserves (also for addressing climate and global changes), as well as to a combined consideration of water quality and quantity.

Therefore, future activities could focus on developing adapted dam operation strategies for mitigating droughts (also taking into consideration the potential changes from hydropower use or irrigation towards drinking water supply).

Additionally, there is a need to adapt the technical design of dams, spillways, and operation to enlarge storage capacities for drought mitigation.

Economic instruments

Basically, there is an ongoing need to adapt economic instruments taking into account of

- water efficiency and investment in water saving technologies
- water pricing, incentives and equity in irrigation schemes
- virtual water trading and its implication for river basis management.

Additional work is needed to quantify the impact of low quality irrigation water on crop productivity, nutrition, as well as on public health in economic terms.

Adapted irrigation strategies
There is still a need to increase knowledge in the field of plant physiology (under field conditions), as well on technical designs to improve the drainage water reuse or the agricultural practices for an increased use of saline water.

However, to support an effective drought or water stress mitigation, work should be concentrated on a more comprehensive assessment of food security, economic growth (especially in developing countries), soil degradation and desertification, and the impact on water quality in ground and surface water resources.

To be Completed*************************************

References

Carmi, N., Bashir, B, and Rabi, A. (2004) Drought analysis and the effect of climate change in the West Bank/Palestine. Symposium on Challenges Facing Water Resources Management in Arid and Semi-Arid Regions, October 2-9, 2004, Beirut, Lebanon

Palestinian Hydrology Group (2005) Water for Life. Ramallah, Palestine

Rabi, A. (1999) Optimum inter sectoral water allocation in the West Bank. PhD Thesis Washington International University, Pennsylvania, USA.

Rabi, A., Khaled, A. & Carmi, N. (2003a) Integrated Water Resources Management Under Complex Hydro-political Conditions – The Palestinian Case Study. In: Third World Water Forum, Kyoto, March 2003

Rabi, A., Khaled, A. & Carmi, N. (2003b) Drought occurrence and impact on Eastern Groundwater Basin–West Bank/Palestine. In: Hydrology of the Mediterranean and Semiarid Regions (Proc. an international Symp. held at Montpellier, April 2003). IAHS Publ. no. 273

J. ALBERGEL,S NASRI, M. BOUFAROUA, Petits barrages et lacs collinaires, aménagements originaux de conservation des eaux et de protection des infrastructures aval : Exemples des barrages en Afrique du nord et au proche orient, Sècheresse No 1 Vol 15, Mars 2004.

M. BOUFAROUA, Strategy of Soil and water conservation, acts of «9 th International conferences on the conservation and management of lakes »; Japan; November 2001.

MAHMOOD, K.; 1987 : Reservoir sedimentation : Impa ct, extent, mitigation.World Bank Technical Paper Number 71. Washington DC : World Bank.

MARGAT J., 1992 M L'eau dans le basin méditerranéen. Situation et prospective Economica – Plan Bleu, 1992 [French edition] Giza ((EGY) : PNUE. CAR-PB ; CEDARE, 1994 [Arabic edition] 196p.

HABAIEB, H and J. ALBERGEL ; 2001 : Vers une gestion optimale des ressources en eau : exemple de la Tunisie. In Séminaire Int. »Hydrologie des Régions Méditerranéennes « ; PHI-V/Documents Techniques en hydrologie. UNESCO Paris France, pp 187-193.

BOUFAROUA M., J. ALBERGEL and Y. PEPIN ; 2000: Erosion processes at catchment scale and hill reservoirs siltation in semi-arid Mediterranean countries. 5 th International Congress on Geology of Arabic World. In Arabic. Cairo , 20-24 Feb 2000. 17p.

HYDROMED ; 2001 : Rapport final du programme de recherché sur les lacs collinaires dans les zones semi-arides du pourtour méditerranéen. Ed. J. Albergel & S. Nasri. Contrat européen INCO DC ERBIC 18 CT 960091 – STD4. IRD /INGREF Tunis, 120p + 6 annexes.

WOOLHISER, D.A., R.E. SMITH and D.C. GOODRICH. 1990 KINEROS, A kinematics runoff and erosion model: documentation and user manual. USDA-Agricultural Research Service, ARS- 77,pp 130.

ANNEX 1

Table 1 – Two indicators to evaluate the situations of water shortage present and future in Mediterranean area

Country		Renewable natural water resources (internal and external) average per capita in m3 year		Exploitation Index (%)	
		2000 a	2025 b	2000 d	in 2025 following trend projection d
Spain		2738	2520	31,6	34
France		3197	2989	17	15,4
Italy		3315	3397	22	19
Malta		128	116	50	30
Slovenia		16 202	16 925	4	4,4
Croatia		15 849	16 717	1,1	1,7
Bosnia&Herzegovina		9748	10024	~ 2,7	3
Serbia&Montenegro		19 772	20 373 c	~ 6,2	5,7
Macedonia FYR		3184	3125	29	30,5
Albania		13 619	11 969	3,4	7,2
Greece		6765	6645	11,7	11,2
Cyprus		992	769	37,8	33
Turkey		3396	2558	15,3	24
Syria		1562	935	54,5 e	65 e
Libanon		1413	1117	26,9	36
Israel		274 c	191 c	107	111
Palestinian Territories	West Bank	~ 375	~ 206	22,7	73
	Gaza	~ 49	~ 20	232	357
Egypt		866 e	576 e	83 e	94 e
Libya		155	103	200	75
Tunisia		478	380	51,4	56
Algeria		470	334	21,8	30
Marocco		992	720	39,4	54

a- According to demographic statistics UN 2003
b- According to population projection UN 2003, « variable medium »
c- Of which Montenegro alone: ~ 25 000
d- Source : Plan Bleu 2004
e- Reported to the actual resources

The results of monitoring and experimental areas were used to develop guidelines for using drainage water in irrigation on environmentally sound basis. The guidelines enable the user to rate salinity hazard factors and suggest irrigation and crop management practices to overcome hazards, forming a decision support system for use of drainage water irrigation for sustainable crop production. The guidelines are intended for use on currently cultivated lands as well as on new land being brought into production by reclamation. They are meant to be applied to a specific crop or to a crop rotation that is to be irrigated with a water of known quality under particular soil salinity and hydrologic conditions. The guidelines contain three matrices organized in categories of crops: salt tolerant, moderately salt tolerant, and salt sensitive crops. The matrices are designed to identify and compare the relative potential hazard of crop yield reduction and soil salinization when using various types of irrigation water.

Three major effects are considered in the organization of each matrix: the direct impact of irrigation water quality on crop yield via irrigation water salinity and sodicity hazard; irrigation water management related to consumptive use and leaching requirement of the crop; and soil quality. This last factor rates the potential of the soil to remain a suitable medium for plant growth related to soil salinity and sodicity. The guidelines also include criteria for environmental protection and public health preservation. Additionally, they rate the degree of socio-economic vulnerability of the farmers involved in the use of drainage water, and list institutional measures indicated to mitigate the risks.