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Euro-Mediterranean Information System on Know How in the Water Sector

Study on irrigation water management in the Mediterranean Region

GENERAL REPORT

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INTRODUCTION

We live in a world where droughts, floods, contaminated waters, diseases, poverty and hunger are closely related with the human existence under a common denominator: the water.

The total volume of water at global level is estimated about 1,4 billions of km^3. Only 2,5 % of this volume (35 millions of km^3) can be considered as freshwater. Its distribution all around of our planet is unequal enough. Moreover, 99,7 % of freshwater (34,895 millions of km^3) is under form of ice and permanent snow. According with these figures, normally available volume of freshwater would be 105.000 km^3. Nevertheless, Ghosn (2006) estimates that total usable freshwater supply for ecosystems and humans is about ~ 200.000 km^3, less than 1% of all freshwater resources and only a 0,01 % of all water on the Earth. Groundwater represents about 90 % of available freshwater.

Population growth and consumption patterns deceased yearly water share from 12.900 m^3/capita, in 1970, to 7.000 m^3/capita, in 2000. It is foreseen that this relation will drop till 5.100 m^3/capita in 2025. In Mediterranean region this index has a value of 2.691 m3/capita.

It has been realized that, actually, one third part of humanity is living under moderate or severe water stress considering that an annual supply below of 1.700 m^3/person defines water stress and below 1.000 m^3/person it is considered as water scarcity situation. It is foreseen that three billions of persons will suffer water stress in 2025. For this year, in Africa, it is expected that 25 countries will be experimenting water stress.

It is said that the world is in water crisis. In this crisis, water pollution is one of most remarkable problems because affect to 1,2 billions of persons. In 1990, water related illness led to 3 millions deaths of which 85 % were children. In 2000, 1,2 billion of person lacked safe water sources and 2 billion persons lacked of adequate sanitation.

Water crisis affects, as well, to the environment. Urban use of water, if there is not a adequate treatment of wastewater effluent produce pollution in downstream ecosystems. Only 5 % of the global sewage is treated. Abstraction of water for agriculture can cause the drying of rivers, overexploitation of aquifers and, at the end of the day, salinity and pollution.

Generally, international organizations, experts, governments and social groups coincide in estimating the existence of a world crisis of the water derived from the scanty availability of its resources and, also, deficient management of those that are available. Because of it, the global problematic of the water is one of the matters that concerns to the international community.

In the way of global concerning on water problem a lot of initiatives had been developed. Among these are:

International Conference on Water and Environment held in Dublin, Ireland, in January of 1992. During this conference were settled water management principles, like:

Fresh water is a finite vulnerable resource, essential to life, development and environment.

Water development and management should be a participatory approach, involving users, planners and policymakers at all levels.

Women role is central in water management and safeguarding.

Water has an economic value and should be recognised as an economic good.

In the frame of dignity, equality and equity to all levels of the human activity that inspires the process of globalization, the UN has proposed, among the aims of this millennium: *to halve, by the year 2015, the proportion of the world's people whose income is less than one dollar a day and the proportion of people who suffer from hunger and, by the same date,* ***to halve the proportion of people who are unable to reach or to afford safe drinking water***.

In the same way, it is remarkable the labour of the World Water Council, a NGO whose fundamental events, the World Water Forums, have turned into places of meeting for all the agents been interested in the water problematic in the world and also as a loudspeaker for the penuries associated with its shortage and management. The forum celebrated in Marrakech (1997), The Hague (2000) and Kyoto (2003) illustrate us on how concerned is the civil society about the water question. During those debates, the concern about the populations lacking potable water to drink and the search for solutions could be consider as fundamental topics. When those lines are been wrote a new Forum, this time at Mexico D.F., will discuss again on the dramatic lack of water in the parts of our planet where the poverty appear as too lasting condition of the human persons.

In 2002, during the Johanesburg Summit (Río +10), under the sustainable development umbrella, States, UN and other relevant organizations, in relation with freshwater problematic, compromised themselves to direct their efforts to improve water management considering the actual and future needs and emphasizing on environmental aspects. It was established the target to develop integrated water resource management (IWRM) plans by 2025.

The water skimps increasingly due to the growth of the world population, the improvement of the manners of life and the industrial development as well as the increasing demand of foods, especially in the arid and semi-arid zones of the planet. Whereas the world population there is triplicate in the last ones seventy years, the water consumption have multiplied for six in this period.

The economical sector that demands more water is the agrarian one in such a way that the agricultural use of the water is, as average, about 75 % of water renewable resources while industrial is demanding 20 % and domestic 5 %. In the Mediterranean region it is realistic consider that demand for agriculture reach 80 %.

Nevertheless, the agrarian activity in this region proves to be increasingly unable to produce the foods need by the population living on it. Because of it, the irrigated agriculture is actually on the crossroads of being the sector that more water demands and consumes and, besides, the one that must produce the foods demanded by the society. In this reality where the water demand grows simultaneously with the exigencies of food security is in the one that it is necessary to analyze the problematic of irrigation over all of Mediterranean region. A heterogeneous stage from the economic, social, political and religious point of views to which, nevertheless, the water shortage is his common denominator and constitutes a fundamental reason for the cooperation and the solidarity.

THE POPULATION IN THE MEDITERRANEAN REGION

The genuine protagonist of the water problematic in this region is the people. On this area are living millions of persons which welfare has a close relation with their geographical reference. North or south, east or west are data providing an approximation to know the current level of life of those persons. Going more in advance it is easy to realize that this level depends, as well, of the quantity and quality of available water resources. In each country of the Mediterranean region, as lower is the availability of water the level of poverty is higher. This becomes aware by the values of the index of development human for each of the countries object of this study. The TABLE 1 contains the values of this index as well as the location of every country, in the global context, determined by it.

This information confirms, for the studied countries, the deep differences in the human development between those of east - south one of the Mediterranean region and these of the north.

The population in those countries changes on constant growth. Actually, its value turns about 475 millions of inhabitants and it is expected to reach 530 millions for 2025. A forecast of demographic evolution till 2025 is represented in the TABLE 2, TABLE 3, TABLE 4, TABLE 5, TABLE 6 and TABLE 7.

The more significant demographic growth happens in the placed countries eastwards and southern of the region. This fact allows differentiate three sub regions in the studied area which demographic data are included in the TABLE 8.

All these tables allow infer the fact that in the next twenty years, in the countries of the south there will be near sixty million inhabitants more that in the year 2000. In absolute terms, the increase more prominent will be that of Egypt with more of thirty three million persons. Also in the Middle East countries it is waited a great population increase, emphasizing Turkey with more than twenty-two million persons.

On the contrary, in the northern region it is possible find the lower rates of demographic growth. Even, in Italy it is expected, for that period, a population decrease estimated in one million and a half of inhabitants.

So, as a first conclusion it is possible to conclude that the countries in which is expected a major increase of the water demands are those of southern and eastern sub-regions of the Mediterranean. Unfortunately, these countries have an index of human development removed enough from that of the countries of the north. So, population increase, in absence of natural resources of water, could mean a way to the poverty for millions of persons in the Mediterranean region.

WATER IN THE MEDITERRANEAN REGION

According with data provided by Shiklomanov (2000), TABLE 9 shows, at global view, the water removals and its effective use grow strongly since the early twenty century. Nowadays, its value can be estimated in 4.200 km^3 per year, of which only one half is effectively used.

The most remarkable use is the agrarian one that consumes, more or less, 65 % of total removals. This so important consume is due to land irrigation mainly in arid and semi-arid regions. During the last century, surface of irrigated land on all over the planet growth near six times its initial value.

In the Mediterranean region the water use represents a 20-25 % of world one.

Having in view the large and disperse information existing on water resources in the Mediterranean Region it is realizable a real difficulty to harmonize all data in order to consolidate a definitive value of renewable resources in this area. Nevertheless, after studying different informative sources, we might accept that this value comes closer to 1.018 km^3 per year. In other hand, the value of water withdrawal could be accepted near to 280 km^3 per year. So, in a theoretical level, is possible to consider that all over the region there is an excess of water bigger that 700 km^3/year. After realize that, perhaps, the more interesting discussion have to centre on the analysis of factor that determines unavailability of those renewal resources in every country. The Table 10 shows the estimation of water renewable resources and water withdrawal for several countries in Mediterranean Region.

To evaluate the degree of sufficiency of natural renewable hydraulic resources for every country there is in use the ratio named water renewable resources per capita. Conventionally it is accepted that the interval between 1000 and 500 m^3/inhabitant corresponds with water poverty status. When this value is lower that 500 m^3/inhabitant, the situation is of penury. The Table 11 shows values of that index in selected countries in the Mediterranean region related to population in 2000.

The information that offers us this table allows to state that, in the year 2000, 49 millions of inhabitants of the Mediterranean region were suffering water penury, being certainly prominent the situation in Jordan. Vision that became more dramatic if instead of the value of the water renewable resources we use that of water withdrawal or, worse even, the volume of water really useful for the population.

During the year of reference, in this region, near hundred millions of persons suffered different degrees of hydraulic poverty.

But, we are speaking of five year ago. At this moment, only taking into account the population growth, it is realistic to think in an impoverishment of the situation, mainly in the poorest countries.

Moreover, exploitation of natural and renewable water resources in the Mediterranean region is useful information to approximate the hydrologic reality on this area. The Table 12 shows the value of exploitation index of natural and renewable water resources in selected countries in the Mediterranean region. Its figures show, in most cases, an intensive use of water possibilities in those countries.

Processing the hydrologic information available, numerous authors try to settle down a forecast of the demands of water for the next years in the region of the Mediterranean. It is remarkable the forecast sustained by J. Margat and his collaborators (2005) that consider a rate of growth of water demand, for all Mediterranean region, of 15 percent annual until 2025.

GROUNDWATER IN THE MEDITERRANEAN REGION

In the Mediterranean region groundwater resources have a very important function on the economies. In general, they represent the fourth part of renewable hydraulic resources of the region. The TABLE 13 shows quantitative information referred to groundwater resources in selected Mediterranean countries.

In many countries, groundwater is the main provider source for all demands. In this sense, Algeria, Cyprus, Israel, Malta Tunisia have a strong dependence of groundwater.

The Mediterranean Groundwater Working Group has described four types of aquifers in this region:

1º.- Aquifers of large sedimentary basins, which may be confined or unconfined and may locally be artesian, either in the North (Paris basin, Danube margins of the Pannonic Basin) or in the South, mostly located in the Maghreb and more extensive in the Saharan region where there are deep aquifers with considerable reserves which, however, are currently hardly replenished (“fossil waters”) and are relatively independent of surface waters.

2º.- Karstic carbonated aquifers, major water towers with perennial drainage which are maintained by their often abundant sources, which however vary considerably in volume and regulatory function.

3º.- Mainly detrital sedimentary aquifers in coastal plains in contact with the sea.

4º.- Alluvial aquifers, located in the valleys and deltas of major rivers which have strong links with watercourses with which they often exchange water; those in the Nile valley and delta and in the Po plain are the most extensive and contain deep captive groundwater.

Relations between surface and groundwater mainly depend of the clime in the area considered.

Dynamics between superficial and groundwaters depends has a strong climatic dependence, mainly of the rainfall regime, in each zone. Some time, permanent flow of watercourses is ensured by aquifers drainage. This fact can be appreciated in the 85 % of water courses in Europe, 42 % in the Near East and 30 % in the south.

The replenishment of aquifers by flooding of surface watercourses is a fact frequent in the South and West Mediterranean, in particular in arid and semi-arid zones.

In both cases, aquifers act as regulatory reservoirs that permit overcome drought situations.

Accordingly, ground and surface waters resources are strongly interdependent.

Coastal aquifers in the Mediterranean basin are important are the main water suppliers for the tourist industry but, at the same time, they are in permanent risk of marine intrusion.

Deep aquifers in several countries of the East and South of the region there are important reserves which renewal normally is very low. In such cases (Algeria, Egypt, Jordan) it is necessary to draw a specific abstractions strategy.

It is considered that groundwater is the safest source of drinking water. Also, that irrigation with this kind of water, directly abstracted by farmers is much more efficient than irrigation with surface water supplied through collective networks. Perhaps this will be a raison of aquifer over exploitation. Since 60^{th} decade of the twenty century, groundwater abstraction increased greatly en the Mediterranean region. For the period of 1970 till our days abstractions have raised by 37 % in France, doubled in Algeria and Turkey, increased threefold in Tunisia and fivefold in Egypt. These facts introduce the reality of a strong groundwater pressure existing in the Mediterranean region. TABLE 14 shows information about this pressure in selected countries of Mediterranean Region.

The precedent data show that there is very high pressure on groundwater in Algeria, Tunisia, Israel and Malta. This pressure overpasses the value of 50 % in Syria and Cyprus. Among the other studied countries Morocco, Egypt and Italy present a significative pressure on groundwater.

In the region studied not only are existing problems of pressure on groundwater resources but as well overexploitation of aquifers. Some authors, especially Spanish scientists, agree in considering this concept as one of most poorly defined. Nevertheless, it cannot be forgotten the influence that in its formulation has to have those aquifers in which water extractions surpass natural water recharge. Artificial water withdrawal from an aquifer produces two main effects: a decrease of the storage and a reduction of previous natural discharge of aquifers. The opposite has, as well, validity.

Scientist and social groups are supporting a big discussion on the sustainability of groundwater use. In some cases, for instance fossil water aquifers lacking of a considerable recharge, there are reasons to restrain as much as possible the abstraction because the difficult to replace any drop of water in them. In agreement with this thought, in many countries it is considered that groundwater withdrawal should not exceed over renewable resources. Nevertheless, in the most arid regions lacking of renewable hydraulic resources in significant amounts and, at same time, with important underground water reserves, non renewable ones, perhaps it could be justified pumps water when there is security to support a social-economical develop during a long period of time, for instance fifty to hundred years. Some authors recommend this way to obtain water resources if they are met conditions like:

a) Before to take up water must be estimated, with acceptable accuracy, the volume of reserves.

b) Abstractions have to be guaranteed for a long period of time (fifty till hundred years)

c) Environments impacts of water abstractions have to be lower that benefits produced by the use of obtained water.

d) It is necessary to envisage solutions for the time when aquifers are fully depleted.

Nevertheless, in many countries it is considered that groundwater withdrawal should not exceed the renewable resources. Also, the aquifer overexploitation is considered as non suitable option for sustainable development and non ethic attitude with respect to future generations.

Some authors think that to defer the social-economical develop of a region till the moment at which there are sufficient and renewable water resources is not realist and fallacious. Ethic of long-term renewable resources sustainability must be considered with ever improving technology. Groundwater withdrawal can help to transform nomadic groups into farmers. Initial high abstraction from underground can be drastically reduced like occurred in Saudi Arabia.

The Nubian sandstone aquifer, located below the western desert of Egypt is an example of this situation. Its fresh water reserves were calculated in a volume higher of 200 km^3. The abstraction of 1 km^3 per year could develop a human establishment on more than 150.000 hectares of irrigated land during more that 200 years.

Now discussions are on the table and affect the future of generations living around the Mediterranean. The arguments from both sides must be considered because all of then concern the sustainability of agrarian developments. In many occasions, the dialectic opposes socioeconomic development to overexploitation of aquifers.

Among all causes of aquifers overexploitation are water abstractions for irrigation and for public and industrial supply. By far, irrigation is the most important one. The TABLE 15 shows information on water demand supplied by groundwater in selected Mediterranean countries.

TABLE 16 shows the same information but expressed as percentage of total demand requirements.

All over the Mediterranean region, 29 % of agrarian demand of water is supplied by groundwater. This figure increase till 49 % in the case of Tunisia and seems really big in case of Algeria, Israel and Morocco. In despite of date of Cyprus, the availability of non-conventional resources in Cyprus decreased the pressure on groundwater.

Agriculture is by far the most important groundwater application in the Mediterranean region. It is written that agriculture not only threatens the water availability but also the quality of resource in risk to be affected by pesticides, fertilizers and release of agricultural wastes. Moreover, groundwater overexploitation in coastal aquifers affects the equilibrium between fresh and marine waters provoking sea water intrusion. The adjoining consequence is the increase of salinity of groundwater affecting its uses. Most of those aquifers located in the shores of Mediterranean Sea actually evidence symptom of overexploitation being causes of it the intensity of agricultural and tourist activities developed in the neighbourhoods of sea. In same of them, the level of water fell below sea level after excessive pumping in Cyprus, Greece, Israel, Italy, Spain, Turkey and Algeria.

The groundwater resources in the Mediterranean region are either the main sources of freshwater or a vitally needed to supplement surface water resources. However, despite their importance, those resources are under stress of overexploitation and contamination. Widely observed effects are decline of the water table as well as deterioration of groundwater quality and in many coastal aquifers of this region seawater intrusion and land subsidence.

Monitoring of water quality, water levels and water extractions in an aquifer is, therefore, of fundamental importance as a basis for groundwater management. Because, monitoring provide data collections which analysis and further interpretation, under rational parameters, permits to make decisions on all of groundwater resources sustainability issues. European Water Frame Work Directive (WFD) settles down the obligation to groundwater monitoring concerning quantitative and chemical aspects.

A problematic situation is that derived from trans-boundary groundwater aquifers. Due the fact that normally the borders between countries do not necessarily coincide with the natural boundaries of groundwater aquifers, is necessary to establish agreement on abstraction regimes according with the share proportion of every country. This is the best method to prevent international disputes on groundwater.

A common problem of aquifers in the Mediterranean region is the degradation of the groundwater quality due to multiple stresses: excessive pumping in relation to average natural recharge, return flow from irrigation water with intense use of agrochemicals, leakage from urban areas (land fills, septic tanks, sewers, mine tailings, among others; Barraque, 1998; Fornes et al., 2005). In addition, drought episodes contribute to the degradation of groundwater quality (Iglesias and Moneo, 2005; Iglesias et al., 2005a).

Many aquifer systems contain vast quantities of brackish water with limited possibilities for exploitation in urban or agricultural supply systems, imposing added stress to those aquifers with water of higher quality. Brackish water desalinisation plants in Egypt confirm the potential of this technological solution (Allam et al., 2003).

Saline intrusion is always an important concern in coastal aquifers, especially in the Mediterranean, where tourism development in the coasts has resulted in over-pumping to meet peak seasonal demands. The intensity of the problem depends on the amount of the abstraction, in relation to the natural groundwater recharge, but also on the well field location and design, and on the geometry and hydro geological parameters of the pumped aquifer (Fornes et al., 2005). New technologies are being developed for the prevention of saline intrusion and offer an optimistic scenario for the future. Artificial local recharge is considered as an effective technology in counteracting sea water encroachment and groundwater depletion. For example, the Korba coastal aquifer of the tourist region of Cap Bon (Tunisia) is pumped by over 7.000 wells, extracting around of 50 hm^3/year. Over the last four decades the water table has dramatically decreased and concentrations of salt have increased to peak values of 5 to 8 g/l (Panicini et al., 2001). Artificial local recharge was applied during the last decade to one of the well, costal clusters, with a constant rate of 3 hm^3 per year. This operation result was a substantial decrease of salinity level in the central costal portion of the aquifer.

Salt and nitrate pollution are exacerbated low irrigation efficiencies coupled to an inadequate management of nitrogen fertilization (Rijsberman, 2003). Thus, higher irrigation efficiencies, optimized nitrogen fertilization and the reuse for irrigation of the low-salt, high-nitrate drainage waters is the key management strategy for a better control of the off-site pollution irrigated agriculture.

QUALITY OF IRRIGATION WATER

Traditionally, the concept of water quality has been developed surroundings to two great axes. One, intrinsic, related to water composition and, other, extrinsic, related to the destiny of this resource. So, the concept of water quality talks about the water characteristics that can affect their adaptability to a specific use. It is defined by one or more chemical, physical and biological parameters. Parameters whose evaluation must allow anticipate the effect that the use of a concrete type of water will have on the activity in which it is used.

One of the greater disadvantages of this way to understand the water quality is that water composition varies continuously. Therefore, the actual knowledge of the quality of the water needs analytical controls whose frequency must be established according with the expectable variations in the same one. Normally, the composition of underground waters usually is less frequent than the one of superficial waters.

From the agronomic point of view, the quality of irrigation water is based on analytical data whose values, isolated or combined, according to scientific and technical knowledge at every moment, they allow to infer the effect that water application will have on soils, plants and, fundamentally, persons.

The predictable effect on soil salinity is evaluated by means of electrical conductivity, CE. This is a fast form to infer total content of dissolved salts in the water because the admitted direct proportionality between both parameters. The value of the electrical conductivity is expressed in dS/m or milimhos/cm, both equivalent ones, referred 25 ºC.

This parameter is interpreted considering that the irrigation water does not have any restriction for its use when the value of EC is lower that 0.7 dS/m; is described between light and moderate when that value varies between 0.7 and 3 dS/m. The restriction is severe when the EC value surpasses 3 dS/m.

One of the effects produced by salt dissolved in water irrigation is to increase osmotic pressure of soil solution and for that to diminish the amount of water available by the plants. This explains the high frequency with which withered plants appear on humid and saline soils. Traditionally, the soil salinity has been related to the production of the cultures in the sense that to greater salinity lower crops production.

Another objective of quality irrigation water study is to predict the effect that its use can have, in each case, on soil structure and water permeability of soil. It is well knew that sodium, in form of monovalent ion, incorporated to the soil, dissolved in the irrigation water, removes divalent ions, calcium and magnesium, from clay-humic soil complex and, in extreme situations, destroying its structure and reducing water infiltration rate across soil profile. This effects, call soil alcalinization, is one of the most serious accidents that can happen to an agricultural soil because it limits drastically and of lasting form their fertility and, in consequence, for its productivity.

To foresee the risk of soil alcalinization are used indexes based on the relation between the concentration of sodium in and those of calcium and magnesium, all of them measured in the water of irrigation. Among these, one of most used is SAR (Sodium Adsorption Relation) that may be calculated using the formula:

$$SAR = [Na^{+}]/[Ca^{++} + Mg^{++}]^{1/2}$$

In which the ionic concentrations are expressed in meq/l.

According with Ayers and Wescot recommendations (FAO, 1985), the risk that has a type of irrigation water to affect water infiltration into a soil (alcalinzation) is presented in the TABLE 17.

When the risk of alcalinization is high it is recommended to use as parameter indicator the value of corrected SAR (FAO, Suarez, 1981) which calculation can be find in the specific literature.

In addition to salinity and alkalinity of irrigation water, the studies of their quality talks about specific effect of each one of ions and substances dissolved in it like chloride, boron, sulphate, etc. It is well known phyto-toxicity of Chloride, Sodium and Boron on citrus crops. Sometime the restriction do not come from the cultures but come for the nature of materials employed in the artificial channels. For instance, excess of sulphate in the water will produce damage in the channel constructed with normal concrete.

Of course, not all kind of plants have the same tolerance to the salinity, not all soils have equal susceptibility to the effects of sodium and not all irrigation systems have same aptitude to use waters with salinity problems. It is by that, the correct diagnosis about irrigation water quality needs the integration between data facilitated by its chemical and physical analysis and the information available on the type of plant that is had to irrigate, the soil where it is going to be cultivated and the system of used irrigation.

The precedent exposition founds that water salinity, considered as total of salts dissolved by unit of volume, and potential effect on water infiltration in the soil, inferred from sodium content, are the predominant criteria for the establishment of the agronomic aptitude of every type of irrigation water.

The study del origin of the salinity is important to manage, to long term, the problem of the salinity and power to anticipate the durability of the expensive projects of reclamation of grounds that depend on an appropriate understanding del local climate, hydrology, geohydrology, geochemistry, rain, meteorism of rocks and the mechanisms of redistribution into the soil.

One of the most frequent sources of saline waters is the subsoil. The arid and semi-arid zones in many countries are, frequently, on saline aquifers of waters. In many regions, rivers as channels flow from humid and sub-humid zones to other where the saline waters are frequent. In the coasts, the fresh water usually makes contact with the marine water. Over there, water pumping form aquifers causes saline intrusion of water that, in extreme situations, drastically affects the quality of the irrigation water.

The world over more important source of salinity problems are: seawater intrusion in coastal zones, tidal effect of sea on coastal surface water, ground water mineralization in rock formations, process of evaporation (or evapotranspiration) that increase salt concentration of superficial and ground waters, water logging and secondary salinisation of soils and influence of drainage and sewage influent.

As it is seated before, the main damage produced by saline waters is a consequence of salts accumulation across the soil profile. It is manifested reducing water availability to plants, slow to poor seeds germination and slow growth rate of plants. This is like that due to the additional effort that plants must to do to absorb water under saline conditions. It is simple to understand because the water flow across the external membrane of root cells depends is steered by the differential of salt concentration between sides, the external soil solution and the solution into the cells. So, as lower is this differential, lower will be, as well, the amount of water entering to the cells. Definitively, this is a question of osmotic potentials.

The osmotic pressure of water can be calculated, in an approximate form, using the expression:

$$\mathbf{P_o = 0{,}36 \times CE}$$

In which, P_o is the value of osmotic pressure, expressed in atmosphere; and, CE is the value of electrical conductivity, measured at 25 ^{o}C and expressed in dS/m.

The use of highly saline water to irrigation provokes an increase of osmotic pressure of soil solution being able to happen that it the soil absorbs water from roots cells. So, the plant loses moisture and, thus, suffers hydraulic stress. It is by that the damage symptoms of salinity have a similarity with those produced by the lack of water. If saline water is sprayed directly on leaves, it can cause salt scorch. This effect is bigger under high sun light exposures because the water drops on leaves can act as lenses concentrating sun energy on small areas of leave surface.

The effect of saline water depends of soil texture. Sandy texture permits use of saline water better that in the case of fine textured soils.

The main effects of sodium presence in water irrigation are disorders in the soil structure. The increase of exchangeable sodium percentage (ESP) in the exchangeable complex of soil is correlated with decrease of rate of infiltration. The use of sodic water during long periods can destroy soil structure. The increase of soil pH reduces the availability of an important number of essential nutrients for the plants like nitrogen, zinc, iron, etc. The availabilities of calcium and magnesium diminish and the toxicity of sodium increases like that one of elements like boron, molybdenum, the fluorine, lithium and the selenium.

The inadequate saline and/or alkaline water use for irrigation affects not only agricultural productions but also it harms to soils until making them unsuitable for the crops. The foreseeable result is physical, chemical and biological degradation of the agricultural land on great scale. The salinity is considered as it is the cause of a loss of more that one billion hectares of culture, mainly, in arid and semi-arid zones.

In the TABLE 18 it is reflected an estimation (1987) of salt-affected soils on continents and subcontinents.

The most of countries bordering Mediterranean basin are under arid and semi-rid conditions. This fact linked with water scarcity and expansion of irrigated lands, is at the basis of salinity problems all over this region. It is said that the salt affected soils in the Mediterranean countries reaches 16 millions of hectares, emphasizing Egypt with 7,4 million hectares, Algeria with 3,2 million hectares and Turkey with 2,5 million hectares. In the northern part of Mediterranean basin emphasizes Spain with a surface affected by the salts variable between 0,8 and 1 million hectares. Perhaps, at this moment the salt affected surface will be bigger.

Certainly, this surface does not correspond totally with irrigated lands in this Region. Nevertheless, it is within the reasonable thing considering that, approximately, 30 % of the irrigated area has problems of salinity and/or alkalinity. The irrigation water management in the Mediterranean basin has in the problems of salinity one of its greater challenges.

The sustainability of agriculture of irrigated lands, under arid and semi-arid climate, demands the accomplishment of tending practices to diminish the effect of salts dissolved in the irrigation water. In these zones, agriculture only can develop its redemption social function when the productivity of the cultures is good enough. On the other hand, the accumulation of salts in agricultural soils does lose their fertility and, after that, they become a sterile conglomerated of mineral particles, without structure, with high toxic ion concentration for the plants, losing itself therefore a patrimony obtained trough centuries of edaphological action.

The magnitude of this risk demands to face him by means of agricultural practices that diminish its impact on cultures and soil because it is necessary to prevent the secondary salinization. Among them we can emphasize: Systems of suitable irrigation that guarantee the suitable leaching in soil profiles, construction of a suitable net of drainage, levelling of lands, suitable configurations of the land for plantation, physical and chemical amendments, suitable fertilization, organic rotation of cultures, etc. At the scale of Public administration is necessary to consider, always, the building of drainage net in the development of irrigation districts.

In all cases, it is important to know the salt tolerance of cultures. This data is necessary, mainly, to introduce new species in an area with salinity problems. In these zones takes place a, historical, selection of cultures according with its salt tolerance. Among the tolerants crops to salinity it is possible to mention: cotton, barley, jojoba, sugar beet, asparagus, alfalfa, and date palm. Highly sensible are: sesame, beans, onions, avocado, lemon tree, orange tree, etc.

Irrigation systems and scheduling.

The irrigation systems are essential factors of the irrigation water management. Based on the force that distributes the water on the ground, the irrigation systems can be grouped in gravitational and of pressured systems. In the first class can be included, mainly, flooding and furrow systems; in the second, are sprinkler and drip irrigation. At the present time, there are a tendency to associate the gravitational systems with archaic forms of agriculture; however, thee second methods seems more appropriate of a developed and modern agriculture. It is possible that in this perception there is something of truth, but not all truth.

Water quality problems

Separate mention deserves the study on aptitude for irrigation of residual waters of urban origin because, mainly, it can affect to the health of persons and animals.

It is evident that the use of not treated urban wastewater for vegetables irrigation increases the risk of infections by helmints (mainly

Ascaris Lumbricoides infections) bacterial infections (typhus, cholera, Helicobacter pylori) and symptomatic diarrhoeal diseases in consumers. When the residual waters are partially treated, there are also evidences of the risks of enteric infections (bacterial or viral origin) when the consumers ate some types of uncooked vegetables irrigated with those waters if the water composition exceeds the WHO guideline of 1000 FC/100 ml. Blumenthal and Peasey (2002) did not find evidence supporting any need to reduce the guideline below 100 FC/100 ml in such circumstances. For those vegetables produced to sell in the market, in dry and hot conditions, the guideline of ≤ 1 egg of nematode egg per litter may be adequate. However, when the vegetables are destinated to fresh consume by local population this guideline has not enough security and would be replaced by ≤ 0,1 nematode eggs per litter.

Studies of the risks of enteric viral and bacterial infections related to use of treated wastewater (both from serological studies and studies of reported enteric infections) suggested that when sprinkler irrigation was used and the population was exposed to wastewater aerosols, there was an increased risk of infection when the quality of the wastewater was 106 TC/100ml but no increased risk of infection when the quality of the wastewater was 103-104 FC/100ml. Studies of the risks of symptomatic diarrhoeal disease and enteric viral infections related to direct contact with treated wastewater through farm work (adults and children) or play (children) suggested that when flood or furrow irrigation occurs there was an increased risk of infection in children when the quality of the wastewater was above 104 FC/100ml. For adults, the threshold level for symptomatic diarrhoeal disease was 105 FC/100ml, but the threshold level for transmission of Human Norwalk-like virus/Mexico (as indicated by an increased level of seroresponse) was below 104 FC/100ml where high levels of contact occurred, even in a rural area where there were many other transmission routes for this virus. This was probably not related to an increase in disease in the study population, but could conceivably lead to increased disease in a population in a non-endemic area.

These data support the need for *a faecal coliform guideline* to protect farm workers, their children, and nearby populations from enteric viral and bacterial infections. The appropriate guideline will depend on which irrigation method is used and who is exposed. For example, if adult farm workers and nearby populations are exposed through spray/sprinkler irrigation, a guideline of ≤105 FC/100ml should be adequate. A reduced guideline of ≤103 FC per 100ml would be safer where adult farm workers are engaged in flood or furrow irrigation, and where children under 15 years are regularly exposed (through farm work or play). However, a faecal coliform guideline of ≤105 FC/100ml could be adopted if effective health promotion measures could be taken to help adult farm workers and children improve hygiene measures post wastewater contact.

Taking into account the risks involved in the agrarian use of wastewater, the WHO (1989) proposed a guideline for use of this type of water in agriculture. The main criteria of this guideline are included in the TABLE 19.

In relation with this guideline, WHO admits that, in specific cases, it is possible to modify it according with local epidemiological, social and environmental factors. In the group of intestinal nematodes they are considered: *Ascarys* and *Trichuris* spices and hookworms. Considering the public lawns, such that hotels lawn, with which the public may come into contact, is suggested a more restrictive guideline for faecal coliforms of ≤ 200 CF per 100 ml. In the case of fruit trees, irrigation should cease two weeks before fruit is picked and no fruit should be picked off the ground.

Considering the normal presence of those organisms into residual waters of urban origin the fulfilment of those criteria is only possible if previously they are put under wastewater treatments.

For the category A, WHO recommended a strong treatment able to eliminate the biological charge in the water till the limits marked by this guideline. For categories B and C recommends the use of stabilization

HYDROLOGIC PLANIFICATION

In the kingdom of Morocco, the Law 10/1995, regulating water, emphasizes in its forework on hydrologic planification as first objective of the water policy in that country. On it is possible to read the interesting paragraph following:

The law on the water constitutes the legal foundation of the water policy in the country and it pays attention, in consequence, the following objectives:

. a coherent and flexible planning of the use of the hydraulic resources, as much at the level of the hydraulic river basin like a national level;

. an optimal mobilization and a rational management of all the hydraulic resources, considering the precedences fixed by the national plan of the water;

. a management of the hydraulic resources within the framework of a geographic unit, the hydraulic river basin, that constitutes an important innovation allowing to conceive and to apply a decentralized management of the water. In effect, the hydraulic river basin constitutes the natural geographic space better adapted to include/understand and to solve the problems of management of the hydraulic resources, as well as to make

an effective regional solidarity between the users affected by a common hydraulic resource;

. a protection and a quantitative and qualitative conservation of the hydraulic public scope as a whole;

. a suitable administration of the water that allows helping to the conception of the use and the control to mentioned operations previously, associating the public authorities and the users to all decision making relative to the water. It on the other hand contemplates to the valuation of the hydraulic resources and the yield of the corresponding investments considering at the same time the economic and social interests of the populations by the protection of the acquired water rights.

In Algeria, the Law 5/2005, dated 4th august, relative to the water, dedicates its title fourth to the institutional instruments of the integrated management of the integrated management of hydraulic resources and, mainly, to the hydraulic planification. Among those instruments describes: Plans directors of management of the hydraulic resources, one for each hydrographic unit, and the National Water Plan.

According with article 47, the *Plan director of management of the hydraulic resources determines, on the base of the supply and demand of water, in amount and quality, the objectives of development and managements of the mobilization and water transference between natural hydrographic units, considering the economic parameters. The plan director of management of the hydraulic resources also defines the objectives of the use of hydraulic resources and as well as the measures to the economy exigencies, valuation and quality protection of the water, in a perspective of lasting management of these resources.*

In Tunisia, the Law 17/1975, dated 31th of March, approved the Code of Water in which article 96th it is possible to find the basic ideas for the hydrologic planification under the terms following:

Planification del use of the national hydraulic resources must be based on the principle of greatest productivity per cubic meter of water in all over the country in agreement with the acceptable economic conditions and technical conditions.

The works of water transference from a hydrographic river basin to another will have to go preceded by an economic study that credits the improvement of the productivity of waters subjected of transference. Nevertheless, the transference from a river basin to other to supply water to drink the population is not subject to any measurement.

The Water Law 5719-1959 of Israel provides that all water resources belong to the public and are to be allocated for specific and recognized purposes only. National water planning is, consequently, based on maximum water conservation, optimum management of water resources and careful water allocation.

In Italy the competence on water planification is in the central public Administration.

Law No. 93-3 of January 3, 1992, on water, defines the Master Water Development and Management Plans as a planification instrument in each river basin establishing the basic guidelines of balanced management of water resources.

The present Spanish water law comes from Law 29/1985, of 2 of August, that to long it of its use has been amended in numerous occasions. The hydrologic planning is regulated in its title III that, practically, has not been altered from its promulgation.

According with this law, the hydrologic planning will have by general missions to obtain to the good state and the suitable protection of hydraulic public dominion and of waters object of this law, the satisfaction of the demands of water, the balance and harmonization of regional and sectorial development, increasing the availabilities of the resource, protecting its quality, saving its use and rationalizing its uses in harmony with the environment and the other natural resources. The planning will be made by means of hydrologic plans of river basins and National Hydrologic Plan.

In Portugal, the article 14 of Law 58/2005, 29th December, introduces the hydrologic planning with the following terms: The ordering and planning of the hydraulic resources try to make compatible, under integrated form, the sustainable use of those resources with its protection and valuation, thus like with the protection of the people and goods against associated extreme phenomena to waters. They must be glided and to regulated the uses of the hydric resources of the zones next to them in order to protect the amount and the aquatic quality of waters, ecosystems and the sedimentologic resources.

This superficial vision of the hydrological planning in the Mediterranean river basin allows verify that it is a present concept in the legislation of many countries although this verification is not sufficient to infer the accomplishment degree that it has in each one of them.

In the middle of this stage where countries of diverse level of development coexist, the discussion on irrigation water management is centred on a fundamental premise: the increase of the efficiency of water use in agriculture can increase significantly the general availability of this resource. For many specialists in hydrology the main reason to focused the water crisis on agriculture is not only because this sector consumes 60 % of hydric resources at the global level, consume that increase till 80 % in the Mediterranean Region, but as well due to a high potentiality of reducing water losses by increasing water use efficiency in the agrarian activities. However, to save water increasing the irrigation efficiency at the parcels level is a complex question that demands to know what types of losses take place and what is it impact on environment. Schematically it is possible to be considered that surface run-off and deep percolation are the two main causes of loss of water during the field irrigation. When are used superficial irrigation systems like basins irrigation, borders irrigation, furrows irrigation or uncontrolled flooding, the surface run-off can be reduced suitably practically reducing the to zero minimizing the slope of the parcels, establishing contour dikes and adapting the income flow of water to the slope and the soil characteristics. In general terms, quasi elimination of this cause of water losses is an inherent fact consequent to good irrigation practices. Perhaps, this is the first lesson in process of teaching water management in agriculture.

The water losses due deep percolation have ambivalent effects. From one hand, it increases, above by of the technical necessities of cultures, the real amount of water required for irrigation but from another side it allows to leach and remove salts from the soil profile keeping it in an adequate level of fertility. So, it is necessary to maintain the percolation, in amount variable between ten and twenty percent of theoretical dose of irrigation, with the aim to maintain to the soil fertility. Moreover, an irrigation system that does not remove salts from the rizosphere can be qualified as unsustainable. Those considerations found an attention call on that irrigation systems, like drip systems, designed to only supply the hydric necessities of the plants without taking care of which requires the soils conservation. That way to do can be opportune when it is applied to hydroponics cultures but not if the system is designed to irrigated water cultures seated on the arable earth. In conclusion, zero percolation is an opposite objective to the sustainability of the irrigated areas and, by that, the percolation necessary to remove salts out from biosphere does not have to be considered as water loss affecting irrigation water efficiency.

All said before indicates that percolation cannot be considered loss of water if is limited to the amount necessary to leach the soil profile. In this case, as it is logical, it must be completed by a suitable structure of land drainage.

The use of irrigation water fulfilling the rational criteria before mentioned allows increase significantly, at parcel level, its efficiency and, in addition, it allows formulate the suitable answer to the current topics, frequent in the global discussion on water uses, on the water wastefulness in agriculture. In order to make face to all those imputations the best way is, by means of a suitable water management, to irrigate only with the necessary amount, nor a drop more. In that case, it would be clear that more significant inefficiencies in agrarian use of water occur during their storage, transports and distribution into irrigation districts.

But the only losses of water are not these that affect to agrarian sector. At general level, within the river basins, the handling of superficial waters usually is quite inefficient, in such magnitude that between a twenty and forty percent of total losses of water take place during their storage waters up stream of dams, transport by the rivers and artificial channels and distribution between the main users. It is by that to centre wastefulness mainly on the agrarian sector can be quite unjust. Just like to make this one in charge of liberation, by way of increase of efficiency, out of to much volumes of water.

As it is said before, water pricing is an economic approach to water management in order to reach the objective of to reduce irrigation water demand, to rationalize water use and recovery cost of all services associated to the water.

WATER DEMANDS IN SELECTED COUNTRIES OF THE MEDITERRANEAN REGION

The human persons need about 30 litters per day to drink, cooking and cleanliness that is equivalent to 11 cubic meters per year. Nevertheless, water withdrawal for urban purposes usually is bigger due to the degree of efficiency in the supply of all uses. The TABLE 20 shows the caput withdrawal for domestic and municipal usages in different parts of the world.

Agricultural usage is, as far, the biggest one. The TABLE 21 shows the caput withdrawal for this purpose in different parts of the world. Finally, an estimation of industrial usage is contained in the TABLE 22.

Having in mind the hydrological experience in the territory of the basin of river Segura (Spain), it is found trustworthy the estimation of 109, 5 cubic meters per year and caput for the domestic and municipal withdrawal. For the agricultural purposes it is reasonable to consider a gross demand of 6176 cubic meters for hectare and year. The industrial demand can be determined as a percentage of urban consume, around 8 %.

The TABLE 23 shows, for the all countries studied, all gross water demands estimated for 2000. The next one, TABLE 24, contents estimated demands for 2025. Those figures represent the water needs according with developed patterns before stated.

Observing water withdrawal it is possible to realize the situation in different countries of Mediterranean region. Also, considering a standard preference of uses that give priority to domestic and municipal consumption, after to irrigation, after to industry and finally other uses, including environmental one.

Since this position it is rational to assume that, in 2000, total water withdrawal was sufficient for, with an efficient management, to attend to all the water needs in the majority of the countries of the region, determined with the parameters before established. The Table 25 contents the values index of water demands satisfaction in selected countries of the region, expressed as percentage of theoretical needs.

The analysis covering selected countries in Mediterranean region permits do a distribution in four groups (Margall et all, 2002) according to a homogeneity of situations relative on the one hand to the risks of shortages that threaten them and on the other hand to present and future water the requests of coming.

Group 1: countries without own risk of shortage after 2025. (Turkey, Greece, Italy and France)

Group 2: countries with risk, rather located, of conjunctural shortage (Morocco, Lebanon, Syria, Cyprus and Spain)

Group 3: countries in situation ranging since conjunctural shortage to structural deficit, from 2000, in spite of a demand of little water (Algeria, Tunisia, Israel, Palestinian territories and Malta).

Group 4: countries in situation of structural shortage as of 2000 made worse by an important demand of water (Egypt, Libya).

According with this analysis, four countries – Tunisia, Jordan, Cyprus and Greece – are in permanent status of not satisfaction of water demands. Nevertheless, all of those dispose of enough resources to supply the urban and industrial and, also, a part of agrarian demands. In the other hand, Morocco, Algeria and Egypt that traditionally pass as dry territories have water to attend their necessities till the horizon of year 2025.

After that it is easy to realize for a great number of countries, especially those of south and east of Mediterranean region, the need of internal politics to improve the availability of their renewable water resources. This implies an intense development of the activities of hydrologic planning to give a sustainable answer to the imbalances caused by the natural distribution of the water resources. And after, to make the financial efforts necessaries to establish the necessary hydraulic infrastructures that satisfies the general necessities of water in each country.

Water scarcity has become a topic of frequent use in the international context. Nevertheless, its intense repetition does not have to serve to hide the necessity of an effective and sustainable management of available resources in each country.

WATER AND ECONOMY IN SELECTED COUNTRIES OF MEDITERRANEAN REGION.

The TABLE 26 shows the participation of economic sectors in the gross domestic product of selected countries in the Mediterranean region, referred to 2003 and 2004. It is remarkable the strong influence of agriculture in the economy of southern and eastern countries of this area with the exception of Israel and Jordan.

Taking into account that the agriculture based on irrigation is the more important among all of agrarian activities in the majority of those countries, it is obvious to remake the importance of water on its economies.

The irrigation is a vital component of the agricultural production in many developing countries. In the 1997-99 (FAO, 2004), irrigated lands, representing one-fifths of cultivated lads, provided two-fifths parts of vegetal production in developing countries. The divergence in this statistic reflects the high production yields that are possible to reach through irrigation. In the Mediterranean region this divergence is bigger being realistic to consider that irrigation agriculture provides more or less the three-fifth of agrarian production. In same countries of south and east, this participation is very close to the five-fifth, like in Egypt.

The developing countries are particularly dependent in the irrigation: in 1997-99, 59 % of production of the cereal crops in developing countries were irrigated (Bruinsma, 2003). The production of the food in developing countries is increasing in answer to the demands of an increase of population looking for prosperity. Something of this demand will be solved by increasing productivity of rainfed agriculture, something by the increasing imports, but irrigated agriculture will be an important contributor.

Virtual transfer of water in Mediterranean Region

Virtual water is considered (Hoekstra, 2003) as the water “embodied” not in real sense, but in virtual sense. It refers to water needs to produce one unit of product. In the agriculture context can be defined as the quantity of water that needs to be evapotranspirated to allow the agricultural production. The per capita consumption of virtual water contained in our diets varies according to the type of diets, from 1 m^3/day for a survival diet to 2.6 m^3/day for a vegetarian diet and over 5 m^3 for a USA style meat based diet.

A country that imports one million tons of wheat is importing as well the equivalent to one billion cubic meters of water, increasing by that its available hydric resources. It is because of it that the international trade of food, and of its water associated, has become an essential component of water management at global and, also, regional level.

Le concept of virtual water is applied to different visions of water management. So, it can appear associated with a strategic vision of food security when a country uses international markets to food supply, total or partially, its population with the purpose to relieve the pressure on natural resources. The influence of this acceptation is remarkable in those countries with structural water scarcity.

There is a liberal face of virtual water that consider food imports as a means to open the national water market and in ensuring the water will be conducted to its more profitable use.

The ecological vision aims to improve the rational use of natural resources and to redirect agricultural production to areas where the natural conditions are best to match efficiency on sustainable basis.

Finally, it is possible to find the solidarity facet in the virtual water concept emphasizing those agricultural decisions on areas producing surplus foods can affect the pressure exercised on water resources in poorly endowed areas.

All these visions (Ranault, 2002) affect to the unitary concept of virtual water that, necessarily, is appears relativized depending on the time, space and of the aims reserved to its employment.

The virtual water value is defined as the relation between the quantity of water evapotranspired at field level and the crop yield. It is expressed in cubic meter per kilogram of crop production according the expression:

VWV = ET [m3]/Yield [kg]

As it is logical, this value changes from one place to other. A study on the value of the virtual water in a wheat durum crop, only rainfed, provided 1,45 m^3/kg in Morocco and 1,63 m^3/kg in Tunisia as virtual water value. In the case of irrigated lands, the values were, respectively, 1,23 m^3/kg and 1,17 kg/m^3. Those values evidence the needed to make local studies on virtual water as basis of methodological development for water management associated with that concept.

In the TABLE 27 it is possible find data on specific water demands of different agricultural products.

Also, in the TABLE 28 it is possible find data referred to animal products.

Hoekstra and Young (2003) have introduced the concept *water footprint* to express the accumulative virtual water content of all goods and services consumed by one individual person or a concrete country. Dealing on this indicator, Renault (2003), cites an earlier study according to which a survival diet would require 1 cubic metre of water per capita per day, whereas an animal product based diet needs some 10 m3/cap/day. More common diets are ranking from about 2.5 m3/cap/day for low animal product intake, e.g. in North Africa, to 5 m3/cap/day for high animal product intake such as in Europe or the USA.

At national level there are not too much studies realized. Nevertheless, according with estimations of Hoekstra and Young (2002, 2003), countries with a relatively high water footprint per capita, roughly in the order of 2000 m^3/yr per capita, are Belgium and the Netherlands. Countries with a more average footprint, in the order of 1000 m^3/yr per capita, are for instance Japan, Mexico and the USA. Countries with a relatively low water footprint, roughly in the order of 500 m^3/yr per capita, are China, India and Indonesia.

On world-wide scale, from 1995 to 1999, only considering water virtual of the cultures, the five first exporting countries, in decreasing order, are: United States of America, Canada, Thailand, Argentina and India.

In the Mediterranean Region, according with Hoekstra and Hung (2003) the value of net virtual water import for selected countries are represented in the TABLE 29.

From the figures in the TABLE 29 it is possible to be deduced, for the set of studied countries, a roughly annual deficit of virtual water of 60.000 hm^3. This situation can have its explanation in a weakness of national agricultures or in policies that prioritize the water use directing it to activities diverses of basic food production for the people or the cattle as they can be wheat, barley or maize; and that are based on the confidence of which in the international market they will find them with a smaller cost of opportunity. The irrigation already occupies a central place in this problematic that allows to one better valorisation of water and one stabilization of the production in countries where the climatic risk is important. But this tendency to an intensification of the agricultural production based on the development of the irrigation encounters over a main difficulty: the one of the increasing physical shortage of the hydraulic resources.

Among those, there is a group integrated by four countries, with very high rates of virtual water importations, they are: Spain, Egypt, Italy and Algeria.

In the case of Spain and Italy, the net virtual water imports, very high, can be explained for its national options giving priority to the agricultural products with a high valorisation of water (fruits, vegetables), leaving those others which water valorisation is lower (Cereals, corn, etc). But, taking into account their economies, those policies are based on the security that the international market will allow them to satisfy the food necessities of its populations.

In Egypt, almost the totality of the hydraulic resources is used without being able to cover the totality of food needs of its population. Therefore, the country had to resort to increasing virtual water imports.

Perhaps, it will be necessary to analyze in depth the case of Algeria to know the effect of its agrarian development policies on the national food security.

The net exporters of virtual water in the Mediterranean Region are France, Syria and Greece.

The important dependency of countries in septentrional Africa and Middle East respect of North America, for the virtual water import, are explained in great part by the importance of maize importations (mainly from United States of America) and wheat (United States of America and Canada), that are basic products of these countries. Therefore, in Algeria, near 90% of the imports of wheat came, in 1999, from Canada. As well, the importations of soybean are very significatives due the fact that this product is in many countries the base of cattle nutrition.

These facts introduce the question of food security in the arid and semi-arid zones of Mediterranean Region because the demands of food are growing according with the population growth and, also, with the change in diet habits.

Certainly, the international market can compensate the food production deficiencies at national level but with strong economic obligations. The question is if their economies allow be only a passive subject of the global food production and until what level of dependency can arrive each one without putting in risk the adequate nutrition of its habitants.

Economics of irrigation water

Water is an especial good. Certainly, it is a natural resource, component essential of the environment and substance fundamental for persons and living beings. Water is life. These characteristics determine the need to protect it and the correlative obligation of public powers to do so.

In arid and semi-arid zones it is said that water is an economical good because its participation in all productive processes of agriculture as factor of production and due its unquestionable effect on population well-being. Nevertheless, there are aspects determining nature of water that put its entity far away of the economical good concept.

Also, for economical doctrine, water is a complex good because, is impossible to be appropriate definitively due its constant pertinence to hydrological cycle, a physic reality exceeding of that domain in which economic laws, including market ones, work with success.

These facts can justify why they are necessaries extra-market measures to manage this resource and why it is a question of justice to ensure social and environmental efficiency of its use. And, as well, the needs to concrete what aspects of its functions must be considered under economical discipline.

From the agricultural point of view, the reality of productive processes in which water takes part allows to infer that it is water use, not water itself, which economic relevance give leave to appreciate it as economic good.

According with this premise, the economic functions of demand and supply must be applied to water use. Also must be applied to the called water markets that, in consequence, they would have to be called water use markets.

It is possible to realize that in arid and semi-arid zones water use is a real economic good which value can be estimated by users who would be at readiness to intensify, quantitatively, the use del water as much as its application continues producing benefits.

The demand of water irrigation use is affected (Zakri, 2006) by price of water, reliability of the network, type of network (turn or on demand) price of agricultural concrete inputs, price of agricultural outputs produced in a concrete activity, weather, type of crop considered and technology applied.

It look like a tautology the though that, for a given price, quantity of water demanded by farmers is the amount that they would buy at that price. But, in reality, this sentence sets down the elemental concept of demand. The addition of all individual demands of farmers into a concrete area o country determines irrigation demand. It is predictable that an increase in the price of water, being constants all other conditions, decreases the demanded quantity of water.

In general economics terms, when the price of a good increase the consumers trends to replace it with a cheaper good able to act in the same process that do the first one as a substitute of this. In the case of irrigation it is physically impossible to replace substitute water because no exists in the nature a physical entity able to replace water into the evapotranspiration processes. Nevertheless, there are possibilities to find substitutes for processes of water use. Considering, for instance, a cattle farm, when an increase of water use price occurs the farmer can replace forage production activities by the purchase at the market the animal feed required by his cattle. Technology, in the measure that let save water increase availability of water use can provide partial substitution of it.

This example illustrates how much easy is to substitute water use that water. In these, under water scarcity situation it is appreciable the substitution of water use by acquired agrarian product offered by the markets at local, national or international scale.

In similar terms it is possible to describe water use substitution operated by massive importation of virtual water, under form of cereals or other foods, made by many countries in the Mediterranean region to compensate their deficient food security.

As economical good, irrigation water use has a price and, with not changing other conditions, when demand of water use increase the price will move up. In the contrary, if demand falls the price of water use will became lower.

More or less, to the water use demand are applicable the general criteria demand whose changes can come, mainly, from economics results of agriculture activity.

Water Supply

Into the economy of irrigation water use, the supply function is affected by conditions such as:

a) Generally, the use for irrigation of the water available in a territory is a right running with the possession of a concrete earth.

b) Public powers orders the use of the resource.

c) Price for water use is settled down by public Administrations and, in few occasions, by operators in a free trade.

d) Significant increases in the supply of water, in a concrete territory, usually is a consequence of new wells opening, water transfer from other places, reuse of (treated) waste water or desalination of saline waters and sea.

e) Virtual water import is a solution every extended to compensate food insecurity in each country.

Under situations of water scarcity the total water use supply can have a close coincidence with hydric resources availability into a concrete territory.

In strict sense, it is no very much realistic to speak of water use supply and either to speak of a market of the rights of water use. In general these rights are assigned and, in many cases, linked to land object of irrigation. So, they are fixed to the space. In most of studied cases it was found out that exists a strong governmental intervention of water use that restricts free disposition by the holders.

Nevertheless, the absence of a conventional market of water use does not prevent to reflect on aspects such as value of this use and the need to recovery, by means of a price, the cost of all the services associated to the same one.

Although it is a limited good, very limited, the absence of a free trade of water use it does not to prevent the reflection on the hydrologic meaning of right price concept as determined, according with economy theory, by the intersection of curves of supply and demand. It is a generalized opinion that, in all region of the Mediterranean, into districts of irrigation managed by the public Administrations, the amount of money which farmers must to pay for use water is lower that the value it would reach in a free market. This verification could explain, in strict economic terms, the fact of great water use demand coexisting with a lasting water scarcity in Mediterranean region which contributes to perpetuate the water deficit of in many territories.

In general, it is noticed that, under those conditions, the demand elasticity of water use has a value lower that one because the increase of water use demand does not correspond with an increase in the price. Nevertheless, when that happens in activities driven by public powers like occurs in the irrigation districts; often appear speculators of the water who put prices to its use without being out from the mechanism of the competition provided by the free market.

It is very important to know the real effect that the price increase provokes on the demand of water use. For that it is necessary to have a suitable study of cost of the crops that will be cultivated in order to determine the relative influence of water use price on its final cost of production. This is very important when for the project to introduce new hydric resources coming for the reuse of urban waste water (treated) or the desalination plants of brackish or marine water. It has been proved that those cultures developed with intense technological inputs can absorb the water use cost better that others developed under traditional customs. For example, in a culture of peppers under green house the elasticity of the water use demand is lower that this crop was developed outdoors.

As conclusion of the previous comments, it is possible to be considered that:

a) Pricing of water use can introduce realism in the agrarian activities, diminish the demand and correcting deficit situations, being prevented that the farmers develop activities that generate low income or, even, losses.

b) Recovery of the costs associated to water use can have a positive effect in the reduction of the demand of agrarian use of the water.

c) Development of water markets it can contribute to rationalize the irrigation water use.

AGRICULTURAL USE OF WATER

At the level of the Mediterranean Region a constant expansion of irrigated land can be verified. The Table 30 contains information available, originating of diverse sources, supporting this assertion.

During the period between 2000 and 2025 it is expected, a growth of the irrigated surface, into the countries situated in the South and the East of Mediterranean Region, of about 2.5 million hectares. In the same period, the growth expected for the countries in the north, into the group studied, is about 0,2 millions of hectares. By as much, we attended the tendency to expand the irrigated land much but it is accused in those countries between which are some with remarkable shortage of renewable resources.

According to the made studies, into Turkey almost a million hectares will be transformed during those twenty-five years. Taking into account the natural and renewable hydric resources of this country, it perishes that this expansion will not offer more problems of which they are associated with this type of transformations. The same thing can be comment about Syria and Lebanon.

Problematic is the case of Egypt. With a 91 % of exploitation of renewable hydric resources in 1999, the awaited expansion would need an intense policy to increase to the water efficiency in the present irrigable areas with the aim to economize 3 km^3 of water to develop and to maintain, under sustainable form, the new irrigated lands.

But even problematic it appears, prima facie, the case of Jordan. An increase of 241000 hectares of the irrigated land will need, at least, 1,5 km^3 of water, volume that surpasses its total renewable natural hydric resources.

For Morocco, at national level, with an index of operation of hydric resources of 41 %, does not fit any doubt that the putting in irrigated land of 239000 hectares is going to also demand an enormous no single effort of provision of water but of construction of hydraulic infrastructures.

Irrigation water management

To manage water properly in a sustainable manner is one of the most crucial water issues in the coming decades and has an enormous potential for the conflict (Hamdy, 2004). From a social point of view, sustainability means water for today and also water availability for the coming generations considering the narrow relation existing between availability of water and foods or, the one that is same, between drought and poverty. Nevertheless, the actual dynamic of globalization allows to note that the logic of the relation water scarcity-poverty is more evident that water scarcity-lack of foods because the global market, with its virtual water transfers, can satisfies food needs of countries whenever they have enough money to buy them. Thus, the question acquires its greater dramatic level when due lack of water a country cannot reach the sufficient degree of development that allows him to choose between producing its foods or buy them in the outside.

Generally, it is possible to be verified that the development of countries appears associated to the influence of the agrarian sector on its gross domestic product. The western model of development is familiarized with the increase of the participation of services and industry in the GDP and with the diminution of the economic importance of the primary sectors. So, for many countries, the external demand of foods appears joined with each step of development level in such way that both grow in the same sense. This fact indicates a leaving behind of purposes of national food security that could be compensated by the security of the international market. When it happens is when is possible to appreciate the residual role of the agriculture as employer of those that not have another professional options and, also, as instrument to maintain social groups in the rural environment. The developed countries have faced the problem that raises its agrarian sector when the food security is guaranteed from the outside. Frequently, the answer is to intensify the agrarian activity of such way that allows them to export materials, techniques, methods or systems necessaries to implement the agrarian production in other countries with lower economical develop. So, the paradigm is to be exporter of ideas instead export agricultural products.

These reflections allow consider the management of irrigation water as activity included in a superior instrument like is the hydrological planificatión formulated after a national debar on the present and future of hydric resources, its use and priorities. To what to dedicate the existing water? What role is assigned to the agrarian activity in each region? What to do with the irrigable lands, to stimulate them or to prevent its extension. These questions must appear formulated in the hydrologic plans of each territory and, as well, the answers given by the political power at the very concrete moment.

The dramatic situation of water in the world, and in the Mediterranean region, forces the countries to attempt a national water debate and to materialize its results in particular hydrologic plans, valid on perfectly defined territories, and in a national hydrologic plan which functions may be that to order and harmonize the others.

Indeed, integrated management of all the water resources is a rational answer to harmonize resources with uses under him imperative of present and future interest of population.

Integrated water resources management (IWRM) is a multi-user participatory systematic process for the sustainable development, allocation and monitoring of water resources use in the context of social, economic and environmental objectives.

IWRM Governance is supporting three important tools:

a) Enabling environment of appropriate policies and strategies.

b) Adequate legislation

c) Institutional framework and management instruments.

At the same time, it is based on the same founds that sustainable development:

a) Social sustainability (social equity), considered as a basic right for all including future generations to have access to water of adequate quantity and quality for their basic needs.

b) Environmental and ecological sustainability. Under this premise water resources should be managed in a way that does not affect the life support ecosystems, to ensure third sustainability for futures generations.

c) Economic sustainability that implies water development and use operations must seek the most possible economic efficiency to allow fair accessibility, especially to the poorest, at reasonable costs.

IWRM also tries to induce a balance between supply and demand.

Under the dialectic of IWRM are growing initiatives very much transcendent for water use, especially for the use of irrigation water. These are the economic incentives to reduce water demand o, much better, to rationalize water irrigation demand. Among these are the economical instruments based on water pricing and water markets.

The main purposes of irrigation water pricing can be summarized as:

a) To reach a balance between water supply and water demand

b) To possibilitate the reallocation to others waters uses

c) To increase productivity of consumed water

d) To avoid an inefficient use

e) To provide a cost recovery

Usualy, water pricing are realized on by half of volumetric water charges, crop based charges and area-based charges.

IRRIGATION WATER PRICING AND WATER MARKETS

Perhaps the main incentive to develop these techniques of water management is to reduce water demand, recovery cost of services associated to water or, much better, rationalize water use.

The main method to charge water costs basically are: area-based charges, volumetric charges and market prices, of which the latter two are primarily found in private transactions.

Area-Based Charges

Area-based water charges are fixed charges, based on the area irrigated or “supposed” to be irrigated. They are often calculated by dividing the total area irrigated into the operation and maintenance costs of providing irrigation water. This a complex method needed to define what costs have to be consider, what is the surface of reference because in an irrigation district the surface can change every season.

The main objection against this pricing system is that water charge does not have dissuasive effect on water demand. The marginal cost of application of additional water volumes per hectare is almost zero. Thus water demand is usually higher due he water charge is under the equilibrium price. In the other hand, the management of this system is rather simple that others based on volumetric measures. It is easy to calculate and also to understand the calculations. This system can be recommended for areas where water is enough and also excess the farmers demand.

Nowadays, this method is moving to new features like area-crop, area-season and area-technology based systems that permit to policymakers to prevent excessive water consumes and push the farmers to choice crops with lower needs of irrigation water and to apply technologies in order to induce the farmers to crop less water demanding cultures and to apply irrigation using techniques that allow it saves the resource.

Volumetric Charge

Volumetric water charges are based on the real volume of water delivered to the farmers. The main advantage of this type of charge is that it encourages farmers to reduce as much as possible their water use.

A big inconvenient of this system are the high costs of devices necessary to do its implementation. It requires transparency for the function of read and report.

Block pricing

This system is appropriate when there is a concern on both purposes: to maintain, in a concrete area, agriculture with low crop incomes and to prevent the excessive irrigation water consume. It involves variation of water charges when water use for a given period of time exceeds a set volume. Under these conditions, they are considered various charging blocks. The water price into de first one is lower that for the second and so on. Generally, the initial price usually is under value of operation and maintenance costs. The amount of the first block is often considered the basic amount of water needed to support a farm family, so this method can also be used to address equity issues.

Farmers pay a low rate for the first block but a much higher price for any water used that exceeds the first block. This method operates like a quota. In fact, a quota is an extreme case of increasing block pricing. Even when an official quota exists, farmers can usually obtain additional water by paying irrigation officials or private sources a high enough fee.

Two-part charge

Two-part charge is a system than combines two components: volumetric charges and fixed admission charge. The volumetric part can be based on marginal cost, to prevent water wastefulness; the fixed part could secure a certain revenue flow to recover investment costs. The most important inconvenient of this system is its complexity and, as well, the misunderstanding of farmer.

Water markets

In countries with either formal or informal water markets, companies or individuals can trade water at a particular market equilibrium price that may change throughout the season. To operate effectively, water markets require a well-defined structure of water rights, a clear and comprehensive set of rules for trading, an entity to manage water delivery, and oversee trading activities and a judicial or administrative body to resolve disputes. They also require a well-developed conveyance system for transporting water to all participants (Tsur and Dinar, 1998). If these requirements are in place, market equilibrium prices will effectively adjust supply and demand and reflect the scarcity value of water. Such prices will encourage water conservation and can recover project costs if the water is sold by the entity managing the system. However, a fixed fee may be required in addition to the market price if the project is to cover costs. There are a number of successful cases of water markets around the world such as in Chile, Australia, Cariri region of Ceara state in northeast Brazil, and Northern Colorado in the U.S. In Spain, actual water law, since 1999, permits the existence of water banks but under a strong administrative intervention. Now are in the way to be developed in order to solve structural water deficits in the Iberian peninsula.

Water cost recovery [1]

An essential part of any cost recovery is its implementation. One means to improve implementation is to review successful projects or countries and determine what factors have been important in their success. Such a review suggests there are a number of key factors that can help improve cost recovery and in some cases reduce water use.

Two basic steps are necessary to achieve cost recovery: the first is to design a set of charges that cover the appropriate costs; the second is to achieve high collection rates through effective water management. The design involves working with water supplier and farmers to determine what should be included in the costs and which of these costs should be collected through a water fee rather than through other taxes such as a land tax or a local property tax. Once this decision is made, setting the appropriate fee level becomes basically an accounting problem that is influenced by the type of irrigation system and ability to measure and monitor water use. When the volume of water delivered cannot be measured, water charges are usually based on some measure of area irrigated. Sometimes the area-based charges are adjusted to account for crops grown and season of the year. Once the appropriate level and type of water charge is determined, the more difficult step still remains: achieving high collection rates.

[1] According with William and Liu, 2006

Financial Autonomy

A key to achieving high collection rates suggested by both the literature and field experience is some level of financial autonomy (Easter and Liu, 2005). Without financial autonomy, collecting sufficient funds from users does not guarantee improved O&M because revenues from water charges usually do not go back to the project but are commingled with other taxes in the central treasury. This probably explains why Jones (1995) found that, in many projects, there is no direct relation between water charges and the service quality. In addition, shifting irrigation project management to a financially autonomous organization creates a financial incentive for improving irrigation services. Better service gives farmers an incentive to pay their fees as well as an increased ability to pay because better service means higher crop yields and farm incomes. Financial autonomy can provide a positive feedback system through a direct financial link between farmers and the service delivered by water suppliers.

To improve cost recovery and conserve water, can be incentives were implemented through volumetric water pricing, improved water delivery and a reduction in the irrigation time cycle. On average, each WUA has saved over one million cubic meters of water annually and increased productivity. After the introduction of WUAs, average crop yields increased by 6 percent of which 40 percent was due to the improved irrigation (Lin, 2003). Financial autonomy also ensures that revenue from water charges will revert to the project. Service providers no longer receive subsidies from the central government, which means they have to collect water fees from users to recover their costs. In such cases, they are likely to create incentives to achieve high fee collection rates. Some suppliers strictly enforce penalties against payment defaulters (Table 2). In Bayi Irrigation District, China, payment defaulters' irrigation water is cut off until they pay their debts (Johnson et al., 1996). In Shangdong, China, the use of integrated circuit (IC) machines insures that farmers cannot obtain irrigation water without paying. Farmers must purchase a prepaid IC card to operate the IC machine that measures and controls the water release (Wang and Lu, 1999). Using IC machines is an innovative way to collect charges, which gives farmers full control over water use and also effectively enforces payment collection. This system reduced water use per hectare and achieved 100 percent collection rates at the same time.

Incentive Mechanisms

Incentives both to pay and to collect the fees help increase cost recovery. In Haryana, India, land can be taken away from people who do not pay their water fees (Cornish and Perry, 2003). An example of suppliers creating awards or penalties to encourage staff to achieve high collection levels is found in Awati, China. They make staff salaries completely dependent on the water charges. Since they do not receive any government funding, staff salaries must come from revenues collected from farmers. Collection rates reached 98 percent after the institutional reform that established the financially autonomous management entity (Awati County Government, 2002). In Bayi Irrigation District, China, the staff members receive rewards for turning in the collected fees by a set deadline and are fined for late payments (Johnson et al., 1996).

Water User Group Participation

User participation throughout the entire irrigation management process through local WUAs appears to be another important factor in high collection rates. Farmers are more likely to pay if they are involved in a transparent decision-making process, and the earlier the involvement, the better. In fact, they are more likely to be willing to pay for system improvements that they help design and build. Coward (1980) cites the Laur project in the Philippines where the WUA had a chance to scrutinize the irrigation agency's rehabilitation design and expenditures on their project. He found the irrigation agency gained in terms of improved design as well as a local commitment to pay for the project.

These ideas were transferred to all communal system in the early 1980s and then to the national irrigation systems. User participation improved the distribution of water, increased financial transparency and raised the level of collection of water charges. Collection efficiency for service fees increased from 45 to 74% while recurrent maintenance costs were reduced by 60% and personnel costs were cut by 44%. Dry-season rice yields also increased 12% and net income increased substantially (World Bank, 1996).

The irrigation management transfer in Indonesia, started in 1987, also illustrates the benefits of involving farmers in planning, especially in the preparation stage of renovation or new project construction. Joint walk-throughs with farmers were found to be the single most effective technique for communication and cooperation. It allowed farmers to suggest their top priorities and concerns for improving O&M and has generated more farmer interest and contributed to better design of the projects (Bruns and Helmi, 1996). In addition, it is important that farmers are involved in cost-sharing decisions and in decisions concerning what costs are to be recovered. In the Indonesia and Philippines examples, cost-sharing appears to have provided farmers with a strong incentive to insist on higher quality construction that better serves their needs. They began treating the project as their own. Almost every successful case in table 2 involves some type of local user participation in water management, suggesting that it is likely to be a necessary reform to improve cost recovery.

Mexico is another recent case of major improvements in water fee collections after the management transfer to water users based on three principles: decentralized management, fee collection to cover O&M costs and efficient budget allocation. After experiencing serious problems with water delivery and fee collection, Mexico in 1990 began a program to set up and turn over, to WUAs, management and tradable water rights. By the end of 1997, 400 WUAs were operational, and each controlled an average irrigated area of about 7,600 ha. Surveys conducted in 6 percent of the districts found that water use per hectare had been reduced and maintenance improved. Water charges went up in most districts due to the financial self-sufficiency target, increasing more than 500 percent in some cases. As a result, O&M cost recovery increased from 18% to 78%.

Many WUAs have made significant investments to repair or modernize the infrastructure using bank loans. The irrigation fees serve as a guarantee to the banks. More than 90 percent of farmers paid their assessed charges, mainly because they have to pay the irrigation charges before receiving WUA service. One of the major reasons for the positive Mexican experience is the commitment at the highest level of government. The success of WUAs is also enhanced by the skills of its hired technical staff. In many districts in Mexico, WUAs assist their members in commercializing their operations, obtaining inputs and renting machinery (Palacios, 1999).

In Senegal, after a 1990 World Bank sponsored irrigation management transfer project, farmers were more willing to pay irrigation charges since they gain control over the irrigation system. Farmers demanded the right to hire their own staff, choosing agency operators only if they had performed well, and even then reducing their salaries from the full civil service package. Following the transfer, agency staff was allowed to enter the schemes only with farmers' permission. Also, education and technical assistance were provided to improve farmers' management capacity. Manuals were prepared for each system; along with training in basic literacy as well as technical and financial trainings for organizational leaders. Farmers were willing to pay at least part of the training costs. Before the transfer, assessed fees covered only 17 to 21 percent of maintenance and replacement costs and less than a quarter of these were actually collected. After the transfer, farmers paid fees four times as high, covering full O&M and contributing to a replacement fund for capital investment. Moreover, because they now monitored the pump operators, electricity requirements were reduced by half (World Bank, 1996).

A survey of two minor canals in Mula and Bhima, Maharashtra, India summarized the general benefits of WUAs. By comparing four districts, two with WUAs already in place and two without WUAs, Naik and Kalro (2000) found that in systems with WUAs, 75 percent of the farmers were willing to pay 25 percent higher water charges because of the better service they received. The major reasons for choosing WUAs were assurance of water delivery and supply, fewer disputes among farmers, better maintenance, and no corruption.

System Transparency

System transparency is another key factor that has had a significant impact on farmers' willingness to pay their water charges. System transparency means that farmers can see how much water they received, how their payments are used, and how water charges are determined. The IC machines in Shangdong, China, illustrate good system transparency in terms of water delivery and payments. Farmers interviewed said they were satisfied because they received an electronic printout indicating how much water was released, the water price per unit, and the total amount they paid each time they use their IC card to release water. The case in Sindh Pakistan is a counter example. Farmers are not willing to pay because their financial system is not transparent, and they do not see that the charges paid are being used in their system due to the corruption of irrigation officials. The farmers said that they were willing to pay for the services, but not for "someone's wife's jewelry" (Cornish and Perry, 2003). This report also suggests that when corruption is well embedded in an irrigation system, it may be very difficult to completely eliminate.

Rinaudo's study (2002) in Pakistan shows that corruption and bribery are deeply imbedded in their irrigation system, and have even become part of the system. The study shows that not only economically and politically powerful farmers are involved in the corruption but also small landowners/farmers. The system of administrative corruption involves about one fourth of the rural population in the studied irrigation system. Therefore, the author points out that it is very difficult to completely change since the "work rules" of the system are so well established. He suggests that improving the transparency of the functioning of the hydraulic system should help, i.e. for each irrigation system, reliable data on the discharge entering the main canal and its distribution canals should be collected and made available to all the Water Users.

Assurance of Water Delivery

Another way to improve cost recovery is to provide farmers assurances regarding water deliveries through formal or informal service contracts that specify water delivery times and quantities. If this is done, farmers will not have an incentive to store water on their field by over irrigating. Since system reform in Katepurna, India, farmers stopped over-irrigating because irrigation scheduling is planned and announced before the crop season, based on water requirements and soil type. Farmers do not have to irrigate in the monsoon season just so that they will have adequate soil moisture for the dry season crop.

Farmers now have an adequate and timely water supply, which has resulted in reduced water use per hectare.

Not only do they save 7.7 million m^3 of water annually but they have also expanded the irrigated area from 2,027 to 3,646 ha. This case shows a real increase in productivity (Belsare, 2001). In Shangdong, China, the implementation of IC automatic machines gave farmers full control over water use. They were able to obtain the right amount of water when they wanted it. The end result is a 5 billion m^3 saving of irrigation water in the province annually (Wang and Lu, 1999).

Public Education

Public education campaigns can also increase farmers' awareness and help persuade them to pay their water charges. This is especially important in places where people traditionally view water as a free good and a basic right. In many projects, public education programs, combined with good service have increased collection rates. In Katepurna, India, efficient water utilization was promoted through newspapers, radio, exhibitions, pamphlets, and posters. Slogans on participatory irrigation management and efficient water use were written on compound walls, canal structures, offices, and public buildings. To motivate irrigators, cultural groups were formed from department staff members and cultural programs (e.g., songs, drama) were arranged at the village level (Belsare, 2001). This helped motivate irrigators to pay their water fees by improving the community understands of the value and importance of irrigation water. In Mexico, education also played an important role. They used mass media campaigns prepared by communication specialists from FAO along with assistance from universities and industry (World Bank, 1996).

WATER USER ORGANIZATIONS

Since the 1980´s, governments around the world did efforts to transfer management of irrigation systems from governmental agencies to farmer's organizations or other non-governmental entities (FAO, 2003). Depending of each country, the transfer may include all or part of management functions, full or partial authority, an entire irrigation district or only a part of it. In this process, water user organizations (WUO´s) are playing a fundamental role.

WUO´s are very known entities since centuries ago when water laws regulated its establishment and operations. They serve as main task operation and maintenance of irrigation system but, depending of each place, also management of polders and land drainage schemes, the maintenance of dikes and flood-defence structures, the removal and treatment of waste waters, the supply of water for domestic purposes and the management of groundwater's. Now it is possible to affirm that

WUO´s are becoming involved in water resource management and conservation.

Dramatic changes have taken place in the irrigation sector during the past two decades. Farmers organized into Water User Organizations have replaced government agencies in managing the lower sections of large irrigation networks and in many cases managing entire systems. This transformation of management from government to users has brought many benefits including improved management, lower overall management costs, and the empowerment of local people that has multiplier effects in community building and quality of life.

Despite geographic, cultural and historical diversities from that WUO´s appear it is remarkable the convergence of its internal structure to a very similar pattern common for all of them. This hypothesis is confirmed by relevant fact (FAO, 2003) as:

- are governed or controlled in a participatory and democratic manner by those who benefit from, and pay, for the services that they supply;

undertake a discrete task related to water management;

operate on a non-commercial, or non-profit basis;

are self-funding;

due the public service nature of the tasks that they perform, are usually subject to some form of regulatory statal oversight.

In many cases, legislation gives to WUO´s independent personality making them able to take part in juridical relations with its same participant and with third people.

Ii is descried the internal conflict of WUO´s because, like other cooperative institutions, they are subjected to a basic contradiction derived from the premise that every WUO´s is established on the statement that the interest of its participants are best served through mutual cooperation. Nevertheless, at same time, inside these entities participants may often be in competition with each other for water use. The existence of legal rules ordering the internal functioning of WUO´s is the best method to prevent and mitigate those conflicts. So, legislation is the key stone for peaceful convivence among irrigator associated to WUO´s.

The water legislations around the world provide a surprising variety of names given to water user organizations like farmer organization, users organization, users society, irrigators association, users association, irrigators organization, users community, irrigation community, amelioration associations, syndic association, and consortium. All of them are functionally related with territorial irrigation entities that in every place receive an appropriate denomination. The most used at international level is irrigation districts.

The tasks assigned to WUO´s depend of the country legislation. In Morocco law provides for the establishment for agricultural water users associations. In Turkey, the law in preparation in 2003 focuses the activity of WUO´s on water use and distingued two types of use: irrigation and domestic supply. Tunisian legislation rules on similar way creating public interest associations with competences on irrigation, drainage, potable water supply and sanitation activities. In Spain, the specific tasks of water communities are no well defined by water law. Into that category there are irrigator communities, urban supplier communities, user of groundwater communities and waste water discharge communities. French legislation enables WUO´s to carry out a wide range of tasks, some fifteen in all, relating with construction and operation works, including those related with irrigation and drainage. In Italy law provides the establishment of different type of WUO´s in function of tasks assigned. So, among those are land reclamation consortia *(consorzi di bonifica*), dealing on irrigation and drainage activities; land improvement consortia (*consorzi di miglioramento fondario*) working on land improvement; and voluntary irrigation consortia (*consorzi voluntary di irrigazione*) dedicated to irrigation tasks.

The internal structure of WUO´s responds to a very topic scheme, normally it is constituted by a general assembly, an ejective body or management board, the chairperson and, in several cases, discipline council.

The allocation of votes in the general assembly, in the most cases, can be adjusted to two models. The first one is that of equality voting, expressed as one member, one vote. The second responds to a vote distribution according with objectives criteria like size of land owned by members or volume of water used by them.

Management board is a body charged of policy development and routine operation of WUO´s. Usually its members are elected by the general assembling and the regimen of its mandate is determined by law or by the particular rules of the organization.

Normally the chair person of a WUO´s is elected by general assembly voting and among his competences is that to represent the organization. He can be member of the management board or not, depending of particular rules of every organization.

It is possible to realize that WUO´s are institution presents all around the Mediterranean basin. An, as well, without its participation in water management is not easy to responds to the needs of persons involved in the water problems as user or as manager.

WATER LEGISLATION

In all studied countries, laws and regulations exist to order use a disposition of water by the people. In the majority of cases, water scarcity is at the origin of these norms and it serves as justification of rules that they settle down.

However, we cannot forget that in the Mediterranean basin are co-existing diverse philosophical funds of law taken root in history, the culture and religion of social groups. According with their forms of promulgations, the sources of water law can be classified into the categories following:

a) International and bilateral treaties adopted, in every country, according with its internal constitution.

b) Law in formal sense promulgated by the statal organ having the legislative power.

c) Consuetudes and usages consolidated by a long term vigence into social groups.

d) Jurisprudence expressed in the sentences pronounced by the highest court of countries that become source of law in the measure that they have to be applied by inferior tribunals.

e) Juridical doctrine formulated by experts in water rights could be a residual source of water law interpretation when the authority of its authors is accepted generally.

At the beginning of human history, during the last freezing, rain was enough to cover all water necessities. When global warming started began diminished rainfall on some zones of planet and, then, the human beings were themselves forced to transport water from its sources to satisfy their personal necessities and also to irrigate their crops. This explains why the more important old civilizations, for instance the Sumerios civilization, arose on places with abundance of water. Also they had to protect it of the floods. Channel, diques and dams were conceived to control the waters and to defend of their risks. The old communities were themselves forced to organize itself to face the floods and to prevent their injurious effects. Enormous efforts were necessary to fulfil this function and for that the community, not isolated individual them, assumed the accomplishment of management of water and protection again its threats.

During the old times the water was the first priority. Social groups fought to obtain the water that needed their families, their cattle and its cultures. Land as a pasture or as agricultural field was the essential food producer. The pacific development of this function required the formulation of laws to regulate the rights and the obligations of members into the communities in relation with the use of water.

Actually, it is possible to find out, into existing water laws, elements of the following legal systems: Customary, roman, soviet, hindú and Islamic.

The rights related to the water have consolidated like customs and traditions, transmitted of generation in generation under oral form. The study of the customary rules in matter of water evidences that this one usually responds to basic questions like the legal nature of the water, public or deprived; rights of the users in relation to its management and distribution; procedures for solve conflicts need of water use; and administration of the water. Considering the dense regulation of the consuetudinary norms it would be possible to be said that the water laws in their origin were a codification of them.

Roman laws were used in Europe and grand part of Latin America for a long period of time. Initially, those laws were the basic reference for water legislation in many European countries, especially in these seated in the north of Mediterranean region.

For the aims of this study, the Islamic law deserves special attention. The value of water in Islam is reflected in the Holy Quran whom it indicates that "from water was created each alive creature". In addition, Mohammed prophet declared that all the people have free access to the water.

In agreement with the quoranic doctrine, the wells were protected not allowing dig new wells in the proximity of the old ones. The protection area received the name of "harim".

As a religious institution, it was established the waqf or collective property of some sources and water.

In this context, some of the water resources and the wells were declared as "waqf" and all the public had the right to use them.

Generally, the Islamic water right responds to two fundamental necessities, the necessity to satiate personal thirst and the demand of cattle. And, when water is available, the necessity to irrigate lands and crops.

The sources of Islamic water law are:

1.- Holy Quran

Holy Qurant contains 500 ayats[2] concerning water which are reflected in Islamic water laws.

2.- Suma or Hadiths

Prophet Mohammed´s instructions and explanations of certain problems considered as guideline to solve new questions.

3.- Ijma

Express the consensuated opinion of all Muslim community on a matter. The Ijma authority is based on Prophet Mohammed´s sentence: my people will never agree on error.

4.- Qivas

This term express deduction by analogy. It not accepted in the domain of fundamental principles of Islam.

5.- Customs

[2] The text of Holy Quran is divided in 114 suras, or azoras, placed of way that gives precedence to longest on shortest. These suras can be classified by the place in which they were revealed: Mecca or Medina. The first, most poetics, usually transmit a powerful sensation to the listener, inasmuch as they speak of the relation of the world with God, whereas those of Medina rather usually they contain legislation. These suras are divided, as well in versicles (ayat, or aleyas), having the Holy Quran in their totality, about 6,700 versicles.

The customs are respected in Islam and cab be used as source of law when it is proved that they are not contrary to the fundamental principles of Islam.

The Ottoman Empire played an important role in the diffusion and implantation of Islamic law. During the period 1300-1922 the ottoman legal system was integrated by Islamic Shariah and, also, decrees of Sultan. In the 19th century, civil law was modified to adequate to the real needs of the society and provide solutions to the problems originated by differences among the Muslims and, also, by the relations with neighbouring states. These changes, also based in Islamic principles, were effective till the final of Empire in 1923. After that, Turkey established the Turkish Civil Code of 1926 that was adopted by other countries.

Algeria, Morocco, Tunisia, Indonesia and India were the first states that established water laws during the period of colonial domination. Others like Iraq, Lebanon, Jordan and Palestine used the Ottoman laws, in addition to its national laws. All of that were inspired by the Islamic foundations. The water resources were considered property of the state being, therefore, necessary the governmental approval for their use. When these countries assumed their own sovereignty, they instituted his own regulations and laws for the use of the water resources; this is the case of Iraq and Jordan. Other countries like Saudi Arabia, Yemen and Omán use the Islamic Shariah as it bases for his water laws.

Egypt has used local regulations for the management of its water resources since the nineteenth century.

International rules, needed from treaties and bilateral agreements, are essential to know the water law in the Mediterranean basin due to the fact that water flux under its own impulse and, in many cases, its course exceeds the limits of the nations. Very often, the share of a source of water is a permanent cause of conflict as happen when a river or a lake acts like border between countries. In transboundary rivers, the construction of dam upstream may affect the water available down. The agreement on the water availabilities in one or another country usually is cause of frequent disputes. Water quality affected by irrigation practices upstream is other additional problem in the shared waters. Finally, use of ground water of aquifers extended under different national territories creates very complex problems with difficult solution.

Navigation, pollution, dam security and environment protection are other sources of international problems that make as essential the establishment of agreements and treaties among countries in order to define rights and obligations of each state and establish measures to solve conflicts.

In the legislative aspect of water in the Mediterranean region it is necessary to mention the 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" or short the EU Water Framework Directive (or even shorter the WFD).

This is the european answer to the demand of its citizens to stablish a supranational legal estructure with the aim to maintain clean rivers, lakes, groundwaters and coastal waters into European Union territory. And, where it could be possible, a good status of the waters. A representative oponion pool Eurobarometer (2005), in all of 25 countries, showed that when citizens were asked for the five main environmental issues that Europeans are worried about, near one half (47 %) of those consulted respond, in the first place, water pollution.

This Directive signifies a restructuration of european water policies followed till 2000 and it was conceived as operational tool to set down the objetives for water protection in the future.

Initialy, European water normative focused on drinking conditions and so paied attention to rivers and lakes providing the resource to this purpose, an example of that are the quality target established (1975, 1980) by european authorities. During this first legislative step, they issued norms establishing objectives of quality for fish waters, shellfish water, bathing waters and ground waters. Also, in this periode, was published the Dangerous Substances Directive.

A second phase started in 1988 during the Frankfurt ministerial seminar on water which first results were:

- Council Directive Directive 91/271/EEC, of 21 May, concerning urban waste-water treatment. This Directive proclaimed the requirement of a secondary (biological) waste water treatment, and, iven more stringent treatment where necessary.

- Council Directive 91/616/EEC, of 12 December, concerning the protection of waters agains pollution caused by nitrates from agricultural sources.

In this periode it is remakable the Commission proposal concluded as the followed new directives:

- Amendement of Drinking Water Directive adopted in November 1998.

- Council Directive 96/61/EC, of 24 September, concerning integrated pollution prevention control. This directive is adressed to large industruial instalation.

The Environment Committee of European Parlament and the Council of Minsiters of Environment requested to the European Commission to a reconsider the water police into the Community. In 1995, considering these requests this last body procaimed:

Whilst EU actions of the past such as the Drinking Water Directive and the Urban Waste Water Directive can duly be considered milestones, European Water Policy has to address the increasing awareness of citizens and other involved parties for their water. At the same time water policy and water management are to address problems in a coherent way. This is why the new European Water Policy was developed in an open consultation process involving all interested parties

This comunication was adreesed not only o the Community Institutions but as well to all intrested parties, local and regional authorities, water users and non-gubernamental organizations (NGOs). Many of them were grateful expressly for the invitation.

In May 1996, as result of this invitation, under hostage of European Commission was celebrated a Conference attended by some 250 delegates of Member States, regional and local authorities, water providers, industry, enforcement agencies, agriculture, and, among others, consumers and environmentalistes.

This conference permited to reach a consensus to draw up a single legislative framework to resolve the fragmentation operated during the precedent fases in the european water policy. The answer of the European Commission was a proposal fo a Water Framework Directive (WFD) that, after diversses vicisitudes were aproved in 2000, as 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" which aims are:

expanding the scope of water protection to all waters, surface waters and groundwaters.

- achieving “good statuts” for all waters stablishing for that a set deadline.

- water management based on river basins.

- “combined approach” of emission limit values and quality standars.

- getting prices right.

- getting the citizens involved more closely.

- streamlining legislation.

Those principles are traslated to the water policies into the operational modes, mainly, by putting in practice the policies that follow:

- River basin management.

The river basin, considered as natural and hydrological unit, is taking as base of administratives polices and water management activities. For each river into the Community must be defined its river basin district and for every one it must be formulated a river basin management plan. This plan must be updated every six years.

- Good status of waters.

In the WFD, the most important purpose into the quality water mater is the general protection of the aquatic ecosystems because the foundational Treaty of the European Union establish that the environment have to be protected to a higest level. This protection will be ordered according with a explicit calendar and will have to be refferred to both, surface water and groundwater. Ecological protection and a general minumun chemical standards are the keys to achieve both good ecological status and good chemical status.

The question of aquifer over explotation is present in the WFD that considers they are under a good management when water abstraction are limited to that portion of overall yearly recharge not necessary for ecology conditions.

Co-ordination of measures.

WFD aims to coordinate the application of all community norms referred to water use, mainly Urban Waste Treatment Directive, Nitrates Directive and Integrated Pollution Control Directive. The attainment of objectives derived from each one of those Directives had to be concreted for every river basin. In the same territorial scope the impact of the human activity must be analyzed in order to have a diagnostic on the existing deviation between the reality of the state of waters and the objective on its good state. The Member States have to identify

- The combined approach

Concerning water pollution, WFD praises the combination of control in the source with expressed necessities of environment receiver under the form of quality objectives.

- River basin managing plan

This Plan will have to contain all elements of analysis for water management at level of river basin. It will contain a detailed account of the objectives for the corresponding territory in relation to the ecological state, quantitative state, chemical state and objectives in the protected zones that must be reached in a concrete time. An important component of the Plan is the economic analysis of use of water that must be able to base discussion on cost-efficiency of all measures to be implemented. It is very important that all the parts affected by the Plan participate in its discussion and application.

- Public participation

WFD have, as fundamental agreement, the necessity of public participation in measures adoption processes concerning water management. This is reasonable because there are many social groups involved and concerned on the objectives of River Basin Managing Plan and its adoption needs the support of a balance of all interests involved in it. Moreover, the enforceability of this instrument of hydrologic planification demands a consensus among social agents, as wide as possible, on those objectives and measures to reach them.

- Seven old directives to be repealed

The WFD approach tries to rationalise the Community´s water legislation by replacing seven directives promulgated during the first legislative period. They are those dealing on surface water and its two related directives on measurement methods and sampling frequencies and exchanges of information on fresh water quality; the fish water, shellfish water, and groundwater directives; and the directive on dangerous substances discharges.

Pricing

The article 9 of the WFD implants the principle of cost recovery of all services associated to water use in the whole territory of the European Union. This supposes, in some cases, breaking with the traditional tolerance of the public power towards the low levels of recovery of the public investments in the districts of irrigation. Nevertheless, the same norm foresees that the Members States will be able to excepcionate the application of this principle in certain cases.

In all of studied countries of the Mediterranean basin exists legislation on use and management of waters. In the Mediterranean right of waters its is possible to discover one component of consuetudinary rules which roots go to the being of water problematic and, also, another component more rational or academic component faced to the duty to be of that use and management. The coexistence between both components are not easy because the first one has a wide popular support whereas the second one occurs as answers to expositions very much abstract that them of the reality that is lived day after day. Frequently, in the second one appears the influence of professional dedicated to the public Administration of water.

It is a common denominator of water legislations to define water as a public resource which special property corresponds to the collectivity. But, often, the same laws authorize the exception of this principle.

There is a general coincidence to preserve the water of the pollution but studying in deep the legislative develop of this principle it is possible to find that it is focused on pollution control more that in pollution prevention.

The purpose of this study is to describe the current situation and not to judge on kindness of private or public property or deal on the principle: who contaminates pays. Nevertheless, the previous examples illustrate the prominent fact that, like in an alluvial process, new principles joins to water laws without, in many occasions, have enough conscience, in view of the situation of every country, that there is had the safety of which it can be fulfilled by the society.

TABLES MENTIONED IN THIS REPORT

TABLE 1- Human development index (2003) in selected countries of Mediterranean Region

Countries	HDI	World ranking
Moroco	0,631	124
Algeria	0,772	103
Tunisia	0,753	89
Egypt	0,659	119
Israel	0,915	23
Jordan	0,753	90
Lebanon	0,759	81
Syria	0,721	106
Turkey	0,75	94
Greece	0,912	24
Cyprus	0,891	29
Malta	0,867	32
Italia	0,934	18
Francia	0,938	16
España	0,928	21
Portugal	0,904	27

Source: UN. Human Development Repports

TABLE 2 - Population of selected countries of Mediterranean region and its gender distribution in 2000 year

(Thousand of habitants)

COUNTRY	TOTAL	MALE	FEMALE
Morocco	29231	14549	14681
Algeria	30463	15360	15103
Tunisia	9563	4824	4740
Egypt	67285	33804	33482
Palestina	3150	1601	1549
Israel	6084	3004	3080
Jordan	4972	2590	2382
Lebanon	3398	1665	1732
Syria	16813	8456	8356
Turkey	68234	34437	33798
Greece	10975	5423	5582
Cyprus	786	387	399
Malta	392	194	198
Italia	57715	28004	29710
Francia	59278	28847	30431
Spain	40717	19970	20747
Portugal	10225	4934	5292
TOTAL	419281	208049	211262

Source: World Population Prospect. The 2004 Revision and World Urbanization Prospect. Population Division of the Department of Economical and Social Affairs of the United Nations Secretariat.

TABLE 3 - Population of selected countries of Mediterranean region and its gender distribution in 2005 year

(Thousand of habitants)

COUNTRY	TOTAL	MALE	FEMALE
Morocco	31478	15646	15833
Algeria	32854	16577	16277
Tunisia	10102	5090	5013
Egypt	74033	37120	36913
Palestina	3702	1883	1819
Israel	6725	3327	3398
Jordan	5703	2964	2739
Lebanon	3577	1753	1824
Syria	19043	9585	9459
Turkey	73193	36878	36314
Greece	11120	5494	5626
Cyprus	835	406	429
Malta	31478	15646	15833
Italia	58093	28195	29898
Francia	60496	29463	31033
Spain	43064	21148	21916
Portugal	10495	5072	5422
TOTAL	475991	236247	239746

Source: World Population Prospect. The 2004 Revision and World Urbanization Prospect. Population Division of the Department of Economical and Social Affairs of the United Nations Secretariat.

TABLE 4 - Inferred population of selected countries of Mediterranean region and its gender distribution for 2010 year

(Thousand of habitants)

COUNTRY	TOTAL	MALE	FEMALE
Morocco	33832	16804	17028
Algeria	35420	17874	17546
Tunisia	10639	5356	5284
Egypt	81133	40616	40517
Palestina	4330	2204	2126
Israel	7315	3627	3688
Jordan	6338	3283	3056
Lebanon	3773	1850	1923
Syria	21432	10798	10634
Turkey	78081	39288	38792
Greece	11205	5538	5667
Cyprus	881	429	452
Malta	411	204	207
Italia	58176	28246	29930
Francia	61535	29986	31549
Spain	43993	21597	22397
Portugal	10712	5186	5526
TOTAL	469206	232886	236322

Source: World Population Prospect. The 2004 Revision and World Urbanization Prospect. Population Division of the Department of Economical and Social Affairs of the United Nations Secretariat.

TABLE 5 - Inferred population of selected countries of Mediterranean region and its gender distribution for 2015 year

(Thousand habitants)

COUNTRY	TOTAL	MALE	FEMALE
Morocco	36152	17951	18201
Algeria	38085	19217	18868
Tunisia	11140	5604	5535
Egypt	88175	44075	44100
Palestina	4996	2544	2452
Israel	7838	3897	3942
Jordan	6956	3592	3365
Lebanon	3965	1944	2020
Syria	23802	12000	11802
Turkey	82640	41528	41113
Greece	11233	5557	5676
Cyprus	927	452	475
Malta	419	208	211
Italia	57818	28082	29736
Francia	62339	30387	31952
Spain	44372	21774	22598
Portugal	10827	5248	5579
TOTAL	491684	244060	247625

Source: World Population Prospect. The 2004 Revision and World Urbanization Prospect. Population Division of the Department of Economical and Social Affairs of the United Nations Secretariat.

TABLE 6 - Inferred population of selected countries of Mediterranean region and its gender distribution for 2020 year

(Thousand habitants)

COUNTRY	TOTAL	MALE	FEMALE
Morocco	38327	19025	19302
Algeria	40624	20491	20133
Tunisia	11604	5835	5769
Egypt	94834	47327	47507
Palestina	5694	2900	2794
Israel	8296	41345	4160
Jordan	7556	3890	3666
Lebanon	4140	2031	2108
Syria	26029	13127	12902
Turkey	86774	43538	43236
Greece	11217	5556	5661
Cyprus	972	475	497
Malta	426	212	214
Italia	57132	27760	29372
Francia	62954	30694	32260
Spain	44419	21794	22626
Portugal	10902	5294	5608
TOTAL	511900	291294	257815

Source: World Population Prospect. The 2004 Revision and World Urbanization Prospect. Population Division of the Department of Economical and Social Affairs of the United Nations Secretariat.

TABLE 7 - Inferred population of selected countries of Mediterranean region and its gender distribution for 2025 year

(Thousand of habitants)

COUNTRY	TOTAL	MALE	FEMALE
Morocco	40280	19982	20298
Algeria	42871	21613	21258
Tunisia	12028	6045	5983
Egypt	101092	50364	50728
Palestina	6422	3270	3151
Israel	8734	4363	4371
Jordan	8134	4176	3957
Lebanon	4297	211	2186
Syria	28081	14164	13918
Turkey	90565	45353	45212
Greece	11173	5543	5630
Cyprus	1014	495	518
Malta	432	215	217
Italia	56307	27371	28936
Francia	63407	30913	32494
Spain	44244	21701	22544
Portugal	10924	5312	5612
TOTAL	530005	261091	267013

Source: World Population Prospect. The 2004 Revision and World Urbanization Prospect. Population Division of the Department of Economical and Social Affairs of the United Nations Secretariat.

TABLE 8 - Population growth inference for the period 2000-2025 in selected countries of Mediterranean Region

(Thousand of habitants).

Sub-region	Countries	2000	2025	Difference	Annual growth %
South	Morocco	29231	40280	11049	1,511
	Algeria	30463	42871	12408	1,62
	Tunisia	9563	12028	2465	1,03
	Egypt	67285	101092	33807	2,00
	TOTAL	136542	196271	59729	1,74
East	Palestina	3150	6422	3272	4,15
	Israel	6084	8734	2650	1,74
	Jordan	4972	8134	3162	2,54
	Lebanon	3398	4297	899	1,05
	Syria	16813	28081	11268	2,68
	Turkey	68234	90565	22331	1,30
	TOTAL	102651	146233	43582	1,69
North	Greece	10975	11173	198	0,07
	Cyprus	786	1014	228	1,16
	Malta	392	432	40	0,40
	Itali	57	56	-1408	0,0

	a	715	307		9
	Francia	59278	63407	4129	0,27
	Spain	40717	44244	3527	0,34
	Portugal	10225	10924	699	0,27
	TOTAL	180088	187501	7413	0,16

TABLE 9 - Dynamics of water use in the world over the kinds of economic activities

(km3/year)

Sector	Assessment							Forecast		
	900	940	950	960	970	980	990	995	000	010	025
Population (million)			542	029	603	410	285	735	181	113	877
Irrigated land area (mln.ha)	7.3	5.9	01	42	69	98	43	53	64	88	29
Agricultural Use	13	95	080	481	743	112	425	504	605	817	189
	21	86	22	005	186	445	691	753	834	987	252
Municipal Use	1.5	8.9	6.7	18	60	19	05	44	84	72	07
	.61	2.5	6.7	0.6	8.5	8.3	5.0	9.8	2.8	0.8	4.1
Industrial Use	3.7	27	04	39	47	13	35	52	76	08	170
	.81	1.9	9.1	0.6	1.0	0.9	8.8	2.6	7.9	17	69
Reservoirs	.30	.00	1.1	0.2	6.1	31	67	88	08	35	69
Total (rounded)	79	088	382	968	526	175	633	788	973	431	235
	31	17	68	086	341	686	982	074	182	399	764

Remarks: Nominator - water withdrawal, denominator - water consumption.

TABLE 10 - Renewable water resources in selected countries of Mediterranean region, 2000

(Hm³/year).

Country	Renewable resources	Water withdrawal	Difference
Morocco	29	11,7	17,3
Algeria	13,9	5,91	7,99
Tunisia	4,59	3,14	1,45
Egypt	58,3	54,3	4
Israel	2	2,03	-0,03
Jordan	1	1,19	-0,19
Lebanon	4	1,75	2,25
Syria	26	11,6	14,4
Turkey	229	35	194
Greece	74	8,7	65,3
Cyprus	0,211	0,211	0
Malta	0,055	0,055	0
Italia	191	56,6	134,4
Francia	204	37,7	166,3
España	112	44,1	67,9
Portugal	69	8,3	60,7
TOTAL	1018,056	282,286	735,77

TABLE 11 - Water renewable water resources per capita in selected Mediterranean countries

Country	M^3/inhabitant
Morocco	963,5
Algeria	448,4
Tunisia	476,14
Egypt	847,4
Israel	333,3
Jordan	153,8
Lebanon	1242,2
Syria	1452,5
Turkey	3423,0
Greece	6789,0
Cyprus	305,8
Malta	144,7
Italy	3355,0
France	3472,4
Spain	2802,8
Portugal	6771,3

TABLE 12 - Exploitation index of natural and renewable water resources in selected Mediterranean countries (1999)

Country	Index (%)
Morocco	41
Algeria	25
Tunisia	57
Egypt	91
Israel	95
Jordan	n.a.
Lebanon	27
Syria	48
Turkey	15
Greece	10
Cyprus	27
Malta	50
Italy	23
France	21
Spain	33
Portugal	n.a.

Source: Plan Bleu, 1999.

TABLE 13 - Groundwater resources in selected Mediterranean countries

Country	Year of estimation	Groundwater resources km^3/year
Morocco	1991	10,00
Algeria	1989	2,30
Tunisia	1995	1,51
Egypt	1993	8,00
Israel	1994	0,50
Jordan	1997	(*) 0,27
Lebanon	1994	3,20
Syria	1993	4,20
Turkey	1998	41,30
Greece	1990	10,30
Cyprus	1993	0,28
Malta	2003	0,03
Italy	1990	43,00
Francia	1994	100,00
España	1997	29,90
Portugal	2001	(**) 4,00
TOTAL	258,79	

Sources: Margat and Valle, Plan Bleu (2000) * FAO AQUASTAT ** Earthtrends country profiles.

TABLE 14 - Groundwater pressure in selected Mediterranean countries

Country	Groundwater resources km³/year [1]	Groundwater abstractions km³/year [2]	Groundwater presure [2]/[1]
Morocco	10,00	3,80	38
Algeria	2,30	3,30	142
Tunisia	1,51	1,60	108
Egypt	8,00	2,70	33
Israel	0,50	1,00	200
Jordan	0,27	Na	na
Lebanon	3,20	0,40	13
Syria	4,20	2,30	55
Turkey	41,30	6,30	15
Greece	10,30	2,00	19
Cyprus	0,28	0,20	54
Malta	0,03	0,03	100
Italy	43,00	13,90	32
France	100,00	6,00	6
España	29,90	5,50	19
Portugal	4,00	Na	na

Source: Margat and Valle, 2000 in Blue Plan

TABLE 15 - Water demand supplied with groundwater in selected countries of Mediterranean region

Co untry	Total water demand km³/year	Grounwater sectorial water demand Supply km³/year		
		Agricul ture	u rban	Self-supplied industries
Mo rocco	11,80	3,18	0 ,61	-
Alg eria	4,50	1,4	1 ,3	0,15
Tu nisia	2,83	1,4	0 ,163	0,063
Egy pt	56,10	1,11	1 ,56	-
Isr ael	2,05	0,80	0 ,18	0,02
Jor dan	na	Na	n a	Na
Leb anon	1,25	0,31	0 ,052	0,036
Syr ia	14,41	1,90	0 ,30	0,10
Tur key	35,50	3,8	1 ,95	0,55
Gre ece	7,03	1,16	0 ,74	0,10
Cy prus	0,235	0,269	0 ,039	0,0005
Mal ta	0,059	0,0157	0 ,0082	0,0015
Ital y	40,61	8,00	5 ,40	0,50
Fra nce	40,67	1,007	3 ,381	1,594
Es	35,52	4,364	0	0,103

paña			,961	
Portugal	na	na	na	Na

Source: Margat and Valle, 2000 in Blue Plan

TABLE 16 - Percentage of water demand supplied with groundwater in selected countries of Mediterranean region

Country	Agriculture	Urban	Self-supplied industries	Total
Morocco	27	5	0	32
Algeria	31	29	3	63
Tunisia	49	6	2	57
Egypt	2	3	0	5
Israel	39	9	1	49
Jordan	na	Na	na	Na
Lebanon	25	4	3	32
Syria	13	2	1	16
Turkey	11	5	2	18
Greece	17	11	1	28
Cyprus	114	17	0	131
Malta	27	14	3	44
Italy	20	13	1	34
France	2	8	4	14
España	12	3	0	15
Portugal	na	Na	Na	Na

Source: Margat and Valle, 2000 Blue Plan

TABLE 17 - Clasification of water irrigation quality according with FAO (Ayers and Westcot, 1985)

	Use restrictions		
	None	Light	Severe
Potential problem: **S A L I N I T Y**			
CE dS/m	< 0,7	0,7-3,0	> 3,0
Potential problem: **I N F I L T R A T I O N** (ALCALINITY)			
SAR = 0 – 3 and CE =	> 0,7	0,7 – 0,2	< 0,2
SAR = 3 – 6 and CE =	> 1,2	1,2 – 0,3	< 0,3
SAR = 6 - 12 and CE =	> 1,9	1,9 – 0,5	< 0,5
SAR = 12 – 20 and CE =	> 2,9	2,9 – 1,3	< 1,3
SAR = 20 – 40 and CE =	> 5,0	5,0 – 2,9	< 2,9

TABLE 18 - Extent for salt-affected soils by continent and subcontinent

Continent or subcontinent	**Million of hectares**
Africa	80,5
Australia	357,3
Europa	50,8
Mexico an Central America	2,0
North America	15,7
North and Central Asia	211,7

South America	129,2
South Asia	87,6
South East Asia	20,0
TOTAL	**954,8**

TABLE 19 - The 1989 WHO guidelines for the use of treated wastewater in agriculture

Category	Reuse conditions	Exposed group	Instestinal nematode (arithmetic mean of number of eggs per liter)	Fecal coliforms (geometric mean of number per 100 ml)
A	Irrigation of crops likely to be eaten uncooked, sports filds, public parks.	Workers, consumers, public	≤ 1	≤ 1.000
B	Irrigation of cereal crops, industrial crops, fodder crops, pastures and tres.	Workers	≤ 1	No standard recommended
C	Localized irrigation of crops in category B if exposure to workers and the public does not occur.	None	Not applicable	No standard recommended

TABLE 20 - Caput water withdrawal for domestic and municipal usages in different regions of the world

Region	m^3/year
Africa	17
Asia	31
North and central America	167
South America	86
Europe	92
Former USSR	90
World estimation	52

Source: FAO

TABLE 21- Caput water withdrawal for agricultural usages in different regions of the world

Region	m^3/year
Africa	216
Asia	446
North and central America	912
South America	282
Europe	235
Former USSR	832
World estimation	444

Source: FAO

TABLE 22 - Caput water withdrawal for industrial usages in different regions of the world

Region	m^3/year
Africa	12
Asia	42
North and central America	782

South America	110
Europe	385
Former USSR	346
World estimation	148

Source: FAO

TABLE 23 - Theoretical demands of water, for main uses, in selected countries of Mediterranean Region in 2000

Country	Population x 1000	Irrigated land has x 1000	Water Demands Km^3/year		
			Urban	Agrarian	Industrial
Morocco	29231	1313	3,2007945	8,109088	0,25606356
Algeria	30463	385	3,3356985	2,37776	0,26685588
Tunisia	9563	410	1,0471485	2,53216	0,08377188
Egypt	67285	2650	7,3677075	16,3664	0,5894166
Israel	6084	193	0,666198	1,191968	0,05329584
Jordan	4972	154	0,544434	0,951104	0,04355472
Lebanon	3398	101	0,372081	0,623776	0,02976648
Syria	16813	1280	1,8410235	7,90528	0,14728188
Turkey	63234	2679	6,924123	16,545504	0,55392984
Greece	10975	1500	1,2017625	9,264	0,096141
Cyprus	786	39	0,086067	0,240864	0,00688536
Malta	392	0,763	0,042924	0,00471229	0,00343392
Italia	57715	3110	6,3197925	19,20736	0,5055834
Francia	59278	1400	6,490941	8,6464	0,51927528
España	40717	3840	4,4585115	23,71	0,35668092
Po	1022	750	1,119	4,632	0,089

rtugal	5		6375		571
T OTAL	4111 31	198 04,763	45,01 88445	122,3 14216	3,601 50756

Hay Que ajustar esta cifra a 1.460.000 has que se deducen del trabajo de Basilis Manos.

TABLE 24 - Theoretical demands of water, for main uses, in selected countries of Mediterranean Region in 2025

Country	Population x 1000	Irrigated land has x 1000	Water Demands Km^3/year		
			Urban	Agrarian	Industrial
Morocco	40280	1552	4,41066	9,585152	0,3528528
Algeria	42871	425	4,6943745	2,6248	0,37554996
Tunisia	12028	560	1,317066	3,45856	0,10536528
Egypt	101092	3100	11,069574	19,1456	0,88556592
Israel	8734	193	0,956373	1,191968	0,07650984
Jordan	8134	395	0,890673	2,43952	0,07125384
Lebanon	4297	85	0,4705215	0,52496	0,03764172
Syria	28081	1780	3,0748695	10,99328	0,24598956
Turkey	90565	3595	9,9168675	22,20272	0,7933494
Greece	11173	1500	1,2234435	9,264	0,09787548
Cyprus	1014	39	0,111033	0,240864	0,00888264
Malta	432	0,763	0,047304	0,00471229	0,00378432
Italia	56307	3020	6,1656165	18,65152	0,49324932
Francia	63407	1400	6,9430665	8,6464	0,55544532
España	44244	4020	4,844718	24,82752	0,38757744
Portugal	10924	820	1,196178	5,06432	0,09569424

TOTAL	523583	22484,763	57,3323385	138,865896	4,58658708

TABLE 25 - Values of satisfaction water demands index for selected countries in the Mediterranean region (2000, 2025)

Country	SWDI (2000)	SWDI (2025)
Morocco	101,1	105,2
Algeria	98,8	128,6
Tunisia	85,7	71,7
Egypt	223,2	217,6
Israel	106,2	103,3
Jordan	77,3	73,4
Lebanon	170,6	290,3
Syria	117,2	125,0
Turkey	145,6	152,2
Greece	82,3	na
Cyprus	63,2	na
Malta	107,6	na
Italia	217,4	232,7
Francia	240,7	261,3
España	154,5	166,0
Portugal	142,0	133,7
TOTAL	165,1	

TABLE 26 - Values of participation of agriculture in the gross domestic product

(thousand millions USD)

		%		
Country	GDP	Agriculture	Industry	Services
Morocco	128,3 (4)	22,9	35,45	41,5
Algeria	196,0 (3)	10,2	56,5	33,4
Tunisia	68,23 (4)	13,9	32,2	53,9
Egypt	294,3 (3)	17,0	33,0	50,0
Israel	120,9 (4)	2,8	37,7	59,5
Jordan	23,64 (4)	3,6	29,0	67,4
Lebanon	17,82 (4)	12,0	21,0	67,0
Syria	58,01 (4)	28,5	29,4	42,1
Turkey	455,3 (3)	11,7	29,8	58,5
Greece	212,2 (3)	6,7	22	71,2
Cyprus (Gr)	8,90 (3)	4,9	19,9	75,6
Cyprus (Tk)	1,22 (3)	10,6	20,5	68,9
Malta	7,082 (3)	3,0	23,0	74,0
Italia	1.552 (3)	2,2	28,9	68,9
Francia	1.654 (3)	2,7	24,4	72,9
España	885,5 (4)	3,6	28,6	67,8
Portug	181,8	5,8	30,7	63,2

al	(4)			

Fuente:
www.classbrain.com/art_cr/publish/printer_**morocco_economy**.shtml
(Yahoo; country economy)

TABLE 27 - Specific water demands for selected agricultural products

Products	Specific water demands (m3/kg)
Apples	0,387
Bananas	0,499
Barley	1,910
Dates	1,660
Grapes	0,455
Grapefruit	0,286
Groundnuts	2,547
Lemons, limes	0,344
Maize	0,710
Oats	2,374
Olives	2,500
Onions	0,168
Oranges	0,378
Patatoes	0,105
Pineapples	0,418
Pulses	1,754
Rice	1,408
Rye	1,159
Sorghum	0,542
Soybeans	2,752
Sugar beet	0,193
Sugar cane	0,318
Sunflower	3,283
Tomatoes	0,130
Tree nuts	4,936
Wheat	1,159

Source: Zimmer and Renault, 2004.

TABLE 28 - Specific water demand for selected animal products

Products	Unit considered	Water (m^3/unit)
Cattle	Head	4.000
Sheep and goats	Head	500
Fresh beef	Kg	15
Fresh poultry	Kg	6

Source: FAO, 1997. UN World Water Development Repport.

TABLE 29 - Values of virtual water imports for selected countries in the Mediterranean Region

Country	Hm^3/year
Morocco	5.530,4
Algeria	9.803,7
Tunisia	3.867,4
Egypt	16.035,5
Israel	4.598,2
Jordan	4.481,0
Lebanon	746,8
Syria	- 4.378,6
Turkey	2.053,1
Greece	- 1.966,6
Cyprus	1.064,8
Malta	271,7
Italy	12.863,7
France	- 17.675,1
Spain	16.503,6
Portugal	6.228,1

Source: Hoekstra and Young (2003)

TABLE 30 - Situation and forecast of irrigated lands (thousand hectares) in selected countries of the Mediterranean Region

Country	1990	2000	2010	2025
Morocco	1270	1313	1353	1552
Algeria	238	385	406	425
Tunisia	280	410	490	560
Egypt	2607	2650	3000	3100
Israel	206	193	193	193
Jordan	63	154	276	395
Lebanon	86	101	102	85
Syria	693	1280	1480	1780
Turkey	2370	2679	3116	3596
Greece	1163	1460	na	na
Cyprus	na	39	na	na
Malta	na	0,763	na	na
Italia	3120	3110	3160	3020
Francia	1170	1400	1500	1400
España	3370	3840	4100	4020
Portugal	630	750	820	820

DEFINITIONS

Irrigation system, by basins.- Basin irrigation is the most common form of surface irrigation, particularly in regions with layouts of small fields. If a field is level in all directions, is encompassed by a dyke to prevent runoff, and provides an undirected flow of water onto the field, it is herein called a basin. A basin is typically square in shape but exists in all sorts of irregular and rectangular configurations. It may be furrowed or corrugated, have raised beds for the benefit of certain crops, but as long as the inflow is undirected and uncontrolled into these field modifications, it remains a basin (Source: Walker, W.R., 1989, Guidelines for designing and evaluating surface irrigation systems).

Irrigation system, by borders.- Border irrigation can be viewed as an extension of basin irrigation to sloping, long rectangular or contoured field shapes, with free draining conditions at the lower end. Water is applied to individual borders from small hand-dug checks from the field head ditch. When the water is shut off, it recedes from the upper end to the lower end. Sloping borders are suitable for nearly any crop except those that require prolonged ponding. Soils can be efficiently irrigated which have moderately low to moderately high intake rates but, as with basins, should not form dense crusts unless provisions are made to furrow or construct raised borders for the crops. The stream size per unit width must be large, particularly following a major tillage operation, although not so large for basins owing to the effects of slope. The precision of the field topography is also critical, but the extended lengths permit better levelling through the use of farm machinery. (Source: Walker, W.R., 1989, Guidelines for designing and evaluating surface irrigation systems).

Irrigation system, by furrows. Furrow irrigation avoids flooding the entire field surface by channelling the flow along the primary direction of the field using 'furrows,' 'creases,' or 'corrugations'. Water infiltrates through the wetted perimeter and spreads vertically and horizontally to refill the soil reservoir. Furrows are often employed in basins and borders to reduce the effects of topographical variation and crusting. The distinctive feature of furrow irrigation is that the flow into each furrow is independently set and controlled as opposed to furrowed borders and basins where the flow is set and controlled on a border by border or basin by basin basis.

Furrows provide better on-farm water management flexibility under many surface irrigation conditions. The discharge per unit width of the field is substantially reduced and topographical variations can be more severe. A smaller wetted area reduces evaporation losses. Furrows provide the irrigator more opportunity to manage irrigations toward higher efficiencies as field conditions change for each irrigation throughout a season. This is not to say, however, that furrow irrigation enjoys higher application efficiencies than borders and basins.

There are several disadvantages with furrow irrigation. These may include: (1) an accumulation of salinity between furrows; (2) an increased level of tailwater losses; (3) the difficulty of moving farm equipment across the furrows; (4) the added expense and time to make extra tillage practice (furrow construction); (5) an increase in the erosive potential of the flow; (6) a higher commitment of labour to operate efficiently; and (7) generally furrow systems are more difficult to automate, particularly with regard to regulating an equal discharge in each furrow. (Source: Walker, W.R., 1989, Guidelines for designing and

evaluating surface irrigation systems).

Irrigation system, uncontrolled flooding.- There are many cases where croplands are irrigated without regard to efficiency or uniformity. These are generally situations where the value of the crop is very small or the field is used for grazing or recreation purposes. Small land holdings are generally not subject to the array of surface irrigation practices of the large commercial farming systems. Also in this category are the surface irrigation systems like check-basins which irrigate individual trees in an orchard, for example. (Source: Walker, W.R., 1989, Guidelines for designing and evaluating surface irrigation systems).

Human Development Index (HDI). The HDI is a socio-economic index used by United Nations Development Programe that measures the average achievements in a country in three basic dimensions of human development:

A long and healthy life, as measured by life expectancy at birth.

Knowledge, as measured by the adults literacy rate (with two-thirds weight) and the combined primary, secondary and tertiary gross enrolment ratio (with one-third weight).

A decent standard of living, as measured by GDP per capita (PPP US$).Calculation of HDI is an evolving methodology, and comparisons should not be made between years (when methods might have varied) but can be made between countries, as issued by the same source.

Uncontroled flooding irrigation system.

Water.

Blue water: water supplied by irrigation.

Green water: water supplied by ranfall.

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stablization ponds. In the case of employ drip irrigation systems an additional process of sedimentation are required.