CHAPTER 7

Present and future roles of water and food trade in achieving food security, reducing poverty and water use

Juan A. Sagardoy
Mediterranean Agronomic Institute of Bari, Italy (MAI–B); International Center for Advanced Mediterranean Agronomic Studies (CIHEAM)

Consuelo Varela-Ortega
Technical University of Madrid, Spain (UPM)

ABSTRACT: The development of scarce water resources in the Mediterranean Region has been very important to satisfy the high demands for food, drinking and industrial water of a population that at regional levels has increased substantially. The chapter analyses, in the first part, the past trend of the irrigation development and the future demand. It is evident that irrigation development has contributed substantially to increase the food security. From the point of view of the water resources irrigation development has been and continues to be the largest user. Although irrigation areas have been growing substantially over the last 25 years the possibilities for continue such trend appear small, exception made of few countries, due to scarcity of the water resources. The chapter also reviews the interrelations between poverty, hunger, gender with the development of the water resources and the increased agricultural trade.

The scarcity of the water resources has reached alarming levels in several countries of the Region that made a call to reconsider the future options. One of such option is to use agricultural trade as a source to supplement the national agricultural production capacity. But here several options open to countries in terms of deciding what to produce and what to import/export. The concept of virtual water developed in recent years has helped to understand better the implications of trade in terms of water. However, this concept has not yet penetrated the sphere of the trade decision makers. The chapter intends to look further into this possibility by analyzing historical statistical data (production, irrigation areas, net trade and virtual water) of two selected countries (Egypt and Syria) to identify feasible possibilities of modifying the production cropping pattern – and consequently the trade– so that the water resources are used more efficiently.

The second part of the chapter focuses on a specific country (Syria) to assess the implications that would have changing the cropping pattern of main crops (wheat, cotton, maize) so that the water resources are used in a more sustainable manner while the income of the farmers do not deteriorate. This analysis is made at farm level and shows that, when attempting such changes, other aspects (labor, environmental consequences and incomes) are also important considerations. The consequences of this change at farm level are extrapolated at the national level to analyze the impact that such changes will have in the agricultural trade and the consequences for the government.

The chapter concludes that analyzing trade and production data through *water policy lenses* provides useful orientations regarding possible changes that can be attempted in the production and trade. However political decisions require consideration of several other factors that affect the production patterns and this may call for detailed studies. Ultimately governments have to make trade off choices between the trade policies and the use of the production factors.

Keywords: water resources, irrigation development, virtual water, agricultural trade, food security, poverty, Mediterranean Region

1 INTRODUCTION

The development of the water resources has been mainly geared to satisfy the food and domestic demand of the increasing population by expanding the irrigation areas and extending the distribution of domestic water supply. However this policy is approaching the limits of the available water resources in many countries and new ideas and policies are emerging that are influencing the sector. These new trends are reflected by the evolution of the different paradigms that have been proposed in the last decades. The first one was *more food per drop* that soon evolved to *more crops and jobs per drop* and now recently to *more cash and nature per drop.*

It is clear that several countries of the Mediterranean Region have not sufficient water resources to produce all the food they need and will have to rely on the import of food. The number of countries in this situation is likely to increase in the future. Consequently, it is relevant to look into the likely impact of the agricultural trade in the use of water resources. This has been done through the work on *Virtual Water* (VW) and *Foot print Water* by several authors (Chapagain & Hoekstra, 2004). The concept of virtual water has contributed to understand the flows of water involved in food trade, however rarely are used as a policy decision instrument. The chapter, in its second part, will simulate with a country example what are the issues that policy makers will have to face when reorienting production having into consideration the agricultural trade

The geographical focus of this chapter is the Mediterranean Region. The reason for this selection is related to aridity conditions of this region that makes the role of available water resources very essential, and the second reason to the fact that agricultural trade among all Mediterranean countries is already intensive and is likely to increase in the future. This second point is particularly relevant for the scope of the chapter.

2 THE PRESENT SITUATION OF THE WATER RESOURCES DEVELOPMENT AND MANAGEMENT

The available natural water resources per capita in the countries of the Mediterranean Region are the lowest among other regions of the world. For this reason their development and management constitute one of the leading sectors in the government actions. So far governments have tried to respond to the increased demand by spending sizeable sums of their budgets in the development of the resources (regulating dams, distribution networks, etc.). However, it has become evident that for several countries this policy is no longer possible due to the scarcity of the water resources and other alternatives need to be considered including demand management. There is however a great variability of situations and a closer analysis is needed and is attempted in the following sections.

2.1 *A Region of limited natural renewable water resources and high demand*

In the Mediterranean countries there is considerable variability of available natural water resources and their use by the populations of the respective countries. Figure 1 illustrates this variability. The scarcity index (the ratio of total water withdrawals/average natural renewable resources flow) already exceeds 50% in eight Mediterranean countries. When such rates reach or even exceed 100%, they indicate that there is a deliberate, but unsustainable use of non-renewable resource (Libya) or indeed reuse of part of the non-conventional resource such as treated wastewater or drainage water as in Egypt and Israel. However, the scarcity index refers to the totality of renewable water resources; the situation would appear even more critical if the indicator is referred to those resources considered exploitable (Hamdy & Lacirignola, 2005). In this case, a more dramatic picture will emerge, but the criteria used for determining the exploitable resources are quite variable and the figures are hardly comparable and hence the analysis is restricted to the natural renewable water resources.

However not only the availability of water resources is limited but also the variability of their occurrence is very high. Thus the figures of the natural available water resources can be misleading since only a small fraction of them is available under natural conditions. This makes necessary the

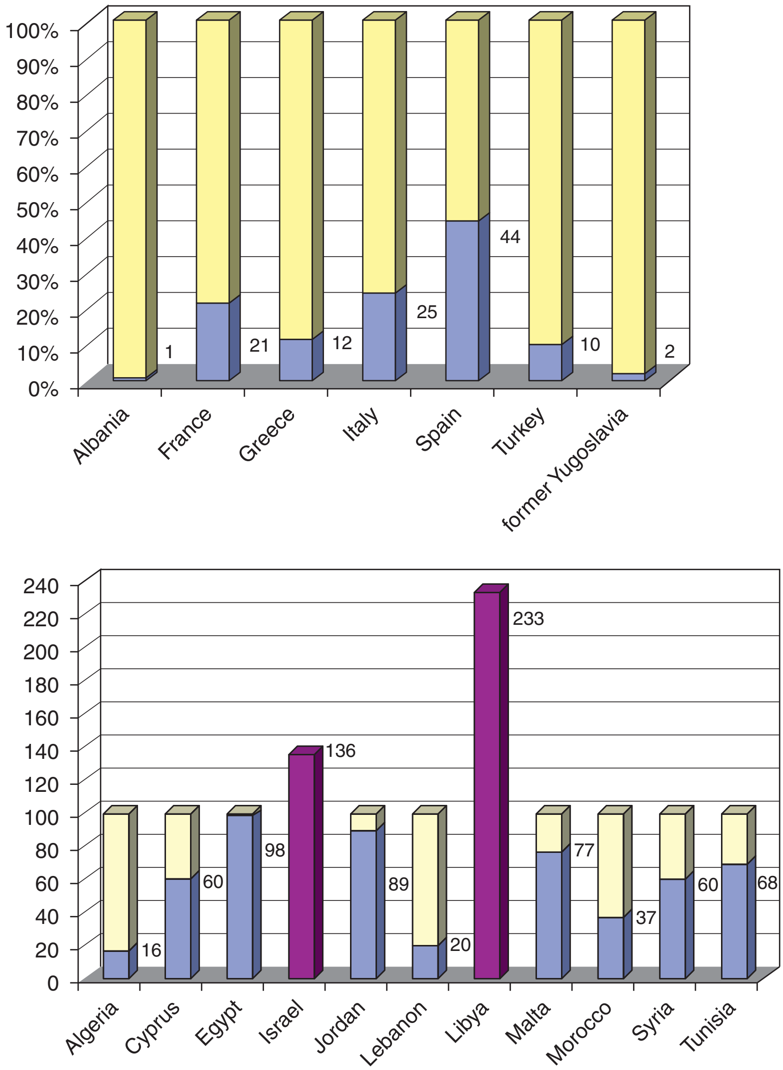


Figure 1. Ratio between the total water withdrawal and average natural renewable water resources (in percentage).
Source: Hamdy & Lacirignola (2005).

construction of regulating dams and in fact the Mediterranean region contains the largest proportion (80%) in the word of available water resources regulated by dams. Although dams have been the object of heated debates particularly from environmentalists, recognizing that the construction of some would be difficult to justify, the large majority has brought considerable benefits to the Region.

From the present high levels of regulation: 80% according to the World Bank (2006), is implicit that the opportunities for more regulating dams are very small and surely they are highly expensive and difficult to justify in economic terms. Here again another limit is being approached.

Most of the studies carried out about the water resources in the Mediterranean agree that there are three groups of countries that can be established:

The first group consists of countries where water availability will remain adequate up to 2025 and beyond, and where there is even a fairly comfortable margin for increased per capita draw-offs. This

Table 1. Water uses in the Mediterranean Region (in percentage).

Water Uses	Northern countries (%)	South and East countries (%)
Agriculture	49	79
Domestic	13	13
Industrial	38	8

group includes some countries with low population growth (France, Italy, ex-Yugoslavia) and some with stronger population growth (Albania, Turkey, Lebanon). In these countries there are limited possibilities for irrigation expansion provided that it keeps pace with the growth of population.

The second group is made of countries where water resources are barely adequate at present and this include: Spain, Morocco, Algeria and Cyprus. Any significant growth in the per capita draw-off or further increase of the irrigation areas will put these countries quite quickly in the critical situation being faced by the countries in the next group. Demand management is absolutely essential in these countries.

The third group is made by the countries where current water availability is already limited or negligible and includes: Malta, Egypt, Syria, Libya, Israel, Jordan, Tunisia and Palestinian Territories. These countries will probably have to face per capita draw-offs of conventional resources, or compensate it through the import of virtual water or increase dramatically the use of non-conventional water resources. As this second alternative may be too expensive for agricultural uses it is evident that food trade, and consequently virtual water, will play a major role in the future of these countries. The consequences of being a net importer of food are that the country has to dedicate a good part of the economic resources produced in the country to purchase agricultural goods produced elsewhere. It becomes therefore critical in these countries to allocate water to the most beneficial uses, use water with high efficiency and when possible to produce agriculture products of high value. Under these assumptions virtual water can play an important role.

It is evident that each group will require different policies to maintain satisfactory levels of use, and even within each group the conditions of every country will surely justify somewhat different emphasis in the policies applied.

2.2 *Water sectorial uses: domestic and industrial uses gaining grounds*

The sectorial uses of water in the Mediterranean Region are quite different in the North and South-East countries as indicated in Table 1. This clearly indicates the different economic development trends in both regions and in particular the different development of the industrial sector. It remains the fact that irrigation uses are very high in the South-East Mediterranean Region (SEMR) as agriculture remains an important sector of the economy while in the Northern countries the contribution to the GDP is less than 5%.

The figures of Table 1 do not reflect an important trend that is taking place in the domestic uses of the SEMR where the growth of the population is still high and where future demand is expected to increase several times the present values. Furthermore the coverage of the water supply in the EU countries is practically 100% while in some Mediterranean countries (Morocco, Algeria, Syria, Jordan and Egypt) still the coverage, particularly in the rural areas, is often far from complete as shown in Figure 2.

The growth of tourism in the Mediterranean countries exerts a strong seasonal increase of the domestic demand considering that the estimated number of tourists exceeds 250 million with an estimated demand of 1,000 Mm^3/yr. The basic question remains if these additional needs can be met from existing water resources or unconventional water resources will have to be developed. Another feasible alternative would be to reduce the agriculture use (using more virtual water) and transferring resources to the domestic and industrial sectors.

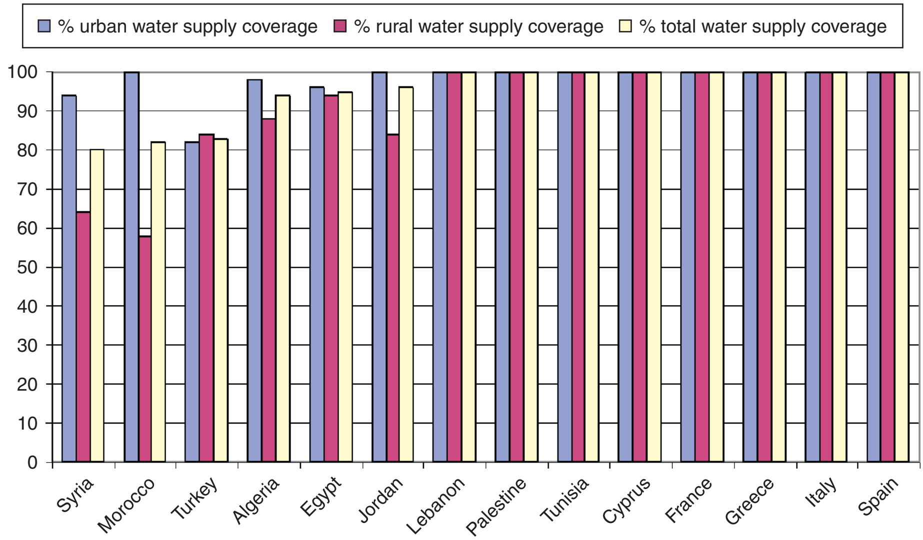


Figure 2. Percentage of coverage of the domestic water supply.

The use of non-conventional water resources can be an important component of coping with the future demand, particularly in the domestic and industrial sectors. Their use for agriculture is very limited as the costs are incompatible with the production of most crops. Countries of the MENA (Middle East and North Africa) Region are increasingly producing water for municipal and industrial use by removing salt from sea or brackish water. The region has 60% of the world's capacity and has been using this technology to supply more than half of all municipal water needs since 1990, producing 2,377 Mm^3/yr (World Bank, 2006). It is therefore foreseeable that they will continue to play an important role in satisfying the demand of the domestic and industrial sectors. Therefore it is foreseeable that much of the demand of the urban-industrial sector will be met from these non-conventional resources and will not add additional pressure over the existing conventional water resources.

2.3 *Investing in water resources development. The EU structural support policies and other financial resources*

The structural policies were established in the European Community (EC) to support the development of regions that have lower indexes of economic development than the averages. Essentially they are funds that do not need to be returned and constitute a part of the investments made. The main sources are the FEDER (European Fund for Regional Development), the Cohesion Funds, and the FEOGA (European Fund of Agricultural Orientation and Guarantee). In general, the subsidy ranges between 10 and 25% of the total investments, and the requesting regions must comply with the eligibility criteria. These European funds (FEOGA and Cohesion Fund) have been widely used in the National Plan for the Modernization of Irrigation in Spain, but still the larger part of the total investments is shared in nearly equal parts by the government and the users.

To some extent this policy has greatly contributed to the irrigation development in Spain which is one of the countries that have been using these European funds intensively in the modernization plan and in the provision of domestic water supply (FEDER). However, not all European Union (EU) countries of the Mediterranean Region has been using these funds effectively, as for example Italy and Greece, where there is a real contraction of the irrigated area (Table 1) particularly in the period 2000–2009.

The countries outside of the EU in the Mediterranean region have heavily invested in water development works. The investments represent a sizeable share of the public expenditures ranging from 20% (Algeria) to 30% (Egypt and Morocco) (World Bank, 2006). Large public expenditures do not mean that the money has been expended efficiently. Many local experiences document the contrary. The lack of accountability in these expenditures is perhaps one of the most serious problems that the sector was facing and continues to dominate the sector. The World Bank (2006) estimates that the public investments made in the water sector of the MENA (Middle East and North Africa) Region range between 1.3% (Algeria) to 3.6% (Morocco and Egypt) of the GDP, which are relative important percentages but do not show any excessive weight in the GDP considering that the weight of the whole agricultural sector is between 13 and 15% of the GDP for the SEMR countries (Table 4). These figures exclude what the private farmers and individuals have invested in irrigation, which also is an important figure considering that much of the development of the groundwater has been done by private farmers. If this would be included the above figures will increase substantially.

In the EU countries most of these investments have been used for the development of new areas and the domestic water distribution works, but in recent years modernization of the irrigation networks has taken a substantial share, particularly in Spain. For the SEMR countries, the expansion of the irrigated area has continued and constitutes the greater part of the investments. The modernization of irrigation systems is limited to some modest government contribution to the farmers willing to modernize their irrigation methods. As traditional surface water distribution methods (mostly using rotations of different kinds) are incompatible with the requirements of localized irrigation, this type of modernization has been largely restricted to groundwater areas where the water availability is not constrained by rotation rules.

3 IRRIGATION DEVELOPMENT. APPROACHING THE LIMITS

Governments and private individuals have invested large sums to provide irrigation water to their farms. The main reason for governments to support this development is to increase the food security of the country, provide employment and additional rents for farmers. Individual farmers are mostly geared by the aim of improving their financial situations but they contribute to increase food security directly or indirectly (by the exports). In the following sections the past trends are reviewed and the future possibilities discussed.

3.1 *The past irrigation expansion. Was population growth a real driver?*

Table 2 provides an overview of the irrigation development in the last 25 years for selected EU and SEMR countries. The growth patterns of the EU countries are quite high although they tend to be lower than those of the SEMR, exception made of France where the irrigated area is mostly made of supplemental irrigation where the additional irrigation water provided to crops are lower than for the rest of the countries. However this has proved to be economically attractive (largely due to the relatively low cost of the available water) and has produced a large expansion of the irrigated area in France. However in nearly all countries a slowdown of the growth during the last period reported is evident.

For the SEMR countries, the data available show the impressive growth made by all of them. Even Egypt that has extremely limited water resources has been able to expand the irrigated area in a substantial manner. In the case of Egypt much of this expansion is due to the reuse of drainage water making the overall water use efficiency of the country rather high. Another interesting case is Syria where a large expansion has taken place but the country has reached the ceiling of the available water resources and recent information (Sagardoy & Varela-Ortega, 2007) shows a decline in the irrigated area. In general the SEMR countries have made enormous effort to cope with the demand but the level of efficiency in the management of the resources is low.

Table 2. Irrigated land and its share in arable land and permanent crops for selected countries of the Mediterranean region.

Countries	Irrigated land 79–81 (10^3 ha)	89–91 (10^3 ha)	99–01 (10^3 ha)	02–03 (10^3 ha)	% of increase	Share in arable land and permanent crops 79–81 (%)	89–91 (%)	9–01 (%)	03 (%)
EU Countries									
France	1,369	1,980	2,628	2,600	89.87	7.24	10.33	13.44	13.28
Greece	950	1,200	1,441	1,431	50.58	24.16	30.33	37.34	37.93
Italy	2,400	2,615	2,699	2,750	14.58	19.30	21.92	23.93	25.71
Spain	3,028	3,387	3,719	3,780	24.83	14.77	16.77	20.31	20.20
Subtotal	7,748	9,183	10,487	10,561	36.31				
SEMR Countries									
Egypt	2,453	2,621	3,310	3,422	39.48	100.00	100.00	98.19	99.94
Morocco	1,208	1,258	1,397	1,445	19.59	14.96	13.45	14.60	15.41
Syrian Arab Rep.	548	717	1,221	1,333	143.10	9.60	12.88	22.47	24.59
Tunisia	232	328	393	394	69.83	4.83	6.75	7.90	7.99
Turkey	2,712	4,024	4,743	5,215	92.32	9.48	14.50	17.89	20.05
Subtotal	7,154	8,948	11,064	11,809	65.08				
Total	14,901	18,130	21,551	22,370	50.12				

Source: FAOSTAT (FAO, 2009).

The other important point that Table 2 illustrates is that the share of the irrigated area in the arable land and permanent crops has also increased considerably. In most cases the percentage of the increase exceeds the 100% reaching 200% and more (Turkey and Syria). In any case the higher the percentage the higher is the dependency of food security on irrigated agriculture. But even more important is the fact that even when the share is around 20% the value of the corresponding agricultural production is often larger than 50%. For this reason most countries in the region have seen irrigation development as the main strategy to ensure food security.

One relevant question is to what extend the above growth of the irrigated areas correspond or is parallel to the growth of the population to ensure their food needs. A simple way to estimate this relationship is to compare the growth of the irrigated area with the growth of the population. Table 3 provides the estimation of the growth of the population for selected countries and the growth of the irrigated area for the years 1980 and 2003. An indicator has been developed to relate irrigated area with population by dividing the two factors. It can be observed that the indicator of the number of persons to the irrigated hectares has decreased in general for most countries and therefore the situation has generally improved. However, when the percentages of increase in the number of person per irrigated hectare are compared with the percentages of increase in the population, the picture changes considerably. Most of the European countries show that the percentage of increase in persons per irrigated hectare is greater than the percentage of growth of the population while it is the opposite for most of the SEMR countries during the period considered. In other words, the capacity of the irrigated lands to contribute to food security has improved for most countries, but not sufficiently to compensate the growth of the population in most of the SEMR countries and for some, like Egypt and Tunisia, it has deteriorated. However for most of the European countries the situation has improved except for Spain.

The above consideration explains why the agricultural trade has increased substantially in the period considered. In particular the imports have increased much more than the exports (see Table 5) for most countries of the region and particularly for the SEMR countries. In a way, the SEMR countries have decreased its food security in relative terms and this is compensated by the increase in trade.

Table 3. Irrigated area per capita of selected European countries (1980–2003).

Countries	Year 1980 Persons (10^3)	Year 1980 Irrigated (10^3 ha)	Year 1980 Persons per irrigated ha	Year 2003 Persons (10^3)	Year 2003 Irrigated (10^3 ha)	Year 2003 Persons per irrigated ha	% decrease [increase –] of the persons per ha	% population growth
EU Countries								
France	53,950	1,369	39	61,013	2,600	23	40	13
Greece	9,643	950	10	11,064	1,431	8	24	15
Italy	56,307	2,400	23	58,645	2,750	21	9	4
Spain	37,527	3,028	12	43,060	3,780	11	8	15
Subtotal	159,407	7,748	21	175,785	10,561	17	19	10
SEMR Countries								
Egypt	44,433	2,453	18	77,154	3,422	23	−24	74
Morocco	19,567	1,208	16	30,495	1,445	21	−30	56
Syria	8,971	548	16	19,121	1,333	14	12	113
Tunisia	6,457	232	28	9,878	394	25	10	53
Turkey	46,161	2,712	17	71,169	5,215	14	20	54
Subtotal	125,589	7,154	18	207,817	11,809	18	0	65

Source: UN, 2008; FAOSTAT (FAO, 2009).

3.2 *What future for irrigation development?*

Several institutions (FAO, INWI, World Bank, Plan Bleu and others) have developed scenarios of the possible future development of irrigation in the next 25–50 years at the global, regional and national scales. Most of them agree that the future development of irrigation will be selected and limited to few countries in the world that will be the main drivers of this development.

At the Mediterranean level the Plan Bleu has been particularly active in this area, and Figure 3 contains the projections made for the future water demand up to year 2025 (Benoit & Comeau, 2005). Only 3 countries, namely Turkey, Egypt and Syria show an important growth of the demand with regard to the present situation. For most countries of the Mediterranean, the foreseeable expansion of the water demand is small. For some European countries like Italy and France even a decline is foreseen. Consequently for most of the Mediterranean countries the expansion of the irrigated area will be modest partly due to the scarcity of water but also due to the fact that the demand is not increasing in a substantial manner. For those countries where the demand will grow significantly, like Syria and Egypt, and do not have enough water resources to satisfy the future demand, much will depend on the international agreements with neighbor countries to obtain additional water resources or they will have to increase the imports of agricultural products. Turkey has enough water resources to meet the increasing demand so it is foreseeable that the expansion of irrigation will continue for some time.

Certainly, the demand management represents an additional possibility to increase food production with a more efficient management of the existing water resources (*more crops per drop*). This search for a greater efficiency will continue in most countries of the region. While some countries, like Spain, are betting strongly on this option, most countries of the Region move slowly in this direction limiting their support to some economic incentives for those farmers willing to invest in the modernization of their irrigation systems.

4 FOOD SECURITY, POVERTY AND HUNGER

The basic equation of food security is that what is produced internally plus the net balance of imports and exports should be adequate to cover the needs of the country populations, provided that the people have the financial resources to buy the necessary food. It is precisely this last *proviso*

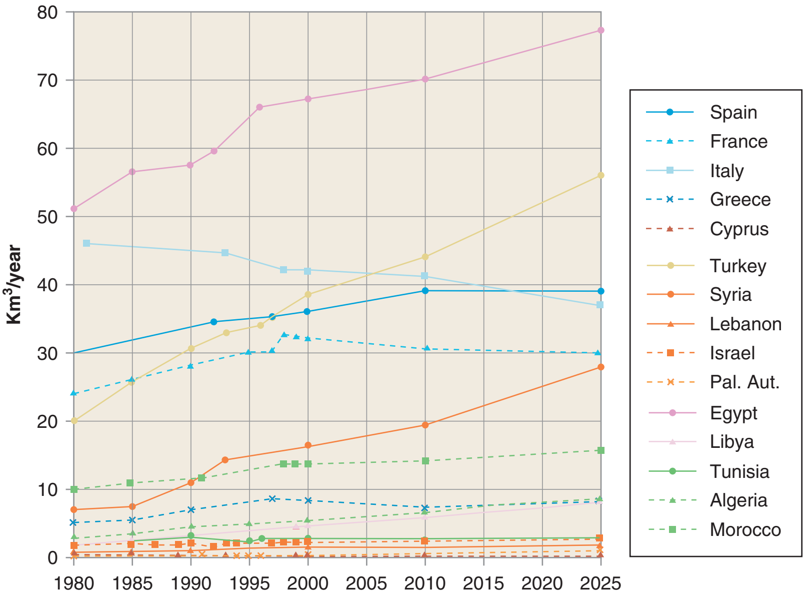


Figure 3. Total water demand by country in the Mediterranean (1980–2025).
Source: Plan Bleu, baseline scenario (Benoit & Comeau, 2005).

that during the last few years has been missing in many countries and that has produced an increase of 75 million people of undernourished people. According to the FAO estimates, in 2003–2004 the number of undernourished people was 848 million while it has increased to 923 in 2007 (FAO, 2008). This is largely attributed to the increases in food prices during this period. As the trend of high prices has continued in 2008 the figure of hungry people has increased further. In fact, the estimations for 2009 are of 1,000 million of undernourished people.

It is remarkable that hunger has increased as the world has grown richer and produced more food than ever in the last decade. This shows that in reality the levels of under nourishment are more connected to poverty than to the food production capacity. It also shows that when such circumstances arise, those that suffer most are the poorer strata of the society: landless workers and females-headed households. On the other hand high prices are also an opportunity for small farmers if the increases in food prices are accompanied for higher prices of inputs that may write off any potential gain.

While the above arguments are of fundamental importance at world level, when we look at the Mediterranean Region the situation is less dramatic because the levels of food insecurity in most countries of the Region are low. Figure 4 shows the *Hunger Map* prepared by FAO and it is evident that for all countries of the Mediterranean the under nourishment levels are below 5%, exception made of the Palestinian Territories where the level is estimated at 34%.

At country level there are large differences in the Region. The percentage of poor people in Syria is 61%, out of which approximately 19% of people are estimated as food insecure; in Egypt the population still falling below the poverty line is 23%; in Jordan this percentage varies between 15–20% due to the country's very limited resources and high dependency on imported food and agricultural products. In the Palestinian Territories 34% of the population is food insecure and the proportion of households living under poverty conditions reaches 60%, a number that gets to 73% in households headed by women[1].

[1] Most of the poverty and malnutrition figures mentioned here are coming from national reports where the criteria used to define poverty and under nourishment were different from those used internationally.

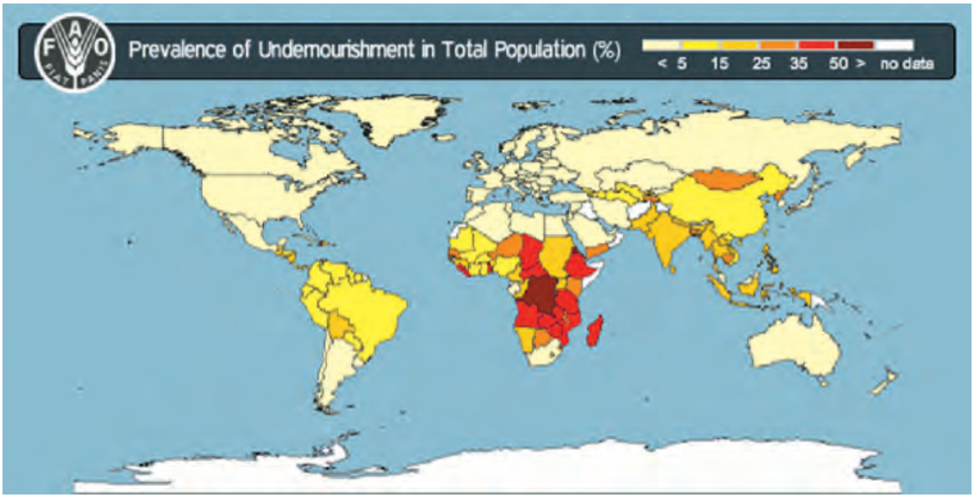


Figure 4. The FAO Hunger Map.
Source: FAOSTAT (FAO, 2009).

Often the concepts of poverty and hunger are used in similar contexts but in reality there is a considerable difference. Poverty is basically an economic concept that establishes levels of income below which acceptable living standards are not possible in a national context, while hunger is a physiological concept related to the caloric intake. Up to recent years the poverty level was internationally established in 1 US$/day but recently have been increased to 1.25 US$/day. However, often countries use different thresholds to assess poverty within their boundaries.

At the level of 1.25 US$/day the number of poor people in the world is estimated at 1,374 millions in 2005 (World Bank, 2008) and 11 million for the countries of the Middle East and North Africa (which include most of the countries of the SEMR). If the poverty line is raised to 2 US$/day the figures become respectively 2,564 million and 51 million, which indicate the large extent of poverty in the world (nearly 50% of the active population) and even in the Mediterranean countries it appears quite relevant. The tragedy associated with these figures is that much of this poverty (70%) live in the rural environments.

The most striking consequence of poverty is that if you are a poor person you may have the capacity to buy some of the local food, but imported food will be far too expensive. If the water scarcity is compensated with food imports, the poor will not have much access to such food as it may be too expensive for them. Here the role of governments may be fundamental to guarantee that basic food remains accessible to all levels of the population.

4.1 *The role of irrigation development in alleviating poverty*

The role of irrigation development to reduce poverty appears quite significant. Most of the irrigated farms in the Mediterranean Region are small. For instance in Egypt the average size of farms is 1.7 ha and the revenue generated by this average farm is 1,705 E£ (Egyptian pound)[2] (IFPRI, 2000), i.e. slightly over 300 US$, but these figures do not account for the internal farm food consumption and therefore this income is somewhat beyond the poverty line earlier mentioned. In Morocco the average size farm is 5 ha but those under irrigation are much smaller. Similarly, in Spain the number of farms with less than 5 ha is 647,134, representing 53% of the total (INE, 1997) and those under irrigation are even smaller. In summary, the prevalence of the small farms in the Mediterranean irrigated agriculture has provided the opportunity to millions of farmers to earn revenues that place

[2] 100 E£ (EGP) = 13.54 US$ (USD) = 18.03 € (EUR) (April 27, 2010).

them beyond the poverty lines. Certainly, national averages may hide the fact that there are also large irrigation farms which owners are far from poor. However, even in these large farms owners employ seasonal and permanent workers earning salaries that may place them also beyond the poverty lines.

If the expansion of irrigation development in the coming years will reduce, or grow little, the consequence will be that its contribution to reduce poverty will be also much smaller. So far, countries have been reluctant to finance *social irrigation* and it is unlikely that this may change in the future. The general response to the poverty problems has been the implementation of rural development programs that not only reduce poverty but enhance rural life. Such programs have gained considerable recognition and support and they are widely used in the Mediterranean countries, not only to reduce poverty but also to improve the living conditions of the rural communities. The EU has specific programs (The Co-operation Specific Programme and the Sustainable Development Strategy –SDS– in the Seventh Framework Programme –FP7) dedicated to support these programs and many of the bilateral projects have focused in these types of projects. Also governments of the SEMR are quite supportive of the rural development programs, but the resources allocated to them are still modest and need to be increase to improve the living conditions of the rural poor.

4.2 *The role of food aid*

Food trade is playing an increasingly important role in the economies and in the agriculture sector of many countries. However, it is not at all clear that the poor sections of the population are benefiting from this increase in trade (FAO, 2005). For many, the trade restrictions are increasing poverty and hunger and the need for reforming trade rules are strongly felt. Trade reforms must be accompanied by government policies to enhance the capacity of the poor to share the gains from trade and to compensate those who lose from the process, perhaps through social safety net programs. The overall domestic policy environment is just as important as trade policies, and must be conducive to private investment and private activity.

The role of food trade in alleviating poverty can be highly relevant when food imports are used to alleviate the hunger of the poorest people through the food emergency programs and small farmers have a better access to markets. It may be worth noting that the recent increase rate of natural disasters has lead to an increase in the number of food emergency programs in recent years. In fact, several of the SEMR countries have been receiving food aid in a consistent manner up to very recently. As an example, in 2009 the EC has approved emergency food aid for 6 million € to the Palestinian Territories and Syria to assist in the problems originated by the persistent droughts and the effect of the recent war conflicts. In addition to these emergency situations governments provide food for children in many public schools and also in many pro-poor institutions.

In crisis situations food aid is of critical importance, but in the short term. The key to sustainability, however, is to ensure that the aid provided does not create dependency or harm the communities and stakeholders it hopes to assist. Since women are typically responsible for food production, preparation, storage, and marketing, it is crucial to include them in emergency-related food security planning and decision-making as potential agents of change and decision-makers, rather than as the *victims* they are often portrayed to be. Traditional forms of food aid have largely failed to recognize and enhance the productive capacity of women, and this in turn means that food aid has been ineffective in contributing to lasting solutions to poverty. While short-term emergency food aid is often essential, it must be balanced with longer-term assistance and more comprehensive programs for agricultural development that are designed to support men and women crucial contributions to agricultural production.

5 AGRICULTURAL TRADE. THE NEW FRONTIER OF FOOD SECURITY

5.1 *A general overview of agriculture and trade in the Mediterranean Region*

Before entering into the analysis of what role is now playing agricultural trade, it will be relevant to address a more general question related to what role is now playing the agricultural sector in

Table 4. General economic data for selected Mediterranean countries.

	GDP per capita (US$, 1990)			Agriculture (as % of GDP)		Agriculture value added per worker (US$, 2000)	
	1990	2004 *	% increase	1990	2004	1990–92	2002–04
SEMR countries							
Egypt	1,185	1,600	35.0	19	15	1,575	2,007
Morocco	1,057	1,150	8.8	18	16	1,275	1,582
Syria	1,129	1,650	46.1	28	23	2,356	2,977
Tunisia	1,485	2,300	54.9	16	13	2,365	2,415
Turkey	2,563	3,100	21.0	18	13	1,772	1,793
EU countries							
France	21,321	25,000	17.3	4	3	24,724	40,521
Greece	8,360	9,950	19.0	11	7	8,315	9,303
Italy	19,401	22,450	15.7	4	3	13,672	21,553
Spain	12,928	17,750	37.3	7	4	12,611	19,132

* Values are estimated for the year 2004
Source: [http://www.un.org/esa/population/publications/countryprofile/]

the economies of countries and how has been evolving in the last few years. Table 4 provides an overview of the GDP and other economic data for some selected Mediterranean countries (EU and SEMR) and some of the following observations emerge:

- The first point that emerges is that in spite of the efforts made to increase the agricultural production, its impact in the GDP has decreased, for the period considered, by at least 2–5 percentage points and this applies equally to all countries analyzed.
- The increase in the GDP for countries of the SEMR is generally greater than for those of the EU. However, as the impact of the agricultural sector in the GDP has decreased in 2004 it is evident that there are other sectors of the economy that have grown more dynamically than agriculture.
- The agriculture added value per worker is much higher in the EU countries than in the SEMR countries. This is a clear indication that most of the agricultural products in the SEMR countries are subject to little processing and probably exported as raw materials. This is an indication that the opportunities for rural industries and food processing in these countries are still ample.

The overall conclusion is that all Mediterranean countries are making a substantial economic progress but the agriculture sector is reducing its importance in the national economies.

Table 5 provides the national data regarding the agricultural net trade (imports minus exports) for the years 1990 and 2004. Also the virtual water traded is included. The analysis of these data provides the bases for the following relevant observations:

- All SEMR countries are net importers of agricultural products, except Turkey that is exporter. The fact that they are mostly importers seems to have some correlation with the limited availability of water resources. During the period considered only Tunisia and Egypt have managed to reduce the net trade. Morocco and Syria have largely increased the net agricultural trade during the period (see percentage of increase per capita). Syria has increased its exporting capacity to the expense of a critical exploitation of the water resources.
- The European countries show a dichotomy that is interesting. France and Spain are net exporters of agricultural products. On the contrary, Greece and Italy are net importers. It is interesting to note that France and Spain have greatly increased their respective irrigated areas in the period considered while Greece and Italy have not. It seems that the expansion of the irrigated area has led to an increase of the agricultural exports in these countries.

Table 5. Agricultural net trade balance (imports – exports).

Country	Agricultural Net trade (imports – exports) value Year 1990 10^6US$	Per capita	Year 2004 10^6 US$	Per capita	% of increase per cap.	% of net trade over GDP per capita Year 1990	Year 2004	Net balance of virtual water (m^3 per capita) *	Value of m^3 (2004) **
SEMR countries									
Egypt	2,649	46	1,700	22	−51	4	1	−250	−0.09
Morocco	153	6	1,094	36	491	1	3	−1,050	−0.03
Syria	28	2	123	7	200	0	0	−200	−0.03
Tunisia	371	45	207	21	−53	3	1	−1,250	−0.02
Turkey	−858	−15	−1,298	−19	21	−1	−1	−100	0.19
EU countries									
France	−10,819	−190	−12,026	−211	11	−1	−1	200	−1.06
Greece	564	56	2,632	238	329	1	2	−600	−0.40
Italy	12,517	220	7,270	132	−40	1	1	−300	−0.44
Spain	213	5	−4,495	−112	−2,140	0	−1	−90	1.25

* *Source*: Fernandez, 2007
** Net trade value/virtual water per capita.
Source: FAOSTAT (FAO, 2009).

– The percentage of the net agricultural trade per capita over the GDP per capita shows some interesting features. For all countries and the two years (1990 and 2004) the impact remains low (1 to 4%) indicating that trade remains a minor component in the GDP per capita. The per capita values are generally higher for 2004 than in 1990 indicating a growing trend in the net trade. As the impact of the increases on the GDP per capita remains small it is apparent that they are not affecting the purchasing power of the individuals in a substantial manner.
– The net balance of the virtual water values per capita, taken from Fernandez (2007), has been included in Table 5 to examine the possible correlation with the net trade values per capita. If the net values of trade for the year 2004 are divided by the net balance of virtual water per capita one finds the *net trade value of the m^3*. The resulting figures present reasonable values for most of the countries, indicating a certain consistency among the two parameters. The fact that the higher values correspond to Spain and France also makes sense since both countries are net exporters of predominantly high value crops. This value of the m^3 can be useful in the economic evaluations related to virtual water trade.

In summary, the analysis of this information at national level permits to assess the financial impact of agricultural trade on the consumer and the trends that emerge. It does also provide an assessment of how much the consumer is paying for the m^3 of virtual water trade imported providing some warning when unusual values emerge.

5.2 *Analyzing agricultural production, trade and virtual water trade to reorient national crop production. A methodological approach*

The essential question that we are addressing here is to what extent countries should change their internal production crop patterns to reduce the net crop trade to the lowest possible level, and at the same time maintain the water abstractions within reasonable limits or even reduce them. To try to respond to this important question the authors propose an outline of a methodology consisting in analyzing 4 sets of data. The first set of data contains the production data (area, quantity and value) for the main crops in the period chosen. The second set of data includes the irrigation water used

Table 6. Evolution of the surface, production and value of main crops in Egypt (1990–2004).

	Year 1990						
Main crops	Surface (10^3 ha)	%	Production (10^3 t)	%	Price (US$/t)	Value (10^6 US$)	%
Cotton	417	13	838	3	91	76	2
Sugar cane	111	3	8,895	34	18	164	4
Rice	436	13	3,167	12	127	404	9
Wheat	821	25	4,268	16	159	678	16
Maize	830	26	4,799	18	141	674	16
Other crops	616	19	4,101	16	Not avail.	2,281	53
Total	3,232	100	26,069	100		4,277	100

	Year 2004							Increase 1990–2004		
Main crops	Surface (10^3 ha)	%	Product. (10^3 t)	%	Price (US$/t)	Value (10^6 US$)	%	Surf. (%)	Prod. (%)	Value (%)
Cotton	300	8	785	2	93	73	1	−28	−6	−5
Sugar cane	135	3	11,230	27	18	205	4	−22	26	24
Rice	646	17	6,352	15	186	1,183	20	−48	101	193
Wheat	1,095	28	7,178	17	132	945	16	−33	68	39
Maize	789	20	6,236	15	121	754	13	−5	30	12
Other crops	903	23	9,314	23	Not av.	2,619	45	−46	127	15
Total	3,867	100	41,096	100		5,778	100	−20	58	35

Source: FAOSTAT (FAO, 2009).
[t = tonne = 1,000 kg]

in the production of the selected crops. The third one refers to the export and import of the same products and the net trade. The fourth estimates the blue virtual water traded for the selected crops. The examination of these sets of information provides some interesting indications regarding the convenience or not to modify the production patterns at national level. Although these indications are very useful they are not sufficient to make policy decisions. Any intend to modify the existing national cropping pattern will require a more detailed analysis of local information. This exercise will be attempted in the last section of this chapter through the simulation of a number of scenarios at farm level and analyzing their impact at national level.

The two countries selected for this exercise are Egypt and Syria. The reason for selecting Egypt is because practically all agriculture is irrigated and this facilitates the interrelation with the water side. Syria has been selected because the authors have access to detailed farm information resulting from earlier work. The analysis of data from Egypt follows but stops at the level of the analysis of the national information. The one of Syria is included in a separate section since it contains a more complete analysis covering from the national to the farm level.

5.2.1 *Analysis of the agricultural production, trade and virtual water. A case study for Egypt.* This analysis is based in the following tables: Table 6, Evolution of the surface, production and value of main crops in Egypt (1990–2004); Table 7, Irrigation water use for the main crops of Egypt (2004); Table 8, Net trade of the crops selected (import–exports); and Table 9, Estimation of the blue virtual water traded in 2004. Nearly all the information presented is derived from the FAOSTAT data bases.

The crops selected for this analysis are cotton, sugar cane, rice, maize and wheat. In the year 2004 they represent 78% of the food production in tonnes (t = 1,000 kg) and 53% in value (Table 6). Hence the group chosen represents a large portion of the agriculture in Egypt. As in Egypt all these crops are irrigated no differentiation is made between rainfed and irrigated production.

Table 7. Irrigation water use (IWU) for the main crops of Egypt (2004).

	Irrigation water use (IWU) at farm				Total IWU (2004)		Irrigation water per tonne		
Main crops	Irrigation req. (m^3/ha)	Mm^3 1990	Mm^3 2004	Increase (%)	Distribut. efficiency	Total IWU (Mm^3)	Main crop	Yield (t/ha)	m^3 of total IWU per tonne
Cotton	9,000	3,755	2,703	−28	0.70	3,861	Cotton seed	2.61	4,926
Sugar cane	10,000	1,106	1,353	22	0.70	1,933	Sugar cane	83.00	172
Rice	11,000	4,795	7,102	48	0.70	10,146	Rice	9.84	1,597
Wheat	4,000	3,285	4,379	33	0.70	6,256	Wheat	6.56	872
Maize	8,000	6,641	6,308	−5	0.70	9,012	Maize	7.91	1,445
Other crops	6,000	3,698	5,416	46	0.70	7,737	Cotton lint	0.87	14,778
Total						38,945			
Total per inhabitant						505			

Source: elaborated data.

Table 8. Net trade of the crops selected (import – exports).

	Net trade (import – exports)			
	1990		2004	
Main crops	Quantity (t)	Value (10^6 US$)	Quantity (t)	Value (10^6 US$)
Cotton	20,562	−66	−101,549	−389.66
Maize	1,899,937	249	2,427,724	364.45
Rice	−63,924	−15	−804,730	−222.97
Sugar cane	−548	0	−4,227	−0.69
Wheat	5,400,000	853	4,366,462	727.57
Total Merchandise Trade	No data	6,617	No data	7,522.70

Table 9. Estimation of the blue virtual water traded in 2004.

Blue virtual water traded (year 2004)		
Main crops	m^3/t	Mm^3(*)
Cotton lint	14,778	−1,500.72
Maize	1,587	3,853.53
Rice	1,597	−1,285.34
Sugar cane	172	−0.73
Wheat	872	3,805.47
Net Total		4,872.20
m^3 per inhabitant		63.15

* [Quantity 2004 (Table 8) × m^3/t (Table 9)]

For each crop the mentioned set of tables are examined and conclusion drawn. They are reflected in the following sections:

a) Rice

Rice is a crop that has been expanding in area (48.12%) during the last 14 years; and the production (101%) and its value (193%) have also increased considerably (Table 6). Much of this expansion is due to the fact that an important part of the drainage water is being re-used to irrigate the predominantly saline soils of the *new lands* located in the delta. The increase in the production indicates that the productivity for unit of land has increase considerably. In fact the yields of rice in Egypt are high.

Table 7 indicates that the irrigation water used for this crop is quite high: 10,146 Mm^3/yr (in 2004), which represent nearly 26% of the total irrigation water used in the country.

Already in 1990, Egypt was a modest net exporter of rice with 63,924 t, but in 2004 it has grown to 804,730 t, which is about the 12% of the total rice production. Although this represents a modest share of the production, the trade value is significant: 223 million US$ (Table 8). In 2004 rice was the second export crop (in value) after cotton. The value of the crop has benefited from the high international prices of this commodity in recent years.

The quantity of blue virtual water exported through this crop amounts to 1,285 Mm^3/yr (Table 9). This represents about the 26% of the total net blue virtual water traded. In spite of the revenue generated by the export of this crop remains questionable if this export policy is sustainable from the point of view of the water resources.

In summary, the analysis of the data suggests not to expand further the production of rice and where possible to reduce the area and replace it for another crop. However, as rice is mostly produced in saline soils with drainage water of medium level of salinity, the replacement of rice for another crop does not seem feasible in many areas. This is a clear example where the analyses of data suggest replacement of a crop for a less consuming water crop, but the environmental conditions where rice is grown will limit the possible change. To quantify the magnitude of the areas that could be subject to the cultivation of other crops soils information and other local data are needed. This points out that a reduction of the rice area cannot be implemented without a closer analysis at the local level.

b) Cotton

Cotton has been an important traditional crop in Egypt and its production has been under government control. The cotton area was almost halved between 1952 and 1987, due to the government policy requiring farmers to sell all their cotton output to the government at fixed prices that were kept below world market prices thus rendering its cultivation not very attractive. During the period considered the area of cotton crop has further declined (28%) and logically also the total production (−6%) and value of the production (−6%) (Table 6). Although the area has reduced by 28%, the production has only reduced by 6%, indicating that there has been some modest increase in the productivity. Cotton has high labor requirements and since wages have increased in the period considered the net returns for farmer may have decreased.

As the area dedicated to cotton has reduced, the use of the irrigation water has also declined in the period considered by about 28%. The total irrigation water used in 2004 (Table 7) was 3,861 Mm^3 which represents 10% of the total irrigation water use (38,945 Mm^3). Therefore it has not a great impact in the irrigation water used.

Table 8 shows that Egypt has evolved from being an importer of cotton in 1990 to be a large exporter with 101,549 t of cotton lint exported and a value of 389.6 million US$. Cotton is the main export crop of Egypt. As the relation between cotton seed and cotton lint is approximately 3:1, it can be estimated that nearly 39% of the production was exported in 2004.

Regarding the blue virtual water (Table 9) the amount exported by the cotton lint is 1,500 Mm^3 which is quite a substantial figure (35% of the total net blue virtual water).

Given the above observations it seems reasonable to conclude that there is margin for a further modest reduction of the cotton area cultivated. This may happen if Government policy prices are maintained at the same time that production cost increase due to labor increasing wages. This may free some 10–20% of the area for other crops and reduce the water use.

c) Sugar cane

The area dedicated to this crop has increased by 22.36% and production by 31.64% indicating a modest increase in the productivity due to new varieties and improved cultivation practices. The price of the crop has remained nearly constant (18 US$/t) and therefore the increase in the value of the crop (30.6%) (Table 6) is basically due to the increase in area. This increase in area probably goes in parallel with the increasing internal demand for sugar.

The amount of irrigation water used in the production in 2004 was 1,933 Mm^3. Therefore it accounts for a modest share (4.9%) of the total irrigation water (38,945 Mm^3).

Sugar has been exported in very modest quantities: 4,227 t in 2004 (see Table 9) that have very little impact in the total trade. For practical purposes it can be said that is a crop grown for internal consumption. Consequently the blue virtual water traded is also very small (-0.73 Mm^3) and therefore with small significance in the total traded.

The above observations do not point for the need of any substantial change in the planted areas of this crop.

d) Wheat

Wheat is now the main crop of Egypt with more than 1 million ha cultivated in the year 2004. The area has been expanding considerably (33%), as well as the production (68%) and the market value (39%) (Table 6). The yields are high and there have been a further increase in the productivity during the considered period.

Although wheat has low irrigation requirements, the large area cultivated makes that the total irrigation water used be very high with 6,256 Mm^3 in 2004 (Table 7) which represents 16% of the total irrigation water use.

The national production of wheat is not sufficient to satisfy the demand, and Egypt is a large importer of wheat with 4.3×10^6 t imported in 2004. Interestingly, the imports of wheat have been reducing from 5.4×10^6 t in 1990 (Table 8). Egypt subsidizes the price of flour and therefore the imported wheat represents an important lost to the Government. This may be the reason behind the expansion of the production area. However if the subsidies are removed, the expansion of the wheat may no longer be attractive.

From the point of view of the blue virtual water trade the imported amount is very high: 3,805 Mm^3, because the amount of wheat traded is also high. In a way, this imported virtual water serves to compensate the scarcity of water resources in the country.

Consequently, on one hand it seems advisable to expand the area cultivated of wheat, since this will contribute to reduce the gap between production and demand. Furthermore this will contribute to reduce the imports and the financial loses associated with the subsidy of imported flour. On the other hand, increasing the national production of wheat will create additional pressure on the limited water resources. Adopting one or the other solution not only depends on economic considerations but on the social acceptance of the alternatives.

e) Maize

Maize is an important crop for the diet of the rural populations. For this reason maize was as important as wheat in 1990 in terms of area cultivated but it has declined moderately (-5%) in 2004. However the production has increased by 30% indicating substantial gains in productivity. The value of the crop has only increased by 15% due to the fact that the international price of maize has declined in the period. Maize is part of the traditional rotation of Egyptian farmers that includes: wheat, clover and maize. In terms of farmers' revenue it has very similar values than those of wheat. Maize is a competitive crop for cotton because the revenue is also similar and requires much less labor.

The total irrigation water used is 9,012 for the year 2004, i.e. 23.3% of the irrigation water used at national level. Therefore is the second largest consuming crop from those selected.

Egypt has been a traditional large importer of maize. The net imports in 2004 were 2.42×10^6 t with an increase of 27.8% with respect to the values of 1990 (Table 8). Consequently the values of these imports have increased by 46%.

The blue virtual water imported has a substantial value of 3,853 Mm^3.

In summary maize appears as a stable crop with some potential for expanding and replace some of the crops earlier mentioned (cotton and rice mainly).

The analysis made above for the different crops indicates some desirable changes in the production and in the trade of the crops considered. This analysis is based on information that is easily accessible from international organizations (mostly FAO) and known references through Internet. The emerging suggestions for change have therefore a preliminary nature. Before attempting the suggested changes a much more detailed examination is required. This is attempted in the case of study of Syria that follows in the next section of the chapter.

A final consideration is that the suggested methodological approach can also be used to make projections following the existing national crop patterns.

6 THE ROLE OF IRRIGATION, TRADE AND VIRTUAL WATER FOR DESIGNING PRODUCTION POLICIES: A CASE STUDY IN SYRIA

This country case study is intended to assess the impact at farm and national levels of the application of certain policies related to water use in agriculture in Syria. These policies emerge from the analysis of the general data of production and trade in Syria, one of the countries in the Mediterranean region that faces a long-trend increase in water demand towards 2025 (see Figure 3, in Section 3.2) and that, consequently, is prone to severe water deficits in some regions.

In its first section, the Syria case study follows a similar pattern than the previous section dedicated to Egypt and it is based on the analysis of the evolution, at national level, of agricultural production, irrigation trends and trade balance along several selected years (Sections 6.1 to 6.6). Emerging from this analysis, it is possible to foresee a set of potential policies that will seek to reduce the negative agricultural trade balance, and at the same time, will try to preserve the scarce water resources in Syria. These policies could be translated into specific policy scenarios, of which three have been selected to illustrate the methodological approach used in this case study. These are, on the one side, a land use policy aimed at encouraging a cropping shift towards less water consuming crops and, on the other side, an irrigation modernization policy aimed at reducing water use in the farms (Section 6.7). Both policies have the common objective of reducing water use in the farms and at national level but the land use police makes use of agronomic instruments whereas the irrigation modernization policy is based on technological instruments, defined by the adoption of new irrigation technologies. The center of this case study is the analysis of the impact of these two policies on statistically-based representative farms that characterize irrigation agriculture in Syria and that consider various regions, cropping and irrigation technologies. The farm-level results are then scaled-up to the country's national level (Section 6.8). Throughout the analysis, we compare the implementation of both types of policies with the purpose of deriving policy relevant conclusions for the Syrian agricultural sector and for different types of farms as well (Sections 6.9 and 6.10). The implementation of both policies is defined by different environmental and socio-economic indicators, such as crop mix, water use for irrigation, farmers' income and overall farm employment.

6.1 *Main features of the agricultural production in Syria*

From the 18.5 million ha (Mha) of total lands of the Syrian Arab Republic, cultivated land extends over an area of 5.48 Mha of which 1.40 Mha are irrigated land (22%), 3.47 Mha are rainfed (63%) and 0.62 Mha are fallow land (11%). Of the total irrigated area, 551,000 ha are irrigated from surface waters while the remaining 851,000 ha use groundwater resources (Table 10).

As Table 10 indicates, the main driver for the expansion of irrigation in Syria has been predominantly the use of groundwater resources to the point that the area has nearly tripled with respect to 1985. As a consequence, most of the aquifers of the country have been overexploited and in some areas the decline of the water table has even surpassed 50 m, placing some farmers in the difficult position of having to close some of their wells. It is worth noting that in 2006, for the first time in the last two decades, the area irrigated from groundwater sources has diminished by 10,000 ha which is a clear sign that for some farmers this type of water source is no longer feasible. This

Table 10. Evolution of the irrigated agriculture in Syria by type of water resources (modified from Somi *et al*., 2002).

	Irrigated area				Total irrigated area	
	From surface water		From groundwater			
Year	10^3 ha	% of the total	10^3 ha	% of the total	10^3 ha	% increase with respect to the area in 1985
1985	334	51	318	49	652	
1990	351	51	342	49	693	6
1995	388	36	694	64	1,082	66
2000	512	42	698	58	1,210	86
2002	583	43	764	57	1,347	107
2004*	624	43	815	57	1,439	121
2005	561	39	865	61	1,426	121
2006	551	39	851	61	1,402	115

Source: Sagardoy & Varela-Ortega (2007).
**Source*: MAAR (2004).

Table 11. Available Water Resources in Syria (in Mm^3 for year 2000).

	Barada Awag	Yarmouk	Al Badia	Orontos (Al Asi)	Coastal	Al Khabour	Euphrates and Tigris	Total
Total available for use	1,277	272	70	1,831	1,257	1,371	9,981	16,058
Water use								
Irrigation water use	1,207	360	43	2,306	433	4,283	7,228	15,860
Domestic water use	298	69	8	185	134	49	300	1,042
Industry water use	77	18	2	48	35	13	78	315
Evaporation	5	31	15	148	16	132	1,643	1,990
Total uses	1,588	478	68	2,687	617	4,477	9,249	19,162
Water balance	−311	−206	2	−856	640	−3,105	732	−3,104

Source: Own elaboration based on Varela-Ortega & Sagardoy (2003).

situation is a clear sign that the exploitation of groundwater resources has reached the point of no recovery and therefore the reduction in irrigated area is likely to continue for several years to come.

6.2 *Available water resources of Syria and main river basins*

Water resources in Syria are very limited compared to the needs of the country. Estimations of the available water resources in Syria vary considerably depending on the source of information. One of the major problems for getting reliable estimations arises from the difficulty to obtain realistic data of the natural flows of the Euphrates River. Since the construction of the large dam of the Great Anatolia Project (GAP) in Turkey the data related to the flows of the Euphrates River have not been published and are not available for the international community. Nevertheless in this study it has been assumed that the flow share of Syria from the Euphrates River is 210 m^3/sec, an equivalent to 6,818 Mm^3/yr, which is the most conservative hypothesis. Estimations of available water resources tend to be rather constant unless severe climate changes take place, and therefore the estimations that we have made for this study can be considered a good approximation to the actual available resources in year 2007.

Water uses are estimated in Table 11 for the year 2000 for each of the Syrian basins and for the nation's total. Irrigation water use represents 82% of total uses whereas domestic and industrial uses are only 7% of the total.

Based on the values shown in Table 11, at country level, Syria has a negative water balance that results in a structural water deficit of 3,104 Mm^3/yr. In this case, the total annual water resources for the country are 16,058 Mm^3 while the total annual uses are 19,162 Mm^3. Although this estimation is for the year 2000, it indicates the gravity of the water situation in Syria which has certainly deteriorated to the current year.

The water balance per basin shows that only three basins, namely Euphrates, Coastal and Al Badia have positive balances. The remaining ones have considerable negative water balances. The case of the Al Khabour basin with an annual deficit of 3,104 Mm^3 is of extreme gravity as evidenced by the persistent annual increase in pumping depth due to the depletion of the aquifers. This is followed by the Orontes basin with an annual deficit of 856 Mm^3. The magnitude of the deficit of the Al Khabour basin indicates that it will be difficult to correct it without special and severe measures. Putting to a halt the drilling of wells has shown limited effectiveness to control the problem. Changing the cropping pattern in favor of less water consuming crops has often been advocated as one potential solution to the excessive water mining and will be analyzed later in this chapter.

6.3 *Evolution of the cultivated area, production and value for the main crops of Syria*

Table 12 shows the evolution of the main crops in Syria in terms of area, production and value. The crops selected for this analysis covered 85% of the total cultivated area in 1999 while in 2004 it diminished to 61% indicating that the cropping pattern of the country has evolved considerably over the period considered. Nevertheless the selected crops still represent the largest part of the agricultural production in Syria.

The analysis of the data and of some complementary information allows for the following observations:

a) Wheat is a highly relevant crop in Syria and object of food security policies by the government. Prices are high compared to international standards and thus make the crop very attractive to farmers. Table 12 shows that the area cultivated has increased by 37%, but the production has more than duplicated in the period considered. This represents a large increase in productivity probably due to the increase of irrigated areas where wheat is planted. The present production level seems stabilized around 4.5×10^6 t and the area planted around 1.7 Mha. The price per tonne has improved in the period considered and is slightly over the international price. Favorable prices have surely contributed to increase the interest in the cultivation of the crop.
b) Cotton production in Syria is controlled to a great extent by the Cotton Bureau of the Syrian Ministry of Agriculture and Agrarian Reform. The Cotton Bureau sets the total planted areas and encourages early planting and harvesting of seed cotton. When irrigation water is not a constraint, farmers exceed the licensed areas and the crop exceeds 10^6 t of seed cotton as in the year 2004 (see Table 12). Cotton production has been encouraged by the Government and in the period considered the production has duplicated (133% increase). The area planted in 2004 was 234,181 ha, but Government of Syria plans to reduce its cotton planted areas to 225,000 ha and produce 900,000 t of seed cotton in 2006/2007. Actual cotton production exceeds production plans by about 20% in order to maintain higher prices and reduce water use.
c) Barley is the most important feed grain grown in Syria and is used principally as sheep and cattle feed, but sometimes replaces corn in poultry feed rations. Barley is a non irrigated crop in Syria and the variability of the production is very high depending on climate conditions. Table 12 shows the large reduction in cultivated area (53%) for the year 2004 due to shortage in rainfall. Year 2000 was a record drought and the production of barley fall to less than 150,000 t of production. Normally the annual production ranges in the order of 700,000–800,000 t but the yields are very low compared to international standards.
d) Sugar beet appears as a stable crop in the agricultural production. The area cultivated has increased from 21,400 ha to 27,500 ha in the period considered. The considerable increase in the price (more than 100%) has stimulated the growth of the area and the production. The area cultivated represents less than 4% of the total and therefore is a crop of modest importance at national level.

Table 12. Evolution of cultivated area, production and value for the main crops of Syria.

		Wheat		Cotton Seed		Barley	
		Quantity	%	Quantity	%	Quantity	%
Year 1990	Surface (ha)	1,341,000	24	156,400	3	2,729,000	49
	Production (t)	2,070,000	25	441,200	5	846,000	10
	Price (S£/t) *	8,500		2,070		6,250	
	Value (10^6 S£)	17,595	63	913	3	5,288	19
	Value (US$)	391	63	20	3	118	19
Year 2004	Surface (ha)	1,831,226	37	234,181	5	1,290,570	26
	Production (t)	4,537,459	32	1,029,232	7	527,193	4
	Price (S£/t)	12,588		5,673		7,484	
	Value (10^6S£)	57,118	77	5,839	8	3,946	5
	Value (US$)	1,071	77	109	8	74	5
% of increase in the period	Surface	37%		50%		−53%	
	Production	119 %		133%		−38%	
	Value	174 %		439%		−37%	

		Sugar beet		Maize		Other crops		
		Quantity	%	Quantity	%	Quantity	%	Total
Year 1990	Surface (ha)	21,400	0	60,200	1	1,313,713	23	5,621,789
	Production (t)	421,800	5	180,000	2	4,194,559	51	8,153,605
	Price (S£/t) *	1,400		7,300				
	Value (10^6 S£)	591	2	1,314	5	2,373	8	28,073
	Value (US$)	13	2	29	5	53	8	624
Year 2004	Surface (ha)	27,590	1	56,516	1	2,632,023	53	4,965,885
	Production (t)	1,217,658	9	210,166	1	6,792,339	47	14,314,098
	Price (S£/t)	2,424		8,619				
	Value (10^6S£)	2,952	4	1,811	2	2,073	3	73,738
	Value (US$)	55	4	34	2	39	3	1,382
% of increase in the period	Surface	29%		−6%		100%		
	Production	189%		17%		62%		
	Value	322%		16%		−26%		

Exchange rate: 1 USD (US$) = 45.5 SYP (S£, Syrian pound) (1990); 1 USD = 53.7 SYP (2004)
*Data from 1991
Source: FAOSTAT (FAO, 2009).

e) Maize is mainly an irrigated crop with relatively low yield in Syria. In general, the agro-meteorological conditions are not favorable for this crop. Table 12 shows a slight reduction in the cultivated area (6%) from year 1990 to 2004 but there is a modest increase (17%) in the production. Maize represents only 1% of the national agricultural production (in t) and its price has increased moderately.

In summary, wheat has some potential for expansion –as long as the high prices are maintained– but cotton should reduce the area. Barley and sugar beet are stable crops and maize has a tendency to reduce the area.

6.4 *Irrigation water use in Syria*

Table 13 provides an overview of the irrigation cropping pattern of the country for the main crops and gives grounds for the following observations.

Table 13. Irrigated crop distribution in Syria.

	Area (ha)	Percentage of irrigated area (%)	On farm irrigat. water use (m^3/ha)	Irrigation distribution efficiency	Total irrig. water use (m^3/ha)	Total irrig. water use (Mm^3)
Wheat	689,868	57	4,000	0.7	5,714	3,942
Maize	72,627	6	5,000	0.7	7,143	519
Cotton	274,585	23	11,000	0.7	15,714	4,315
Sugar beet	28,667	2	6,000	0.7	8,571	246
Potato	21,668	2	5,500	0.7	7,857	170
Tomato	9,743	1	9,300	0.7	13,286	129
Others	109,715	10	6,000	0.7	8,571	940
TOTAL	1,206,873	100				10,262
Total m^3 per inhabitant						537

Source: Area of crops from Agricultural Census of 1998 (Central Bureau of Statistics, 1998).

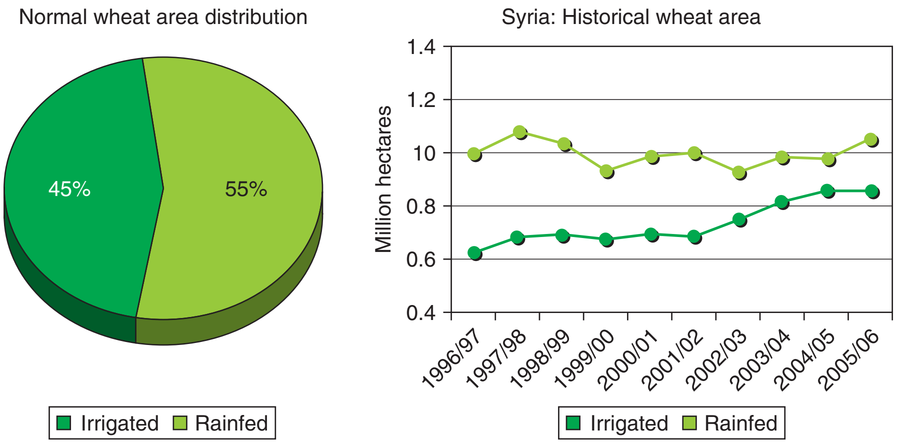


Figure 5. Relation between irrigated and rainfed wheat in Syria.
Source: USDA (2008).

Wheat and cotton together represent 80% of the total irrigated area in Syria and therefore they are by far the main irrigated crops of the country. In the Governorate of Al-Hasakah these two crops cover 73.5% and 23.6% of the surface respectively, which amounts to 98.3% of the total irrigated area in the region.

a) Irrigated wheat with 689,868 ha represented 37% of the total cultivated area, but this proportion has increased nowadays. It is by far the largest irrigated crop in terms of area. It is also the largest consumer of irrigation water with 3,942 Mm^3 (Table 13), which represents nearly 40% of the total. Figure 5 shows the relations between irrigated and non-irrigated wheat in Syria and shows that the irrigated area has been growing during the period while rainfed areas have remained nearly constant. Most of the irrigated wheat (nearly 70%) is cultivated in Al-Hasakah Governorate where water deficits are very high.
b) Cotton is the second largest consumer of irrigation water in the country with nearly 40% of all irrigation water used. More than 50% of this water is used for exporting the production. As earlier indicated, a substantial part (25%) of the cotton production takes place in Al-Hasakah where is mostly irrigated by groundwater wells.

Table 14. Evolution of net trade for main crops of Syria.

	Net trade (import – exports)			
	1990		2004	
Main crops	Quantity (t)	Value (10^6 US$)	Quantity (t)	Value (10^6 US$)
Barley	96,089	17.51	426,326	42.45
Cotton	−66,193	−152.90	−113,601	−164.05
Maize	249,332	60.10	854,841	118.56
Sugar beet	0	0	−1	0
Wheat	934,844	148.20	– 558,471	– 105.34
Total merchandise	No data	– 1,812.57	No data	880.36

Source: FAOSTAT (FAO, 2009).

c) Most of the area dedicated to maize is irrigated and it represents only 5% of the total irrigated area in the country and of a small share of the nation's total use of irrigation water. Maize is very sensitive to water stress in certain critical phases of the crop's growing period, and therefore timing of irrigation is very critical. In general, yields are below international standards.
d) The remaining crops represent small percentages of the irrigated area and of the total irrigation water.

In sum, the two crops that determine the high use of irrigation water in Syria are wheat and cotton. In consequence, reducing the cultivated area of these two crops could be considered a reasonable objective for the conservation of the water resources.

6.5 *Agricultural trade in Syria*

Table 14 summarizes the evolution of net trade for the considered period (1990–2004). For the purpose of the analysis, net trade has been defined by the difference between imports and exports which reflects the actual water flow balance of the country through the trade of agricultural commodities in the two years considered. This is discussed in the next section.

From Table 14 we can draw the following comments.

a) The efforts made in expanding the wheat production in Syria have resulted in the surprising change to be an importer of wheat in 1990 (with 934,844 t) to be a net exporter in 2004 with 558,471 t. However this change is highly dependent on rainfall. Low rainfall years may change completely the situation. Nevertheless, it appears questionable to export part of the production in normal rainfall years since water is a valuable asset. Furthermore, the production costs are higher that the international ones. While a self sufficient policy could be justified the export of wheat needs to be analyzed closely.
b) The government sets the prices for buying cotton seeds from the farmers. The crop, estimated at 1,029,252 t of seed cotton (Table 12), is ginned to produce approximately 350,000 t of cotton lint. Spinning facilities are not sufficient to process the whole crop. Only 150,000 t of cotton lint are utilized locally for yarn production. The balance of the crop, 200,000 t of cotton lint, is exported. Syria needs more than double its current spinning facilities to process all the cotton lint production and make use of the value added in exporting yarn and textiles instead of cotton lint. The Syrian Government does not officially subsidize cotton lint exports. However, the Cotton Market Organization (CMO) faces a difficult situation because international prices for cotton lint are below the cost of production. This is another reason for the government to limit the national production (US Syrian Embassy, 2006).

Table 15. Virtual water traded in Syria. Net trade balance (imports – exports, year 2004).

Crop	Yield (t/ha)	Water use (m^3/ha)	Water use (m^3/t)	Virtual water traded (year 2004) Quantity traded (t)	Virtual water (Mm^3)
Wheat	6	5,714	952	−558,471	−531.85
Cotton lint	1.5	15,714	10,476	−113,601	−1,190.08
Maize	7	7,142	1,020	854,841	872.18
Sugar beet	60	8,571	143	−1	0
Barley	0.4	2,500	6,250	426,326	2,664.54
Net total of virtual water traded					1,814.78
m^3 per inhabitant				94.91	

c) Table 14 shows that cotton is the main export crop of Syria (164 million US$ of net trade) contributing substantially to the agricultural sector. However is evident that the production cost need to be reduced and the area kept under control.
d) The country is a net importer of maize and the demand has more than tripled in the period considered. The value of the imported maize has increased from 60.1 million US$ to 118.5 million US$. This shows that there is considerable space for increasing the maize production and reduce imports.
e) Syria is a net importer of barley but the amounts imported are highly dependent of the rainfed production. Table 14 shows that the net imported quantity in 2004 was nearly 5 times the value of 1990, but this is precisely due to the low rainfed production of year 2004.

Table 14 shows that there is practically no import or export of sugar beet. Hence, it is used mostly for internal consumption and the area is surely proportional to the national needs.

In sum, Table 14 points out that it does not seem reasonable that Syria has become an exporter of wheat and that therefore wheat production should be reduced. Although cotton is an attractive export crop, also its production should be reduced. On the contrary the production of maize should be expanded to reduce the large imports. Sugar beet should be maintained at its current production level. Barley imports are largely depending of climatic conditions but it appears that the production area should be expanded.

6.6 *Virtual water trade in Syria*

Table 15 shows a summary of the blue virtual water traded in Syria in the year 2004 for the main crops considered.

Table 15 illustrates that the export of cotton lint represent the highest value in terms of virtual water exported. It is followed by wheat with 531 Mm^3 exported. This is largely off set by the imports of maize and barley. The final virtual water trade balance shows that Syria is a net importer of water for the total crops considered. On average, Syria is importing annually 94 m^3 per person, which does not appear as an alarming figure considering the limited water resources of the country. This figure is lower than the one estimated by Fernandez (2007), because this study includes all crops in Syria while in our analysis we have considered only the main five crops.

The analysis of the virtual water flows in Syria through agricultural trade points out clearly in the direction of reducing the exports of cotton and wheat and, where feasible, to increase the imports of maize and barley. In conclusion, from the above analysis it is apparent that there are good opportunities to reduce the area allocated to cotton. Wheat under irrigation has been expanding as prices have remained lucrative for the farmers but, according to the recent trends, it is likely that the areas of rainfed wheat will be reduced and, where possible, will be dedicated to maize.

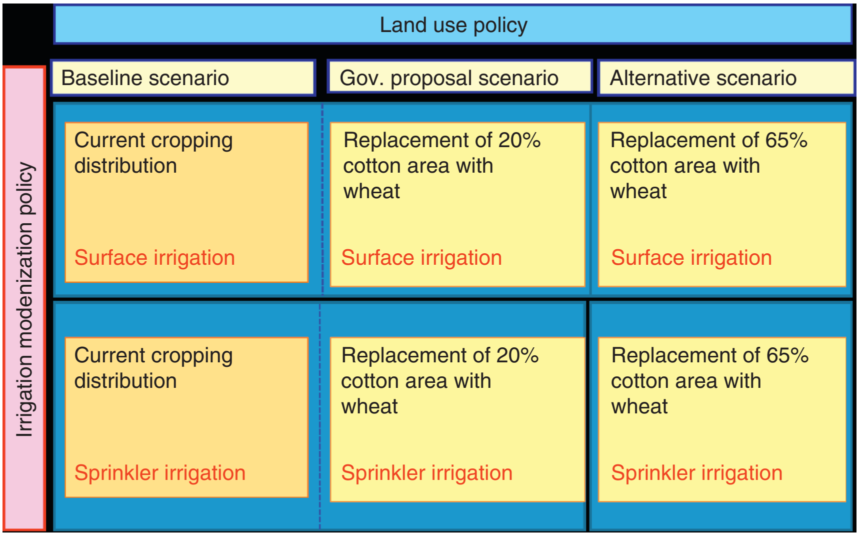


Figure 6. Simulated policy scenarios for Syrian irrigated agriculture.

6.7 *Policy simulations: Comparison between land use and irrigation modernization policies in Syria*

Based on the analysis of the national figures in Syria for the main cultivated crops, agricultural trade and virtual water trade, this section analyzes the comparative effects of the implementation of selected policies aimed to reduce the nation's structural water deficit. The two policies selected respond to the water related problems that have emerged from the analysis carried out in the previous sections. Figure 6 summarizes the two policy options that can be defined as follows:

a) *Land use policy* that seeks to modify the current cropping pattern in the main irrigated areas in Syria towards low water consuming crops. It is represented by two policy alternatives based on the reduction of the area cropped with cotton and the equivalent increase in the area cultivated with wheat. Groundwater irrigation is key in Syria, especially in the cotton growing regions of the water-scarce northeastern plains (region of Al-Hasakah). Within the cotton areas, the main limitation is the availability of groundwater for irrigation that is causing a strong depletion of the aquifers. For this reason the usual relation between wheat and cotton is 2 to 1 for medium size farms. Therefore, given the intentions of the Syrian government to reduce the cotton area by 20%, the challenge is to replace part of the cotton area by some other crop. Wheat is already grown in the areas where cotton is planted and is a technically feasible alternative.
   i. The first land use policy scenario is defined by the reduction of 20% in the cotton growing area and the equivalent increase in the wheat acreage.
   ii. The alternative policy scenario will be a more drastic option defined by a reduction of 65% in the cotton cultivated area and an equivalent increase in the area cropped with wheat. Although this latter option will be difficult to implement it has been chosen to represent the maximum possible level of water use reduction
b) *Irrigation modernization policy* that seeks to attain the same policy goal of reducing water use as in the former land use policy but making use of technical instruments. Modernization of the irrigation systems has been supported widely by the Syrian government during the last decades with the purpose of saving water by increasing technical efficiency. In spite of the recent advances, gravity irrigation continues to be predominant throughout the country, especially in the cereal and cotton growing areas and covers more than 85% of all irrigated lands. Localized drip irrigation is still limited and is mostly concentrated along the coastal zones for the production of higher value-added crops such as fruits and vegetables.

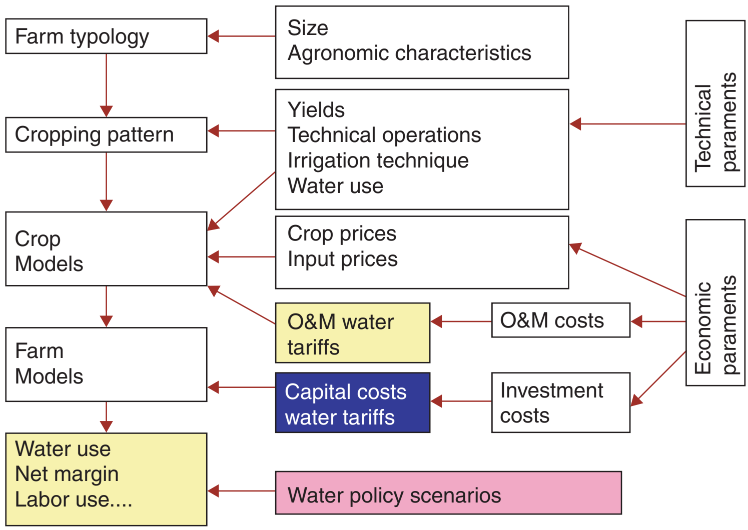


Figure 7. Methodology for assessing the effects of water policies at farm level.
Source: Own elaboration based on Varela-Ortega & Sagardoy (2003).

Implementing water conservation policies has environmental effects as well as economic and social effects for the rural areas. Therefore, these policies have been assessed taking into account their impacts on the use of water resources for agriculture, on farmer's income and on agricultural employment.

6.7.1 *Down-scaling the policy options to the farm level*

However, these global nation-wide policies have distinct effects at regional and local scales, which underline the necessity to downscale the analysis at farm level. This permits to capture the effects of the different policy options on various types of farms and local settings, and evaluate the local actions that could be undertaken. For this reason our analysis focuses on the effects of these policy scenarios at farm level, taking into account different types of farms, water sources and irrigation techniques. In the case of the land use policy the main questions that arise in our analysis are the following: Can water savings be met by changing the crop mix? Is it socially and financially sustainable? Are other factors, besides water use reduction, relevant for the rural livelihoods? In the case of the modernization policy the questions that arise are: Can water savings be met across farm types by changing to more efficient irrigation techniques? What are the economic and social impacts of these technical options? Which of the two policy options is more effective for attaining the desired water reduction objectives at the lowest social cost? All these questions are the object of our analysis that is presented in the following sections.

6.8 *A methodology for assessing the effects of water conservation policies*

Figure 7 summarizes the methodology for the disaggregated farm-level analysis that is required for the evaluation of the different policy options selected. Based on an ample field work, a farm model typology was constructed based on the combination of three statistically-based representative farms, two types of water sources (surface and ground water) and three types of irrigation techniques (gravity, sprinkler and drip). The representative farms are intended to represent the Syrian irrigated agriculture in different regional environments and the selection was made according to farm size, production potential, factor allocation, cropping pattern and type of water source. The characteristics of these farms appear in Table 16 and their location in the different Syrian regions in

Table 16. Selection of representative farms for irrigated agriculture in Syria.

Farm typology	Size (ha)	Cropping pattern: Crop	Cropping pattern: % of surface	Region
Large farm	14	Wheat	70	Al-Hasakah
		Cotton	30	
Medium farm	5	Wheat	50	Hama
		Cotton	20	
		Potato	15	
		Sugar beet	15	
Small farm	1.5	Tomato	50	Lattakia
		Potato	25	
		Oranges	25	

Source: Varela-Ortega & Sagardoy (2003).

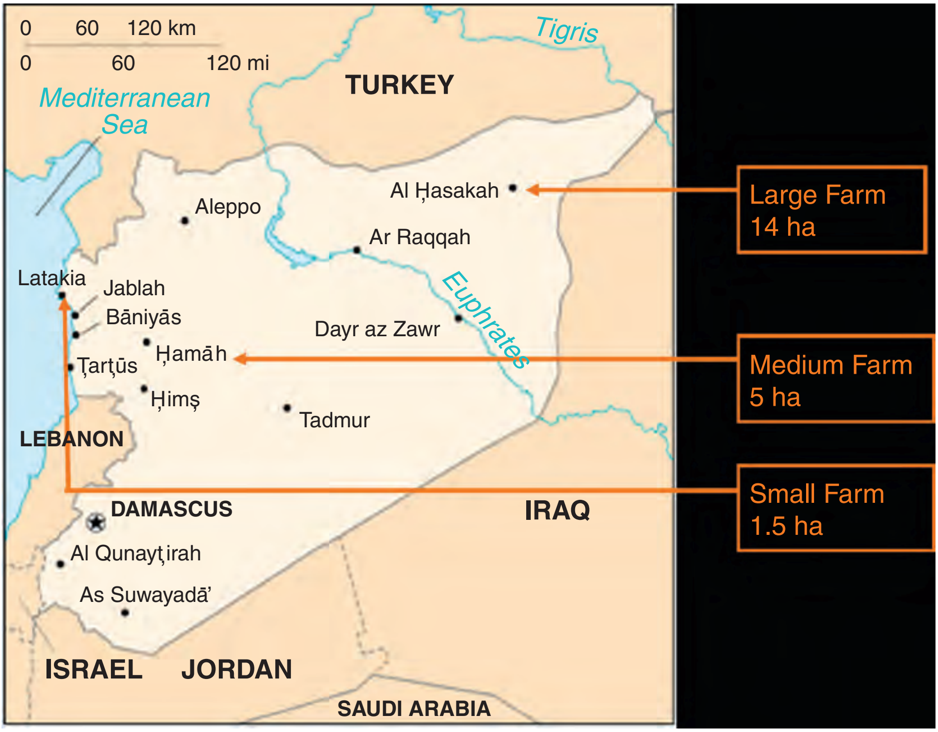


Figure 8. Location of the representative farms in the selected regions in Syria.
Source: The World Factbook 2002 [www.faqs.org/docs/factbook/print/sy.html]

shown in Figure 8. These are namely a large extensive farm of 14 ha, a medium size semi-intensive farm of 5 ha and a small intensive farm of 1.5 ha, which together represent 77% of all irrigated holdings and 64% of the irrigated surface (Varela-Ortega & Sagardoy, 2001; Varela-Ortega & Sagardoy, 2003).

Table 17. Effects at national level of the land use policy on water use, farm income and employment (year 2004).

Land Use Policy Comparisons (Gravity Irrigation)									
	Water use (Mm^3)			Gross Margin (10^6 US$)			Labor Use (10^6 working days)		
Policy Scenarios	Total	%	Balance	Total	%	Balance	Total	%	Balance
Current situation	5,764	100		497	100		31	100	
Cotton/wheat 20%	5,386	93	−378	473	95	−24	27	85	−4.63
Cotton/wheat 65%	4,536	79	−1,228	419	84	−78	16	52	−15.04

6.8.1 *Farm models for the current situation and simulated scenarios*

Water sources in the different farm models are shallow water diverted from rivers, and groundwater extracted from wells (at different levels of well depth). The technical, agronomic and economic parameters of the farms were obtained from the field survey as well as all irrigation variables. These are, for instance, water use volumes and technical efficiency for each irrigation technique, water abstraction costs and water delivery costs, as well as water application standards for all the irrigation options in the farm models. The combination of farm types, water sources and irrigation techniques results in an ample number of farm models which has permitted to compare the effects of the different policy scenarios that were selected for this analysis. From all the farm models of the original study (Varela-Ortega & Sagardoy, 2001) we have selected for this analysis a subset of models in which the economic parameters were up-dated for 2004[3]. This subset includes, for the analysis at national level for both types of policy scenarios, the large-farm models in the region of Al-Hasakah, specifically the groundwater models of 100 m. well depth. For the simulations of the irrigation modernization policy, we selected the sprinkler irrigation models in all farm types, which permitted to assess the impact of the transformation from gravity irrigation to pressurized sprinklers at national level and across farm types.

6.9 *Effects of the implementation of the selected policies at national level*

For the purpose of the policy comparison at national level, we have centered our analysis in the cereal and cotton growing region of Al-Hasakah, in the northeastern part of Syria (see map in Figure 8). This region accounts for 98% of the entire nation's irrigated surface for cotton and wheat and therefore it seems reasonable to select this region for the simulation of a change in the cotton-wheat crop mix. In the case of the modernization policy, we selected the sprinkler irrigation farm models in Al-Hasakah for simulating the transformation form gravity irrigation to modern pressurized sprinklers. The final results of the crop models were then aggregated at national level.

6.9.1 *Results of the land use policy (change in the cotton-wheat cropping pattern)*

Table 17 shows the aggregate results of the application of the two land use policy scenarios that were defined in Section 6.7. As a baseline, we have considered the current situation of the wheat-cotton irrigated crop mix (70%–30%). The other two simulated scenarios included, respectively, a reduction of 20% and 65% of the cotton surface and the equivalent increase in the wheat panting area.

From the results we observe that in the case that the cotton growing area will be reduced by 20%, the volume of water used is a mere 7% less of what was used in the current crop mix situation. In total, water savings reach 378 Mm^3, well below the nation's annual shortage. A more drastic reduction of 65% in the area planted with cotton will reduce water use by 20%, still less than

[3] This year was chosen for consistency with the 2004 data presented in the tables of the previous sections. Data were updated considering the annual inflation rate in Syria for the period 2001–2004, and converted into US$ using the official exchange rate 53.52 S£/US$.

Table 18. Effects at national level of irrigation modernization on water use and farm income.

Irrigation Modernization Comparisons									
	Water use (Mm^3)			Gross Margin (10^6 US$)			Labor Use (10^6 working days)		
Policy Scenarios	Total	%	Balance	Total	%	Balance	Total	%	Balance
Current situation (gravity)	5,764	100		497	100		31	100	
Current situation (modernization sprinkler)	4,323	75	– 1,441	831	167	335	24	77	−7.05
Cotton/wheat 20%	5,386	93		473	95		27	85	
Cotton/wheat 20% (modernization sprinkler)	4,040	70	−1,347	786	158	313	20	64	−6.51
Cotton/wheat 65%	4,536	79		419	84		16	52	
Cotton/wheat 65% (modernization sprinkler)	3,402	59	−1,134	683	137	264	11	35	−5.29

proportional, and the volume of water saved will reach 1,228 m^3/yr, about one third of the total deficit in the country (see Table 11). Looking at the economic and social effects of this land use policy, we observe that the first policy option produces a negative impact on farm income and employment. A total 24 million US$ and 4.63 million working days will be lost, in the nation's aggregate, as a response to this cotton-reduction cropping change. Equivalently, the more drastic 65% reduction of the cotton growing area, in the alternative scenario, will likely diminish farm income by 78 million US$ as labor use will diminish by 15 million working days. According to these preliminary results, the social impact of this cotton-reduction policy is not negligible, being cotton a labor intensive crop. In fact, in its less drastic version of 20% cotton reduction, this policy brings about 7% reduction in water use, which is clearly insufficient to balance the overall annual water deficit, but, in turn, it provokes an aggregate loss of 15% working days, more than twofold the water saving percent. From an overall policy perspective, balancing environmental and social objectives is a desired policy goal and, in this respect, it remains questionable whether it will be possible for the Syrian agrarian economy, to provide sufficient employment opportunities in the cotton growing areas, to compensate for this potential negative social impact.

6.9.2 *Results of the irrigation modernization policy*

Table 18 shows the aggregate results at national level of the application of the irrigation modernization policy in Syria. The Table summarizes the effects on water use and farm income. Irrigation modernization is represented by the substitution of gravity irrigation by sprinkler irrigation in the farm models. This substitution entails a reduction in water losses in the irrigation system, and hence an increase in technical efficiency for irrigation applications that reduces the water volumes applied to the crops. It also entails an increase in investment costs in the farms related to the installation of the pressurized system, the pump set and the sprinklers.

We can observe that when irrigation modernization takes place (that is, gravity systems are substituted by sprinklers) water use is reduced in all types of land use policy scenarios. These are defined as before by a reduction of, respectively, 20% and 65% of the cotton surface and an equivalent increase in the whet growing surface. This trend is larger when modernization occurs in the current situation with a larger proportion of cotton surface with respect to the cotton-reduction options.

With respect to the *effects on water consumption*, when gravity systems are substituted by pressurized sprinklers, in the current scenario, water use diminishes by 25% that amounts to 1,441 Mm^3, about half of the nation's water deficit. In the case of the 20% cotton-reduction scenario, water use is reduced by a slightly smaller percent amount of 23%, which corresponds to a volume of 1,347 Mm^3. Equivalently, in the case of the 65% cotton-reduction scenario, water use is reduced by a lesser percent amount, 20%, that totals a volume saved of 1,134 Mm^3. In sum, as land use favors less water intensive crops, such as wheat, by increasing its surface, the modernization of irrigation systems has a smaller impact on water savings than in the case of more intensive cropping patterns with more cotton acreage.

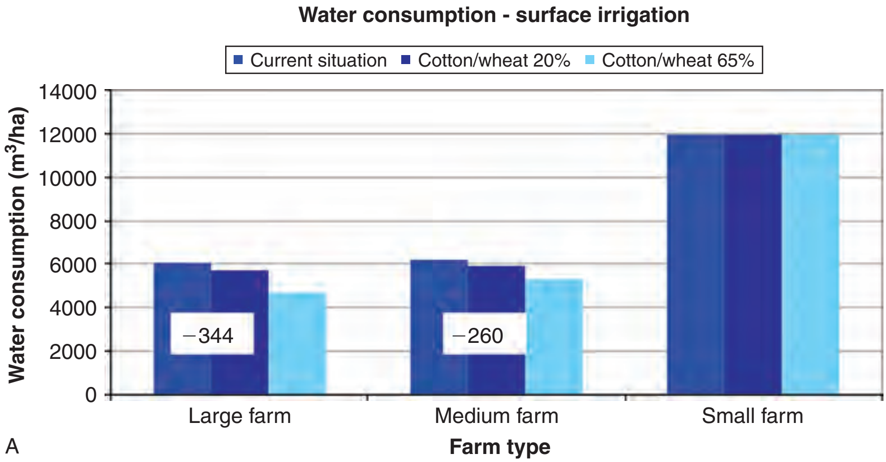
If we compare the results of the modernization policy to the results of the land use policy presented in the previous section (Tables 17 and 18), we can observe that irrigation modernization is a much more effective policy for attaining water savings that the land use policy. In fact, in the current situation, irrigation modernization attains a water use reduction that is fourfold the volume saved by the land use policy (1,441 Mm^3 and 378 Mm^3 respectively).

Observing the *effects on farm income*, the irrigation modernization policy produces an increase in farm income across all policy scenarios. When sprinklers are installed substituting for gravity systems in the baseline scenario, the 20% cotton-reduction scenario and the 65% cotton-reduction scenario, farm income increases respectively by 335, 313 and 264 million US$. In average, modernization of irrigation systems results in income gains that range between 70 to 40% of their non-modernized original farm income. When comparing these results to those obtained by the land use policy, we observe, as in the case of water use discussed above, that the modernization policy is more effective and does not inflict income losses to the farmers. On the contrary, adopting sprinkler irrigation has clear incentives to the farmers for using less water in their crops. It saves water and therefore results in clear income gains to the farmers, as water is measured and priced by the volume consumed in the pressurized systems. Conversely, the land use policy that foresees a reduction of 20% and 65% in the cotton cultivation area provoked a farm income loss of 24 and 78 million US$ respectively.

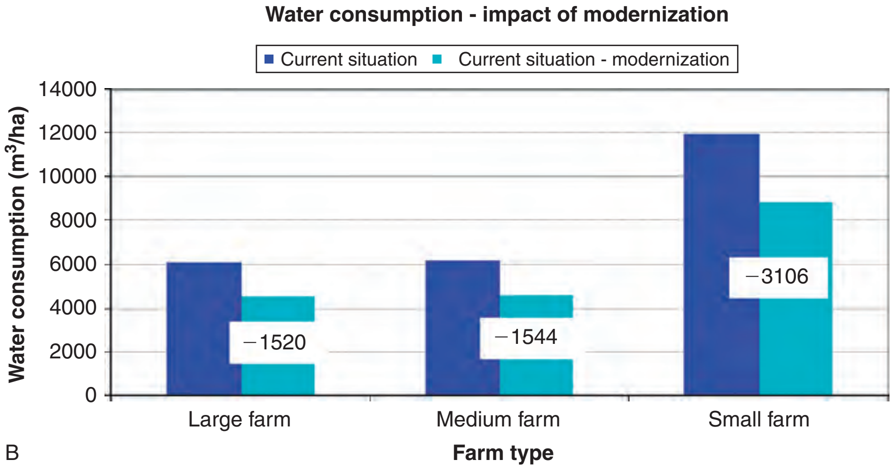
Equivalently, the *effects on labor use* and farm employment are less drastic in the case of the modernization policy than in the case of the land use policy. In fact, as land use becomes more extensive and wheat occupies a larger proportion of the cropping land, the impact of the modernization policy on labor use is progressively effaced. Farm employment is reduced by about 7 million, 6 million and 5 million working days when modernization takes place respectively in the current cropping scenario and in the 20% and 60% cotton-reduction scenarios. By itself, the land use policy inflicted a total job loss of three times more (15 million working days) in the case of the more drastic cotton-reduction case than when irrigation systems are upgraded. However, it has to be noted that half of the labor used in the large Syrian farms is family labor and therefore the employment loss that comes along the installment of pressurized irrigation systems will be partially absorbed by the families' on-farm labor commitments.

6.10 *Impacts at farm level*

Figure 9 shows the water use comparative results in the case of the land use policy and the modernization policy for the different types of farms. Figure 10 shows the farm income equivalent results. In both figures, the numbers shown in the small rectangles refer, respectively, to the difference between the current scenario and the cotton-reduction scenario in the case of the land use policy, and in the case of the modernization policy, for the difference between the gravity systems and the modern pressurized sprinklers. Comparatively, we can state that the aggregate nation-wide policy effects are also apparent across farm types. Water savings are substantially larger in the case of the modernization policy than in the case of the cotton-reduction policy for all farm types. In fact, in the current situation, installing modern irrigation systems in the larger farm saves five times more water per ha than substituting wheat for cotton (1,520 m^3/ha and 344 m^3/ha respectively). In the medium-size farm, this difference is increased to seven times more. Economies of scale favor the land use policy, as large farms save more water (344 m^3/ha) than medium size farms (260 m^3/ha). However, the adoption of modern irrigation technologies favors inverse economies of scale, and water savings increase as farm size diminishes. That is, the smaller more intensive farms have a higher water-saving capacity than their larger less intensive counterparts (3,106, 1,544 and 1,520 m^3/ha for the small, medium and large farms respectively).



A



B

Figure 9. Comparative effects of land use and modernization policies across farm types: Impact on water consumption[4].

Adopting the cotton-reduction land use policy inflicts income losses to the farmers, almost equally in the large and medium-size farms (30 and 35 US$/ha respectively). However, adopting modern irrigation technologies produces an inverse effect and water savings come along with clear income gains for the farmers (around 50% for all farm types). Parallel to water use, modern irrigation technologies show inverse economies of scale with respect to farm income. Farmers' profits mount as farm size diminishes. The more intense small farms, that are capable of better adjusting to water-saving technologies, use less water and hence farm income is augmented (2,003, 548 and 362 US$/ha in the small, medium and large farm respectively) as water volumes and costs diminish in the pressurized systems. In sum, an irrigation modernization policy seems more effective and more socially acceptable for all farm types than the land use policy. However, even if both policies have the same goal of reducing water use, their impact varies for different types of farms and regions, and therefore, a local regionally-based vision is needed for a careful assessment of the effects of these policies.

---

[4]The land use policy has no effects on the small farm as this farm does not cultivate cotton or wheat and is therefore out of the crop-mix change defined in this policy (see Table 16).

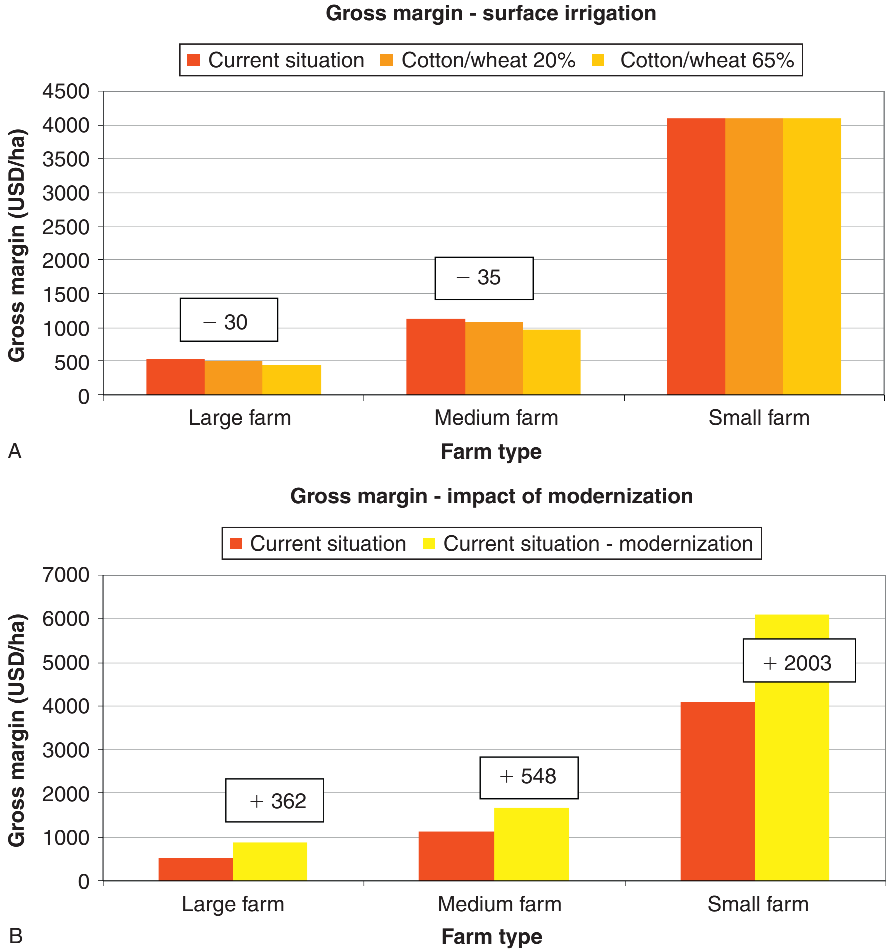


Figure 10. Comparative effects of land use and modernization policies across farm types: Impact on farm income.

Looking at the *combined application of the two types of policies*, the cotton-reduction scenarios do not provoke greater water savings when more efficient modern irrigation systems are installed (Table 17). Moreover, farm income gains are not augmented when modern irrigation systems are installed in conjunction with cotton-reduction options (Table 18). This evidences that both policies do not necessarily complement their water-saving objectives and that, for the Syrian economy, as well as for the economies of other Mediterranean arid countries, policy synergies have to be developed to attain commonly defined goals. These policies will have to interact with the aim of balancing the trade-offs between using water for conserving the environment and for maintaining the rural livelihoods. This is the case of the semi-arid regions in Spain in which the EU water and agricultural policies are seeking to converge, in specific rural settings, to balance the conservation of water resources and the irrigation-based agrarian economy (Varela-Ortega, 2010). In a regional perspective, the application of these two types of policies can have distinct effects across different types of farms. Hence, the regional and local effects of nation-wide policies have to be carefully explored to achieve a sound and socially-accepted implementation of water conservation policies in Syria.

7 CONCLUSIONS

The scarcity of water resources in the Mediterranean countries is reaching alarming levels. The scarcity index (the ratio of total water withdrawals to the average of natural renewable resources flow) already exceeds 50% in eight Mediterranean countries and this number will increase in the future.

The increasing water scarcity has led to high investments in regulating river flows. The region has the highest percentage of river regulation (80%) in the world. Also high investments have been made in irrigation development resulting in high increases in the irrigated areas during the last 25 years. The reuse of non-conventional waters has not escaped to these efforts and in the MENA (Middle East and North Africa) Region a high percentage (60% of the world capacity) of the domestic supply comes from this type of water resources. Still most of these efforts are not sufficient to compensate the growing demand.

Irrigation development has contributed to increase food security in most of the European countries. However in SEMR (South East Mediterranean Region) countries the situation has improved, but not sufficiently to compensate population growth. Some countries like Egypt and Morocco have reduced their food security standards in recent years, and this situation will worsen due to significant population growth rates.

The chapter also analyzes the interrelation between poverty and development and water scarcity. It concludes that the poor sections of the population suffer more from water scarcity. It also acknowledges that irrigation development has contributed substantially to reduce poverty. Food aid can be a useful instrument to alleviate emergency situations of hunger, but cannot be the remedy to poverty and hunger.

The SEMR countries, and to some extent the EU countries, have resorted to augment agricultural trade to meet the growing domestic demand that could not be satisfied by the national agricultural production. Net trade increases are moderate in all countries analyzed, mostly due to increased demand driven by population growth.

The increase in trade leads also to great transfers of virtual water. The use of this relatively new concept is becoming more common, but still rarely used for planning agricultural production in a given country. To contribute to this purpose, this chapter advances a methodology that through the systematic analysis of some basic information related to production, irrigation water use, agricultural trade and virtual water trade, provides some policy lines for redirecting the agricultural production. However these policies require careful analyses before attempting their implementation. A first attempt has been made with Egypt where the mentioned information has been analyzed for the main crops and a period of 15 years. Some interesting conclusions emerge, but it is obvious that in order to translate them into executable policies a deeper analysis is required and this was done in the case study of Syria were the authors had access to detailed field information.

The same methodology has been tested for Syria and has proven its usefulness for identifying the effects of the main policy actions that could be undertaken. However the implementation of these policies requires testing their feasibility through more detailed studies. Some of the emerging conclusions state that, given the structural water deficit in Syria, policies that aim to conserve water resources can have very different effects on the overall economy and on the rural livelihoods depending on the instruments chosen to attain the desired objectives.

A nationwide land use policy that foresees the reduction of water intensive crops, such as cotton, and the equivalent increase in wheat, will only attain water savings up to a mere 10% of the nation's water deficit. From the social perspective, the economic and societal impacts of this cotton-reduction policy are not negligible, being cotton a labor intensive crop, as the overall farm income and employment are severely impaired at the nation's aggregate. Therefore, this policy will be neither environmentally sustainable nor socially acceptable. It remains questionable if the Syrian economy will be flexible enough to provide alternative employment opportunities in the agricultural sector, or in any other economic sector, to compensate for this potential social loss.

If Syria chooses to implement a technically-oriented water saving policy, such as the modernization of the existing irrigation systems, we can conclude, based on our preliminary findings, that this policy is much more effective and socially balanced than the land use policy for attaining water conservation objectives. Provided that irrigators are faced with proper volume-based and price-based incentives to use less water in the new pressurized systems, the total volume saved in the nation can be up to four times larger than in the case of the land use policy. Under this latter policy, water is diverted and charged by surface in the non-modernized gravity systems in the absence of technically-driven incentives. In turn, proper economic and technical incentives result in social gains. Farm income can rise substantially across all farm types and regions, family labor will have to be more technically oriented and trained, and employment opportunities will have to shift to the production of more labor intensive higher value-added crops.

In Syria, as in other Mediterranean arid countries, policy synergies have to be developed to attain commonly defined goals in the entire nation and in the different regions as well. These policies need to balance the environmental objectives of water conservation and the socio-economic objectives of maintaining the rural livelihoods. However, it seems conclusive that the nation-wide policies that emerge from agricultural trade and production have distinct regional and local effects. Then, these implications have to be carefully explored to achieve a sound and socially-accepted implementation of water conservation policies in the water-scarce Mediterranean basin.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the EU project SCENES ("Water Scenarios for Europe and Neighbouring States" FP6 GOCE, 036822) for supporting partially the data-base processing of this research at Universidad Politécnica de Madrid, Spain (UPM), and the Mediterranean Agronomic Institute of Bari, Italy (CIHEAM).

REFERENCES

Benoit, G. & Comeau, A. (eds.) (2005). Plan Bleu. *A Sustainable Future for the Mediterranean: The Blue Plan's Environment and Development Outlook*. UNEP-MAP-Blue Plan. Earthscan, London, UK: 464 pp.

Central Bureau of Statistics (1998). Agricultural census of 1998, Crop harvested areas. Damascus, Syria.

Chapagain, A.K. & Hoekstra, A.Y. (2004). *Water footprint of nations. Volume 1: Main Report*. Value of Water Research Report Series, 16. UNESCO-IHE, Delft, the Netherlands.

FAO (2005). The state of food and agriculture. Agricultural trade and poverty. Can trade work for the poor? Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO (2008). *The state of food insecurity. High food prices and food security –threats and opportunities*. Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO (2009). *FAOSTAT Database* [http://faostat.fao.org].

Fernandez, S. (2007). *L'eau virtuelle dans les pays méditerranéens: un indicateur pour contribuer à l'analyse des questions de gestion et de répartition de l'eau en situation de pénurie?* Rapport d'étude régionale du Plan Bleu [www.planbleu.org].

Hamdy, A. & Lacirignola, C. (2005). *Coping with water scarcity in the Mediterranean. What, Why and How?* Mediterranean Agronomic Institute of Bari, Italy: 17–45.

IFPRI (2000). *Wheat policy reform in Egypt: Adjustment of local markets and options for future reforms*. By M. Kherallah. Research Report, 115. Washington, D.C., USA.

INE (1997). *Encuesta sobre las estructuras agrarias de 1997*. Instituto Nacional de Estadística, Spain. [www.ine.es].

MAAR (Ministry of Agriculture and Agrarian Reform) (2004). Memorandum of Transfer to Modern Irrigation. Administration of Natural Resources. Research General Commission for Scientific Agriculture Research. Internal Communication. Damascus, Syria.

Sagardoy, J.A. & Varela-Ortega, C. (2007). *Sustainability of the exploitation of the water resources of Syria and its implications for the future development of the irrigated agriculture*. Paper presented at the Seminar: *The Contribution of Agriculture and Rural Development to the Process of Economic Reforms of Syria.* FAO Project GCP/SYR/006/ITA Phase III. Damascus, Syria.

Somi, G.; Zein, A.; Dawood, M. & Sayyed-Hassan, A. (2002). *Progress Report on the transformation to modern Irrigation Methods until the end of 2001*. Internal report. Ministry of Agriculture and Agrarian Reform. Damascus, Syria.

UN (2008). *World Population Prospects*. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, New York, USA.

US Syrian Embassy (2006). *The Syria Cotton Report 2006. Executive Summary*. [http://damascus.usembassy.gov/uploads/].

USDA (2008). *Syria: wheat production in 2008/09 declines owing to season-long drought*. Foreign Agriculture Service. Commodity Intelligence Report, May 2008. Washington, D.C., USA.

Varela-Ortega C. (2010). The Water Policies in Spain: Balancing water for food and water for nature. In: A. Garrido & H. Ingram (eds.), *Water for Food in a Changing World*. Routledge, Abingdon, UK.

Varela-Ortega, C. & Sagardoy, J.A. (2001). *The utilization of water resources for agriculture: Analysis of current regime and policy.* Final Report. FAO project GCP/SYR/006/ITA. FAO-Italian Government Cooperative Program. Damascus, Syria.

Varela-Ortega C. & Sagardoy, J.A. (2003). Water Policies in Syria: Current Developments and Future Options. In: C. Fiorillo & J. Vercueil (eds.), *Syrian Agriculture and the Crossroads*. FAO Agricultural Policy and Economic Development Series, 8. Policy Assistance Division. Food and Agriculture Organization of the United Nations, Rome, Italy.

World Bank (2006). *Making the Most of Scarcity Accountability for Better Water Management Results in the Middle East and North Africa*. MENA Development Report. The World Bank, Washington, D.C., USA.

World Bank (2008). *World Development Indicators. Poverty Data Supplement to the 2008 World Development indicators*. The World Bank, Washington, D.C., USA.