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SECURING FOOD FOR A GROWING POPULATION: THE WATER SCARCITY CHALLENGE

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SUMMARY – With an average of 70 percent of all water used for human purposes, agriculture is by far the largest consumer of water. While we need about 3 to 4 litres of water for drinking purposes, the water needed to produce our daily food varies between 2000 and 5000 litres. For the last 50 years, the world food system has responded to a doubling of the world population, providing more food per capita at a progressively lower price. Global nutrition has consistently improved and, if today a large number of people still face undernutrition and hunger, the question is not any more one of supply, rather, it is much more related to poverty and to the people's capacity to access food (FAO, 2003a). The success of agriculture came at a cost. In the latter half of last century, massive investments were made in irrigation and agricultural research, leading to a rapid increase in water abstraction, in particular in countries where water is scarce. Today, a growing number of countries and region suffer extreme water scarcity, leading to competition between sectors and negative impacts on the environment. In the future, changes in diets and population growth will continue to influence the demand for food and water abstraction for agriculture will continue to rise in several regions, albeit at a slower rate. Food trade will increase, partly as a result of water scarcity in water scarce countries. The paper presents the global food and water situation and perspectives for the future, in particular in the Near East, and the challenge it imposes on water scarce countries. It analyses how countries react to increased water scarcity and reviews the policy, institutional and technological responses available at local, national and global levels with a particular focus on enhancement of water productivity in agriculture.

Key words: Water scarcity, food security, water productivity, agriculture

1 INTRODUCTION

The world's growing population drives the demand for food which now claims the dominant share of freshwater abstractions. In the latter half of last century, significant investment in agriculture has resulted in accelerated productivity gains, allowing for a rapid closure of the food security gaps, particularly in areas otherwise vulnerable to climatic variability. It has played a major role in stabilizing and boosting agriculture-based economies in the arid and semi-arid areas of the Middle East and Southern Mediterranean regions.

Providing enough water is an enormous challenge, especially in those regions and countries where water is scarce. A substantial increase of water productivity, investments in demand management, modernization of existing irrigation systems, and, when possible, new water resources developments are clearly needed. However, as the world food system becomes increasingly productive and the global markets offer staple food at a steadily decreasing price, irrigated agriculture in arid regions needs to be carefully examined to discern where their societies can benefit most effectively from its application.

Access to natural resources will have to be negotiated with other users in a transparent fashion in order to affect optimal use of limited water resources to deal with human welfare, food security and poverty reduction. Irrigation is under pressure to perform as a service to agriculture, not as an end in itself. This will involve a shift in approach from a supply-driven to a demand-responsive activity in which a much clearer rationale for the participation of users and the mobilisation of investment is established. In the Near East and North Africa, a rapidly increasing population is pushing agriculture beyond its limits and competition for water with other sectors result in a slow decrease in water

allocation for agriculture. The challenge for agriculture in the region is to combine increased water productivity with a legitimate quest for security in the supply of basic food commodities.

2. THREE LEVELS OF FOOD SECURITY

The words “Food security” can be understood in many different ways. In the food and agriculture community, a distinction is usually made between issues at global, national and household level.

At global level, food security relates to the world’s capacity to produce enough food to feed the world, in a sustainable way, in the years to come. Recent studies by FAO and by the International Food Policy Research Institute have both shown that the world is capable to produce sufficient food to feed its growing population at least until 2030. Later, with the world population projected to stabilise by 2050, the issue of food production capacity should not represent a serious problem.

At national level, the term food security has often been used, in the past, to indicate the capacity of the country to produce the food it needs to feed its own population. The term food self-sufficiency is now preferred, as it better represents the policy problem related to this issue. Although, in the recent past, major progresses have been made in the development of international trade, food self-sufficiency remains, for several countries, a strategic issue having implication on their agricultural policies.

It is now widely admitted that the issue of food security is related to the capacity of peoples to feed themselves. At the World Food Summit of 1996, food security was defined as the *Physical, social and economic access for all people to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life*.

Such a definition implies that the capacity to produce food is not necessarily linked to people’s food security situation. In rural areas of developing countries and in agriculture-based economies, however, this link remains important.

3. THE DIMENSION OF HUNGER

In the year 2000 there were around 800 million people undernourished. On a total world population of about 6 billion this is about 13 percent. During the World Food Summit of 1996 in Rome, all participating countries pledged their political will to reduce the number of undernourished people to half the level of 1996 by 2015 at the latest. Since the World Food Summit FAO reports on regular intervals on the progress made to reach this target. Unfortunately, achievements so far have been below expectations, and it is unlikely that the targets of the World Food Summit will be reached by 2015.

Food insecurity is always associated with poverty: unavailability of jobs for landless labour, inability to access sufficient productive resources, such as land, water, seeds, or fertilisers for farmers. Most often, food insecurity is part of a package with environmental degradation and civil strife or war. Typically, food insecurity is also associated with people’s incapacity to cope with difficult situations due to their precarious living conditions.

Nutritional conditions do not always correlate with water scarcity. For example, some of the most water scarce regions of the world, the Near East and Northern Africa, are nutritionally relatively well off. In the future, they will probably increase trade with other regions, in particular Europe, and earn foreign exchange from manufacturing and services. This will make it possible for them to pay for the increasing food imports that will be needed to feed their people. On the other side, many countries in the humid tropics have a poor nutritional status that can hardly be attributed to lack of water. Here, poverty and the incapacity to take advantage of the existing resources are the main causes of hunger. More than any other causes, war, that devastates the countryside, takes a terrible toll on rural people.

On the other hand, water does play an important role for food production and food security. Without massive investments in water development and irrigation, countries like India, China, Mexico, or Egypt would show a much darker picture, and there would probably be much more internal conflicts

today because of hunger. As several economies, in particular in Africa, are still very much based on agriculture, increased productivity in agriculture remains the sole engine of their growth.

4. WATER AND FOOD PRODUCTION

4.1. Irrigation systems across the world

There is a multitude of typologies of irrigation systems across the world, a manifestation of the various farming systems they sustain. The two more widespread irrigation systems are the hillside paddy fields of most of south-eastern Asia, and the large scale irrigation systems bordering the main rivers of arid regions.

Irrigation has been practised for thousands of years. Historians associate the emergence of early civilisations with the development of large-scale irrigation able to provide the food necessary to sustain urban life. Irrigated agriculture in ancient Egypt, for example, sustained an estimated 300 persons per km^2 of cultivated land, ten times as much as tropical slash-and-burn systems and the fallow systems of the ancient Mediterranean and European world. In the early states founded on large-scale irrigation the responsibility for food security was centralised and the prestige and legitimacy of the state depended on fulfilling this function. Food security management was entrusted to specialists in such matters as infrastructure development, water management and accounting (Mazoyer & Roudart, 1997).

Irrigation is widespread in the densely populated areas of the dry belt between 15 and 35 northern latitude. More than 40% of all cropped land in these regions has some kind of irrigation. National figures, in particular in large countries, mask enormous local differences. In those countries where insufficient or erratic rainfall constrains rainfed agriculture, but rivers and/or groundwater provide a convenient source of water to replenish soil moisture for crops; irrigated land represents a sizeable percentage of arable land. In the extreme cases like Egypt, all cropland is irrigated. When more than 20% of all water available is abstracted, it is usually considered that water becomes a constraint to economic development. Most countries of the Near East and Mediterranean region already use more than 20% of their resources.

The remaining potential for expansion of irrigated agriculture, both in terms of land and water resources is unevenly distributed. While overall sub-Saharan Africa and Latin America still have large surpluses of available land and water, regions like the Near East (for water) and south-eastern Asia (for land) are stretching to the limits of their potential. In such region, the only way out is increased productivity of land and water.

4.2. How much more water will we need to feed a growing world population

Overall, the world's population is growing at a slower pace than in the past. Still, from the 6 billion people living on the planet in 2000, it is expected that we will reach 8 billion in 2030, an increase by one third. FAO has recently performed a perspective study on food and agriculture between now and 2030 (FAO, 2003). In order to respond to food demand in 2030, which is expected to be 55% higher than in 1997/99, under the joint effect of population growth and changes in diets, global food production should increase at an annual rate of 1.4 percent. According to FAO projections, this growth would occur mostly in developing countries, at an annual rate of 1.6 percent, while crop production growth in industrialised countries would be of only 0.9 percent. About 80 percent of the projected growth in crop production in developing countries will come from intensification in the form of yield increases (67%) and higher cropping intensities (12%). The remaining 20 percent will come from cultivated land expansion in some countries of sub-Saharan Africa, Latin America and East Asia that have a large land potential.

According to FAO estimates, irrigated agriculture in developing countries accounts for 40 percent of all crop production, and almost 60 percent of cereal production. In 2030, irrigated agriculture in developing countries would account for a third of the increase in cultivated land and for over 70 percent of the projected increase in cereal production. The area equipped for irrigation in developing

countries is expected to expand from 1997/99 until 2030 by 20 percent, or 40 million hectares (FAO, 2002). This is a net increase and assumes that losses of existing irrigated land resulting from, for example, water shortages or degradation because of salinisation, will be compensated through rehabilitation or substitution by new areas for those lost. The projected net increase in irrigated land (40 million hectares) is less than half of the increase in the preceding period (100 million hectares), a result of combined increase in productivity and reduced population growth rate.

5. THE CHALLENGE FOR THE MEDITERRANEAN REGION

The Region covering Near East and North Africa is the most water-scarce in the world. It covers 14 percent of the total area of the world and contains 10 percent of its population. Its renewable water resources are only 2.2 percent of the global total. The issue of water scarcity is further exacerbated by a high dependence on water resources that originate outside the region, in terms of both freshwater inflow and imports of foodstuffs. Growing population and the need for food and drinking water, usually coupled with a short-term vision on water resources planning and management, have resulted in an imbalance between water supply and demand. Pollution, salinisation, climate change and frequent severe droughts are making the problem more serious and the future uncertain. This is all leading to greater competition for water and, consequently, to greater risks of food insecurity in the region (Faurès, 2002).

A recent study, developed in the framework of the World Water Vision, gives a comprehensive overview of the region's water situation. The Mediterranean region is one of the rare natural water bodies in the world separating two adjacent areas with opposite demographic characteristics and contrasted economic development levels.

Total population in the countries of the Mediterranean region amounted to 446 million in 2000 and should reach 579 million in 2025. Population in the countries of the North has stabilised or is decreasing, while in the South it is still increasing at the rate of 1.8% per year, with some countries above 3% per year. This dual evolution of population has important implications on employment, food trade, social security (pensions, health care), land use, and, of course, pressure on water resources and pollution.

Economically, the contrast is also strong. Per capita GNP is about 30 times higher in southern France than in Egypt. It is ten times higher in Italy than in Algeria, and foreign investments in the Southern Mediterranean countries are decreasing: today, they represent only 2% of world foreign investments. As a result of this discrepancy in wealth, migrations from South to North tend to intensify. Agriculture represents 70 to 90% of total water withdrawal, and rural population is still high, up to 55% in Egypt. The share of agriculture in the nation's GNP is between 5 and 15% in most of the countries.

Mediterranean water resources are limited, vulnerable and threatened. Pressure on the water resources is already high, mostly in the southern countries, and yet, the efficiency of use is still relatively low. Efficiency in the water sector is usually calculated as the ratio between beneficial use of the water and total water abstraction. When it is close to 100%, little water is wasted. In agriculture, it is estimated that less than 50% of the water taken from the rivers and groundwater reserves effectively reach the crops, leaving plenty of opportunities for the remaining 50% to be lost in evaporation further down.

Natural supply of water is distributed unevenly between the countries of the region: 72% of the water flows in the countries of the Northern Mediterranean, 23% in the Eastern part, and only 5% in the North African countries.

In addition, the Mediterranean region is also characterised by a large seasonal and inter-annual variability of rainfall, with long periods of droughts having an important impact on the availability of water resources. Such variability in climate is reflected in yield of major crops, which shows large variations from one year to another: while statistics show that on average the production is slowly increasing with time, under the combined effect of increased cropland area and yields, yearly production is subject to extreme inter-annual variations due mainly to unstable climatic conditions.

With their rapidly increasing population and limited water resources, countries of the Southern and Eastern part of the Mediterranean region show a high intensity of use of the resources. Water use is also characterised by seasonal patterns, most of the water being needed in summer, mainly by agriculture, but also, in several countries, by tourism, which is steadily developing in the Mediterranean region.

In a number of countries, water is extracted at a rate higher than replenishment, leading to a progressive mining of the resources. The most famous case is Libya, which relies on the mining of the important resources of its fossil aquifers through the Great manmade river, but also of part of the Eastern Mediterranean, and of the islands of Malta and Cyprus, where excessive groundwater pumping often leads to intrusion of sea water into coastal aquifers and their subsequent salinisation.

In conclusion, most of the southern and eastern Mediterranean regions are already in a situation of water crisis. Water shortages in several countries already limit significantly their possibility to produce enough food to feed their population, forcing them to buy food on the international market.

6. OPTIONS FOR WATER MANAGEMENT IN CONDITIONS OF SCARCITY

6.1. Enhancing crop water productivity

Over the last 40 years, plant breeding has made it possible to double the yield of the main staple crops, with no additional water requirement. This has led to an overall doubling in agricultural water productivity. Water-related plant breeding are also the subject of research, like resistance to dry spells, reduced transpiration rates, increase of the harvest ratio, enhancement of the photosynthetic efficiency or changes in growing cycles to better match the rainy season (FAO, 2003b). Yet, transpiration is needed and will always be needed to bring nutrients from the soil to the leaves where photosynthesis takes place.

Genetic engineering has made it possible to isolate and transfer genes from one organism to another, creating genetically modified organisms and considerably accelerating the speed of genetic selection. Development of drought- and salinity resistant crops is certainly of interest in the context of water scarcity. However, experts disagree on the possibility to develop such crops in the near future: while some success is being reported in tackling drought and salinity tolerance, there have been no big breakthroughs in developing such crops to date (FAO, 2003c.).

6.2. Instruments for water scarcity management in irrigation

Three instruments are available to improve water management. *Supply management* consists in developing the necessary infrastructure to allow for a safe and reliable use of the resources. Construction of dams and canals, groundwater development or transfer of water between river basins are among the instruments used to manage water supply. Supply management has been the prime way of developing water resources in the region, and major programme are still on-going in several of the region's countries. Yet, with the progressive reduction of untapped water sources and increased environmental cost of new water development, the relative importance of supply management in water programmes should decrease progressively.

In a water scarce region, *demand management* is the immediate step following supply. Traditional irrigation, in most of the countries of the region, consumes only a fraction of the water it withdraws (about 50%), the rest being evaporated in unproductive areas or returns to the rivers, usually of poor quality. While not all that water is lost, inefficient management of water in irrigation usually translate into inequitable water distribution in the irrigation schemes, ineffective water delivery, waterlogging in lower areas and problems of salinisation in the most arid zones. All these factors impact average yield and restrain the overall productivity of the irrigation infrastructures. Unreliable water supply also affects the cropping patterns in the irrigated schemes, forcing farmers to opt for robust crops and to avoid high return, usually water sensitive cultures.

The last, and necessary step in conditions of extreme water scarcity, is to *increase the productivity of irrigated water*. Here, the objective is not only to control losses, but to make sure that return on water is optimised. A classical example of improved water productivity in irrigation consists in switching from cereals to marketable vegetable products. However, improving the productivity of water in irrigation requires that a series of conditions be fulfilled. Typically, high value crops (vegetable, fruits, potatoes, etc.) are very sensitive to market conditions. Investment in those crops may represent a risk that poor farmers in developing countries are not ready to take. Examples exist of successful intensive production of high value crops for the European market, but they are difficult to repeat because of the inelastic demand and limited market opportunities. In terms of irrigation, switching to high value crops implies an upgrading of the managerial capacities within the irrigation scheme, which includes much higher levels of reliability in the water delivery service, flexibility and transparency. This is usually obtained through institutional changes, with increased authority given to the water users, coupled with technological upgrading allowing for higher levels of flexibility in water delivery.

Access to credit and technology is also a major condition for improved demand management and increased water productivity. Techniques exist to reduce to a few percent losses in irrigation (localised irrigation systems), but they are adapted only to certain crops and require important investments. Making these techniques available to the farmers requires modern, flexible irrigation systems, reliable irrigation water delivery services, trained support staff and a dynamic sector of manufacturers and dealers. Cyprus and Israel are two countries where localised irrigation has revolutionised agriculture. Experience has also shown that strong farmer organisations were an important condition to improve performances of irrigation, in particular in large irrigation schemes.

6.3. Improving water use in rainfed agriculture

Improving water use in irrigation is not the only way to make better use of water for agriculture. Considerable scope also exists to improve supply efficiency of water in rainfed agriculture. Soil and water conservation techniques include reduction of run-off and increase of water infiltration in the root zone. Classical water conservation techniques include contour stripping, terracing and the construction of micro-basins and small dams.

Conservation agriculture techniques, applicable in some cases, improve the structure of the soil, reduce erosion and enhance its water retention capacity. They consist mainly in reducing or suppressing tillage and leaving crop residues on the ground.

Supplementary irrigation is much practised in the northern part of the Mediterranean region (France, Italy). It consists in applying limited amounts of irrigation water on rainfed crops to avoid or mitigate the devastating effects of sudden droughts. While this approach is economically attractive to farmers in the Northern countries, poor farmers in the Southern part of the region do not have the financial capacity or the necessary infrastructures that would allow them to reduce the variability they undergo in cereal production. Yet, promotion of supplementary irrigation in the region could go a long way in increasing water productivity in agriculture and providing much needed support to the livelihood of rural populations. Better rainfall forecasting is also related to supplementary irrigation and the capacity to predict short-term variations in precipitation.

6.4. Virtual water and regional co-operation: where food security meets regional security

Virtual water is the amount of water embedded in a product, that is, the water consumed in its process of production (Renault, 2003). Virtual water trade has been advocated as a means to alleviate water scarcity at global level. The concept makes it clear that, in a reasonably safe, interdependent and prosperous world, a country with limited water resources can depend on the import of agricultural products showing low levels of water productivity (cereals for instance) and apply its own water resources to produce other commodities (agricultural or other) of higher value. The concept of virtual water is attracting increasing attention in relation with the analysis of trade flows.

A representation of food trade in the form of virtual water gives the measure of the gap between water supply and potential demand. Trade in agricultural commodities has grown at about the rate of global economic output – which amounts to one third of the growth in international trade. The share of developing countries' agricultural exports in their overall exports fell from nearly 50 percent in the 1960s to close to 5 percent in 2000. Together with the overall decline in the share of agriculture in international trade, the structure of agricultural trade has also changed, resulting in a widening agricultural trade deficit of the group of developing countries projected to increase by a factor of four until 2030. Agricultural trade deficits are often, but not necessarily, an indication of a deteriorated overall economic situation; such deficits can also indicate rapid overall development, as in the case of China and the Republic of Korea. But a declining agricultural trade balance is a negative outcome in countries that depend to a high degree on export earnings from agriculture, as they may build up an unsustainable level of foreign debt.

The analysis of food trade shows that most trade takes place between countries showing substantial endowments in water resources, indicating clearly that factors other than water drive international food trade. However, it can also be an indicator of constraint to agricultural production. Egypt, which uses almost all the water it receives from the Nile, would need much more water if it was to produce all the food its people need. The total amount of virtual water captured in the food imported by the Near East countries represents 52 000 million m^3/yr, almost the equivalent of the amount of water Egypt receives, by treaty, from Sudan through the Nile. In 1995, in spite of a steady increase in cereal production in the last decades (27% p.a.), the region imported 33% of the 123 million tons of cereals it consumed.

In those countries, like in many other developing countries, food self sufficiency has for long been an important driver of agricultural policies. As the rapidly increasing population put pressure on the resources and other sectors compete for water with agriculture, these countries have to recognise that national food self-sufficiency is not achievable, and are now progressively embracing policies aiming at increasing their dependency on trade for staple crops and releasing water for more productive uses. Yet, in a region where security remains an unresolved problem, the reluctance of countries to depend on the international market to satisfy its people's most basic needs is politically understandable. Only sustained improvements in the quality and level of regional co-operation can be expected to influence agricultural policies, allowing countries to redirect water to productive uses and sustain an open, water-productive economy.

7. CONCLUSIONS

There is no doubt that the countries of the Mediterranean region suffer from water scarcity that affects their economic development. The situation in the near future, with an increasing population and demand from cities and industries will have a negative impact on irrigated agriculture and therefore on the living conditions of the rural populations.

The list is long, however, of the possibilities to improve crop production and food security in the Mediterranean region. In large irrigation systems, modernisation is a pre-requisite to reduction of losses and improved water productivity. Irrigation is expensive, and Governments have increasing difficulties in financing such large infrastructures while, at the same time, external aid is reducing. The main sources of investment are local resources of the individual stakeholder and the concerned communities. The private sector could play a more active role in irrigation investment, and such a move would require stable political frameworks and the rule of the law. At this stage successful investment of the private sector in irrigation infrastructure or the management of irrigation services is rather the exception than the rule, but it must change.

The launching of the Euro-Mediterranean free trade zone can represent interesting development opportunity for the Southern Mediterranean agriculture. It could open competitive markets in Europe and induce a progressive reduction of the production of low value crops. Such a pattern is already visible in countries like Cyprus, Malta and Tunisia. Care must be taken, however, not to destroy the agricultural economy of countries still showing important rates of rural population. Remote rural areas not only need protection against excessively rapid transformations, they also deserve the increased investments they need to improve their quality of life, maintain sustainable land management practices and control emigration. Water supply, small scale irrigation and improved management of

dryland areas can play an important role in reaching these goals, in areas of the where local water resources are still abundant.

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