Water management towards sustainable food production

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Abstract

In arid and semi-arid regions, particularly those of the Mediterranean, the water crisis is creeping closer. Water scarcity is threatening peace within countries and between countries, the food supply and the people's health and is increasing the poverty and famine. Such features characterizing water resources perspectives need a new convergence in thinking and water use practice and management to develop the synergies required to achieve the common goal of sustainable development.

Technically and politically, it is well recognized that water and water services are essential because they touch on almost all Millennium Development Goals.

Investments in water infrastructures to protect against droughts and floods and provide water supply to grow food is basic for economic growth, poverty reduction and malnutrition alleviation.

Presently, water shortage in the Mediterranean Southern and Eastern countries has obliged those countries to increase food imports because the local agricultural sector is no longer able to produce sufficient food to fulfill the existing food gap. Food production and its perspectives are not promising in spite of the fact agriculture is by far the largest user of water: on a consumptive use basis, in fact, almost over 80% of all available water is consumed in agriculture.

n the region, most countries are working hard towards achieving water security and food security. Nowadays, this is what are challenging the countries. It is quite evident that in spite of its complexity, yet, through an appropriate water use and management, we can overcome the food shortage gap, achieving the needed food security and the food production sustainability.

Introduction

The availability of freshwater is one of the great issues facing human kind today, in some ways the greatest, because problems associated with it affect the lives of many millions of people. During the next 50 years problems associated with a lack of water or the pollution of water bodies will affect virtually everyone on the planet. Water shortages and needs are increasing, and the competition for water among urban, industrial, and agricultural sectors, as well as other resources users, is growing more intensive.

Presently, water shortages have led most of arid and semi-arid countries to increase food imports because the local agriculture sector is not able to produce sufficient food to fulfill the existing food gaps. The increasing food gaps is posing serious challenges beyond the economic and political capacity required for the necessary adjustments concerning the allocation and use of water in all sectors, particularly the agriculture.

In developing countries it is expected that agriculture will remain the foundation of the rural

economy for the foreseeable future. In the UN Secretary General's Report to the 2003 meeting of the Economic and Social Council (ECOSOC) of the United Nations it was stated that: "*Three quarters of the poor world live in rural areas of developing countries and depend mainly on agriculture and related activities for their livelihood. In 2025, when the majority of the world population is expected to be urban, 60 percent of poverty will still be rural. Thus the millennium development goals of halving the proportion of people living on less than a dollar per day and the proportion of those who suffer from hunger by 2015 cannot be achieved unless rural poverty is urgently reduced*" (UN, 2003).

Today, in most countries suffering the water shortages, at the heart of the question of whether a water crisis can be adverted or whether water can be made productive. Increasing the productivity of water is central to producing food, to fighting poverty, to reducing competition for water and to ensuring that there is enough water for the nature. The more we produce with less water and/or with the same amount of water, the less the need for infrastructure development, the less the conflicts among the sectorial water uses, the greater the local food security and the more water for agricultural, household and industrial uses, and the more remain in nature.

However, to achieve such goals, major improvements are still required in water resources use and irrigation technology and management. Meeting such challenges will require a far greater effort and significant changes in how water is managed? What needs to be changed? What are the improvement required? to achieve food security with the increased water security.

Water and food production

Agriculture has long accounted for the greater part of human water use and currently claims some 70 per cent of world water withdrawals. Agriculture may claim more than 90 per cent of water in arid developing countries.

We know, through experience, that nowadays our planet could feed over six billion people if agricultural products were equally distributed basically thanks to the enhanced production resulting from the "Green Revolution" which permitted to tame the periodical, biblical famines afflicting the whole population. According to Pretty and Hine (2001), between the early 1960's and mid 1990's, average cereal/yields grew from 1.2 t/ha to 2.52 t/ha in developing countries, while total cereal production passed from 420 to 1.176 million tons per year.

But to achieve such a success a toll has been paid in terms of pollution and agro-ecosystems decay – how heavy this toll has been, is a matter of debate. The world agriculture is now facing the challenge of feeding an estimated 10 billion people by the year 2050 while alleviating the pressure on agro-ecosystems, namely reducing chemical and physical pollution, avoiding any enlargement of cropped areas and protecting biodiversity, curbing natural resources decay and protecting the landscape and the environmental amenities: not an easy task indeed! Further challenges are put by those who highlight the need for a new "food systems paradigm" (it is not sufficient to produce food enough, but the quality of nutrition must be taken into account as well: e.g. Welch and Graham, 1999); those who want to ban the use of all synthetic fertilizers and pesticides; those against the radiation of foods; those against the reuse of treated urban wastewaters for irrigation or against irrigation altogether; those against genetically modified organisms. A second Green Revolution is expected, a "more green" revolution, reconciling intensification and sustainability (Sherwood and Uphoff, 2000; Horne and McDermott, 2002).

According to FAO, by mid-1999 thirty-four countries in the developing world are plaqued with serious food shortages. The ability to produce food is unmatched by the ability to get the food to those who are in need, especially the poor and vulnerable in rural areas of developing countries. The International Food Policy Research Institute (IFPRI) currently estimates that demand for cereals in developing countries will increase by nearly 50 per cent from 1997 to 2020, rising to nearly 1.7 billion metric tons (Fig. 1).

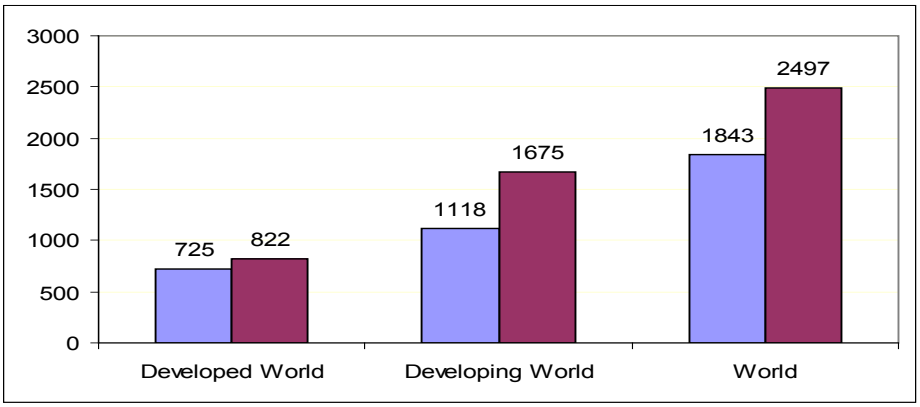

Fig. 1 - World Demand for Cereals, 1997 and 2020 (millions of metric tons)

Excluding China and India, developing countries are expected to account for about 50% of this increased demand that is nearly three times greater than of the developed countries (Fig. 2).

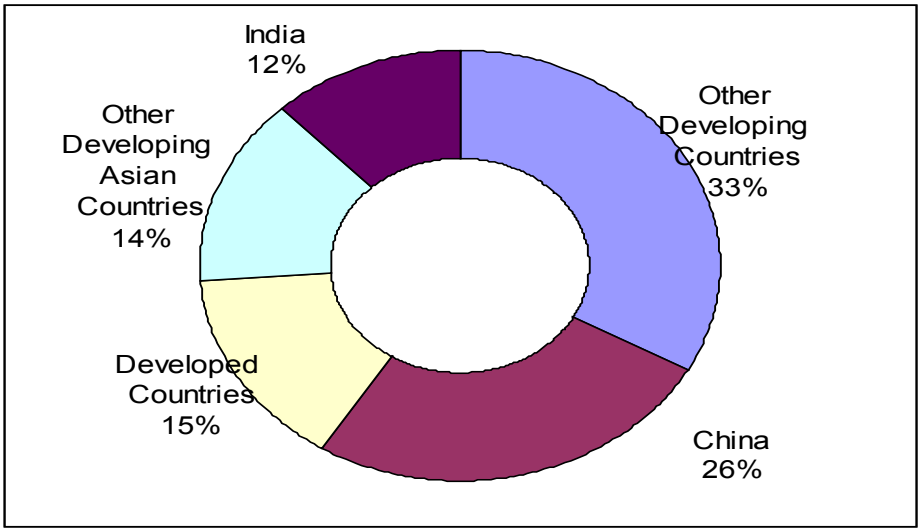

Fig. 2 - Increased Cereal Demand, 1997 – 2000

In this regard, irrigation can play an important role in satisfying the increased cereal demands. IFPRI expects the irrigated cereal area to increase from the 1997 total of 218 million hectares to 248 million hectares by 2020 with an additional one million hectares in developed countries and 29 million hectares in developing ones. Today, irrigation is practiced on more than 250 million ha worldwide, representing about 17% of cultivated lands. These irrigated lands produce about 40% of the agricultural outputs, which in turn employ, directly and indirectly, more than 2 billion rural people, who are largely small and subsistence farms.

New irrigation development has slowed down, since the 1970, due to escalating construction costs, low and declining prices of staple cereals, declining quality of land available for new irrigation and increasing concerns over the environmental and social impacts of large scale irrigation projects.

Sustainable food production system: the barriers

Many of the key components of a more sustainable food production system depend on the policy environment and the overcoming of barriers. In most of the developing countries, more attention is now given to the development of rural areas through ample programs and well defined approaches and strategies to increase food production, alleviate poverty, increasing farmers' income and diminish the relatively high urbanization rate. However, in spite of the major efforts already carried out on both international and national levels, the implementation of the outlined plans and programs is still facing several constraints and barriers that produce limited positive impacts on the beneficiaries, the rural poor. Some of those barriers are:

• *Lack of integrated land and water resources management approach*

Land and water management institutions tend to be centralized, technically-oriented agencies that support limited and specific aspects of management. Indeed, the single-sector approach to land and water resources often leads to short-term economic gains. In the meantime, such approach can result in long-term environmental degradation because it fails to account for the complex linkages among various components of the ecosystem. In addition, this approach tends to rely heavily on technical and engineering solutions, making little or no attempt to address related policies and institutional issues. Both are fundamental issues to be carefully considered as far as we are seeking the sustainability of rural development programs.

• *Lack of land tenure and water rights*

Many farmers lack secure land tenure, which greatly increases the risk of investing in land and water conservation or other improvements. Land tenure is a particularly important issue for women farmers. In some developing countries, as many as one-third of rural households are headed by women, yet less than 2 percent of all land is owned by women. Partly, as a consequence, women have less access to credit and inputs, and receive only 5 percent of agricultural extension services worldwide.

Rights to water use are usually closely connected to land rights. In irrigated areas, rights to irrigation water are generally distributed among those who have land in the command area. Where land is unequally distributed, water is also often unequally distributed.

The establishment and strengthening of the regulatory and institutional framework for land tenure and land market development is a priority. This calls for comparative studies and innovative research in land policy analysis, formulation and implementation, involving, whenever possible, community and co-operative action for land (and water) management.

It would also be useful to conduct a review of the experiences of land banks and land funds and try to draw conclusions as to which kind of approaches to land banks are providing the most

effective, and why.

In addition to the land tenure and gender issues, other obstacles aggravating this problem include:

- the lack of access to affordable technologies for small farmers accounting for 80 percent or more of the farm population;
- high costs of the equipment with prices not at all affordable by the small, poor rural farmers;
- poor transportation and marketing facilities, and

• *Urbanization and inter-sectoral water allocation*

By the year 2025, the urban population numbers can be expected to double from 2.5 billion today to 5 billion. We can expect a further imbalance between population size and water availability and food sufficiency in many more countries. Attention needs to be paid to this change, particularly in the rural economics of the developing world that has switched to urban-oriented economics and societies. Rapid urbanization is turning the rural majority into a minority, even in Africa that is the least urbanized region on the planet. Beyond these statistics, the challenges lie in promoting sustainable practices. Already in some water scarce countries, there is inevitable competition between expanding urban and rural populations on one side and agricultural, household and industrial users of water on the other.

• *Valuation of water and its trade-off*

The Dublin Conference in 1992 advocated water as an economic good. Since then, many decision-makers have come to subscribe to this principle. However, the popularity of this notion tends to overlook the social, cultural and environmental aspects of water.

On an economic basis, it has been shown that water use by subsistence farmers and grain crop producers has a lower economic value. On the other hand, industrial and municipal usage of water brings in a higher return. At the extreme end, water is to be diverted towards the users of recreation and tourism. If water allocation is based on this "economic good" principle, it then jeopardizes access to water and food for millions of people on the planet. Furthermore, such a principle could have negative consequences for the cultural and social fabric, as we know it; not to mention disastrous changes to the environmental ecosystem. Therefore, market forces alone should not be the dictating factor in these social decisions.

On the other hand, in many developing countries, water is mostly subsidized by governments; hence water is kept at low prices. However, such low priced water does not provide sufficient revenues to operate and maintain water systems, to invest in new infrastructures or to research new technologies. Low water pricing and its subsidy also have slowed the introduction of water saving and reduced the incentives of farmers to invest in efficiency. Similarly, energy subsidies in many countries have artificially reduced the cost of groundwater pumping and encouraged farmers to overuse this vital drinking water resource.

• *Poor Institutional Capacity Building*

Institutional capacity plays a central role in any decentralization process.

Failure of local governments to take advantage of the opportunities provided by decentralization because of lack of capacity will result in poor outcomes. Local governments and other institutions that cannot adequately administer and account for grants or effectively mobilize local resources will find those powers swiftly taken back. Non-Governmental Organizations (NGOs) and Community Base Organizations (CBOs) that lack managerial capacity or, alternatively, focus on furthering their organization's own ends at the expense of broader community will undermine successful outcomes.

Improved capacity will not, however, on its own solve all the shortcomings. Capacity building efforts that are carried out in highly centralized systems soon run into limits related to central constraints. Capacity enhancement and devolution of functions must be pursued together and paced to complement each other.

What to be stressed here is that the success and or failure of rural development programs are not only a matter of decentralization. Decentralization without explicit efforts to strengthen rural institutions and enhance participation of rural poor people carries a high danger of urban-bias and prolonged rural incapacitation.

• *Rural data assessment*

There are considerable data problems not only with the quality and reliability of rural data in many developing countries, but, also, with the non-existence of vital data. Even, data are collected; most are aggregated at the national level with no possibility of breaking this down to urban-rural and regional level.

Improved monitoring of rural development will require a significant effort in data collection on a long-term basis. The "ad hoc" surveys are not advisable because these do not provide consistent coverage of the different aspects of rural development. Instead, comprehensive household surveys and extended coverage of the agricultural consensus are proposed, focusing on family status, access to services, economic activities, production practices, expenditures and social activities.

The Challenges

We now face the challenge of feeding 8 billion people by the end of the first quarter of the twenty-first century.

The United Nations medium growth projection will expand from present 6 billion to nearly 8 billion in the 2025. More than 80% of these people will live in developing countries. This implies that nearly the same water and land resources base, we must grow food for 2 billion more people as well as supplying expanding domestic and industrial water use.

The experience leads us to the fact that to feed 2 billion people water supplies used in agriculture will have to be augmented by an additional 15 to 20% over the next 25 years, even under favorable assumptions regarding improvements in irrigation efficiency and agronomic potential to meet food requirements. This will amounts to an additional 0.6% to 0.7% of water supply per year.

This will lead us to what are the options and tools to be implemented that could lead us to reasonable answers to meet our future water and food needs.

Options and Tools

For sustainable use of water resources in irrigated agriculture to meet the challenge it is now facing, and the future difficult ones is not one way solution but it consists in crucial issues and options putting all together may provide a better understanding of the problems we face and their consequences, possible solutions and the interconnections and tradeoffs among them.

In order to survive the consequences of water scarcity, approaches have to be undertaken by professionals such as:

• strictly manage the demand for that precious resources, preserve and augment the supply or more preferably to combine the previous two options in an integrated management plane aiming ultimately towards sustainable development;

• effective water saving programs and strategies in all water uses sectors and, particularly, the agriculture;

• increasing water productivity;
• the re-use and recycling of non-conventional water sources as additional ones.

Our attempt here is to outline key issues that warrant our priority attention as we seek to move from a common understanding of the problems to concrete actions to be implemented in order to fight hunger and to achieve water security, food security and environment sustainability.

Growing food demand and how to meet

- Water planning and management: the need for a new approach

Why do we need a new approach to water resources management? Quite simply, it is clear that in many countries, existing approaches are not sustainable in the physical, economic, or environmental sense.

The experience gained and the lessons learned clearly emphasize that the fragmented approach we are still using in managing water resources in the agricultural sector resulting in enormous water loss will never provide the countries suffering water shortages with both water and food security. In the majority of the arid and semi-arid countries, the increase in water demand faced with limited water supply on one hand, and the arising water scarcity problems on the other hand, are steadily mounting; the response to such acute water shortages require immediate actions and plans with appropriate changes in the way those countries are using and managing the water resources.

- The traditional hardware approach

Traditionally, solutions were fully focusing on the supply side, relying on an ever-larger number of dams, reservoirs, and aqueducts to capture and store ever-larger fractions of freshwater run-off. Such approach is now criticized for environmental, economic and social reasons. Basic human needs for water still remain unmet and it is becoming harder and harder to find new water resources, or even to maintain the existing ones to supply croplands.

Under such traditional approach, water-planning efforts usually did not include a detailed analysis of how water is actually used. Equally, there was no clear identification of the common goals for water development to seek agreement on principles to resolve conflicts over water. In addition, little attention has been paid to protecting natural ecosystems from which water supplies have been withdrawn. Those could be some of the driving forces, beside others including high costs of construction, tight budgets, deep environmental concerns, changing the way we are following in planning and managing our water resources.

Under these circumstances, what is the alternative? In our opinion, our efforts and re-thinking should be directed to change the traditional approach in managing and planning our water resources to a sustainable soft path putting greater emphasis on development principles that reflect environmental, social and cultural values.

- The new soft path approach

It is well recognized that the reliance on physical solutions, although still continuing to dominate the traditional planning approach, failed in satisfying basic water requirements for human activities and, above all, it gave origin to several social, economic and environmental problems.

Nowadays, many countries are changing the way of thinking and approaches in managing their water resources, re-directing them towards the soft path approach through developing new methods to meet the demands of growing population without requiring major new constructions or new large scale water transfer from one region to another.

This can be clearly seen in many developing countries, and particularly in those arid and semiarid regions where more and more water authorities and planning agencies are beginning to shift their focus and explore the possibility for efficiency improvements, to implement options for managing demand and reallocate water among users to reduce projected gaps and meet future needs, particularly those regarding food. (Gleick, 2002, 2003 and RMI, 2002).

Future perspectives to meet agricultural and human demand for water successfully will increasingly depend upon non-structural solutions and a completely new approach for water planning and management. Two approaches should be followed: the first, by increasing the efficiency with which current needs are met, and the second by increasing the efficiency with which water is allocated among different users and, in particular, the irrigation sector.

In both the approaches, efficiency is the key element towards producing more with less water in order to meet the increasingly food demands.

- Managing water scarcity

A basic distinction can be drawn between supply-management oriented approaches and demand-management ones: the difference between the two approaches is sometimes exaggerated but, indeed, some solutions overlap the two categories.

The choice of measures will differ from one country to another in the region according to the options of each country. The country's choice will depend on its level of development, the hydrological situation, the political and social institutions, management skills, financial resources, people attitudes to water and several other factors. Those factors have their important impact on the water management approach to be practiced in the countries of the region. However, in the region, and particularly for the countries suffering from water scarcity, the water management approach to be recommended is the one that integrates the supply-oriented management with the demand-oriented one.

- Irrigation water policy: major issues

Policy issues here refer to various technical and non-technical issues in managing irrigation water. The list of such issues is long. In this part, emphasis will be placed on the highly relevant ones (Fig. 3).

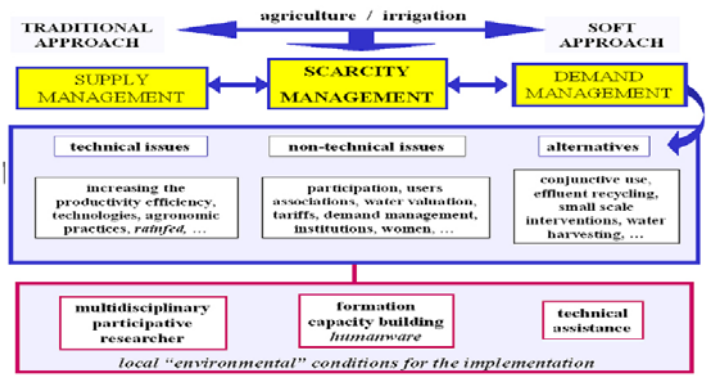

Fig.3. Managing water scarcity: major issues (Hamdy et al., 2002A)

- Technical issues

Among the technical issues to be ranked as a priority in the region is the non-structural water development with its several techniques leading to the increase in crop water productivity, i.e. producing more with less water, reducing water losses and thereby lowering the water demand in the agricultural activities, and automatically increasing the foreseen water supply needed to increase the rate of irrigated agriculture without the need for any further irrigation infrastructure. This could be achieved through improvements in water use efficiency or preferably "water productivity".

This is a key component of non-structural approaches to water management in all sectors and in agriculture in particular, the highest in its water consumption and the lowest in its efficiency, and thus the one with the highest potentiality for water saving. Irrigation managers, water specialists and decision-makers all well recognize that if we succeed in increasing water productivity in the irrigation sector through implementing intelligent water conservation and demand management programs, installing efficient equipment and appropriate economic and institutional incentives to shift water among users, then new sources of water supply to irrigation can be provided putting more lands under irrigation, increasing food production and reducing the food shortage gap.

Indeed, vast improvements in water use efficiency in the irrigation sector could be easily achieved, since large losses occur in distribution systems as water moves through leaking pipes and unlined aqueducts. This is frequently the case due to faulty or old equipment and poorly designed or maintained irrigation system (Hamdy and Lacirignola, 1999).

From a purely technical point of view, important water savings are possible, if one thinks that under realistic conditions water efficiency can vary from about 25% to 75% depending on the cases, the modes and the equipment, understanding that moving from the former to the latter value means not only to triple the irrigated surface but also that of food production at equal water volumes. There is great potential for improving the water efficiency in producing food, by changing cropping patterns towards less water-demanding crops, by reducing wasteful applications of water, by cutting field-to-plate losses, and by alternating diets and functioning of international markets (Hamdy and Lacirignola, 2001).

Identifying technical and institutional ways for improving efficiency of agricultural water system will go a long way toward increasing agricultural production without developing new supplies of water. Furthermore, this also will address some of the countries major environmental problems of waterlogging and salinity, declining groundwater tables, and shrinking lakes. But finding such methods will require that a wide range of alternative approaches such as small-scale irrigation and conjunctive use and re-use of non-conventional water resources be developed, tested and implemented (Hamdy and Sardo, 2002).

- Increasing water productivity

In our opinion, improving water productivity in agriculture is the immediate answer to the question whether we will be able to produce enough food to feed the arid and semi-arid burgeoning population and get it to where it is needed?

Net gains in water productivity are to be potential in certain areas having specific features, such as:

• areas where poverty is high and water productivity is low; where improvement could particularly benefit the poor. For the rural poor more productive use of water can mean better nutrition for families, more income, productive employment and greater equity;

• areas with physical water scarcity and intense competition for water where gains in economic water productivity are possible;

• areas where water resources development is limited; targeting high water productivity can reduce investment costs by reducing the amount of water that has to be withdrawn; and

• areas of water degraded eco-system such as falling ground-water tables, river dessication and intense competition for water.

However, the point is: *how can water productivity be increased in the agricultural sector?* To answer the raised question, major efforts are still needed on: *how can water productivity be increased in the agricultural sector and what are the different promising pathways to be developed?*

Evidently, achieving greater productivity to resolve the water crisis will not happen automatically, it will require great effort and it is especially feasible in the developing countries of the region, where water productivity is far below potential. For cereal grains, as an example, the range in water productivity in dry biomass produced is between 0.2 and 1.5 kilogram per cubic meter. As a rule of thumb, that value should be about 1 kilogram per cubic meter (IWMI, 2000). If a country's demand for grains grows by 50%, one way to match this rise is to increase water productivity by 50%. Meeting this challenge will require further greater efforts and significant changes in how water is managed (Hamdy et al., 2003B).

The key principles for improving water productivity at field, farm and basin level, which apply regardless of whether the crop is grown under rainfed or irrigated conditions, are: (i) increase the marketable yield of the crop per each unit of water transpired; (ii) reduce all outflows (e.g. drainage, seepage and percolation), including evaporative outflows other than the crop stomatal transpiration; and (iii) increase the effective use of rainfall, stored water and water of marginal quality.

The first principle relates to the need to increase crop yields or values. The second one aims at decreasing all "losses" except crop transpiration. The third principle aims at making use of alternative water resources. The second and third principles should be considered parts of basin-wide integrated water resources management (IWRM) for water productivity improvement.

These three principles apply at all scales, from plant to field and agro-ecological levels. However, options and practices associated with these principles require different approaches and technologies at different spatial scales.

Again, it is worthy to repeat that increasing the water productivity is the appropriate answer to meet the future challenges towards water and food security, particularly in the arid and semi-arid regions where water supply is becoming more and more restricted due to source availability and financial constraints. However, this implies large improvements in the basin efficiency in order to increase significantly the water productivity and reduce water withdrawal constraints.

This would lead us to what are the options and tools to be implemented that could lead us to reasonable answers to meet our future water and food need in order to reduce rural hunger and alleviate poverty. The key element is mainly a matter on the way we are using and managing our water resources in the agriculture sector. The sustainable use of water in irrigated agriculture is not one way solution but it consists of crucial issues and options to be put all together to provide a better understanding of the problems and their consequences, possible solutions and the interconnections and trade-offs among them. An intensive work is needed to modernize irrigated agriculture, through technological upgrading and institutional reform will be essential in ensuring much-needed gain in water productivity. This will not only require changes in attitude, but, also well targeted investments in infrastructure modernization, institutional restructuring and upgrading of the technical capacities of farmers and water managers.

Improving the productivity of water in agriculture requires the integrated efforts of many players. This does not fall in the domain of one group of specialists, but, rather requires the

efforts of breeders, natural resource management specialists, physical scientists, sociologists and above all the synergistic efforts of the farmers and the water resources managers.

- *Improvement of irrigation systems*

At present, if our knowledge is combined to the maximum effect, a notable improvement in agricultural water productivity could be achieved and thereby meeting the complex challenge: producing more food of better quality while using less water per unit of output.

Globally, for most countries, the major physical and technical problems and constraints in irrigation systems are: inefficient water use, shortage of water supply at the source, poor canal regulation, waterlogging and salinity, poor operation and maintenance, small-scale programs and scarce water resources. Such problems and constraints require a set of common supporting actions, namely the development of adequate data bases, adaptive research, institutional strengthening, human resource development, improvements in socio-economic analysis, environmental protection, technology transfer and infra-structure development.

In many cases, technology-related problems have been accumulating for long time and their adverse impact on system performance is increasing because solutions have not been found or proven effective, and maintenance has been neglected.

Operation and maintenance (O&M) is one of the most underestimated aspects of irrigation projects in developing countries. As a result, the efficiency of projects continues to decline, and during a crisis situation, problems faced become too complex to be resolved technically.

The bad performance and poor maintenance of irrigation systems are seriously affecting the food production, being for many crops with production, nearly one half and even much less than that of the standard production values.

Experiences in this field evidently demonstrate that increasing irrigation efficiency through better control and allocation of water can often double crop yields with existing technologies. What is generally required is the improved maintenance, better linkages to seasonal production requirements to individual crops, more responsiveness to farmers and stepped up management, training and supervision.

Increasing food production: promising approaches

Despite the barriers and constraints described above, many promising and encouraging initiatives are taken to promote environmentally sound food production and, thereby, working towards eradication of poverty and rural development sustainability.

IMPROVING WATER-USE EFFICIENCY

A critical need in the next few decades is to improve the efficiency of water use, especially for agriculture. World Water Vision (2000) lists a range of technical and management options to improve productivity, including:

- developing new crop varieties with higher yields per unit of water –for example, crops with comparable yields but shorter growth periods;
- switching to crops that consume less water or use water more efficiently;
- improving soil management, fertilization and pest and weed control;
- improving the reliability of water supplies at critical crop growth periods; this would encourage farmers to invest more in other inputs and lead to higher output per unit of water;
- promoting deficit irrigation, which can increase productivity per unit of water by providing less-than-full irrigation requirements; and supplemental irrigation, which uses limited

irrigation at critical periods to supplement rainfall. In the Syrian Arab Republic, for example, researchers have demonstrated that reducing full irrigation by 50 percent results in a yield loss of only 10 percent.

A broad range of irrigation technologies now available can increase water productivity. For example, drip irrigation, which uses a network of perforated plastic tubes that deliver water directly to the roots of plants, can cut water use by 30-70 percent and increase crop yields by 20-90 percent.

Another efficient sprinkler system known as low-energy precision application has drop tubes extending vertically from the sprinkler arm. These tubes deliver water much closer to the plants, reducing evaporation losses. Used in combination with time-controlled surge valves, which distribute water more uniformly down the furrows, these systems can produce water savings of 25-37 percent compared with conventional furrow irrigation.

There is also a variety of management techniques that can improve irrigation efficiency. These include improving irrigation timing, improving canal operations for more efficient deliveries, applying water only at crucial periods, using water-conserving tillage and field preparation methods, improving canal maintenance, and recycling drainage and tail water.

In addition, there is a wide array of small-scale irrigation strategies for areas with scarce water supplies. For example, check dams built across gullies can trap large amounts of runoff, which can be channeled to fields or stored for later use.

Above all, reducing water subsidies will help promote more efficient water use. The World Water Vision (2000) recommends that consumers be charged the full cost of providing water services, including the cost of obtaining the water and of collecting, treating and disposing of wastewater. Full cost pricing will make water suppliers accountable to users, reduce water withdrawals from ecosystems, and provide the revenue needed to cover operation and maintenance costs. Such policies must be accompanied by targeted, transparent subsidies to low-income communities and individuals.

Indeed, irrigation efficiency concepts need to be adapted in meaningful and easy to understand principles. Equating a unit of consumers' food per units of water needed for its production should be easily understood by the public which could then bring about changes in the pattern of food consumption that is not water efficient (Shady, 1999).

- Increasing community participation: irrigation management transfer and the emerging role of the private sector

Historically, many irrigation regimes have been financed, managed and operated by governments, public sector or parastatal cooperation. In the last two decades, the trend was to adopt the management transfer from the public sector to its users. More than 25 governments are now in the process of transferring responsibility for irrigation systems to local farmers' groups or other private organizations.

The case of Irrigation Management Transfer (IMT) is very relevant in Mexico. Management of more than 85 percent of the nations publicly irrigated lands has been turned off to Water User's Associations (WUAs). Water fees have been increased to cover costs, and the irrigation districts are about 80% financially self-sufficient (Kemper and Douglas, 2000).

Water Users' Associations are an effective way to improve efficiency, productivity, accountability, and responsiveness to farmers. They give users the authority to operate and maintain water systems, collect fees, hire professionals and manage water rights (Hamdy, 2005).

Indeed, rehabilitation and improvement of existing irrigation systems had resulted in bringing new life to potentially highly productive land as well as in correcting operation and management of wrongly planned irrigation systems, which are not producing and having such effective

improvement in food production.

Regarding the private sector and its involvement in the water sector, it is advisable that before the privatization of public services can fully occur, the roles of the public sector needs to be fully redefined. As it stands today, without private sector financing and input, it would become increasingly difficult to create new infrastructures or rehabilitate and expand existing ones. The question then becomes how to mobilize the private sector, so that they would want to assume the risk of financing, operating and managing this costly infrastructure. *What kind of environment is needed to stimulate their participation?* The few successful case studies of this should be examined. The telecommunications industry could be held up as a sterling example.

Under this scenario of increasing privatization and management transfer, the areas of regulatory functions identified to protect the public interest should occur through legislation, regulations and the endorsement of standards of practice, and through a dispute settlement mechanism. Financing of research and development, education and partnerships should ideally remain in the domain of the public sector (Hamdy, 2003A; 2005A and B).

- Agricultural research and technological progress

In the quest for sustainable rural development and poverty alleviation, increased food security and sustainability, a key role is played by agricultural research and technology advancement. Technological progress can help produce more, safer and higher quality food and agricultural products, at lower cost and with lower depletion of the natural resources.

To date agricultural research in developing countries have been mostly concentrated on production in relatively high potential environments and on traditional export and the main staple food commodities. Partial shift is now needed in research strategies to include the development of technologies for indigenous food crops and non-traditional export commodities.

Low cost, simple technology packages emphasizing improved cultivation practices could increase smallholder's food production and, consequently, their consumption in a comparatively short time. However, if smallholder programs are to realize this potential a higher degree of political priority and administrative support should be provided than do programs for larger farms.

A still very much open field is that of biotechnology. *What are the prospects of it being used to address the needs of the poor and enhance food security? What role can the National and International Agricultural Research systems play in this respect? Conversely, what are the risks of polarization of production in developed countries on the rural poor and rural agriculture?*

In rural areas specific work has to be done to establish accessibility to communications media and information and the way to enhance the promotion of Agricultural Information Systems by the National Agricultural Research Centers (NARS).

- Access to capital and micro-credit initiatives

Access to capital is the other major factor for improving the material conditions of small farmers and other rural poor. Greater access to credit by the rural poor would entail improvements in a whole range of financial services.

This is also the case with the micro-credit initiatives. In this regard, it is highly recommended to carry out an international comparison and synthesis of the lessons that can be learned from micro-credit initiatives undertaken in different countries over the last decade or so, of their advantages and shortcomings. This could offer a useful guidance for the support of such initiatives in other countries and areas.

Improved credit arrangements can result in high returns to smallholders in the short term. Better credit facilities, emphasizing improvement of loan administration, will be a key element in any package of smallholder assistance. Providing small loans for small land holders and tenant farmers is a promising new approach to increase food production as it gives the opportunity to about half of the world's hunger people to grow their own food.

For the developing countries, it is needed to move from general knowledge to the analysis of specific implementation mechanisms, facilitating awareness of the most effective practical modalities of micro-credit for food security.

- Upgrading rainfed agriculture

According to FAO (2005) projections food demand in 2030 is expected to be 55 percent higher than 1998. To respond to this demand, global food production should increase at an annual rate of 1.4 percent.

At present, 55% of the gross value of food is produced under rain-fed conditions on nearly 72% of the world's harvested crop land. The subject receiving intense debate is the future food demands whether it will be provided by rain-fed or irrigated agriculture. Indeed, in the past many countries focused their water attention and resources on irrigation development to fulfill both present as well as future food production gaps.

However, what should be clearly understood is that most of the world's food production does not rely on freshwater withdrawals at all and does not necessarily accelerate the naturally occurring rates of evapotranspiration. This evidently means that the bulk of the world's agriculture production is rain-fed not irrigated.

Evidence from water balance analyses on farmers' fields around the world shows that only a small fraction of rainfall, generally, less than 30%, is used as productive green water flow (plant transpiration) supporting plant growth (Rockstrom, 2003). Rainfall partitioning in the semi-arid tropics indicating rainfall losses from the farm scale is given in (Fig. 4).

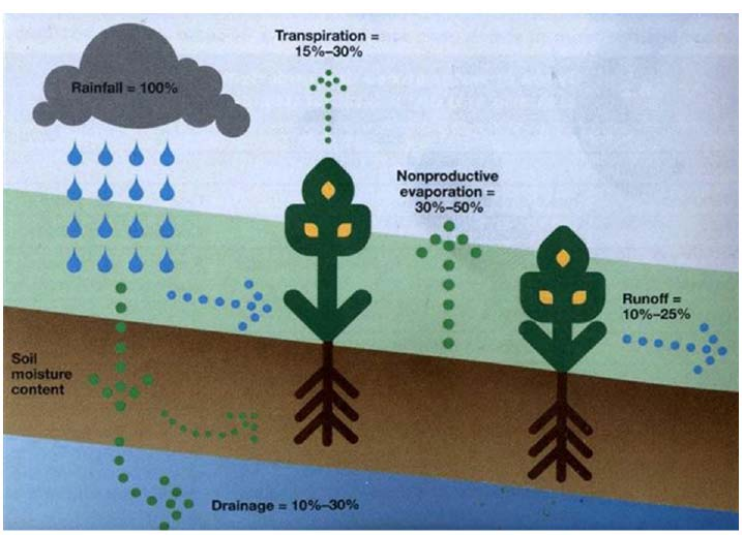

Fig.4: Rainfall partitioning in the semiarid tropics. Source: Water for Life, Water for Food: a comprehensive assessment of water management in agriculture (2007) (ed) D. Molden

The presented data show that losses in rainfall through drainage, surface runoff and non-productive evaporation is extremely high (70 up to 85 percent), where as the part of the rainfall used productively, to produce food is of minimum values lying between 15% up to 30%. In arid areas, only as little as 10% of rainfall is consumed as productive green water flow with most of the remainder going to non-productive evaporation flow (Oweis and Hachum, 2003).

At the global level, it is well recognised that the potential of rain-fed agriculture is large enough to meet present and future food demand through increased productivity. In this regard, an important option is to upgrade rain-fed agriculture through better water, soil and land management practices. This can be done through several ways, including the following diverse options (Fig. 5):

- increasing productivity in rain-fed areas through enhanced management of soil moisture and supplemental irrigation where small water storage is feasible;
- improving soil fertility management including the reversal of land degradation, and
- expanding cropped areas

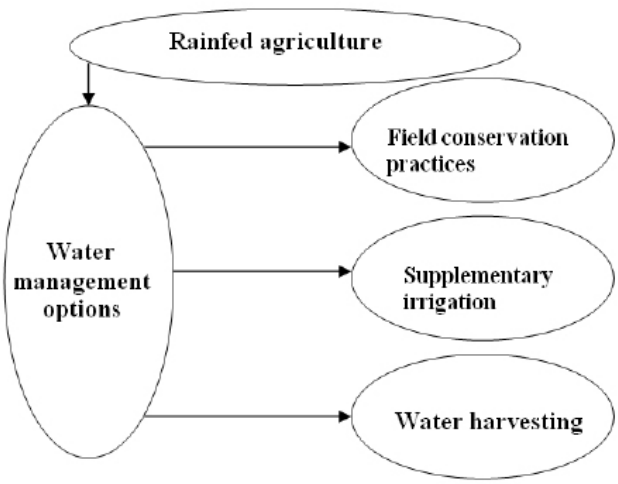

Fig.5 – Diverse options for water management in rain-fed conditions (Trisorio-Liuzzi and Hamdy, 2008)

The global analysis of more than 100 agricultural development projects, Pretty and Hine (2001) found that in projects that focused on improving rain-fed agriculture, yields doubled on average and often increased several hundred percent. This clearly demonstrates and emphasizes again the large potential for investments in upgrading rain-fed agriculture.

However, what to be stressed here is that the investments required today differ greatly from those in the last half century. They will have to increase human and institutional capacity and improve management and infrastructure. Investments should be more strategic, planned within the overall national framework regarding the rain-fed agriculture upgrading. A combination of investments, policy and research approaches will clearly be needed, in order to overcome the lack of commitment and targeted investment, insufficient human capacity, infective institutions and poor governance.

- Adoption of deficit irrigation

Deficit irrigation is an optimising strategy under which crops are deliberately allowed to sustain some degree of water deficit and yield reduction (English et al.,1990). Implementation of deficit irrigation seems to be a sounding strategy to increase food production as basically it leads water saving and improving crop water productivity.

From the practical point of view, there are different ways to manage deficit irrigation. The irrigator can reduce the irrigation depth, refilling only part of the root-zone soil water capacity, or reduce the irrigation frequency by increasing the time interval between successive irrigations. In surface irrigation, wetting furrows alternatively or placing them further part is one way to implement deficit irrigation.

The experiences gained in many parts around the world, clearly indicate that whatever, the approach to be followed for managing deficit irrigation, the gaining benefits in optimising water use and improving water productivity is a function of different important management factors including the selection of crop variety, the crop rotation, sowing dates, crop density, soil fertility management and weed, pests and diseases control.

Discussions and Concluding Remarks

Insufficient food production to meet the increasingly food demand is a major problem causing food insecurity in most developing countries.

How did we get here?

The point to be asked is "*how did we get here and what are the major causes behind food insufficiency and increasingly hunger and poverty in many countries around the world*"?

The reasons to such unbalanced food supply to meet the food demand are numerous, among them we would like to highlight the following:

• *what are the most common causes of inadequate food supply to meet the increasingly food demand?* The answer to this question could be attributed to low agricultural productivity due in many cases to its dependence on rain, a low level of knowledge about agricultural production practices, an insufficient supply of inputs and their high cost. Market access is a dominant issue linked to food production. With access to markets, farmers have an incentive to produce more as they have somewhere places to sell their products. Indeed, the cause of the historical decline in food production in most arid and semi-arid regions are multifaceted and complex, but at the heart of the problem remains the vulnerability of poor communities to land degradation, water scarcity and climatic variability, particularly drought.

• We have not been very creative in introducing new technologies, just as we have generally mismanaged cooperatives and policies that will boost output, increase income, and promote better nutritional practices. Perhaps more important, we have dampened creativity and confidence in our people and decreased investment in agriculture through wrong policies, inconsistent and false strategies.

• Another issue is the role of women in food and nutrition security. Women are the producers of food. Yet, women in many developing countries do not have access to and control over land and this limits the types of food crops they can grow. Because they do not own or control land, they cannot easily diversify their food crops in order to meet the food demands of their families. It is time to put the role of women in food production high on the agenda of priorities. Let those people who are operating on the land have rights to it (Abu-Zeid and Hamdy, 2006).

• Another point at the macro level is the failure to translate macro-economic policies to the micro, grassroots level. Many countries are now having poverty reduction strategies. However, the point is how many of these strategies are translated to the grassroots level or even understood at the grassroots levels.

• One area on which we spend little time is the quality of the farmer associations and the leadership of farmers. They tend to be led by the politicians. We need to listen to the farmers. Government do not listen to the farmers, they tell the farmers. Why don't the farmers lead themselves? We need to develop commodity associations of farmers so that the farmers can talk to each other and produce beyond subsistence.

• The lack of private sector response has led to a drastic reduction of support services and inputs to many farming systems. At the same time, in some countries the absence of land tenure security, rural financial institutions, market infrastructures, information systems and appropriate farmer advisory services seriously inhibited long-term investments and the development of sustainable production systems in small-holders sector.

• Key institutions that support small holder farmers in research, extension and training are weak. Even the capacity of the private sector to supply the needs and inputs of farmers is very weak.

What must be done?

The foundation of success lies in two major areas. *The first*, is investment in agricultural productivity growth and *the second*, is investing in human resources development.

Clearly, urgent actions are required. In trying to list priorities for actions and designs policies, therefore, it is much more important to focus on the questions "how" and at "what" cost.

• Many of the challenges of increasing food production to meet the increasingly food demand can be met if all role players and stakeholders are committed to a common vision and strategy. Ensuring that all stakeholders (government departments, politicians, farmers unions and their leaders, traders, agribusiness, community leaders) internalized the same vision and strategic plans to increase food production, shortage in food production and increasingly hunger problems will have an appropriate way towards solutions.

• In order to seriously attack food shortages and food insecurity, we have to come back to consistency. Coming back to consistency can be seen in two ways: we can look to it either in terms of technological, institutional, infrastructural and policy requirements or in terms of different pillars within the agricultural sector.

One of the first pillar to work on is market at the national, regional and even global levels. We know that for most developing countries, their markets are incomplete. They are poorly endowed with infrastructure, with information, with market intelligence and with difficulties in accessing global markets. We have to start developing our national and regional markets.

If we have markets functioning well, the second pillar is water and how to use and manage in the agricultural sector to reduce losses to improve its on-farm use efficiency and its productivity.

The third pillar is land. There are not only soil fertility and productivity issues, but also serious issues of security of land tenure.

Next is science and technology. What's kinds of technologies are we going to develop for the next generation of farmers? What is the land conservation and water saving technologies to be implemented to meet the increasingly gap in food production? We have to think about these

questions and decide the technology to be implemented by farmers.

• To achieve the required food production to meet the growing demand, the priority actions should be focused on four areas:

1) agricultural productivity;

2) fostering pro-poor economic growth through improved markets, better infrastructure and greater trade competitiveness;

3) building institutional and human capacity;

4) strengthening governance.

• If we want seriously and correctly to identify food and nutrition problems and accurately assess the economic and agronomic programs, associated with them, we must set up a lasting system of observation, information and analysis. We need thinking about a partnership between research, the concerned administrations and professional organizations. This implies a long term commitment of these stakeholders in human and institutional capacity building.

• For the increasing demand in food to be attained, agriculture must be intensified. The developing countries cannot continue relying on rainfed agriculture coupled with application of inappropriate technologies. It needs to explore all avenues for transforming agriculture, including irrigation.

• We should establish partnerships for food and nutrition security on three levels: the national level, the regional level and the pan-continental level. An effective, fruitful partnership means that each partner has something to offer. The skills and know-how required for the partnerships should be forged at the national level. Without this, it will be impossible for partnership to develop at the other two, broader levels.

• We need to set up appropriate strategies for food and nutrition security that can be implemented. If strategies cannot be implemented, they are not sound. But, if implementation without a sound strategy is attempted, that is also not satisfactory. Successful implementation must happen at a local level. Communities are key to achieving food and nutrition security. We need effective decentralized management for public investment. But we also need sound public administration, wise public investment and adequate resource allocation.

• There is no progress in food production without research. Agronomic research should be firstly considered. Whatever technical path is envisaged to improve food production research must continue. Research organizations must also become more involved in partnerships with producer organizations, public services and private operators.

• Our conclusions about key priorities for actions are outlined in the following:

o *first*, we need better integration between food production and natural resources management (land-water and climate);

o *second*, we need an enabling condition that determines the roles of all the stakeholders and promotes synergies in their interaction.

For action to take place, there are some political requirements, some institutional requirements and some technical requirements. We need to move from rhetoric to action. We need capacity building for better policies and more timely implementation. This means that we need to train decision-makers to make the right decisions at the right time. It is also important to create the conditions for promoting successful technological breakthroughs that have been tested.

We also face technical requirements. We ought to strengthen agronomic research. We need

better linkages between research and education and better communication of research findings.

There are also institutional requirements. We need to enhance public and private investments in material and financial infrastructure. We should pursue regional integration to facilitate trade. We want to re-emphasize decentralization and governance must be improved. Furthermore, we need partnerships in the areas of financial commitment research, policy-makers and implementation.

• Finally, to attack the root causes, balanced, broad-based, pro-poor, growth-oriented programs are required that emphasize both the need to increase food production, agricultural productivity and rural income, in general, and the need for special targeted programs to alleviate hunger. These should include enhancing the political will and financial commitment to implementing existing global, regional and national initiatives, increasing agricultural productivity and access to food and reducing hunger. Success mostly depends on having the conducive policies, adequate institutions, improved market infrastructure, social safety nets and most important peace and stability and all of these must be sustainable overtime.

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