2020 EUROPEAN AGRICULTURE: CHALLENGES & POLICIES

PARIS, 29-30 JANUARY, 2009

SESSION 3: AGRICULTURE AND WATER[1]

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ABSTRACT

The coming 25 - 30 years global food production will have to be doubled in order to maintain food security at the global level. Especially for the emerging countries and to a certain extent also for the least developed countries this implies that to a large extent a transition will be required from subsistence agriculture to food production. In the near and medium term future it will also be required that a substantially larger increase in production will be achieved than continuation of the present trend. In relation to these developments a summarised overview is given of the role of water management for global food production. Improvement and expansion of irrigation and drainage systems, in combination with water saving, increase in water storages and a strong focus on sustainability will play a crucial role to achieve this.

[1] This paper is to a large extent based on the papers *Role of water management for global food production and poverty alleviation* by Bart Schultz, Henri Tardieu and Alain Vidal, to be published in *Irrigation and Drainage.* Special Issue on Water for food and poverty alleviation, February 2009, and Bart Schultz, C.D. Thatte and V.K. Labhsetwar. *Irrigation and drainage. Main contributors to global food production. Irrigation and Drainage* 54.3, 2005.

INTRODUCTION

The coming 25 - 30 years global food production will have to be doubled in order to maintain food security at the global level. Most of the increase (80 – 90%) will have to be realised at existing cultivated land. The remaining would have to come from newly reclaimed land. Especially for the emerging countries and to a certain extent also for the least developed countries this implies that to a large extent a transition will be required from subsistence agriculture to food production. In relation to this development a summarised overview will be given of the role of water management for agriculture, with a focus on global food production. The possibilities of the various options for water management will be presented and reviewed.

POPULATION, POPULATION GROWTH AND GLOBAL FOOD NEEDS

By December 2005, there were 6.5 billion people. Global population is expected to grow to some 9 billion in 2050 (Figure 1). Most of the population (73%) lives in emerging countries and most of the population growth in percentage is expected in the least developed countries[2]. In the developed countries, no growth is expected. Population growth is expected to take place predominantly in the urban areas in the emerging and least developed countries. As a result 60% of the worlds' population is expected to live in cities by 2050 (Figure 2) (K.C., 2008). For emerging countries, there is the additional complication that the standard of living is rapidly rising, resulting in an increase in consumption per person and change in diet (Schultz et al., 2005). When we look at the present and probable future needs for cereals Schultz et al. (2009) have shown that the required increase in production would have to be substantially larger then continuation of the present trend.

The above figures imply that higher yields will have to be obtained at existing cultivated land and that at least a substantial part of the subsistence farming in the emerging and least developed countries will have to be transformed into food production for the urban population.

[2] *Developed countries.* Most of the countries in Western and Central Europe, North America and some countries in Central and South America, the larger countries in Oceania and some countries in Asia;
Emerging countries. Most of the Eastern European countries (including Russia), most of the countries in Central and South America, most of the countries in Asia (including China, India and Indonesia), and several countries in Africa;
Least developed countries. Most of the countries in Africa, several countries in Asia, 1 country in Central America and most of the smaller countries in Oceania.

In the developed countries this process has in general taken place during the past century. A similar trend may be observed in many of the emerging countries, where for centuries farmers cultivated one ha or less, but where nowadays either farm sizes are rapidly increasing and mechanisation is coming up, or farmers shift to specialised cultivations to get more revenue from their small plot, or enter into part time farming. Regarding China, for example, simulations show that food security can be maintained without increasing the current water allocation to agriculture (400 km^3/year) (Jianxin Mu et al., 2008). However, the condition is that high yields of cereals need to be achieved (10 tons/ha for maize) with a very strong growth in the next decades. All these developments will have their implications on the lay out and level of service of water management systems. Therefore significant progress in irrigation efficiency and rainwater management needs to be made (Perry, 2007).

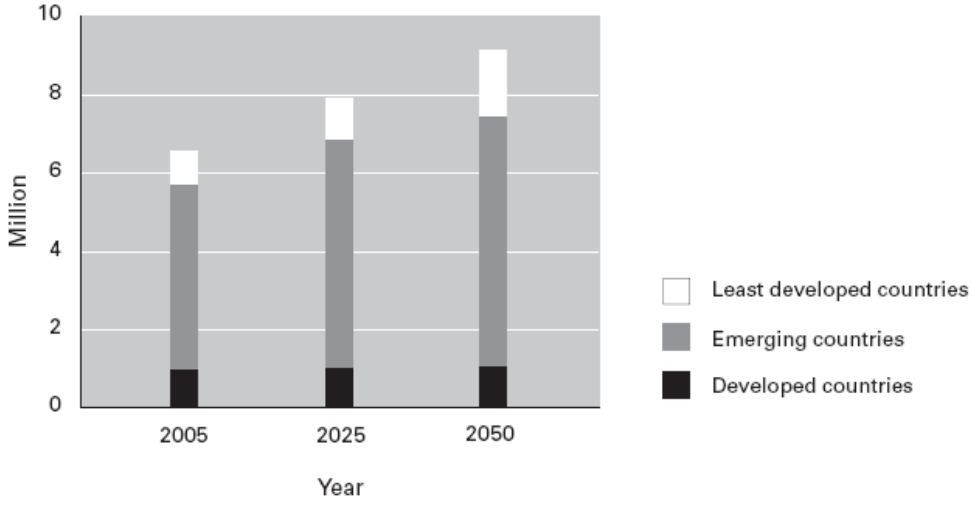

Figure 1. Population in 2005 and prognoses for 2025 and 2050 (UNDP Population Reference Bureau, 2005, Schultz et al., 2005)

THE ROLE OF WATER MANAGEMENT

At present 45% of global food production is achieved on 1,100 million ha without any water management system, 40% is achieved on 270 million ha irrigated land and 15% at 130 million ha rainfed land provided with a drainage system (Schultz et al., 2005). Table 1 shows percentages of no system, irrigation and drainage per continent and type of country.

In the areas without a water management system rainwater management may result in some improvements, especially in the livelihood of poor farm families. There is, however, no way that these areas can contribute significantly to the required increase in food production.

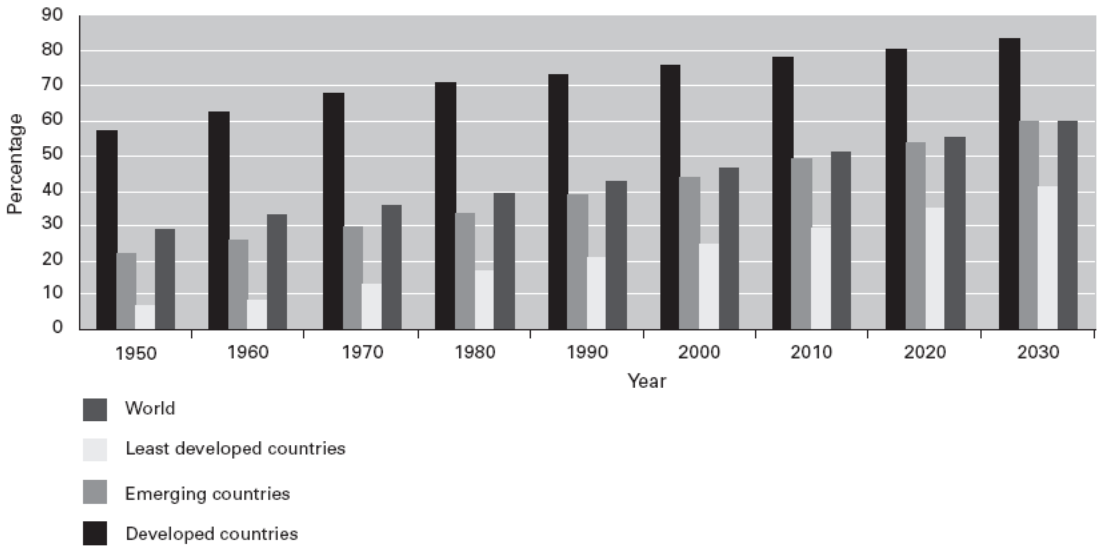

Figure 2. Development of the percentage of urban population in the different types of countries (K.C., 2008)

Table 1. Role of water management in agricultural cultivation practices in the different continents and categories of countries (after Schultz et al., 2005).

Continent	Total area in 10^6 ha	Arable land In 10^6 ha	Total population in million	Water management practice in % of the arable land		
				No system	Drainage *)	Irrigation **)
Asia	3,180	572	3,960	56	10	35
Africa	3,040	225	922	92	2	6
Europe	2,300	301	731	77	15	8
Americas	4,250	391	890	72	17	11
Oceania	852	53	33	91	4	5
World	13,600	1,540	6,540	69	13	18
Developed countries	3,200	372	966	67	22	11
Emerging countries	8,340	1,010	4,810	69	8	23
Least developed countries	2,080	155	766	87	2	12

*) In total about 130 * 10^6 ha rainfed and 60 * 10^6 ha drainage of irrigated areas

**) Irrigation may include drainage as well

In order to achieve the required increase in food production the share of irrigated and drained areas will have to increase. This can be achieved by installation of irrigation or drainage systems in areas without a system, modernisation of existing irrigation and drainage systems,

installation of irrigation systems in rainfed areas with a drainage system, or installation of drainage systems in irrigated areas (Schultz, 2001; Schultz et al., 2005). With respect to this also improvements in institutional aspects of system management need to be considered. There is thus a need to consider a series of water management solutions from purely rainfed to large-scale irrigated agriculture (Figure 3) (International Water Management Institute (IWMI), 2007).

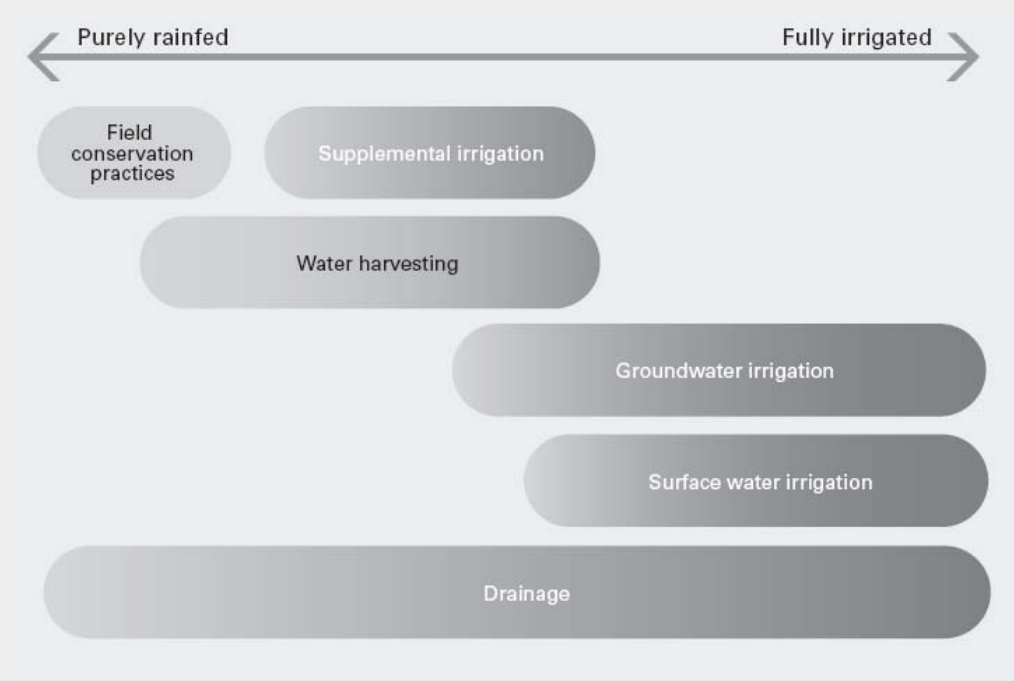

Figure 3. Diverse options for agricultural water management (International Water Management Institute (IWMI), 2007)

Irrigated agriculture counts for some 70% of total water withdrawals on earth. It will therefore be of importance to continue with the efforts to increase the efficiency of irrigation water use. However, even with the most effective measures in the field of water saving it will still be required to increase the withdrawals for irrigation combined with increase in water storages. A complication is that many countries in the arid and semi arid zones have reached, or are already beyond their water carrying capacity: they use more than the renewable amount (Plusquellec, 2002). Pollution of water resources and environmental concerns with respect to the application of agro-chemicals may reduce the potential for their use for agriculture.

VISION ON WATER MANAGEMENT FOR FOOD PRODUCTION

During the Second World Water Forum, which was held in March 2000 in the Hague, the Netherlands, the World Water Council (WWC) has, among others, presented a sector vision on

'Water for Food and Rural Development'. The span of time for the vision was 25 years. In order to achieve the required increase in food production in the framework of sustainable rural development, the following issues with respect to water management were considered to be of major importance (after Van Hofwegen and Svendsen, 2000):

- availability of water and availability in space and time;
- links between irrigation, drainage and flood protection and management, and food security, protection of the environment, sustainable rural development and livelihood;
- need for increasing withdrawals with 15 - 20% to bridge mismatch between demand and supply in combination with water saving and improved efficiency in irrigation;
- need for increasing storages with 10 - 15%;
- basin wide planning for integrated development and management, inter basin transfers, shared rivers, conflict management;
- governance, legal, institutional and environmental issues;
- stakeholder involvement, youth and women participation;
- financing integrated water resources development and management, modernisation and replacement;
- equity, efficiency and economy.

This sector vision would create the basis for the future directions. One cannot forecast the possible directions in specifics, but trends can be seen that may sooner or later result in policy decisions, actual guidelines, or standards for design, implementation, operation, maintenance and management. These directions can be put under the following headings:

- integration in all aspects of water management;
- technological, institutional and environmental developments in irrigation and drainage;
- integrated land use and water resources planning;
- sustainable development;
- acceptable level and size of environmental impacts.

For many centuries, water management was mainly focused on control of water quantity, by means of water supply or drainage. In an increasing number of countries, these days one may speak about control of both water quantity and quality, though at different levels of service, more or less dependent on the respective standards of living. What also can be observed is that water management in many regions is becoming more adapted to diversification in land use, and not predominantly anymore for agricultural use. In future most probably another step will be taken and countries may aim at an ecosystem approach.

It may be estimated that over the next 25 - 30 years the contribution to food production may shift from the areas without a system in the direction of areas that are provided with an irrigation and/or drainage system (Schultz et al., 2005). With respect to this it will be extremely difficult to achieve the improvement and expansion in irrigation and drainage systems without affecting environment at all. One will have to live with an acceptable level of impacts and possibly aim at compensatory measures where possible, especially in the emerging countries.

In relation to the improvement and expansion of irrigation and drainage systems there are certain specific issues that deserve attention. In the developed countries a lot has already been achieved. However, in the emerging countries in particular, several issues are still far from being resolved and significant efforts will be required from the parties concerned (Figure 4) to achieve sustainable solutions. The issues include:

- significant increase in irrigation efficiency and water saving at main and field system level;
- institutional reforms in the direction of stakeholder controlled management and government support for modernisation and reclamation;
- modernisation to achieve more reliable provisions of water delivery services.

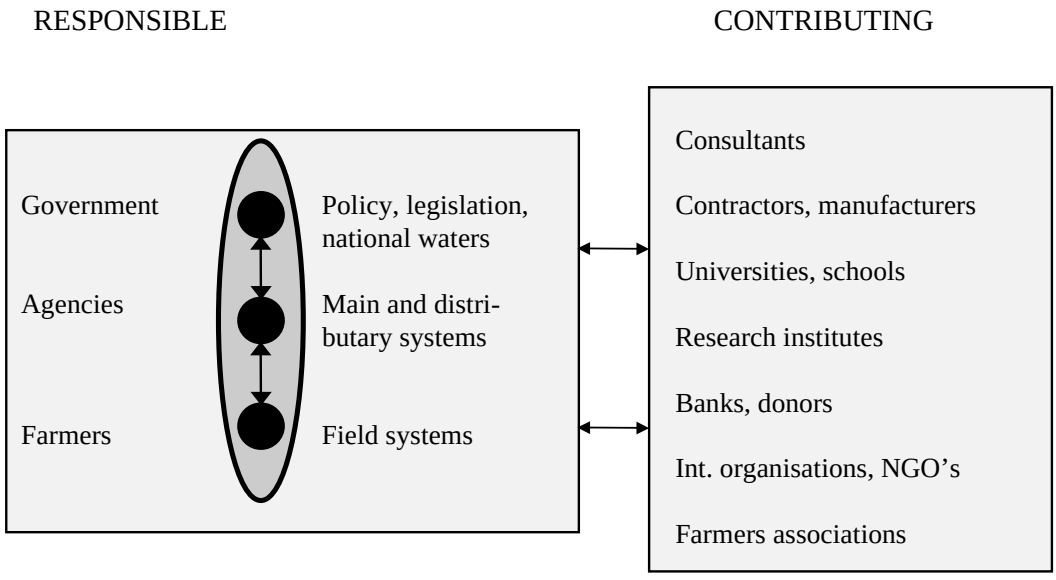

Figure 4. Indicative schematisation of actors in agricultural water management (Schultz, 2001)

In many countries institutional reforms in irrigation and drainage system management towards stakeholder-controlled management are on-going (Japanese National Committee of ICID, 2000, Czech Committee of ICID, 2001, and Ukraine National Committee of ICID, 2002). Transfer of systems, or of responsibilities are especially taking place in the following regions:

- emerging countries: Asia, Central and South America;
- countries with a transition economy: Central and Eastern Europe.

Such transfers are generally desirable, since government controlled organisations in several countries have not really been able to improve the management. Transfers may require quite different approaches (Schultz, 2002). In the emerging countries, there is generally a dominant component of farmers' population. In such cases the transfers concern transfer of responsibility and may be of ownership of parts of the systems from the government to the farmers. In these countries a significant part of the systems is more than thirty years old. Therefore transfers will have to go hand in hand with modernisation. However, in the countries with a transition economy, there are specific problems, like: unsuitable layout of systems, which is mostly based on the former large-scale type of agricultural production, uncertain future of the agriculture sector, required funding of modernisation and resulting operation and maintenance, lack of good governance, unaffordable pumping systems and environmental degradation (after ICID Yalta Declaration, 2002). In some countries, there is even not a clearly identified farmers group. These issues make the transfer process quite complicated.

In several of the countries with a transition economy a complete agricultural reform will be required, before irrigation or drainage system management transfer can be successfully planned and implemented, while in these countries the farmers are completely uncertain about their future and therefore not in a position to commit themselves to responsibilities that they cannot afford. The economic and financial questions that arise with respect to sustainable irrigation and drainage system management after transfer, concern especially to:

- determination of best modernisation options and modernisation cost;
- resulting cost and efforts for operation and maintenance of the modernised systems;
- full cost recovery, or sustainable cost recovery (Tardieu and Préfol, 2002 and Tardieu, 2004);
- cost sharing and capacity to pay.

SUSTAINABLITY OF WATER MANAGEMENT FOR GLOBAL FOOD PRODUCTION

The issues of cost sharing and capacity to pay are the more important in light of the sustainability of the modernisation and transfer activities. In order to promote modernisation and transfers in the emerging countries governments are increasingly funding programmes and projects with respect to the modernisation of irrigation and drainage systems from their own

budget and not anymore through donor funding. Striking examples are China and India - together housing about one-third of the worlds' population - where huge investments are being made in inter basin water transfers and modernisation of irrigation systems. Similar developments may be observed in many of the other emerging countries.

In the least developed countries the situation is quite different. In these countries the application of irrigation and drainage is only taking place at a marginal scale (Table 1). The issues here are not so much the transfer and modernisation, but how can sustainable irrigation and drainage systems be developed in future. For these countries it seems to be advisable to focus on small and medium scale types of systems that can be operated and maintained by individual farmers, or farmers groups.

We are more and more concerned about the sustainability. In the past, we did not have to be so much concerned about this, but increasing population pressure, changes in food production practices, and over-exploitation, or even exhaustion of resources in some extreme cases have increased the concerns. The following tendencies can be observed that in different ways will have an impact on the sector:

- requirement of higher yields per ha;
- increase in farm sizes, higher value crops, or part time farming;
- mechanisation in agriculture;
- competition for water;
- increased application of fertiliser and pesticides;
- depletion of surface and groundwater resources.

All the irrigation and drainage projects have side effects. The challenge has been and will be to keep the negative environmental impacts at an acceptable level and to support positive environmental impacts as far as reasonably possible. Of special importance for the sector are:

- controlled application of fertilisers and pesticides;
- quality criteria and quality control for drainage waters;
- prevention of waterlogging and salinization;
- prevention of depletion of surface and groundwater resources.

Better water management, application of fertilisers and pesticides, soil treatment practices, new varieties and genetic manipulation can contribute to the required increase in yields per hectare. However, there are upper limits to each of these possibilities. Especially the application of fertilisers and pesticides has to be done in a controlled way in order to prevent harmful effects on the water quality.

ANALYSIS

The demand for food production cannot be met with the existing structure and anticipated trends in irrigated and rainfed production. This needs to change significantly, at national, regional and global levels. The optimal mix of small-scale and large-scale systems under prevailing and expected future conditions will have to be identified. With respect to this interactions between agriculture and natural resources need to be considered. This will especially be the case in Asia and in the Near and Middle East where the density of population is the highest.

At global level roughly 7,000 billion m^3/year of water are at present required for food production. This is roughly 1,100 m^3/person/year of which 1,800 billion m^3 are supplied by irrigation, the other 5,200 billion m^3 come directly from precipitation. Producing 1 kg of cereals costs from 500 to 1,500 litres of water. Producing oil or meat costs much more (to the total process involved) from 3,000 to 15,000 litres of water per kg produced. Producing 1 kcal requires roughly 1 litre of water. Each person requires a minimum of 2,800 kcal/day i.e. 2,800 litres/day or 1,020 m^3/year. Increasing the productivity of agricultural water is nevertheless possible and required. With respect to water management two main ways are to be considered:

- *integrated agricultural water management*, preferably at river basin level in combination with efficiency improvements in irrigation systems. Increasing hydraulic efficiency of irrigation systems by reducing 'losses', improvement of the systems, change of irrigation technologies, improvement of operation and maintenance;
- *increasing low yields* (i.e. less than 2 tons/ha) which generally imply excessive evaporation. If all yields would be above 2 - 3 tons/ha, water use at the global level would be reduced by about 1,500 billion m^3 (Schultz et al., 2009). Increase in water use efficiency is mainly caused by reduction of evaporation from the soil, due to the better cover of the plants and the resulting increased interception.

Globally water is not a limiting for agriculture. But heterogeneity prevails and some countries will increasingly face different forms of water scarcity. Future needs for water for food are huge and up-to-date water management systems will be required at a large scale. With respect to the water management options the following can be stated:

- especially in emerging countries modernisation of agricultural water management (technical, management, institutional, financial, environmental) will be required at a large-scale to achieve the required increase in food production;

- it has to be analysed how institutional and technical water management improvements will contribute to increase the food production;
- it has to be analysed what types of investments are necessary to develop additional water resources including non-conventional and to modernise existing irrigation and drainage schemes to improve water productivity;
- special attention needs to be paid to the potential role of rainfed agriculture - either without a system, or with water harvesting, soil conservation, or drainage - in order to let it contribute more effectively to food security and improvement of livelihoods;
- it has to be determined what policies and actions are needed to ensure the sustainability of water resources and river basin services that underpin the increases in agricultural productivity that must be achieved.

The issues as outlined before will most probably result in a set of development scenarios for global food production and the supporting measures in the field of water management. The required increase in food production means a range of water for food between 10,000 and 14,000 billion m^3/year. This depends to a large extent on the capacity of small-scale agriculture to increase productivity, on the modernisation and expansion of irrigation and of modernisation and installation of drainage systems in either rainfed or irrigated agriculture areas.

At each level of this continuum, the issues of water storage, artificial recharge and efficiency need to be considered, depending on the local conditions. Especially in the emerging and least developed countries it will be of importance to analyse how water can be managed more effectively for sustainable agriculture to continue to be a key pathway out of poverty and means to achieve food security. It is basically possible to maintain food security in the near, mid-term and may be even in the long-term future. However, one may expect that at least for the near future the costs will remain at the present high level and may even further increase.

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