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Food Production and Irrigation and Drainage Systems Development Perspective and Challenges

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Introduction

A critical problem challenging mankind today is how to manage the intensifying competition for water between expanding urban centres, traditional agricultural activities and in-stream water uses dictated by environmental concerns. In the agricultural sector, the prospects of increasing the gross cultivated area are limited by the dwindling number of economically attractive sites for large-scale irrigation and drainage projects. Therefore the required increase in agricultural production will necessarily rely largely on the affordability to apply new technologies, a more accurate estimation of crop water requirements, and on major improvements in the construction, operation, management and performance of existing irrigation and drainage systems. The failings of present systems and the inability to sustainably exploit surface and groundwater resources can be attributed essentially to poor planning, design, system management and development. This is partly due to the inability of engineers, planners and managers to adequately quantify the effects of irrigation and drainage projects on water resource systems and to use these effects as guidelines for improving technology, design and management [1-4].

To take full advantage of investments in agriculture, a major effort is required to modernize irrigation and drainage systems and to further develop appropriate management strategies compatible with the financial and socio-economic trends, and the environment. This calls for a holistic approach to irrigation and drainage management and monitoring so as to increase food production, conserve water, prevent soil salinization and waterlogging, and to protect the environment [5-7]. All this requires, among others, enhanced research and a variety of tools such as water control and regulation equipment, remote sensing, geographic information systems, decision support systems and models, as well as field survey and evaluation techniques.

Trends in Food Production and in Irrigation and Drainage Systems

Basis for the water management requirements is the world's population, its growth and its standard of living. With respect to water management related to agricultural production there are broadly speaking three agro-climatologic zones, being: temperate humid zone, arid and semi-arid zone and humid tropical zone. In addition, in principle, four types of cultivation practices may be distinguished, being:

- Rainfed cultivation, without or with a drainage system;
- Irrigated cultivation, without or with a drainage system.

Dependent on the local conditions different types of water management with different levels of service will be appropriate [8]. On about 1,100 million ha agricultural exploitation takes place without a water management system. However, in a certain part of these areas methods like water harvesting or soil treatment may be applied. From these areas 45% of crop output is being obtained. Presently irrigation covers more than 270 million ha and is responsible for 40% of crop output. It uses about 70% of waters withdrawn from global river systems. Drainage of rainfed crops covers about 130 million ha and contributes to about 15% of crop output. In about 60 million ha of the irrigated lands there is a drainage system as well [9,10].

Based on the forecasts for population growth and the improvement in the standard of living it is expected that food production will have to be doubled in the next 25 years. In addition it is expected that 90% of the increase in food production will have to come from existing cultivated land and only 10% from new land reclamations, either in the highlands, or in the lowlands. There is no way that the cultivated area without a water management system can contribute significantly to the required increase in food production. Due to this the share of irrigated and drained areas in food production will have to increase. This can be either achieved by installing irrigation or drainage systems in the areas without a system, improvement, or modernisation of existing irrigation and drainage systems, installation of irrigation systems in the rainfed drained areas, or installation of drainage systems in irrigated areas. A rough estimate may be that over the next 25 years this may result in a shift to the contribution to the total food production in the direction of 30% for the areas without a water management system , 50% for the areas with an irrigation system and 20% for the rainfed areas with a drainage system. It has to be realised that these percentages refer to two times the present day food production. In addition it has to be realised that it will be extremely difficult to achieve this in an environmentally sustainable way, especially in the emerging developing countries [11-13].

Sustainable development can be viewed as a process of change in which the exploitation of resources, the direction of investments, the orientation of technological innovation and adaptation, along with institutional changes, are all in harmony and enhance both the current and future potential, to meet growing human needs and aspirations [14,15]. Concerning agricultural water management, most of the world's irrigated land and rainfed land with drainage facilities were developed on a step-by-step basis over the centuries. In many of the systems structures have aged or are deteriorating. Added to this, the systems have to withstand the pressures of changing needs, demands and social and economic evolution. Consequently, the infrastructure in most irrigated and drained areas needs to be renewed or even replaced and thus redesigned and rebuilt, in order to achieve improved sustainable production. This process depends on a number of common

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and well-co-ordinated factors, such as new and advanced technology, environmental protection, institutional strengthening, economic and financial assessment, research thrust and human resource development. Most of these factors are well known and linked to uncertainties associated with climate change, world market prices and international trade. These uncertainties call for continued attention and suitable action on many fronts, if productivity and flexibility in agricultural systems is to be improved.

Problems and Solutions

All the above factors and constraints compel decision makers to review the strengths and weaknesses of current trends in irrigation and drainage and rethink technology, institutional and financial patterns, research thrust and manpower policy so that service levels and system efficiency can be improved in a sustainable manner. To develop this process in a well-planned and controlled way the following aspects need to be adequately addressed [16,17]:

- Technology;
- Institutional and financial aspects;
- Research thrust;
- Human resources and networking.

Technology in irrigation and drainage development is concerned with the planning, design and control of the systems, including water conveyance, regulation structures, water quality and environmental protection measures. It is also concerned with modernization procedures and methods for conjunctive use of surface and groundwater to minimize water use and reduce deep percolation [18].

In this context, the process of determination of design parameters, selection of systems and materials, construction methods, operation and maintenance aspects has to proceed in a balanced way, in order to optimise designs and to take into account the interactions among land use, agricultural practices and the layout and characteristics of irrigation and drainage networks [19].

Institutional strengthening and proper financial assessment are essential tools for efficient planning, design and management of irrigation and drainage systems. Without a sound institutional framework, at the national or river basin levels, it will not be possible to promote and ensure sustainable water management for agriculture [20].

Economic constraints are equally important. The cost of system improvement is normally substantial and governments, in an era of transition from state to a market economy, will not be able to continue financing irrigation and drainage activities, as they used to do. The new philosophy is based on the principle that the services must be paid for by those who benefit from them. Sustainable development, as defined earlier, should, therefore, meet two basic requirements, namely institutional strengthening and economic viability [21].

In 1990 the International Commission on Irrigation and Drainage (ICID) made an urgent appeal to the World Bank to respond to the need for promoting research and development in irrigation and drainage, both in the developed and developing countries. Insufficient research, application of research findings and access to new and advanced technology in the sector was seen as some of the main reasons for the problems plaguing the sector: poor water use efficiency, environmental degradation, high costs and lack of responsiveness to beneficiaries. Since then, many technology research programs have been launched by different scientific, financial and professional institutions. Their mission has been to enhance the standard of irrigation and drainage research and development, at worldwide level, with a view to improving technology and management so as enhance system performance, food security and sustainability of the irrigation and drainage environment.

Successful technology and research activities in irrigation and drainage development depend on the number and quality of human resources (professional-and-research-related people) involved. They use their know-how and skill to solve priority problems and adapt available techniques to local situations.

Moreover, these experts will have to assist national and international agricultural and irrigation and drainage institutions to improve training in water related topics, as well as scientific organizations to identify subjects that warrant further analysis and investigation.

Concluding Remarks

One critical problem confronting mankind today is how to manage the intensifying competition for water between expanding urban centres, traditional agricultural activities and in-stream water uses dictated by environmental concerns. In the agricultural sector, the prospects of increasing the gross cultivated area are limited by the dwindling number of economically attractive sites for large-scale irrigation and drainage projects. Therefore the required increase in agricultural and food production will necessarily rely largely on a more accurate estimation of crop water requirements on the one hand, and on major improvements in the construction, operation, management and performance of existing irrigation and drainage systems, on the other.

To reach this goal, a major effort is required to modernize irrigation and drainage systems and to further develop appropriate management strategies compatible with the financial and socio-economic trends, and the environment. This calls for a holistic approach to irrigation and drainage management and monitoring so as to increase food production, conserve water, prevent soil salinization and water logging, and to protect the environment. All this requires, among others, enhanced research and a variety of tools such as water control and regulation equipment, remote sensing, geographic information systems, decision support systems and models, as well as field survey and evaluation techniques. To tackle this challenge, it is of paramount importance to focus on the following issues:

- Affordability with respect to the application of new technologies;
- Procedures for integrated planning and management of irrigation and drainage systems;
- Analysis to identify causes and effects constraining irrigation and drainage system performance;
- Evapotranspiration and related calculation methods;
- Estimation of crop water requirements;
- Technologies for the design, construction, and modernization of irrigation and drainage systems;
- Strategies to improve irrigation and drainage system efficiency;
- Environmental impacts of irrigation and drainage systems and suitable measures for creating and maintaining sustainability;
- Institutional strengthening, proper financial assessment, capacity building, training and education.

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