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# The irrigation challenge

## Increasing irrigation contribution to food security through higher water productivity from canal irrigation systems

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## Summary

Irrigation has lost the leading sector status it had in international and bilateral aid during the 1960s and 1970s. This paper discusses some of the reasons why, despite the lower level of investments for developing new irrigable areas and the focus on rehabilitation of existing schemes, the contribution of irrigated agriculture to food and fibre production has continued to increase. The shortages of food production projected for the1990s have been averted because of the explosive exploitation of groundwater and the manifold increase in water-saving application techniques over the last three decades.

Overexploitation of groundwater and an associated decline in water quality have been occurring in many parts of the developing world, particularly in the semi-arid regions. This paper suggests that no further complacency is acceptable in addressing the long-standing issue of poor management practices in the large irrigation systems. Failure to understand the links between the technical improvements of the large surface irrigation schemes and the required management reforms may exacerbate the problem of water scarcity and threaten food security. This paper argues that in the long run, continuing business as usual is not an option. Management practices must change to better serve the farming community.

The paper is the fourth in a series of Issue Papers for the International Programme for Technology and Research in Irrigation and Drainage (IPTRID). The series aims to promote debate on important issues related to the development and sustained operation of irrigated agriculture.

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# Contents

# Global food problems and the role of irrigation

Over the last few years high level gatherings of the World's leaders and their advisors have repeatedly agreed that addressing the multiple needs for water for two billions[1] or more people – the forecast population increase by 2020 – is of high priority. The challenge is to achieve a balance between using water for food while also meeting expanding domestic and industrial needs for water. Opinions differ among the experts regarding some of the issues. However, the consensus reached was that the contribution of irrigation to incremental food production should be substantial.

Different scenarios (options) have been examined to explore a number of issues, such as the expansion of irrigated agriculture, the increase in food production from rainfed areas and the public acceptance of genetically modified crops. On the one hand there is the business-as-usual scenario – a continuation of current trends in production and policy leading to regional water shortages and possibly a global water crisis; and on the other hand there is a policy of major investment – rapidly increasing agricultural research and development of irrigation and drainage.

At the World Food Summit in 1996, the Food and Agriculture Organization (FAO) estimated that 60 percent of the extra food required must in future come from irrigated agriculture. The International Commission on Irrigation and Drainage (ICID) estimated that current food production would have to double within the next 25 years. The ICID strategy for implementing the Vision for Water for Food refers to the same FAO estimate regarding the role of irrigated agriculture in sustaining future world food supplies. The new slogan "more crop per drop" crystallizes the objective to be achieved by ICID member countries, particularly those that have nearly reached full development of their scarce water resources.

Some analysts believe that what is needed is a new and greener revolution to once again increase productivity and boost production. However, the challenges are far more complex than simply producing more food because global conditions are different from what they were at the time of the 'Green Revolution'. Meeting the present challenges is even more difficult because so few opinion leaders appear to be aware that the world may face urgent food and agriculture problems. The abundance of grain produced in the world, and the fact that 840 million hungry people apparently remain invisible, also obscures the challenges (Shah and Strong, 2000).

Severe droughts and sharply rising food prices spurred national governments and international agencies to address the food crisis of the 1960s and 1970s. The 'Green Revolution', consisting of crop variety improvements, increased use of fertilizers and expansion of irrigation, averted the projected shortages in food production. According to some experts, another food crisis predicted by advocates of a new boom in investment for irrigation is not yet in view. Food

[1] billion = $10^9$

grain prices have remained stable for the last 15 years. There is hunger in the world, but that is because the hungry cannot translate their needs into demand or civil disorders disrupt food flows. However, according to the authoritative Consultative Group on International Agricultural Research (CGIAR), the world is entering the 21st century on the brink of a new world food crisis that is as dangerous, but far more complicated than the threats it faced in the 1960s (Shah and Strong, 2000).

Much could be said on the role of demographic and economic factors, such as world trade, price commodities and agricultural subsidies to farmers in meeting the challenge. However, the purpose of this paper is not to contribute more to the debate between experts on food security. It is to examine the probable consequences of the business-as-usual scenario that has been the prevailing model for the development of irrigated agriculture, particularly of the large-scale irrigation systems, in many countries. It also projects the likely benefits of increased investment in irrigation and advocates a new approach to design and management of irrigation systems in association with institutional and policy reforms.

According to the International Water Management Institute (IWMI[2]) reliable and timely delivery is the exception, not the rule, in most developing country irrigation systems. Typically farmers in the more favoured parts of irrigation systems receive an adequate supply, while those at the tail end can face ruin. Poor management directly aggravates existing inequities within the farming community. Many farmers, frustrated by unreliable water deliveries, have opted to install tubewells. Consequently, groundwater use is exploding in many surface systems to compensate for the unreliable service from canal systems. Perhaps it will require a shock such as occurred in the 1960s and 1970s to awaken policy makers and the public at large to take the necessary actions to improve the management of these canal systems.

## Decline in irrigation investments

Expenditures for agriculture over the last decade has fallen significantly due to a number of factors. Most frequently cited are:

- The potential for expansion of irrigated area remains limited: the water resources of many rivers have been fully exploited (for example, the Colorado River in Western USA, Yellow River in China, Godavery and Krishna Rivers in India and Oum Er Rbia River in Morocco). The competition for water resources between agriculture and the demands of an increasing urban population and more stringent environmental rules and regulations reduce the potential for expansion of irrigation.
- World food prices are close to historical lows, reinforcing a perception

[2] This comment by the International Water Management Institute may be an overstatement influenced by the selection of projects in which it is involved. However it reflects the less-than-satisfactory water distribution and allocation in some countries. Undoubtedly some countries have reached a higher level of performance, for example in Latin America where water is distributed on a pre-arranged basis, and in Southern China where farmers draw water from millions of farm reservoirs.

of food sufficiency. The economics of irrigation development is less favourable than in the past two decades.

- The unit cost of development increased as the most suitable sites were exploited. Irrigation construction costs have risen to two to three times their previous level.

- Most investment is now for the rehabilitation of existing schemes. The cost of rehabilitation per hectare is thought to be considerably less than for a new project.

Less well known but equally important are adverse administrative and behavioural reasons:

- Environmental concerns have discouraged investments in irrigation and dam construction, particularly among the international development banks.

- Donors are responding to the new broad agendas of their organizations focusing on poverty alleviation, privatization and environment. Private and public sector development, health and education now receive more aid than traditional infrastructure.

- Budget cuts for project identification, preparation and supervision contribute to the shift away from costly and time-consuming irrigation projects.

The perception of donors, supported by the international community of water resources and irrigation experts, is that the main cause of the poor performance of irrigated agriculture in many developing countries are deficiencies in management, institutions and policies, not the technology. This perception supports the view that fewer investments are needed for irrigation.

The consequence of declining investments for irrigated agriculture is a decline in rate of growth of irrigated areas and a backlog in rehabilitation and modernisation of existing systems. The global irrigated area grew by around 2 percent a year in the 1960s and 1970s, slowing down to 1.5 percent in the 1980s and hardly 1 percent in the 1990s. Irrigated area grew from 150 to 260 million hectares between 1965 and 1995 and is now growing at a very slow rate because of a considerable slowdown in new investments combined with loss of irrigated areas due to salinization and urban encroachment. It is estimated that about 50 million hectares of irrigated lands are affected by waterlogging problems resulting from poor irrigation management practices. About one million hectares go out of production every year because of salinity or sodicity.

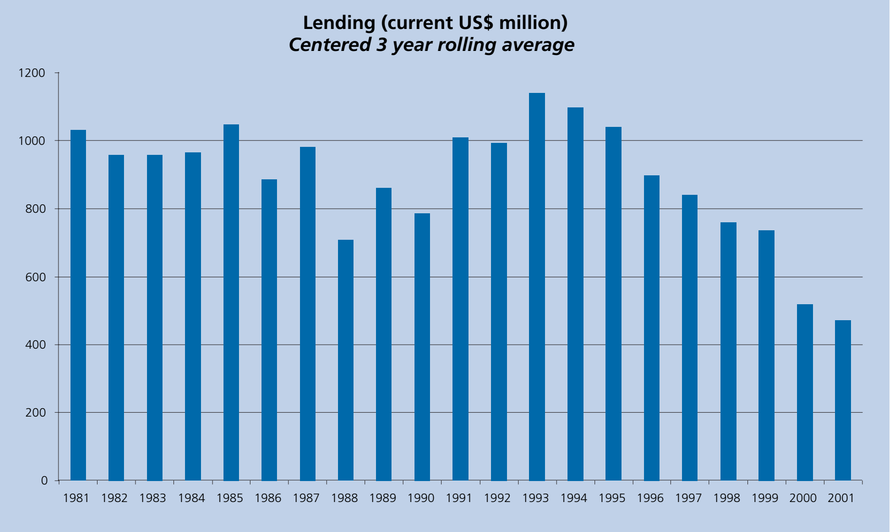
A notable exception to the overall decline in irrigation investment is Saudi Arabia. The irrigated area in that country has increased three times from 0.5 to 1.5 million hectares between 1975 and 1992 resulting in the achievement of self-sufficiency in five agricultural commodities. However, the excessive use of irrigation water has resulted in the rise of shallow groundwater in some areas with negative impacts on the environment, human health and engineering facilities.

### Box no. 1: Evolution of World Bank lending for irrigation

Irrigation accounted for 7 percent of World Bank lending for the 30-year period 1960–1990 more than any other single sector. Since then lending for irrigation by the World Bank has declined. Annual lending for irrigation accounted for only 2.5 percent of Bank lending in the 1990s and is still declining in the early 2000s.

The character of irrigation lending has been changing over time. Up to the early 1970s, emphasis was on infrastructure. The World Bank refused to lend for rehabilitation of irrigation, or of anything else. Rehabilitation was considered something that borrowers should do with their own resources and not truly an investment. To lend for it would simply encourage poor maintenance. Lending for irrigation has shifted progressively to rehabilitation associated with implementation of management, institutional and policy reforms. About two-thirds of recent international lending has been for systems which have suffered premature failure.

**Figure 1**
**World Bank lending for irrigation**




## Groundwater development has delayed the next food crisis

Over time, the area irrigated by groundwater has increased in importance around the world. Groundwater development has been growing at an exceptional rate in recent decades. More reliable water delivery and declining extraction costs due to advances in technology and, in many instances, government subsidies for power and pump installation have encourages private investment in tubewells. For example, in India and Northern China, the area irrigated by groundwater rose from about 25 percent in the 1960s to well over 50 percent in the 1990s. Source of irrigation water varies widely between countries depending on the hydro-geological and climatic conditions and historical development of irrigation. Responses to a recent ICID questionnaire of irrigation practices show that, among the major countries, India has over 50 percent of its area irrigated from groundwater, followed by the USA (43 percent), China (27 percent) and Pakistan (25 percent). That percentage can reach as much as 80 percent in developed countries with mild climate (Germany) and in arid countries (Saudi Arabia, Libya). Table 1 shows the contribution of groundwater used for irrigation for a set of countries that together represent about 150 million hectares or 56.6 percent of the total irrigated area worldwide.

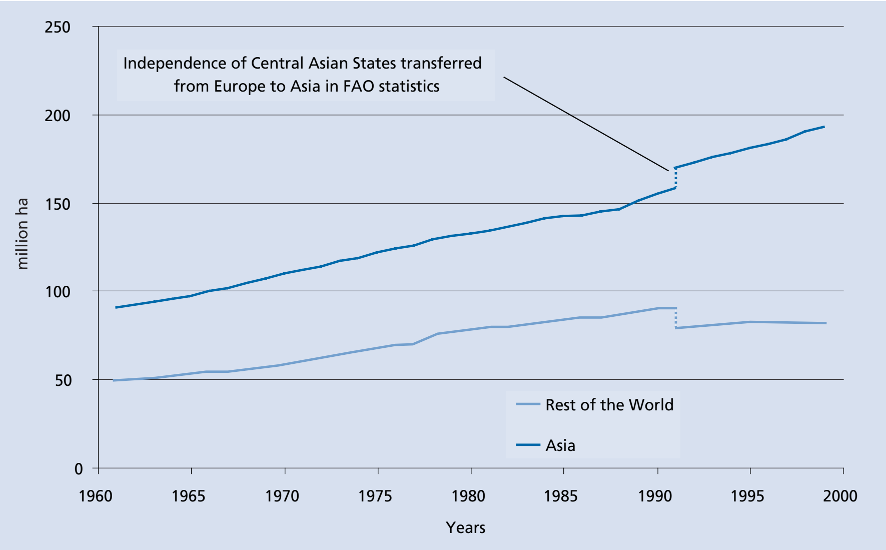
**Table 1: Contribution of groundwater used for irrigation for countries where data are available (source: FAO Aquastat)**

| Country | Percent of groundwater as part of water resource used | Total irrigation water use (million m$^3$/year) |
|---|---|---|
| Saudi Arabia | 96 | 15 310 |
| Bangladesh | 69 | 12 600 |
| Tunisia | 61 | 2 730 |
| Jordan | 55 | 740 |
| India | 53 | 460 000 |
| Iran | 50 | 64 160 |
| Pakistan | 34 | 150 600 |
| Morocco | 31 | 10 180 |
| Mexico | 27 | 61 200 |
| China | 18 | 407 800 |
| South Africa | 18 | 9 580 |
| Nepal | 12 | 28 700 |
| Peru | 11 | 16 300 |
| Malaysia | 8 | 9 700 |
| Egypt | 4 | 45 400 |
| Mali | 3 | 1 320 |
| Indonesia | 1 | 69 200 |

According to a report of the World Commission for Water, aquifers are being mined at an unprecedented rate. About 10 percent of the world's agricultural food production depends on using mined groundwater. Water tables are dropping in fossil aquifers, including in the Western Unites States.

The recent development of groundwater has led to the overexploitation of groundwater resources in some semi-arid regions where water tables have been falling at an alarming rate – often one to three metres a year. These regions include some of the world's major grain producing areas ('breadbaskets') such as the Punjab and the North China plain. Groundwater development for irrigation is more recent in some countries. In Thailand, the explosive use of diesel pumps in the Chao Phraya and Mekong projects has responded to the increased demand for dry season cultivation of high-value crops and the unreliable supply from these large gravity irrigation systems employed. Figure 2 shows that the expansion of irrigated areas during the last 10 years is mostly taking place in the Asian region.

**Figure 2**
**Evolution of irrigation in Asia vs rest of the World (source: FAO)**




## Box no. 2: Groundwater development in India and its contribution to food production

Over the last three decades, the rapid expansion in the use of groundwater primarily for irrigation has contributed significantly to agricultural and economic development in India. Groundwater irrigation potential, the number of wells and the number of energized pump sets have grown exponentially since the early 1950s. Current projections envision that the rapid rate of development will continue until the full irrigation potential estimated to be available from groundwater is reached in about 2007.

With more than 17 million wells nationwide, groundwater now supplies more than 50 percent of the irrigated area and, due to higher yields in groundwater irrigated areas, it is essential for an even higher proportion of the total irrigated output. According to some estimates, 70-80 percent of the value of irrigated production in India may depend on groundwater irrigation.

That yields are higher in groundwater-irrigated areas is primarily due to the fact that groundwater offers greater control over the supply of water than do other sources of water. As a result groundwater irrigation encourages complementary investments in fertilizers, pesticides, and high yielding varieties, leading to higher yields. (World Bank 1998).

[3] Irrigated areas for central Asian countries were transferred from the USSR to the Asian region in 1992

### Box no. 3: Water disaster in India?

In India, which relies on extensive irrigation, water tables are falling. According to IWMI, India currently withdraws groundwater at twice the recharge rate. Eventually, the shortfall could reduce India's harvest by as much as 25 percent. Since India - well on the way to becoming the world's most populous nation - already maintains an uneasy balance between production and consumption, the impact could be disastrous (Shah and Strong, 2000).

### Box no. 4: The changes in the Phitsanulok project, Thailand

The Phitsanulok gravity irrigation project in Thailand built in the 1980s is complex to manage. The performance in terms of canal distribution and plan implementation is very erratic. There are large deviations between the planned and the actual allocation of water and large variations of water levels in the main canal, an indication of poor water control. Although the Phitsanulok project is not old, many changes have affected the way the system operates. Siltation has reduced the capacity of the main canal to supply the tail end of the project. But the increased role of groundwater is the biggest change. With an average of one well for 5 hectares, virtually all farmers now have access to groundwater. The development of groundwater has given farmers a greater level of control over their crop calendar. They do not have to wait for the availability of canal water, and they can plant their crop at the time that seems best according to their own situation. The benefits that the changes have brought to farmers include increased quantity of water, increased reliability of water and freedom for the farm families to choose their own crop strategies.

The same set of changes has been observed in other large-scale irrigation systems in Thailand. These have become dual-source systems, in which groundwater is of similar significance to canal water (Mainuddin et al., 2000).

### Box no. 5: Groundwater development in Pakistan

Over the past 30 years, more than 12 500 public deep tubewells were installed in Pakistan with the primary objective to combat waterlogging and associated salinity. Groundwater development through private tubewells has grown exponentially, especially in Punjab. According to the latest estimates, Pakistan has more than 300 000 tubewells.

According to a 1991 survey, about 46 x $10^9$ cubic meters of groundwater are used for irrigation in the Indus basin, of which 85 percent comes from private tubewells. Because of groundwater extraction, water tables have declined beyond the range over which salinization can be expected. However, salinity continues to present a threat to the sustainability of irrigated agriculture in Punjab because of recycling of large quantities of poor quality groundwater from the top of underlying aquifers. Farmers reduce the risks of crop failures and improve yields by smoothing operational fluctuations in water supplies from the main canals. According to a 1978 study, average yields of wheat from farmers using canal water only (1.7 tonnes per hectare) were 25 percent lower than those from farmers owning wells (2.2 tonnes per hectare). Rice farmers using wells with yields of 2.2 tonnes per hectare are also doing better compared to those using canal water only.

## Is groundwater reaching its limits?

The rapid development in groundwater, however, comes at a price. In many arid areas, more and more areas are in overdraft and the associated water-quality problems are emerging. In India, unreliable power supplies combined with weak management of groundwater resources greatly constrain the growth of irrigated agriculture. The focus of the world's attention on the environmental degradation and dislocation associated with dams has obscured another major environmental issue in the management of water resources. The explosion of the use of pumps for irrigation, domestic and industrial use is degrading groundwater resources. The point has been reached in some areas that the overexploitation is posing a major threat to the environment, health and food security.

The limit of groundwater development for irrigation in the world's major 'breadbasket' countries may be reached in a few years – before the end of the present decade in India. Overexploitation of groundwater resources in arid and semi-arid countries has been documented in recent studies – Ogallala aquifer in the United States, Coastal aquifer and Souss aquifers in Morocco, Hermosillo in Mexico. It is expected that the development of groundwater for irrigated agriculture is going to slow down in the coming years.

## The adoption of water conservation application techniques

A number of farm application irrigation technologies that could contribute to the conservation of water in both surface and piped systems have been developed. These techniques are generally adopted for the cultivation of high value crops. About 20 million hectares worldwide are now irrigated by sprinkler irrigation. Micro-irrigation as a technology has matured into reliable water and fertigation management system for crop production over the past decades and its usage continues to increase rapidly. A total of 3.2 million hectares are being irrigated by micro-irrigation techniques throughout the world, which represent one percent of the total areas irrigated in the world. A growth of more than six times over the last 20 years has been achieved, which is quite a success. Micro-irrigation is an important tool in the drive towards food security. Micro-irrigation systems have great potential to create significant opportunities for smallholder agriculture.

During the 1980s micro-irrigation started penetrating developing countries, mainly India. A few years later, fearing a water and food shortage, the Chinese Government declared drip irrigation technology to be amongst the top priorities for development in the last decade. However, Vidal et al., (2001) have shown that micro-irrigation "is not a miracle technology: excellent as well as poor results were obtained from these technologies, and their adoption really depends on farmers capacity to finance and operate them, as well as on the type of crop production".

According to the ICID database on modern irrigation techniques, it appears that the use of pressurized water application techniques is widely different between countries. The percentage of modern technique decreases with the total area irrigated in developed countries from a low of 21 percent in the USA and 16 percent in Italy to 90 percent or over in Northern European countries (France and Germany). Sprinkler has a much greater application compared to that of the drip systems with the exception of Cyprus, Israel and Jordan.

**Table 2: Sprinkler and drip irrigation in selected countries (source: ICID)**
***(The data refer to different years between 1993 and 2000)***

| Country | Sprinkler irrigation (million ha) | Drip irrigation (million ha) | Total area irrigated by modern methods (million ha) | As percentage of total irrigated area |
|---|---|---|---|---|
| China | 1.20 | 0.27 | 1.47 | 2.8 |
| Cyprus | 0.002 | 0.025 | 0.027 | 49 |
| France | 1.40 | 0.05 | 1.45 | 90 |
| Germany | 0.53 | 0.002 | 0.532 | 100 |
| Israel | 0.07 | 0.16 | 0.23 | 100 |
| India | 0.66 | 0.26 | 0.92 | 1.6 |
| Italy | 0.35 | 0.08 | 0.43 | 16 |
| Jordan | 0.005 | 0.038 | 0.043 | 62 |
| South Africa | 0.26 | 0.22 | 0.48 | 37 |
| USA | 3.38 | 1.05 | 4.43 | 21 |

In South Asia and Africa low cost bucket-and-drip sets are becoming increasingly popular with farmers. In areas where shallow groundwater is plentiful, thousands of poor farmers in Bangladesh have used low-cost treadle pumps to supply water for crops for their own food security and additional income.

Advanced surface irrigation techniques such as precise land levelling, gated pipes or cablegation have also been developed to improve the typical poorly distributed application of water under conventional methods by furrow, border or basin irrigation. Experience shows that these techniques are too sophisticated to be adopted by most smallholders in developing countries. Adaptive research in the Middle East and North Africa has shown the difficulties in introducing surface water conservation techniques. Many attempts to introduce gated pipes in Morocco for example have failed for a number of reasons, mainly the poor maintenance of the quaternary earth canals. Considerable efforts for training of farmers in water conservation in surface systems are needed.

Farmers have adopted pressurised systems much faster than surface application techniques. For example, about 65 percent of the farmers in the Jordan valley have shifted from surface to drip irrigation over a 10-year period. Farmers built on-farm storage reservoirs to provide the flexibility required for drip irrigation.

Although there are no statistical data available on it, it is likely that most of the areas irrigated through water conservation techniques are served from wells or piped systems. There is still a huge potential for development of water conservation techniques in the areas presently irrigated from groundwater. Application of these techniques will continue to expand with the market for high value crops. However, the adoption of these techniques is limited to the cultivation of certain crops because of technical and financial considerations.

## Canal irrigation systems: Water efficiency and water productivity

Much more challenging than that of groundwater is the improvement of performance of canal systems, which will remain the dominant water transfer technique in developing countries in the future. The standards used for design of irrigation canals in many countries have not kept up with the development of new technologies. Most traditional delivery systems have no or little flexibility built into them. Their control strategies and control structures are inadequate for good water management practices. Water deliveries at farm level are not compatible with the key requirements of modern agriculture. Thoughts on how to assess the performance of canal projects are evolving.

The engineering concept of efficiency at different levels of a canal system is important for planning, designing and even operating a canal irrigation system. However, water resources experts have criticised this concept which could be misleading. These experts argue that seepage losses contribute to the recharge of aquifers and losses from a project can be recovered downstream if the water quality has not deteriorated beyond certain limits. These arguments are valid when considering the development of water resources at basin level or even at broader levels when aquifers extend beyond basin boundaries. Advocates of water conservation measures, such as canal lining, then respond that water quality may decline in the recycling process, lands adjacent to canals may be affected by waterlogging and salinization, and an important volume of water can be lost from wasteland. Furthermore, farmers have to support the cost of groundwater pumping to which opponents can argue that farmers use groundwater more efficiently than canal water which is too often unreliable. The application of water conservation measures in irrigation can have negative or positive impact on third parties. The theoretical debate is endless.

Efficiency alone is not a sufficient indicator to define the performance of an irrigation system. Indicators of water productivity expressed in terms of production or value of production per unit of water are very important in increasingly water-scarce situation. A canal irrigation system may have high conveyance efficiency with a minimum of seepage and operational losses. However, if water delivery is too rigid or unreliable, there will be considerable waste further down at the farm level. A water productivity indicator provides a global indication of the effectiveness of water conservation measures and of the quality of service provided to the users, as well as the farm use of water and other inputs.

## The issue of technology *vis-à-vis* management

The opinions differ among experts on the causes of poor performance of canal systems. The following statement epitomises the thinking of many irrigation professionals:

> "Irrigation schemes in many parts of the world are known to be performing well below their full potential… There is now wide recognition that deficiencies in management and related institutional problems, rather than technology of irrigation, were the chief constraints of poor performance of irrigation systems" (ICID, 1992).

There is no question that management of irrigation systems has been haunted by a multitude of problems. Admittedly there are some important management-related and institutional deficiencies, such as conflicts between farmers and irrigation agencies, farmer interference and lack of discipline, poor coordination between government agencies and poor recovery of investments and recovery costs and poor farmer incentives. Few irrigation experts have challenged the widespread wisdom that these are the main causes of poor performance of irrigation systems. A noticeable exception is a recent publication by IWMI.

According to the author, Prof. Horst, the underlying reason for the writing of that book was a combination of the denial of the importance of technology vis-à-vis management, the increasing indifference to system design and the lack of transparency of technology and operational procedures. The preface of that book challenges the well-accepted wisdom on irrigation issues with rather provocative questions:

> Is management really the crux of irrigation problems? … Do we not apply cosmetic surgery by only trying to improve the management environment without considering the technology? Is it not time to examine the root of the problems: the design of irrigation systems? (Horst, 1998)

Why is there so little recognition of the importance of irrigation technology as a principal cause of poor project performance? What are the causes of deficiencies in designing irrigation systems?

- Most civil engineers are well trained in structural engineering and construction techniques but not in the practical and theoretical aspects of unsteady flow hydraulics that are the norm in most irrigation systems. They are also unfamiliar with the constraints of the end user – i.e. on-farm irrigation management requirements. Appropriate irrigation design and management is much more complicated than most engineers, administrators and donors assume.

- Second, designers are rarely confronted with the consequences of how their designs function once they are installed.
- Third, many irrigation agencies cling to outdated design standards and often resist changes by external experts. Most consulting firms have no contractual motivation and no financial incentives to introduce new concepts.
- Operational failures of irrigation systems are not dramatic and are not widely publicized. Operation staff can operate canal for a while by infringing on freeboard and farmers are adjusting to the poor delivery by sinking wells or building reservoirs.

Many failures and problems are caused by a design approach that pays insufficient attention to operational aspects. The point is that if hydraulic systems were simple to operate to attain good water delivery service, safety and efficiency, then management and institutional problems may disappear. Many management and institutional problems are self-inflicted wounds that could be minimized or eliminated with proper designs and operational instructions (Burt, 1999).

A frequently heard argument is that modernization is too costly and too sophisticated. In modern schemes, irrigation is provided as a service to users that should be as efficient and convenient as possible. Modernization is a thought process that starts with the definition of a proper operational plan. The selection of water control equipment is then done in the light of the operational objectives and the requirements of the farming systems.

In most cases, proper hydraulic design and simple automation techniques can make significant improvements. A good design, even with sophisticated devices, results in simple rules of operation at all levels in canal systems.

## Combining technical changes and reforms: A prelude to success

The combination of technical changes with institutional and policy reforms have largely been responsible for the success of reform programmes in irrigation. The examples of the State of Victoria, Australia (box 6) and of the Office du Niger, Mali (box 7) demonstrate that investments in irrigated agriculture can again be worthwhile. The key conditions are a better understanding of the importance of technology in combination with management reforms, the adoption of improved technology and the greater awareness that some action needs to be taken to sustain food supplies.

## Box no. 6: The technical and political reform processes in the State of Victoria, Australia

Irrigation enterprises of low profitability, aging infrastructure, large public debt and environmental degradation through salinity and waterlogging were common in Victoria State, Australia in the early 1980s. Operation of the complex irrigation channel systems was inflexible and highly reactive. Operation of the irrigation systems was driven from the headworks down. Renewing infrastructure provided the opportunity to redesign the system to create much more effective water delivery systems. The first step taken was to fundamentally change the approach to managing the irrigation systems with the objectives of reducing the costs of delivering services and of building a base with new technology to allow more sophisticated water services and tariff arrangements. Instead of merely replacing the existing infrastructure, careful analyses of the system revealed opportunities to create better, more effective irrigation systems. The roster system requiring the irrigators to take water on a fixed schedule was converted into a water-on-order system allowing the farmers to better meet the needs of their crops, make more efficient use of water and reduce pumping costs. A telemetry system combined with Supervisory Control and Data Acquisition (SCADA) provides real operation of flows and water levels.

The new system was a significant step in the development of irrigation in Victoria. The new system allowed leasing of water rights, diversion licenses, and sale entitlements between established farms within certain conditions. The shortfall of revenues was considerably reduced (Langford et al., 1999).

## Box no. 7: Restructuring of the Office du Niger, Mali, West Africa

The Office du Niger in Mali was seen for many years as a heavy financial burden. It is now seen as a "success story". The Office du Niger was created in the early 1930s to reduce the dependence of France on imported cotton from the British Colonies. The project was managed by a parastatal organization, following the model of the Gezira project in Sudan. The 25 000 farmers resettled by force and deportation were seen as agricultural workers. In the 1950s cultivation of cotton was abandoned because of rapid development of waterlogging conditions, a major contrast with the heavy soils of the Gezira project highly suitable to cotton cultivation. The restructuring of the Office du Niger focused on both institutional and technical aspects. The paddy rice processing and commercialization functions of the Office du Niger were progressively privatized. The activities of the Office are now concentrated around its essential functions of water services, planning and maintenance.

The physical upgrading consisted of modern water control of the main conveyance and distribution network, and precise levelling of paddy lands. The improved water delivery and land levelling makes possible the adoption of transplanting and high-yield varieties, resulting in an increase of paddy yields from 1.5 to 6 tonnes per hectare.

The technical and institutional restructuring of the Office du Niger made it possible for the agronomic and economic performances of that project to skyrocket, responding to the need for financial balance, market opportunities in a context of liberalization and privatization (Couture and Lavigne-Delville, 2000).

State officials of the 1960s to 1980s have been criticized for their 'construction bias' and their lack of interest for social considerations. Equally erroneous could be to think that software would solve all the irrigation ills. Most policy and institutional reforms cannot be fully implemented without the right physical environment. Application of volumetric water charges and quotas, implementation of water rights and active water markets, and demand management are reform tools which require confidence from the users in the delivery system, and proper water control to provide that service (Burt, 1999). The implementation of institutional reforms without considering the need for technical changes may lead to a failure of the reform process.

The case of the National Irrigation Authority (NIA) in the Philippines illustrates that point. Created in 1964 as a public corporation, NIA has been experimenting with agency restructuring since then. However, NIA has been unable to accomplish its goal of financing itself despite transferring the operational and management responsibilities to user organizations, reducing NIA staff and increasing collection rates of irrigation service fees. In response to rice shortages and financial problems, the government of the Philippines recently reinstated public subsidies to NIA and reduced service fees. The reasons for this suggested by donors are the lack of political will and weak leadership allowing NIA to avoid making the difficult political decisions needed to become financially self-sufficient. These are not the only causes of the failure of the restructuring experiment in the Philippines.

Lending for irrigation in that country during the last two decades has mostly supported rehabilitation and deferred maintenance. No diagnosis was made to identify the causes of rapid deterioration of the water control infrastructure. The water allocation and delivery was basically unchanged. The conclusion is that the focus was on the financial sustainability of NIA, not on the profitability of farming as has been the case in the State of Victoria and in Mali.

A much better approach was adopted in Viet Nam for the preparation of a water resources development project with a major irrigation modernisation component. Intensive capacity building programme through workshops on irrigation performance and modernisation and study tours is part of the efforts of preparation to broaden government commitment to modernisation and to build up capacity in planning, designing, building and operating modern systems.

The importance of technology in combination with management and policy to improve performance of large irrigation systems is progressively recognized at national and regional levels (box 8). However, this should be more forcefully promoted by donors and international irrigation and water resources organizations.

# Future vision

Thirty years ago, extensive use of fertilizer and expansion of irrigation together with high-yielding food crops were the critical factors in preventing global famine. The drop in rate of yield increase of many grains may be an indication that these instruments have reached their effective limits. Most analysts believe future increases in food supplies will come mainly from improved production, since the natural resource base will not support either significant expansion of farmlands or more extensive irrigation (Shah and Strong, 2000). One option for improving the productivity of irrigated agriculture – and maybe the most important one – is to improve the water distribution service to individual or groups of farmers.

> "The most important of all functions of irrigation projects is to ensure that water is efficiently and fairly distributed. It is only if the main water distribution system is well operated that many other important objectives can be satisfactorily realized; and it is only then that high returns can be obtained from agricultural extension advice and the increased application of other complementary inputs" (Bottrall, 1981)."

Although expressed 20 years ago, the donors and government agencies have not yet translated this statement into effective action for many surface irrigation systems. By contrast, some entrepreneurial farmers have taken the matter in hand, where feasible, by tapping groundwater, building small terminal reservoirs and capturing drained water. Where water supply becomes reliable, farmers invest in water saving techniques which have influenced the choice of crop, amount of fertilizer applied and a host of other agronomic practices depending on market conditions. However, a large majority of farmers cannot do so because of too deep or poor quality groundwater, or because of lack of land for building farm reservoirs. The most important option to increase productivity is to improve the service from delivery systems, which in turn will encourage improved water use at farm level. Improved management at both levels if necessary to achieve the higher water productivity from canal systems. Achieving that objective would require a number of changes.

- First, the irrigation community at large, including agencies, consulting firms and research institutes would have to be convinced that both deficiencies in technology and management are the causes of poor performance of irrigation.
- Second, donors may have to change their criteria for the economic feasibility of irrigation projects, by using 'shadow commodity prices'. At today's low prices it does not pay to invest in improvements in irrigation infrastructure. Because of the long gestation period, failure to invest now could exacerbate the problem of water scarcity, threaten food security, and push prices of agricultural commodities up to unacceptable levels.
- Third, engineers and planners need robust information on the links between

design, maintenance, spending, performance, whole life cost and sustainability. They would have to better understand the process of modernization of large surface systems.

- Fourth, a massive effort is needed to increase awareness of the deficiencies of outdated designs and the potential of modern technologies for water control and sustainable agriculture.

As stressed above, improving the quality of service in large-scale systems is a prerequisite to the adoption of on-farm modern techniques. However, it is not the only limiting factor. Improving water productivity in large-scale systems

### Box 8: The intricate issue of on-farm modern irrigation in large scale systems

Canal irrigation systems with some elements of modernization are better performing than conventional design systems, such as the manually-operated under-shot gated systems. However, these modern systems may be far from reaching their potential agricultural performance if on-farm management is left behind. For example, water delivery from the irrigation systems in Morocco is organized on a bi-weekly rotational basis, a method that excludes the adoption of water-saving techniques and the cultivation of high value vegetable crops in the absence of farm reservoirs. Furthermore, the land consolidation model adopted in that country since the 1960s is now a serious constraint to the adoption of water-saving techniques since the agricultural policy has shifted from an interventionist to a liberal economy. A land-consolidated block of 30 hectares designed for irrigation on a crop-strip basis is poorly adapted to a rotation between farm plots arranged across the crop strips. Changes in both land management and system operation are needed.

Productivity of the modern large-scale granary systems in Malaysia is limited by the low density of canals (about 12 meters/ha), compelling most farmers to practice field-to-field irrigation. Construction of the missing tertiary and quaternary canals as well as farm roads required for farming mechanization is not economically justified under the present depressed rice prices unless crop yields could nearly double.

The conversion from canal to pipe delivery in existing systems leads to serious operational problems if all the users do not shift from surface to pressurized application. The low flow-high frequency is not compatible with the high flow requirement of surface irrigation. In the Jordan Valley the farmers using basin irrigation are unhappy about the low flow delivery and those using drip irrigation are unhappy about the pressure drop when the first group tamper with the flow-controllers. The water fees are presently far too low to convince all farmers to invest in water-saving techniques.

The increased participation of users in the management of irrigation systems offers a unique opportunity to improve system operation. However, the design of user associations, their size, their level of financial autonomy and responsibilities vis-à-vis government agencies determine the type of activities they can undertake. Partial turnover to farmers will not address problems of operation and maintenance of main canals of most large systems. Farmers have little reason to make turnover work unless they get an improved service from the main system.

# Conclusions

Although opinions differ about the risk of a second food crisis, undoubtedly there is a serious problem that must be addressed. There is a false sense of security because of the abundance of grain produced and low staple food prices. As a result, irrigation investments and official development assistance to irrigation in developing countries have fallen and the rate of growth of irrigated areas has dropped. The 'World Bank and Irrigation' publication (Jones, 1995) suggests that public-sector planners typically share the popular perception that agricultural intensification will take care of itself, even though the conjuncture of forces that inspired the Green Revolution is no longer present. If persisting, that perception could be counterproductive. At the very least, the food production will have to increase by about 50 percent to feed some two billion more people by 2020, and a large part of that increase needs to come from irrigated agriculture. Today's situation is much more difficult than the problem solved in the Green Revolution.

The shortages of food production projected for the 1990s have been averted to some extent by the explosive exploitation of groundwater and the increase in water saving technologies over the last three decades. However, overexploitation of the groundwater resource and an associated decline in water quality have been occurring in many parts of the world, particularly in the semi-arid regions. Exploitation of groundwater was originally spurred by the need of farmers for additional water. In many regions, the farmers reacted to the inadequate service they received from the large surface irrigation systems.

There are various examples that support the viewpoint that it is the association of technical changes with institutional and policy reforms that contributes to the success of reform programmes in irrigation. Deficiencies in management as well as in design of irrigation projects are the causes of the poor performance of irrigation. This observation does not suggest that design of irrigation projects should be refocused to the conventional engineering aspects of the past. Modern approach to design means taking into account the quality of service, the ease of operation, the social and institutional aspects, in brief the needs of the farmers and the working conditions of field operators.

With the diminishing availability of groundwater for irrigation, addressing the reasons of the poor management and performance of large-scale surface irrigation projects in a holistic manner can no longer be evaded. Food trade agreements, alleviation of rural poverty and reduction of out-migration from rural to urban areas are also strong arguments in favour of improving irrigation service to users.

In the middle of a food crisis, it would be too late to explore in an efficient way the technical and institutional options for improving the performance of existing and new irrigation systems. The next shock in food production should be anticipated. Changes in management and design of surface irrigation systems are an urgent matter that can no longer be ignored.

### Box 9: Emergence of new thinking

New design criteria, operational rules and water allocation policies have to be set up. Management strategies should consider not only resources but also demands. (Nineteenth European Regional Conference of ICID, Prague, June 2001)

Modernization of irrigation schemes to improve water use efficiency, comprising all aspects like engineering, land consolidation, system management, farmer training, etc. was considered as priority areas. (One of the 21 recommendations of the Nineteenth Spanish National Congress on Irrigation, Zaragossa, June 2001).

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