GUIDANCE FOR INVESTMENTS IN IMPROVED IRRIGATION SERVICES

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ABSTRACT

Population growth, rapid urbanization, economic growth and changes in dietary preferences continue to increase the demand for agricultural produce. The 1996 World Food Summit estimated that 50 to 66% of required gains in crop production would come from irrigated agriculture; noting that yields on irrigated land are typically double that of rain-fed agriculture. Notwithstanding the increasing importance of irrigated agriculture many schemes are currently considered to be under-performing. Irrigation systems, particularly large systems, provide considerable local and national benefits in terms of food and energy security, employment, economic growth and ecosystem services. Substantial investments continue to be made, by governments and international development finance institutions, to create and rehabilitate large-scale irrigation systems; however the performance and sustainability of many of these projects are below expectations. ADB commissioned a regional technical TA7967-REG Innovations for More Food with Less Water in 2011 to provide new insights to guide future investments in rehabilitation and modernization of irrigation.

This paper presents a revised definition of irrigation modernization and recommendations on key issues to be considered in design of investments in irrigation system performance.

Keywords: Modernization, Definition, Irrigation services, Reliability, Flexibility, Investment decisions.

1. INTRODUCTION

Population growth and changes in diet resulting from improved standards of living continue to increase the demand for agricultural produce. The 1996 World Food Summit documentation noted that:

(i)  Irrigated land is more than twice as productive as rainfed cropland. Today, only 16% of the world's croplands are irrigated, but those lands yield some 36% of the global harvest;

(ii) in developing countries, irrigation increases yields for most crops from 100% to 400%. Irrigation also allows farmers to reap additional returns by cultivating higher-value cash crops; and

(iii) half to two-thirds of future gains in crop production are expected to come from irrigated land.(FAO, 1996)

The current performance of many schemes is however poor. Irrigation systems, particularly large systems, provide considerable local and national benefits in terms of food and energy security, employment, economic growth and ecosystem services.

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However, although substantial investments have been made to create and rehabilitate the schemes, large-scale irrigation systems are generally considered to not be achieving the levels of performance expected in terms of crop water productivity, equity of water distribution, sustainable operations and economic return on investment. In the four schemes studied during the technical assistance Innovations for More Food with Less Water, crop yields were typically 30% to 40% below the yield that farmers could expect to achieve under reasonable irrigation conditions.

Despite the importance of large schemes in terms of employment and food security, many of them were designed in the early and mid-20th century to spread water “thinly” among many farmers and to protect them against crop failure and famine, rather than to optimize productivity. This is known as protective irrigation. Frequently these schemes were initially managed under now outdated colonial administrations, and the underlying design and management principles have remained largely unchanged in many systems. Crop productivity and financial performance are sub-optimal and cost recovery is very poor. Improvements will require scheme modernization, both physical and institutional.

Examples of problems that have led to under-performance include: (i) investment in irrigation by governments and development partners have commonly been repeating cycles of build-neglect-rebuild; (ii) water, land and labor productivity in these schemes are frequently substantially less than potential; (iii) large water diversions and weak irrigation services have reduced the water available for other uses; (iv) investments in training and capacity building for irrigation professionals has declined; (v) agency staff, resources and procedures have not kept up with changing needs; (vi) farm sizes and/or field layouts are, in many places, not suitable for efficient mechanized operations; and (vi) investment in irrigation research and agricultural extension is substantially less than is justified by the significance of irrigated agriculture.

In 2007 and 2008 food prices increased rapidly. Possible reasons included (i) oil price increases resulting in escalations in the costs of fertilizers, food transportation, and industrial agriculture; (ii) the increasing use of biofuels in developed countries; (iii) an increasing demand for a more varied diet across the expanding middle-class populations of Asia; (iv) possibly the role of hedge funds speculating on prices, leading to major shifts in prices; and (v) falling world-food stockpiles. Whatever the combination of factors that were the cause, the sudden increase in prices of basic food grains acted as a wake-up call to leaders about the need to reconsider assumptions about food security. This led to increased investments, aimed at improving food security, including strengthening the resilience of international grain markets but without sufficient focus and investment in agriculture, irrigation and rural development.

A number of studies of the state of irrigation and drainage (I&D) services in Asia were initiated in response to the price spikes, including Mukherji et al (2012), a regional technical assistance by Asian Development Bank (ADB, 2011) to identify opportunities to produce more food with less water, and Burke et al (2015). The studies found current performance of many schemes is poor. Irrigation systems, particularly large systems, provide considerable local and national benefits in terms of food and energy security, employment, economic growth and ecosystem services. However, although substantial investments have been made to create and rehabilitate the schemes, large-scale irrigation systems are generally considered to not be achieving the levels of performance expected in terms of crop water productivity, equity of water distribution, sustainable operations and economic return on investment. The ADB (2011) study found crop yields were typically 30% to 40%
below the yield that farmers could expect to achieve under reasonable irrigation conditions.

Notwithstanding the importance of irrigation for employment and food security, many systems were designed in the early and mid-20th century to spread water “thinly” among many farmers to protect the community against crop failure and famine, rather than to optimize productivity. This is known as protective irrigation. Frequently these schemes were initially managed by colonial administrations. Unfortunately, in many systems, the underlying design and management principles have remained largely unchanged. Crop productivity and financial performance are sub-optimal and cost recovery is very poor. Improvements will require both the physical infrastructure and institutional arrangements to be modernized to provide effective services.

To guide irrigation agencies, ministries and development finance organizations selection and design of interventions to improve I&D services we propose an expanded definition for modernization of I&D services. Application of the proposed definition of modernization would, we believe, result in improved system performance, increased food security, and most importantly, the resulting improvement of irrigation services would contribute to further poverty reduction (Lipton and Litchfield. 2003) and support achievement of the 2015 sustainable development goals (United Nations, 2015).

2. MODERNIZATION OF IRRIGATION AND DRAINAGE SERVICES

Large scale, centrally managed irrigation systems were, in most cases, not designed to be demand-driven or to provide the reliable, flexible and equitable year-round water services that modern farming methods require (Facon, 2012). He noted that many efforts to rehabilitate irrigation systems met with mixed results and that transfer of system management responsibilities to farmers had generally been less successful in reforming services than expected.

Langford et al. (2016) observed that, despite cautions by Playán and Mateos (2006), modernization has frequently been defined in narrow terms as some combination of the upgrading of upgraded canal irrigation systems to piped systems; the employment of more computerization and sensors; and, too frequently, simply lining of canals (Kijne, 2003). Plusquellec (1998) stated that modernization is not necessarily the conversion of an irrigation system to the state-of-the-art in technology and management; proposing modernization may be interpreted as any physical or institutional change which would contribute to an improved service to users or some other stated benefit from the intervention. In the following discussions we place farmers as the central target beneficiary of modernization efforts.

We propose that ICID adopts the following definition of modernization:

Modernization is the process of upgrading infrastructure, operations and management of irrigation systems to sustain the current water delivery service requirements of farmers and optimize production and water productivity.

This definition encapsulates concept elements that distinguish “modernization” of irrigation services from “rehabilitation” of irrigation systems. These elements are expanded as:

(a) “Process” reflecting the need that modernization of systems should be a continuous exercise to enable incorporation of future changes in the irrigation
system and service requirements of the farmers. Ideally the process will align with existing government development and budgetary timeframes and systems;

(b) “Upgrading” means improving beyond what is existing; not replacing or rehabilitating. It means applying design best practices to infrastructure to optimize operation requirements and maximize system performance and efficiencies;

(c) “infrastructure” means all physical assets related to the irrigation system, including headworks, conveyance systems, drainage systems, monitoring systems, communication systems, farm and access road networks, operation buildings etc.;

(d) “operations and management” means all human resources and management processes responsible for managing, operating and maintaining the irrigation system including ground and surface water management, and the associated physical infrastructure;

(e) “Irrigation system” encapsulates all physical and non-physical components that contribute to convert water and nutrients into food and fiber. This includes the infrastructure, water resources, agency staff, farmers, services providers, supply and market chains required to enable farmers conduct a viable enterprise, whether for subsistence or in active engagement with external markets;

(f) “Sustain” means that the irrigation system will continue to deliver a defined level of performance after upgrading. This includes managing the water resources to: (i) account for reallocations to other users, (ii) prevent adverse depletion of land and water resources, and (iii) enhance resilience to climate variability and adverse impacts anticipated from climate change. It also means ensuring that all costs relating to management, operation, maintenance, and asset depreciation of the system are affordable and are fully covered through either government, user (farmer), or private sector financing;

(g) “Water delivery service requirements of the farmers” means ensuring reliable, adequate and flexible supply of water as agreed with farmers allowing them to maximize water and agricultural productivity. This requires farmers to be involved in planning, design and operation of the irrigation system, and in routine water management decisions;

(h) “Optimize production and water productivity” means farmers must endeavor, and be supported through technology transfer and extension services, to optimize the productivity of their land with the available water.

In this definition, modernization is not limited to the introduction of modern hardware and/or software techniques but involves fundamental transformation of the way in which the business of irrigated agriculture is done. In the majority of cases, modernization of irrigation infrastructure and services will be a more relevant and cost-effective investment than rehabilitation, or restoration, of the original infrastructure. Necessary transformations may require changing rules and institutional structures related to water rights, water delivery services, accountability mechanisms and incentives, in addition to the transformation of physical structures. Success in modernization relies on strong alignment of the infrastructure and management with the water services requirements of the farming systems supported. This is becoming increasingly important in anticipation of expected changes to agriculture in response to increased migration of youth away from agriculture, the aging and/or feminization of agriculture due to out-migration of male farmers; and changes driven by
increasingly integrated supply-chains linked to the expansion of supermarkets (Reardon et al, 2003).

3. ACHIEVING PLANNED OUTCOMES OF INVESTMENT IN IRRIGATION

Resources for irrigation upgrading are drawn from national irrigation agency budget allocations or, more frequently, from project resources funded by multilateral and/or bilateral loans and grants. Increased concern about declining availability of water resources, resulting from increased competition among water uses and/or increased variability of climate, mean that “water saving” and increased irrigation efficiency are often defined as the objectives of irrigation investments. While each is a useful and valid objective, it is important to recognize that improving irrigation efficiency does not automatically translate into real water savings that can be utilized to meet demands of other users. Real water saving is defined as the reduction non-beneficial depletion, Figure 1, and making the water saved available for other productive uses and the environment. Reduction in non-beneficial depletion can be accomplished by reducing: flows to sinks (Perry, 2007) and ‘non-recoverable’ deep percolation (Allen et al., 1998; Kumar and van Dam, 2013); and non-beneficial evaporation (Gichuki et al., undated; Kumar and van Dam, 2013; Perry, 2007). In crop production, reduction of beneficial depletion or process depletion, Figure 1, will generally result in reduced income for farmers as crop yields are more or less linearly related to transpiration unless agronomic practices or variety of crops are changed. A reduction of non-beneficial depletion can be achieved by reducing weed-growth, flooded areas, and minimizing soil evaporation from inter-crop areas using surface mulching, drip or dry-seeding and alternate wetting and drying irrigation in rice cultivation. Considering a stylized evaporation vs. yield this would involve transitioning from the lower productivity line, Figure 2 passing through point S0, to a higher productivity line through S1, S3, S2a. Similar yield relationships can be developed for other crops.

Figure 1. Basin Water Accounting Framework (Molden, D. et al. 2003)

In many cases the farmer’s expectation is that investments in irrigation infrastructure will enable them to maximize crop production (Figure 2, point S2a) or income. However this does not coincide with the increasingly frequent objective of water resources planners to maximize water productivity (point S1) or simultaneously
increase water productivity and yield and/or income (point S3). Conflicting expectations about outcomes between different stakeholders is likely to result in under-performance of investment projects; highlighting the need for agreements and clear definitions of planned outcomes that are effectively communicated to all stakeholders.

![Figure 2. Wheat Water Productivity - management options (interpretation from Sandras and Angus, 2006)](image)

A transition from Figure 2, point S0 to S1 represents an increase in water productivity which would involve changes to system operations, to ensure reliable irrigation deliveries, and on-farm practices to minimize non-beneficial consumption. This would enable reallocation of water to other uses, but would likely increase the costs for the farmer with no increase in income unless the “saved” water was used to increase irrigated area. Improved reliability of irrigation, without effective regulation of volume of water available to irrigation, would likely result in a transition from point S0 to S2a, providing a substantial increase in yield and/or income, but with no water saving to reallocate for other water users. The transition from S0 to the higher productivity line (S1, S3, S2a) involves and relative increase in the efficiency of the water delivery and application systems, i.e beneficial consumption is a higher proportion of the total volume of water consumed by the system. Points from S1 towards S2a, such as S3, would result in real water savings for potential reallocation to other uses or expansion of irrigated area.

Increasing irrigation efficiency is often considered as a primary goal of irrigation design and management – especially in rehabilitation projects – but as shown in the previous paragraphs considering increasing efficiency is not sufficient if water reallocation is the real objective. Nevertheless, increasing efficiencies is a valid objective for irrigation design and scheme improvement, as this can result in reducing the amount of withdrawal or diversion needed to supply the amount needed for beneficial transpiration. This in turn means that scheme capacities of canals, drains and hydraulic structures can be smaller, with direct impacts on costs – both for initial construction and for subsequent operation and maintenance. However, maximizing
irrigation efficiencies may not always lead to taking the same measures or making the same investments as maximizing yields or optimizing crop water productivity.

With increasing competition for water resources increased focus must be given to investments to maximize crop water productivity. These will involve investments to upgrade physical infrastructure, management processes, systems and the human resource capacities necessary to provide efficient and responsive irrigation services. However, to bring about increased water productivity and enable water to be reallocated to alternate uses (such as for municipal and industrial use, energy generation or ecosystems) will require making, and enforcing, appropriate volumetric allocations of water at the scheme, sub-system and farm boundary. The enforcement of reduced water allocation will depend on effective water governance agencies, supportive leadership and political will to pursue real water savings.

Where fixed water allocations, including both surface and groundwater resources, have been enforced, such as in Israel and Australia, irrigation authorities, farmers and irrigation equipment suppliers have made investments in improving conveyance, distribution and application efficiencies to deliver, or exceed, planned levels of water productivity, yields and net farm income. Where proposed reallocations of water are assumed to occur but are not enforced, adoption of improved technologies (laser graded fields, sprinkler and drip systems, plastic mulches etc.) to improve irrigation efficiencies generally result in increased cropping areas and/or cropping intensities, resulting in increased water consumption rather than the expected water savings.

4. CONCLUSIONS

There is a clear need for new thinking by policy-makers in their considerations on how to prepare for future national and global challenges of food, water, energy and environmental security. Modernization of irrigation services and the supporting infrastructure, institutions and management systems will be an essential part of the efforts that are needed to provide secure nutrition for a global population predicted to reach over 9 billion by 2050. Establishing and maintaining a clear focus of the objectives of all investments to upgrade irrigation services is essential. ICID has a critical role in helping the irrigation and drainage practitioners understand the implications of decisions about the objectives of investments in the sector on agricultural performance, water resources and allocations, and critically on likely poverty reduction outcomes. The ICID network should provide leadership in the appropriate use of: (i) water productivity as a core goal of modernization investments and the measure for evaluation of water saving outcomes; and (ii) irrigation efficiency measures for design of infrastructure and/or management interventions and for the routine evaluation of day-to-day operational performance. In addition, the ICID should take a lead in the communication to the political leadership of major irrigating countries of the essential role of enforcement of rational water resource allocations in achieving improved irrigation performance and real water savings in irrigated agriculture.

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