Agricultural Water Management 97 (2010) 551–560

Contents lists available at ScienceDirect

Agricultural Water Management

journal homepage: www.elsevier.com/locate/agwat

Investing in irrigation: Reviewing the past and looking to the future

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ARTICLE INFO

Article history:
Received 23 October 2007
Accepted 9 July 2009
Available online 22 August 2009

Keywords:
Irrigation
Investment
Climatic change
Performance
Institutions
Groundwater
Storage
Poverty
Food security

ABSTRACT

This article gives a brief review of the development and current situation in global irrigation, and looks at the drivers affecting irrigation performance, development and modernization. The article concludes that the options for new developments are limited, and that future investment will need to be more precisely targeted to specific niches in different agroecological and economic contexts. The paper notes the powerful implications of global climatic change on irrigation through changes in hydrology and water supply that, in conjunction with (1) continued demand for cheap food to satisfy continuously growing populations and changing dietary preferences (projected to 2050) and (2) increasing competition for high reliability water from higher value economic sectors, indicate irrigation performance and the productivity of agricultural water use must further improve, and are also likely to become more targeted at higher value enterprises. Improving management, through better institutions and better technology will require constant adaptation and finessing, with no silver bullets currently on the horizon.

1. Introduction

Irrigation is important, providing approximately 40% of the world's food from less than 20% of its area (FAO, 2003). However, casualties litter the history of irrigation. The equity and cost–benefit performance of many past investments have been called into question, and there have been charges of rent-seeking and misuse of funds (Repetto, 1986). But, on balance, irrigation is thought to have made a massive and useful contribution to global food security (CA, 2007), to improve livelihoods (Lipton et al., 2003), and stimulate broader economic development in Asia. It is even the foundation of society in parts of Asia. Moreover, this role is likely to persist far into the future as irrigation continues to provide a significant proportion of the world's food, including most of its vegetables, fruits and other high-value crops.

Like agriculture, which it serves, irrigation is at a crossroads. The types of irrigation investments being made and the way they are made are changing substantially (FAO, 2003). The era of massive public investment in irrigation is largely over, although there remain many different niches for irrigation expansion, modernization, and improvement, depending on the biophysical and economic setting of individual regions and countries (Renault et al., 2007).

Today's irrigation needs to be adapted to a changing world. Many of the factors that drove irrigation development in the past (population growth, poverty alleviation, changing food preferences) continue to be felt (Rosegrant et al., 2002), but they need to be balanced with new needs for water in cities and industry (Molle and Berkoff, 2006), and we must address and mitigate negative impacts on ecosystems and their health (MA, 2005). Substantial changes are therefore needed in the investment in and management of irrigation. Future investments in irrigation will become more strategic and more aligned with agricultural policies than in the past, and they will need to be better justified if they are from the public purse and better regulated if they involve private capital (Inocencio et al., 2006). Much of the investment will be in improving and adapting existing systems in areas already very reliant on intensively irrigated agriculture, notably, in the developing world, in South, Southeast and East Asia (Renault et al., 2007). There remain niches for new investment in those regions, and there is more potential for development in Africa (Ward et al., 2006), but this will require new and innovative approaches if outcomes are to be successful and economically attractive.

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doi:10.1016/j.agwat.2009.07.012

2. Why do we need irrigation?

Irrigation is an adaptation to rainfall variability on a seasonal and annual basis. The history of irrigation goes back at least 4000 years (Framji et al., 1982), in both the humid tropics, where wet rice became a staple crop, and a cornerstone of civilization, and in the arid and semiarid mid-latitudes, where rainfall was too little, too erratic, or too poorly distributed to ensure a harvestable crop (Postel, 1999). Where extensive irrigation development is found, it has typically been enabled by great rivers and the snowpacks that feed them. The Himalayas, for example, support approximately half of the gravity irrigation in India and China (Thenkabail et al., 2006).

Irrigation allows the impacts of seasonal and interannual hydrological variability on agriculture to be smoothed out. Where water is sourced directly from rivers, the supply has often been buffered by snowpack—with seasonal accumulation and release, as in the Indus and Yellow rivers. Where this has been insufficient to even out supplies, engineers have built storage to allow controlled release of water across seasons and, in some cases, across years. At the same time, the construction and operation of artificial storage have had major impacts on the health of natural ecosystems and the services they provide in supporting agriculture and society (WCD, 2000).

The more recent exploitation of groundwater storage was made possible by the advent of inexpensive small pumps and cheap and widely available energy to drive them. Overabstraction has occurred in many places, notably in India and Pakistan under a policy of perverse energy subsidies, raising major new challenges in the sustainable management and governance of water resources (Shah, 2007).

Ironically, the smoothing of short-term climatic variability provided by irrigation is threatened by long-term shifts in climate resulting from human-induced global warming. One consequence of warming is an increase in variability of precipitation, which, together with the loss of mountain snowpacks, decreases the security provided by irrigation (IPCC, 2001).

Although there is now considerable interest in raising the productivity of rain-fed agriculture, and in shifting more public investment to that sub-sector, it is the storage of water (either behind dams or underground) that enables cropping in droughts and in dry seasons. Although it is certainly possible to enhance rain-fed production in "normal" seasons (Rockström et al., 2001), if there is no rain, then there is no agriculture, bringing us back to the importance of irrigation.

There are many functions of irrigation, which contribute to its utility and relevance. Food security has been of paramount concern in the 19th and 20th centuries, with irrigation used to drought-proof regions such as northern India, provide national granaries (delta irrigation in India, modern systems in Malaysia) and to support the food needs and incomes of burgeoning populations (for example, in the Yellow river and North China Plain in PRC). The mitigation of famine was often driven by political imperatives, which (coupled with tax revenue collection) motivated much colonial investment (Barker and Molle, 2004). A qualitative summary of the impacts of irrigation in different contexts is presented in Table 1, based on a simple typology of irrigation (Faures et al., 2007).

The momentum of the colonial era and the politics of the cold war stimulated massive public investment in irrigation throughout Asia (Barker and Molle, 2004). Although the prime objective of national governments was often national food security, it was increasingly realized that irrigation was a potent mechanism to increase household income and generate employment opportunities (Hussain, 2005). As a key ingredient of the green revolution, irrigation is now credited with serving as the springboard out of poverty for millions of Asians and creating the conditions for subsequent economic and industrial development (IPTRID, 1999). This pump priming to create disposable surplus has long been hoped for in Africa, but has so far failed to materialize (Inocencio et al., 2006).

3. Irrigation from past to present

Governments were the main investors in large-scale irrigation development in colonial India, Central Asia, the western United States, and emerging Australia in the late 19th century. Government has been the key investor in China for many thousands of years. There was a rapid expansion of investment in irrigation through the 20th century, particularly in the inter-war and post-war periods, and development bank lending for irrigation peaked between 1977 and 1979, and declined steadily thereafter (Rosegrant and Svendsen, 1993).

Communities have collectively invested in small-scale irrigation over centuries throughout Asia, and management arrangements evolved over many years continue in use today. Starting in the 1970s, researchers began studying these institutional arrangements intensively, expecting they would offer lessons for improved management of large public irrigation schemes (see inter alia, Ostrom et al., 1993). However while understanding

Table 1
Qualitatitive assessment of irrigation impacts by context (CA, 2007).

	Large-scale public, dry zone	Large-scale public paddy-based	Small–medium-community-managed	Private, commercial	Small-holder, individual
Economic					
Production	Low positive	Low positive	Low positive	High positive	High positive
Food security	High positive	High positive	High positive	Low positive	High positive
Rural employment	High positive	High positive	High positive	Low positive	High positive
Social					
Settlement strategies	Mixed	Mixed	High positive	None	None
Social capital	None	Low positive	High positive	None	None
Health	Mixed	Mixed	Mixed	Low negative	Mixed
Environmental					
Biological diversity	Mixed	Mixed	Mixed	Mixed	None
Soil and water conservation	Mixed	Mixed	Mixed	Mixed	None
Water quality	High negative	Mixed	Mixed	High negative	Low negative
Cultural					
Religious ceremonies	Low negative	None	Low positive	None	None
Landscape, aesthetics	Mixed	High positive	High positive	Low negative	None
Cultural heritage	Mixed	Mixed	High positive	None	None