The Long-run Demand for Irrigation in Asia: Gazing into the Crystal Ball

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Session 4: An Eye to Future

Public sector investments in "agricultural water management," irrigation for short, are among the most complicated and longest-horizon decisions that governments make. The methodology for evaluating the full social costs and benefits of such investments spawned much of modern investment appraisal techniques. As the classic Gittinger (1972) textbook illustrates, appraisal of agricultural projects is often intimately connected to decisions about irrigation investments. Because these are often very large investments, can take a decade or longer to design and build, and if well-maintained, can remain productive for a century, it is important to have the clearest possible picture of the economic environment likely to prevail over that very long time horizon. A clear crystal ball would be most welcome.

This short discussion note attempts to gaze into that crystal ball to gain insights into three basic drivers that will determine the nature of demand for irrigation services for several decades into the future. In turn, the structure of that demand should directly influence the supply of agricultural water management services; in particular, the design of irrigation facilities to fit the needs of end users of these services.

The three drivers are

1. A significant decline in rice consumption that is already well underway in Asia, but which is expected to accelerate in the coming decades;
2. The structural transformation of Asian economies that has been clearly visible for decades in the declining share of agriculture in GDP, but which is just beginning to affect average farm size; and
3. The rapid development of modern supply chains, which is likely to further consolidate the scale of land holdings being managed by highly knowledgeable decision makers who will demand far greater precision in their use of water.

We briefly explain the dynamics in Asia of these three drivers and conclude, speculatively, on their impact on design and management of irrigation systems.

Historical Dynamics

Looking for long-run trends into the future requires an equally lengthy look into the past. Where has the Asian food system come from over the past half century or so?

1. There was a broad political mandate in Asia to feed both urban and rural populations, a mandate not seen as clearly in much of Africa. Food security was politically important.

2. A technological revolution in rice and wheat was coupled with (reasonably) good policies on input and output marketing, and public investments in rural infrastructure to make this mandate (largely) possible. Investments in water control—both irrigation and drainage—were critically important in Asia both for increasing crop productivity and stabilizing yields of rice and wheat.
3. Rapid, inclusive economic growth (resulting largely from (1) and (2)) gave (most) Asian households access to the food in their fields and markets.
4. What's changed Asia over this period is the structural transformation: it has been driven by these processes and the changing role of rice in the economy. Asia is now richer, more urban, better connected both within each country and across borders, and it is much better fed.

The changing role of rice in Asia's food security is both a driver and result of the structural transformation going on in Asia's dynamic economies:

1. Rice is increasingly the food of the poor, which has significant implications for understanding poverty.
2. The share of rice in caloric (energy) intake is falling rapidly (see Table 1):
   a. Asia now has a strongly negative income elasticity of demand for rice (which is why rice consumption is increasingly concentrated among the poor).
   b. Rapid rural to urban migration lowers per capita rice consumption quite sharply (because energy requirements are lower in urban occupations and urban food markets offer a wider diversity of choices)
   c. Better connected food systems mean that rural households can be less self-sufficient in food production and consumption, especially rice.
   d. On average, Asia obtained about 40 percent of calories from rice in the early 1970s, at the peak impact of the Green Revolution, and that share is now below 30 percent and falling.
   e. The budget share spent on rice is falling even faster. Now only 10 percent of the food budget goes to rice (on average—it is higher for the poor), so 90 percent of the food budget is spent on other commodities and value added from processing and convenience.
3. Following the changing patterns of rice consumption, the share of rice in agricultural output and in the overall economy is also falling rapidly.

Rice in Consumption

Momentous changes are underway in rice consumption, especially in Asia. New data, extensive econometric analysis, and a historical perspective help us understand the underlying dynamics of these changes (Timmer, Block and Dawe, 2010). The projections suggest a significant decline in global rice consumption in the next four decades, starting as soon as 2020. The main drivers of this decline will be rapid income growth in Asia, accompanied by a massive shift of labor from rural to urban areas. The sharp negative trend with respect to incomes, and between urban and rural households, is striking (see Figure 1).

With more open trade and the globalization of tastes, a shift to more balanced diets in Asia—less rice and more wheat, animal products, fats and oils, and vegetables

and fruits—means a decline in rice consumption. The foundations of this decline have been apparent in the global data since the early 1990s, when the aggregate income elasticity of demand for rice turned negative. Per capita consumption of rice peaked about the same time. Projecting forward, global rice consumption is expected to rise from the 441 million metric tons (mmt) consumed in 2010 to about 450 mmt in 2020, before declining to just 360 million metric tons in 2050 (see Figure 2).

The total size of rice demand remains important, however, because rice remains the largest single source of calories for a significant majority of Asian consumers. This point returns the discussion to the production situation, where yield growth has stagnated and many key rice-growing basins are threatened by short-run environmental degradation and long-run impacts from climate change. Fortunately, declining consumption will mean less pressure on rice production systems, with the potential to concentrate rice production in highly productive environments and spare fragile ecological settings.

The Structural Transformation

The structural transformation of an economy during the long-run process of economic growth is the appropriate analytical framework for understanding the changing role of agriculture (see Figure 3). Through rising productivity in the agricultural sector, overall economic growth is stimulated, and this then leads to the relative decline of agriculture in both GDP and in the labor force (Timmer, 2009). The apparent paradox has quite real ramifications. Many countries have mistaken the relative decline of agriculture in successfully growing economies as a signal to ignore the sector and starve it of investment resources and policy attention (Timmer, 1988, 2002). The subsequent costs have been very high: stagnation and worsening poverty. History tells us that the only sustainable pathway out of poverty is higher agricultural productivity coupled to a dynamic non-agricultural economy—a structural transformation. It is a general equilibrium process, with agriculture intimately linked to what is going on in the rest of the economy. As Chairman Mao once put it, "the only way out for agriculture is industry."

There are four basic patterns to a successful structural transformation and these have been remarkably uniform across more than two centuries of modern economic growth:

1. A declining share of agriculture in
   a. Value added in the economy (share of GDP)
   b. Employment (share of the labor force)A commensurate rise in the share of urban/industrial/modern service activities.
2. A commensurate rise in the share of urban/industrial/modern service activities.
3. Migration of rural workers to urban settings to allow this transformation to take place.
4. A demographic transition with rapidly falling mortality rates, slowly falling fertility rates and a subsequent period of rapid population growth, which

offers a "demographic bonus" when dependency rates drop to low levels for several decades.

The basic cause and effect of the structural transformation is rising productivity of agricultural labor. There are three ways to raise labor productivity in agriculture (and the first two are usually linked):

1. Use new technology to produce more output for a given amount of labor (an agricultural revolution).
2. Let agricultural workers migrate to other occupations, without lowering output, thus sharing the output with fewer rural people (the classic Lewis model of development, leading to an industrial revolution).
3. Through higher prices for agricultural output (make it worth more in real economic terms, which may well be happening in the current economic era, but is a reversal of historical trends).

From a historical perspective, farm size tends to increase as agricultural laborers leave for more productive jobs in urban (or rural non-farm) areas. This trend accompanies rising real wages in both the rural and urban economies, and tends to mean an increasing reliance on new mechanical technologies that are labor saving. However, in many parts of Asia farm size continues to decline. In these settings, reliance will increase on biological and chemical innovations that raise yields and reduce crop vulnerabilities, and on better control of water.

The agricultural transformation that reflects higher on-farm productivity seems increasingly to be driven by the intensive use of integrated technologies, i.e. where a package of inputs addresses yield potential, control of diseases, pests and weeds, and improved water control and utilization. Three important characteristics of these integrated technologies are crucial:

1. There tends to be a lot of science built into these inputs by the suppliers;
2. Successful use of these inputs is very knowledge-intensive on the part of the farmer; and
3. Better management techniques (in addition to the scientific understanding required) are needed to optimize the use of integrated packages. These techniques lead to sophisticated demand for highly precise input applications, including water. The fixed costs of acquiring this knowledge and learning these management techniques point to greater economies of scale. It may not pay to invest in such learning for a farmer operating one hectare of land, but it may be profitable for a farmer operating ten, fifty or more hectares (Dawe, 2003).

The Dynamics of Modern Food Supply Chains in Asia

A modernizing food marketing system will influence the demand for irrigation services in direct and indirect ways. The analysis here builds on the "10-wheeler" framework developed by Reardon (2010) as an operational model for connecting policy concerns about food security, and the changing role of rice, to the rapid dynamics of modern food supply chains (see Figure 4). Asia's food marketing system is being transformed before our eyes, as modern supply chains and supermarkets change the nature of farm-market-consumer interactions (Reardon, Chen and Minten, 2012). Increasingly, modern supply chains are transmitting demand signals from consumers who are shopping in supermarkets, back up the food system, level by level, to processors, farmers and input suppliers. Traditionally, each cell in the food system depicted in Figure 4 was connected locally by small traders operating with minimal capital and primitive technology (Reardon and Timmer, 2007). Modern supply chains are far more integrated into the farm-level procurement systems of supermarkets and are coordinated by these firms as they seek to "drive costs out of the system."

Three important trends emerge from the "10-wheeler" perspective, when it is overlaid with changing food consumption patterns in Asia. First, the vertical boxes are increasingly connected by market and non-market forces. One key conclusion for suppliers of inputs and technology is that there can be no effective demand for inputs unless farmers are able to sell surpluses into the market. This market is increasingly controlled by procurement officers for supermarket chains, and their tendency to consolidate suppliers may counter the effort by governments seeking to include small farmers. On the other hand, successful efforts to reduce the transactions costs of incorporating small farmers into modern supply chains may simultaneously pay dividends by making these same farmers more accessible to input suppliers.

Second, there is a clear and rapid shift from the left side column of Figure 4 to the right side—from the rice sector to the non-rice sector. This shift reflects Bennett's Law, which argues for an inherent desire among consumers for diversity in their diet. This dietary diversification tends to improve the nutritional quality of the diet, although more processed foods and highly industrialized meat production raise nutritional, environmental, and food safety concerns.

Third, this increasingly diversified, market-driven food economy is more reflective of supply chain dynamics and consumer demand than in the past, which makes it more sensitive to rapid income growth and somewhat less sensitive to population growth.

Implications for Suppliers of Irrigation Services in the Future

What kind of irrigation facilities do we need going forward? The key will be to design and build systems that farmers want, and that will allow a structure of incentives that encourage them to use water efficiently and to maintain the systems. The

dynamics of the three drivers examined here suggest that large-scale systems to support expanded rice production will meet limited demand, and even the rice that will be produced is likely to come from significantly larger operational units than now (even if ownership of individual plots continues to change very slowly).

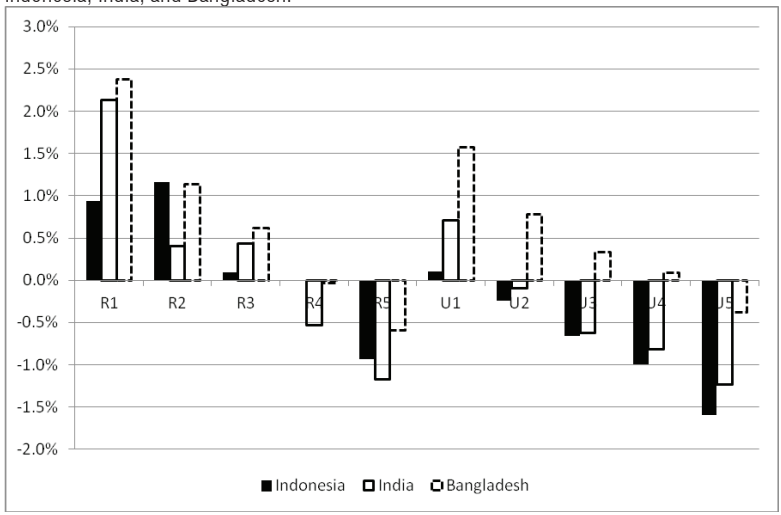
Larger farm units will be encouraged by the structural transformation, as the absolute number of farm workers declines, and by the rapid emergence of modern supply chains, which will permit farmers to diversify production into higher valued commodities. The evidence already suggests that participants in modern supply chains are considerably more knowledgeable than traditional farmers (and often operate larger-scale farms), and they demand much higher quality inputs, with greater precision in how they are applied. The implications for water management are clear; there will be significantly greater demand to control water use in all dimensions, from timing to quantities to drainage. These are not new factors in agricultural management, but demand for them is likely to be much more widespread. Designers of irrigation systems will need to incorporate this new structure of demand if water use is to be more efficient.

Table 1. The Changing Role of Rice in Food Consumption in Asia

Year	Total Calories	Calories from Rice	Rice as % of Total
1961	1805	656	36.3
1970	2069	790	38.2
1980	2200	797	36.2
1990	2443	848	34.7
2000	2606	803	30.8
2007	2668	783	29.3
	Average Annual	% Increase/ (Decrease)	
1961-70	1.53	2.09	0.57
1961-90	1.05	0.89	(0.25)
1970-07	0.69	(0.03)	(0.71)
1990-07	0.52	(0.47)	(1.00)

Source: Data from FAO Food Balance Sheets.
"Calories" are daily per capita energy available.

Figure 1. Annualized percentage change in rice consumption by quintile and location, Indonesia, India, and Bangladesh.



Notes: R refers to rural quintiles, U to urban quintiles. Period over which changes are calculated are 1967-2006 for Indonesia, 1983-2005 for India and 1983-2005 for Bangladesh.

Figure 2. Alternative projections of world rice consumption at different rates of economic growth and rural to urban migration, with real rice price constant at its 2007 level

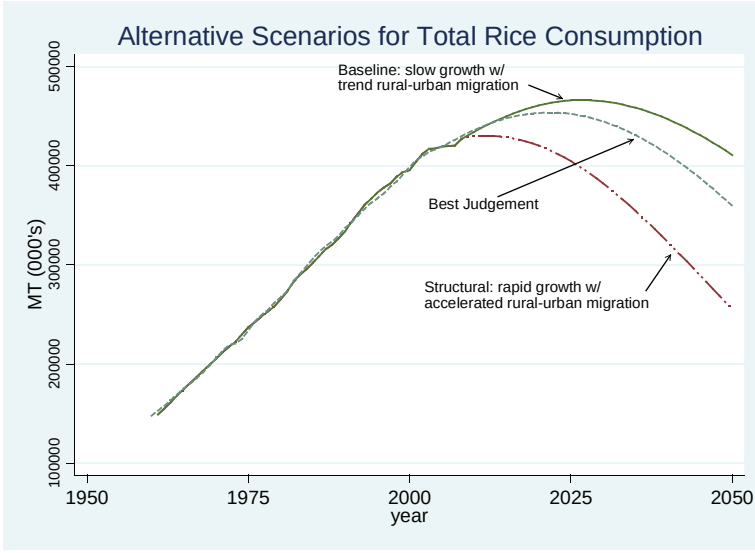
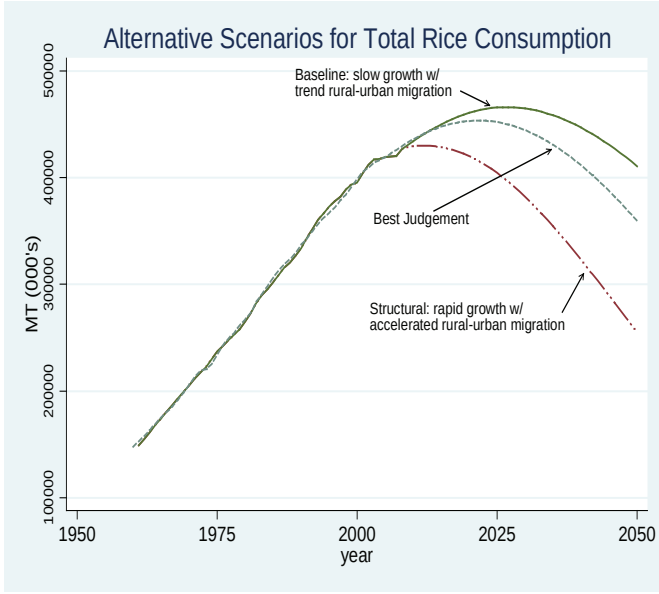


Figure 3. The Structural Transformation in 86 Countries from 1965 to 2000:



Source: Timmer and Akkus, 2008.

Figure 4. Modernizing Food Supply Chains in Asia: The "10-Wheeler" Model

	Rice economy (Starchy staples)	Non-rice Commodities (Fruits and vegetables, meat/dairy, processed foods, wheat)
Farm Inputs/ supplies	Smaller area possible Higher yields, stress tolerance Consumer quality	More value/hectare, but what role for small farmers (what "assets" do they need to stay in?)
Farm production (management and knowledge)	Very knowledge-intensive for good management practices; Access to inputs by farm size	Knowledge intensive; can there be effective extension for new technologies? Role of farm assets
Procurement/ logistics and wholesalers	Less rural consumption as workers leave; more transportation and storage; greater production instability with climate change	High transaction costs of dealing with small farmers; issues of quality control and product traceability
Processing and value added	Milling technology How to add value; branding?	Large share of consumer food expenditure is spent in this box
Retail/consumer welfare and health dimensions	Supermarkets as suppliers of rice? Increased price stability through private actions? Problems of access by the poor?	Modern supply chains are funneling consumer demand back up the system. The food system is less supply driven

Source: Reardon (2010)

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