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Role of Institutions, Infrastructures, and Technologies in Meeting Global Agricultural Water Challenge

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With the declining share of water for agriculture and increasing demand for food and other farm products, many countries are facing a major challenge both in sustaining farm productivity in irrigated areas and in expanding irrigation into rain-fed regions. This challenge has far reaching local and global implications in terms of food security and livelihood, agricultural trade, and agro-based economic activities. This is especially true given persistent water use inefficiency within agriculture and binding physical limits for supply augmentation with a national boundary.

How to tackle the water challenge of agriculture? An invariable answer is the management of water demand within agriculture. While the answer is logical, it gives only the direction but not the complete pathway for the final solution. As such, the answer pegs additional but complex questions. Can the options for implementing water demand management be practical equally across water sources, crops, and socio-economic contexts? Are these options operationally independent? If not, what kinds of linkages and synergies do exist among them? More fundamentally, can the options be effective in achieving their individual and collective goals within a structural and functional vacuum? What roles do institutions, infrastructures, and technologies—both within and beyond agricultural sector—play in filling such a vacuum?

Use Inefficiency, Amid Scarcity

The water challenge of agriculture is characterized by two apparently distinct narratives. The first one captures the macro symptoms of an increasing water scarcity and their next level effects on sectoral water share and on productivity and livelihoods. Binding hydrological limits and political pressures of non-farm sectors magnify these effects. But, the second narrative captures the persisting use inefficiency and low productivity of water and the resultant magnitude of resource and economic loss within and beyond agriculture. Factors like aquifer depletion, pollution, and salinity add additional complications.

These narratives, though distinct, are neither competitive nor mutually exclusive. When taken together, they actually capture not only the crux of the water problem but also the clue to its answer. From an analytical perspective, the first has a focus more on the micro effects of macro and supply side aspects. The second has a focus more on the macro effects of micro and demand side aspects. From a policy perspective, the first underlines large scale investment and infrastructure as well as national and sectoral level institutional reforms. The second emphasizes local and field level aspects like agronomic and farm practices, technologies, and institutions and infrastructures. While their relative focus and priority differ, the narratives negate neither the diagnosis nor the prescription of each other.

Macro policy options are certainly important. But, the justification and pressures for undertaking them have to come from below, particularly from agriculture itself, having the dominant water share. Considering the inefficient water use in agriculture, the sector cannot generate the kind of pressure needed to prompt macro policy reforms. The inefficient water use in agriculture is actually concealing a hidden water potential—with its corresponding dormant output potential—of vast magnitude. If these water and output potentials can be realized through some dramatic rise in use efficiency and productivity, agriculture can certainly enhance farm output even while releasing huge amounts of water for other sectors.

Clearly, a water-wise efficient and productive agriculture can both generate tremendous pressures for performance in other sectors and also provide powerful justification for more infrastructural investments and institutional initiatives at the national level. The central role of improvements in water use efficiency at the local level as a main means for addressing water problems both at the sectoral and national levels is rather unmistakable. So also is the strategic role of water demand management in agriculture.

Options for Water Demand Management

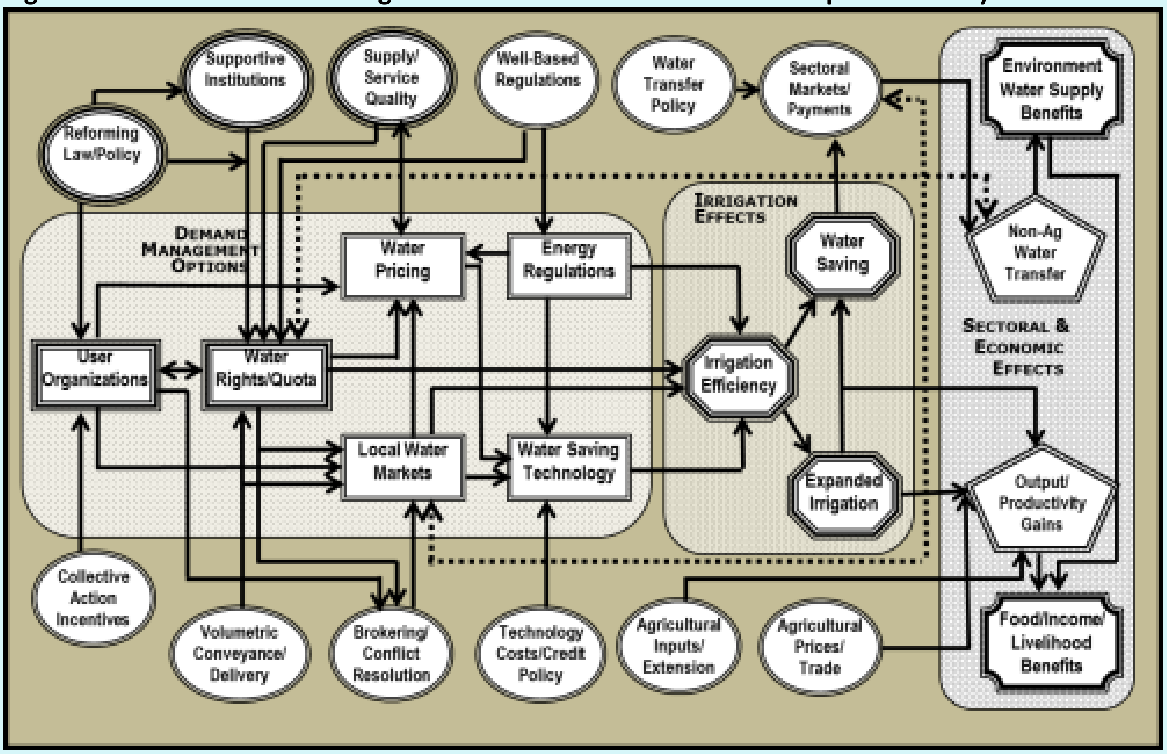
Water demand management is implemented through six main options: water pricing, water markets, water rights, energy regulations, water saving crop and irrigation technologies, and user organizations. The key features of these options include:

- Some are context-specific whereas others are applicable in more generic context. For instance, water pricing is applicable essentially in canal regions, whereas the option of energy regulations and water saving technologies are largely relevant for groundwater regions. But, the remaining two options are context independent.
- Impacts of options such as water saving technologies, water rights, and energy regulations are more direct and immediate whereas the same for others are only indirect and gradual.
- Against their true potential, their actual efficiency effects, as observed in many countries, are too meager and too thinly spread to have any major impact on aggregate water demand. The reasons for this are their limited area coverage and operational effectiveness, which are themselves an outcome of the lack of coherent strategy.
- Options also differ considerably in terms of their immediate adoptability and political economy acceptability. On this count, the option of water rights is the most difficult one in countries that do not have them at present. Although user organizations and water saving technologies are politically easier to implement, they do require active government policies and favorable agronomic conditions.
- Despite their differences and limitations, the options have fundamental operational linkages among them. An understanding of these linkages and their impact pathways is critical for designing a coherent and effective demand management strategy.

The Analytics of Water Demand Management

Figure 1 depicts the analytics of water demand management in agriculture along with its sectoral and economy-wide ramifications. It unbundles the impact pathways and linkages among institutions, infrastructures, technologies, and the general economic and policy environment. The impact pathways trace the effects of agricultural water use to sectoral and economy-wide goals. Figure 1 is able to place water demand management both in the strategic context of water and agricultural institutions as well as in the larger context of sectoral and economic goals. Figure 1 has five analytically distinct but operationally linked segments. The first segment shows the sequential linkages among demand management options. The next segment captures the joint effects of these options on the irrigation sector, where the water savings from efficiency improvement lead to either an expanded irrigation or an increased water savings within existing supply. The third segment captures the sectoral and economy-

Figure 1: Water Demand Management: Functional Structure and Impact Pathways



Source: Adapted from Saleth and Amarasinghe, 2010

wide consequences of the effects from irrigation sector. The remaining two segments cover, respectively, the immediate institutional structure and the fundamental institutional environment. Several points deserve attention.

Since the institutions and their linkages, taken together, form the institutional context of demand management, Figure 1 does capture the institutional structure. But, the institutional environment of demand management, as defined by the interactive roles of hydrological, demographic, cultural, social, economic, and political factors, actually operates beneath the entire system. In addition, given the sequential linkages among them, some options are obviously more important than others. This is either due to them being the necessary conditions for others—for example, user and community organizations—or due to the extent of their linkages with others—for example, water rights and quota system. Thus, the ability of an option to influence water use depends not just on how efficiently it is designed and implemented but also on how well is its aligned with other related options and how effective are the supportive institutional and technical conditions.

Since institutions are defined jointly by legal, policy, and organizational aspects (Saleth and Dinar, 2004), all options—except water saving technology—can be viewed as institutions in themselves. As such, the linkages among these options form part of the institutional setting of water demand management. The institutional structure for demand management covers not only the institutions that are directly related to individual options but also those related to water delivery-related infrastructures, farm input and extension systems, agricultural markets, and price and investment policies. Since these sectoral and macro-economic policies affect the returns to farm level water saving initiatives, they determine the levels of economic incentives and technical scope for the adoption and extension of the options.

Finally, from an impact perspective, the overall performance of a demand management strategy depends on the way it is designed and implemented. The strategy has to be designed in a way to exploit the functional and structural linkages among the options and also benefit from the synergies of the sectoral and macro-economic policies. For instance, the efficiency and equity benefits of water markets can be increased manifold when such markets operate within a volumetric water rights system and are also supported well by user-based management and enforcement mechanisms. Likewise, water pricing policy can be more effective both in cost recovery and in water allocation, if it is combined with volumetric delivery and user based allocation system structures.

Table 1: Functional Linkages and Impact Pathways: International Examples and Evidences

Linkages/Impact Pathways	Geographical Area	Examples/Evidences
Legal and policy reforms-User organization-Water rights-Local water markets-Irrigation efficiency-Output/productivity gains	Asia; Africa; Latin America; Multi-country	Rosegrant and Binswanger (1994); Easter and Quang (2014)
User organization-Volumetric delivery-Water rights-Water pricing-Irrigation efficiency-Productivity gains	North Gujarat, Western India	Kumar (2000 and 2005)
Water rights-Local water markets-Irrigation efficiency-Water saving	Multi-country, South-West Asia, Australia	Easter and Quang (2014); Ahmad (2000); NWC (2010)
Water rights-Local water markets-Irrigation efficiency-Environment flow benefits	Gujarat, Western India	Kay, et al. (1997); Kemper (2007)
Water rights-Water markets-Water saving technology-Irrigation efficiency-Water saving-Urban water transfer	South America	Perry (1999)
Water rights-Local water markets-Water pricing-Irrigation efficiency-Food, income, and livelihood Gains	Victoria, Australia	Bjornlund and McKay (1999)
Supportive institutions-Water rights-User organisation-Water markets-Irrigation efficiency- Food, income, and livelihood benefits	South Asia; Spain; California; Chile	Easter, et al., (1999)
Brokering-Local water markets-Irrigation efficiency-Water saving/ Expanded irrigation/ Output/productivity gains- Food, income, and livelihoods benefits	Multi-country India	Easter and Quang (2014); Saleth (2012);
Water saving technology-Irrigation efficiency-Water saving-Environment flow benefits	Arid and semi-arid areas of China	Deng, et al. (2006)
Technology cost/credit policy-Water saving technology-Irrigation efficiency-Expanded irrigation- Food, income, and livelihoods benefits	Kansas High Plains, US	Peterson and Ding (2005)
Well-based regulations-energy regulation-water pricing	Lower Jordan River Basin	Venot and Molle (2008)
Energy regulation-irrigation efficiency-Output/productivity gains-Food, income, and livelihoods benefits	Batinah Coast, Oman; Bihar, Gujarat, and Uttar Pradesh, India	Zekri (2008) Kumar, et al. (2011)
Water pricing-Water saving technology-irrigation efficiency-Water saving-Productivity gains	India	Dhawan (2002)

International Examples and Anecdotal Evidences

There are many international examples and anecdotal evidences for the functional linkages and impact pathways depicted in Figure 1. Table 1 provides a sample of these.

Many countries have, in fact, exploited the strategic role of these institutional and impact linkages not only in the particular context of water demand management but also in the more general context of water sector institutional reforms (Saleth and Dinar, 2005 and 2006).

Towards a Viable Strategy for Demand Management

In countries already having mature water institutions and superior infrastructural and technological conditions, as in the United States and Australia, the demand management strategy has a fairly straight path. But, in the case of many agrarian countries, the strategy will have a major challenge in view of the prevailing institutional vacuum, infrastructural and technological bottlenecks, and, above all, political apathy. In both cases, however, what is being observed is a casual and *ad hoc* constellation of several uncoordinated demand management efforts that are focused more on goals such as cost recovery, energy saving, and user participation than on efficiency and productivity. It is possible to identify several key design and implementation aspects that are needed for a coherent and viable demand management strategy regardless of the context.

The demand management strategy needs to treat the options as an interrelated configuration that is functioning within an institutional structure capturing the overall legal, policy, and organizational factors and an institutional environment capturing the general economic, infrastructural, technological, and resource conditions. Such an approach will help in exploiting the synergies from institutional linkages and positive feedbacks from the general economic and infrastructural conditions.

The strategic and institutional logic for crafting the demand managed strategy as part of a larger program of water sectors reforms is clear. But, the task is not easy due to the heavy economic and political costs involved in transacting such a change. Fortunately, there are well-tested reform design and implementation principles that can overcome the financial and political constraints to negotiate the reform process. The design principles relate to the prioritization, sequencing, and packaging of institutional components based on impact, costs, and feasibility and the implementation principles cover strategic aspects like timing, coverage, and scale.

The delineation of an appropriate time frame is critical. Within that time frame, options yielding quicker benefits in the short-run—for example, water saving technologies; energy regulations; water pricing—should receive priority while gradually creating conditions for long-term options. For example, user associations are long-term options that can facilitate the emergence of downstream institutions. Options like water rights should be planned after infrastructure development to facilitate volumetric delivery. Besides sequential prioritizing, programs can also be packaged—for example, system modernization with management transfer and improved service quality with higher water rates.

The overall aim is to put in place a critical set of institutions during the time frame, facilitating the natural process of institutional evolution. When a critical mass of institutions is in place, inherent institutional features such as scale economies in reforms will facilitate the emergence of complementary institutions over time.

Finally, it is very important to seize the opportunities provided by both internally caused factors such as a water crisis, financial bankruptcy, and aged water infrastructure as well as factors outside the system, such as a macro-economic crisis, an energy shortage, droughts and floods, and political change. This is because these are the times that the political opposition for change is likely to be low.

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