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Promoting Irrigation Demand Management in India: Policy Options and Institutional Requirements

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Introduction

The symptoms of an ever growing gap between water supply and demand, which are already visible in a few regions around the country, are soon expected to assume a national proportion and become a permanent feature of the Indian water economy. While water demand is growing fast due to population growth and economic expansion, water supply is not growing at the same level due to constraints in expanding supply and also due to the ultimate physical limit for supply expansion. Although water resources developed at present, i.e., 644 billion cubic meters (bcm), constitute only 57 % of the ultimate utilizable potential (1,122 bcm), augmenting supply beyond this level is going to be increasingly constrained by investment bottlenecks, environmental concerns, and political and legal snags. In this respect, the country's ability to meet the increasing water demand in the next few decades will be a major challenge. According to the Ministry of Water Resources, the total demand is projected to increase to 694-710 bcm by 2010 to 784-850 bcm by 2025 and to 973-1,180 bcm by 2050 (Ministry of Water Resources 2000). A recent analysis of water demand and supply scenarios, which accounts for the major changes in the key drivers of water demand and supply, also confirms this demand trend (Amarasinghe et al. 2007b). Particularly, this study projects that under 'business-as-usual' water use patterns, nine basins amounting to over four-fifths of the total water use in India, shall face physical water scarcity by 2050.

From a larger perspective, water scarcity of this magnitude will constrain the ability of the country in meeting the increasing food, livelihood, and water supply needs of an increasing population. Such an inability for a monsoon-dependent and rural-based economy such as India is likely to have devastating social, economic, and political consequences unless water demand is managed through well-designed and implemented policies for improving water use efficiency and productivity, particularly in the irrigation sector, which accounts for the most water consumption. As the scenario facing the Indian water economy is rather grave, any policy prescription would obviously call for a radical change in the development paradigm governing water resources development, allocation, and management. Supply-side solutions

based on physical approaches towards supply augmentation and system improvement, though essential in certain contexts, cannot be the exclusive basis for water sector strategies. A paradigmatic shift is needed for seeking durable solutions rooted in water demand management options, particularly in the irrigation sector that accounts for more than four-fifth of the total water withdrawals in the country. It is even more important as we consider the fact that the consumptive use fraction of the irrigation deliveries at present is only about 40 % (Amarasinghe et al. 2007a).

The demand management options that we consider here for evaluation are well known in literature and practice on water policy. These options include water allocation and management tools such as: (a) water pricing policies that cover both the level and structure of water rates and also the criteria used for fixing them; (b) formal and informal water markets occurring at the micro and macro levels; (c) water rights and entitlement systems for setting access and volumetric limits; (d) energy-based water regulations such as power tariff and supply manipulations; (e) water-saving technologies that cover drip and sprinkler systems as well as crop choice and farm practices; and (f) user and community-based organizations, covering water user associations, *panchayat* organizations, and informal community groups. Although adoptions of these options are critical, what is more critical is the creation of the supportive institutions to ensure their operational effectiveness and water saving performance.

Objectives and Scope

While the importance of demand management options can hardly be disputed, there are still a number of questions that are to be answered from a practical policy perspective in the context of each of the six demand management options. For instance, what is the present status of these options in the irrigation management strategy in India? What is the extent of their application? How effective are they in influencing water use decisions at the farm level? Are there active policies in promoting them at the national and state level? Are there cases of success and best practices in demand management? If so, what are the lessons for policy in up-scaling them? What are the bottlenecks and constraints for promoting them on a wider scale, particularly within the irrigation sector? What are the present potentials and future prospects for these options as an effective means for improving water use efficiency and water saving, which are sufficient enough to either to expand irrigation or to reallocate water to nonagricultural uses and sectors? To explore these and related questions in the context of each of the six demand management options, IWMI has commissioned six separate papers¹ prepared by some of the leading experts on the Indian water sector. These papers were prepared with a common analytical structure to specifically address some of the most relevant practical questions and policy issues (see R. Reddy 2008; Palanisami 2008; Narain 2008; Malik 2008; Narayanamoorthy 2008; and V. Reddy 2008).

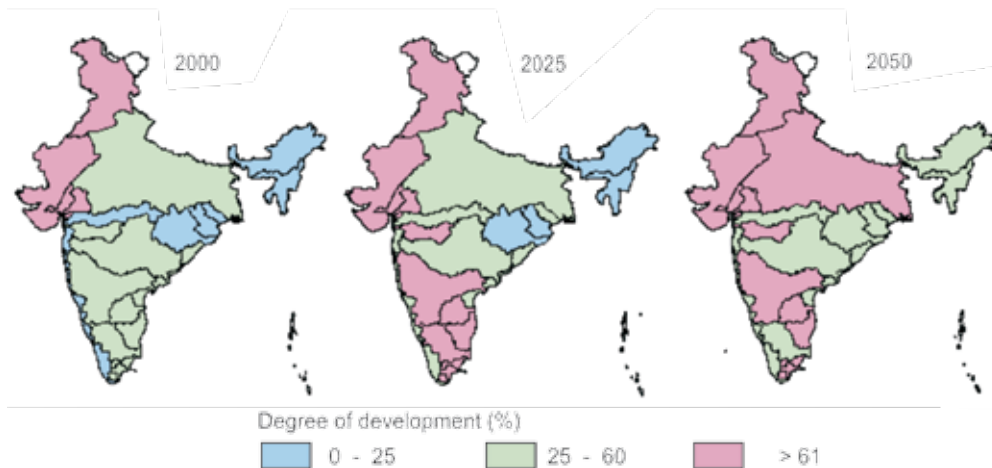
¹ These papers were commissioned in phase III of the IWMI project, 'Strategic Analyses of India's River Linking Project', under the aegis of the Challenge Program for Water and Food. Phase III of the project explores the options that contribute to an alternative water sector perspective plan, in case supply augmenting strategies such as the National River Linking Project (NRLP) fail to meet the increasing water demand.

The main purpose of this paper is to: (a) set the basic economic logic of demand management options; (b) provide an overview and synthesize of the option-specific papers prepared by experts; (c) indicate the key differences and common features emerging from the practical experiences of the demand management options; (d) present an analytical framework that will help understand the operations and linkages among the demand management options and their underlying institutional elements; (e) outline a generic strategy that can better exploit the inherent synergies among the demand management options and align them with the underlying institutional structure and environment; (f) discuss how such a strategy can be effectively promoted within the technical, financial, institutional, and political economy constraints; and (g) conclude with practical insights and policy implications of the discussions in this synthesis paper and in all the six option-specific papers. As to the focus, the discussion on demand management options is specifically confined to the irrigation sector. However, the general implications, especially those related to the institutional dimensions, can also pertain to demand regulations in other sectors, though the relevant options may be different.

Demand Management Options: Logic and Focus

Although the adoption of demand management options on a wider scale is slower than needed, given the changing water supply and demand realities both at the national and local levels, an increasing reliance on these options is inevitable, especially in the irrigation sector and in basins where physical water scarcity is already evident. Considering the predominant share of the irrigation sector in total water use and the small consumptive use factor of irrigation withdrawals, the potential of this sector for water savings and efficiency gains from demand management options are obviously immense. Similarly, larger basins with excessive water withdrawals for agricultural uses also offer a better scope for achieving use efficiency and water savings. Besides their implications for the scope and focus of demand management, the current and prospective physical and economic realities of the water sector also provide the basic rationale for promoting demand management options and strategies.

The total water withdrawal for all uses at the national level in the year 2000 was estimated to be 680 bcm (Amarasinghe et al. 2007a). But, if the ‘business-as-usual’ path of water management and water use pattern continues, water demand is expected to increase by 22 % by 2025 and 32 % by 2050. With such a demand growth, more and more basins are likely to face physical water scarcity, i.e., water withdrawal exceeding 60 % of the potentially utilizable resource. Since withdrawal exceeding this level is expected to be both financially costly and environmentally difficult, more basins are also likely to face economic or financial water scarcity as well. As can be seen in Figure 1, many basins in India are expected to be in this predicament of physical and financial scarcity by the year 2050, if not before. As these basins account for close to three-fifth of the country and cover agriculturally the most important basins, including the Indus, Ganges, Cauvery, and Krishna basins, they will have a pernicious effect on the food and livelihood as well as political fronts.

Figure 1. Degree of development of Indian river basins.

Source: Amarasinghe et al. 2007a

Note: If the degree of development—the ratio of primary water withdrawals to potentially utilizable supply—exceeds 60 %, a basin is physically water scarce. If the additional demand exceeds 25 % of the present level, the basins are economically water-scarce

As can be seen in Table 1, which depicts total water withdrawals by use, source and basins in 2000, the irrigation sector accounts for 89 % of the total withdrawals at the national level. Such a dominant share of irrigation is also evident in most of the basins. Despite such a large share of water withdrawal, the actual consumptive use—the portion that is actually used for the net evapotranspiration of crops—is only 41 % at the national level. The fraction of consumptive use varies from 12 to 59 % across basins, depending obviously on factors such as crop and land use patterns as well as irrigation efficiency at project and farm levels. It is the difference between this consumptive use and the total water withdrawal that provides the physical basis for achieving water use efficiency and water savings through demand management both at the national and basin level. Admittedly, it will not be possible to realize this entire potential for water savings due to various physical, technical, economic, and institutional reasons. But, it is certainly possible to achieve, say, a 20% of this potential water savings with proper targeting of regions for concerted demand management policies and investments.

Table 1. Water withdrawal by use, source and basins, 2000.

River basins	Water withdrawal			NET ³ as % of irrigation withdrawal	Gross irrigated area		
	Total ¹	As % of potentially utilizable resources ²	Share of irrigation		Total	Groundwater share	Groundwater abstraction ratio ⁴
	BCM	%	%	%	Mha	%	%
Indus	98	135	96	37	11.6	58	67
Ganga	285	68	90	41	36.5	69	56
Brahmaputra	6	12	67	14	0.4	14	4
Barak	3	29	76	12	0.3	6	4
Subarnarekha	3	35	81	24	0.4	46	36
Brahmani-Baitarani	6	28	88	24	0.7	28	21
Mahanadi	21	32	92	24	2.2	20	13
Godavari	44	37	85	46	4.3	59	40
Krishna	55	66	89	45	5.2	44	48
Pennar	8	66	90	47	0.7	65	61
Cauvery	22	70	85	39	1.9	48	43
Tapi	9	41	81	55	0.8	80	59
Narmada	13	30	90	46	1.5	61	42
Mahi	6	89	86	43	0.5	55	44
Sabarmati	7	136	86	53	0.9	83	100
WFR1 ⁵	29	112	88	59	3.2	89	132
WRF2 ⁵	14	26	52	34	0.9	40	22
EFR1 ⁵	20	63	92	35	1.9	26	17
EFR2 ⁵	33	95	86	37	2.2	54	46
All basins	684	61	89	41	75.9	61	48

Source: Amarasinghe et al, 2007a

Notes: ¹ Total includes withdrawals for irrigation, domestic and industrial sectors

² Figures more than 100% also include recycling

³ NET is the net evapotranspiration of all irrigated crops

⁴ It relates total groundwater withdrawals to the total groundwater availability through natural recharge and return flows

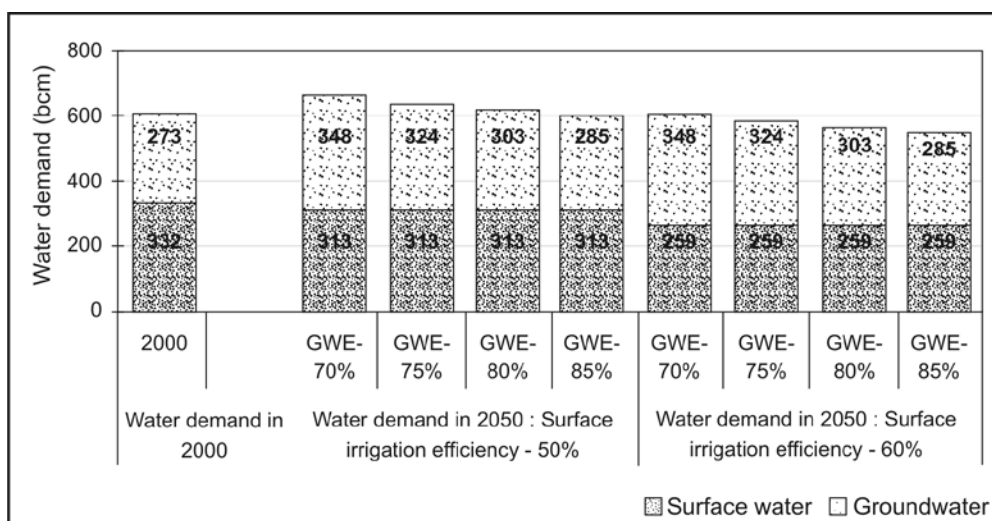
⁵ WFR1 is west flowing rivers of Kutch, Saurashtra and Luni; WFR2 is west flowing rivers from Tapi to Kanayakumari; EFR1 is east flowing rivers between Mahanadi and Pennar and EFR2 is east flowing rivers between Pennar and Kanyakumari

In view of the possibility of greater technical control over the volume and use, the scope for realizing water savings is more in groundwater areas than in surface water areas. Notably, in groundwater areas, where irrigation efficiency is already higher than in canal areas, further efficiency improvements are possible, that too, mainly through policy and institutional changes. In contrast, efficiency improvements require mainly technical changes, especially involving a massive redesign of water conveyance and delivery systems, though policy and

institutional changes are also essential to enhance and sustain the efficiency gains. As a result of their differential policy and institutional requirements, efficiency gains are relatively more immediate in groundwater areas and would also involve relatively smaller public investments on physical structures. Using this fact taken with the dominant (i.e., 60 %) share of groundwater in total irrigation, it is possible to realize the overall irrigation efficiency targets with a greater attention on the groundwater areas, particularly those with severe depletion problems.

Besides their immediate impacts on agricultural productivity, improvements in irrigation efficiency will also have a direct effect on the irrigation water demand and, hence, on the water savings necessary for meeting urban and environmental needs. As can be seen in Figure 2, if the overall irrigation efficiency in canal regions can be raised from the current level of 40 to 50 % and in the groundwater regions from the present level of 60 to 80 %, the future irrigation demand, even with the larger irrigated area, will not exceed the present level of agricultural water withdrawals. But, if the surface irrigation efficiency is increased by an additional 10 %, i.e., to 60 %, while keeping groundwater irrigation efficiency at 80 %, there will be a reduction in irrigation demand to the tune of 43 bcm (Amarasinghe et al. 2007a). If it is possible to raise groundwater irrigation efficiency by an additional 5 %, i.e., 85 %, then, the total reduction in irrigation demand can be as high as 63 bcm. Notably, this reduced irrigation demand or irrigation water savings is close to the total nonirrigation demand in 2000, i.e., 79 bcm. In a sense, this represents the true magnitude of the potential for water savings that exists in the agricultural sector at present. This potential can be realized gradually though the implementation of demand management strategies involving the judicious application of options such as water pricing, water markets, water rights, energy regulations, water saving technologies and user organizations.

Figure 2. Irrigation efficiency and water demand scenarios.



Source: Amarasinghe et al. 2007b

The immediate goal of demand management is not just the reallocation of water away from irrigation but also to set the conditions for a long-term improvement in the productivity and efficiency of irrigated agriculture. In fact, an excessive focus on water reallocation often creates resistance and constraints for the promotion of the demand management options. In reality, the improving efficiency is the most immediate and central goal, whereas the reallocation is only a secondary goal, which flows as an outcome of the former, that too, within a voluntary and compensation-based incentive framework. This point, though seems to be simple and hence, remains often underestimated, is rather crucial, especially from a political economy perspective of creating the necessary economic and institutional conditions for the application of demand management options.

The macro-logic for demand management is clearly underlined by the increasing water supply-demand gap at the national level. There are also other equally compelling reasons—both the macro and micro ones—for the urgency of promoting these options in Indian agriculture. One of them relates to the food and livelihood implications (see Palanisami and Paramasivam 2007). The total food grain area in India has increased about 1.2 times between 1950 and 2005, i.e., from 97 million ha (mha) to about 121 mha whereas the food grain production has increased by 4.1 times, from 51 million tonnes (mt) to 208 mt (GOI 2007). Irrigation has been a major source of determinant for the productivity increase, where the irrigated area under food grains has increased by 3.0 times, from 18 to 54 mha between 1950 and 2005. Over the same period the total or gross irrigated area has increased by 3.6 times from 22 to 80 mha. This shows that while irrigation has been playing a major role in increasing food grain productivity and production, the demand for irrigation for nongrain crops is also increasing.

It is expected that the water demand of nonfood grain crops will further accelerate with changing consumption patterns (Amarasinghe et al 2007a; 2007b). This, along with the increasing water demand of domestic and industrial sectors will have significant implications for increasing food grain productivity and the food security of India. For instance, given the current level of food consumption and the expected population of around 1.6 billion, India is projected to have a food grain demand of about 400 mt—about twice the present food production—by 2050. Unless an increase in water productivity is realized, meeting this food demand would entail the provision of irrigation to an additional 60 mha more than the current irrigated area. The expanded level of irrigation required to meet the food security targets is clearly impractical to achieve through the usual approach of supply augmentation because of the double whammy effects coming from the binding limits for adding new supplies and the increasing inter-sectoral competition over existing supply itself.

A much more potent argument against the additional allocation for irrigation however, comes from the serious magnitude of water use inefficiency found within the irrigation sector itself. It is a well known fact that the average water use efficiency is rather low in irrigation, ranging from 40 % in the canal regions to about 60 % in the groundwater regions (see Amarasinghe et al. 2007). Such a magnitude of water use inefficiency does suggest the existence of a hidden irrigation potential and such a potential can be realized with improved efficiency in water application, as achieved through the use of demand management options. Simplified estimates, made a few years ago, suggest that it is possible to effect a 10 to 20 % improvement in water use efficiency, on an average, over a 5-year period and such improvement would release an additional 10-20 mha of irrigation potential within the existing level of water use (Saleth 1996). This is very close to what is achieved in an entire 5-year plan period

through new supplies obtained with spending so much time and investment. If this time and investment spent on the supply-side solutions are redirected towards the demand side options, it is equally possible to irrigate more areas with the same or, even, a reduced level of water use. This indeed is the central logic for promoting the adoption of demand management options. What is needed, therefore, is not a fringe investment on demand management but rather a major policy and investment shift from supply augmentation to demand management.

As to the focus and coverage, some of the demand management options are context-specific, whereas others are applicable in a more generic context. For instance, water pricing is a tool that is largely applicable to canal regions, whereas the option involving energy regulations—involving both supply and price manipulations—is largely applicable to groundwater contexts, though they may also be relevant in canal regions to the extent water lifting is involved there. This is also true in the case of the options involving both the water markets and water saving technologies, as they occur predominantly in the groundwater regions.² But, the options involving water rights and user organizations are relevant in the context of both canal and groundwater regions. Similarly, some of the options are more direct and immediate in their impacts on water demand, while others have an indirect and gradual effect and, that too, depends on a host of other factors. For instance, water rights and water saving technologies have a more direct effect on water demand, and the options involving user organizations and energy regulations only have an indirect effect.

More importantly, the demand management options also differ considerably in terms of the scope for adoption and implementation, especially from a political economy perspective. Among the options, water rights system is the most difficult one followed by water pricing reforms and energy regulations, but those involving water markets and user organizations are relatively easier to adopt, though their implementation can still remain difficult. Water saving technologies, though politically benign and not controversial, still require favorable cropping systems and effective credit and investment policies. The differences in their application context, political feasibility and the gestation period of impact are very important and should be understood because such factors will determine the relative scale of application and the overall impact of the demand management options.

Demand Management Options in India: An Overview and Synthesis

Before developing the analytical framework that shed light on the strategic and institutional dimensions as well as the dynamics and impact paths of demand management, it is useful to provide an overview and synthesis of the six demand management options (Reddy 2008; Palanisami 2008; Narain 2008; Malik 2008; Narayanamoorthy 2008; V. Reddy 2008). Since these papers provide a comprehensive evaluation of the present status and effectiveness of the individual demand management options in the particular context of irrigation sector, an overview of them can be helpful both to highlight the main issues and challenges, and also to explore the possible avenues for enhancing the individual and joint coverage and demand

² The water saving technologies using micro-irrigation—sprinklers and drip—are rare in canal command areas. However, there are evidences that sprinkler irrigation can be adopted in conjunction with intermediate water storage structures in farms (Amarasinghe et al. 2008). There are also evidences that aerobic rice and system of rice intensification can also be used as demand management strategies for saving water in rice cultivation.

management performance. With this point in mind, let us provide a quick overview and synthesis of the potential, present status, problems and prospects of individual options as presented in each of the option-specific papers.

Water Pricing

Ratna Reddy (2008), in his most comprehensive review of water pricing as a demand management option, concludes that the ability of water pricing to influence water use in India is severely constrained both by the nature and level of water rates as well as by the lack of effective institutional and technical conditions. Although successive Irrigation Commissions have recommended to base water rates on benefits or gross revenues rather than simple provision costs, the prevailing rates in most states are tuned more to cost recovery than to income or benefits. Even this cost focus is also restricted to operation and maintenance (O&M) costs, and in most states the water rates were able to cover no more than 20 % of these costs. Notably, Ratna Reddy (2008) argues that such lower rates are more to do with technical and political factors than with willingness to pay issues, as farmers willing to pay more, especially with an improved supply and service quality, is well documented across the states.

Besides the lower level, the nature and structure of water rates also make them ineffective both in their cost recovery and allocation roles. Since water rates are charged in terms of area, crop and season (or combinations thereof), they fail to create enough incentive for water use efficiency. While water rates in groundwater areas are relatively higher, they also related to average pump costs rather than water productivity or economic value (see R. Reddy 2008—Table 3). Under this condition, it is farfetched to expect the present water pricing policy to play the much needed economic role of water allocation. Based on a careful review of both water pricing literature and actual experience in India and abroad, Ratna Reddy (2008) argues that water pricing policy can be an effective tool to manage demand, if it is designed within a marginal cost principle, volumetric allocation and block or tier structure. Besides the design aspects, he has also elaborated on supportive institutional conditions such as the user organizations, locally managed water rights, water markets and system redesigns to improve conveyance and delivery.

Although Indian experience shows that water pricing is largely ineffective in influencing water use, there are interesting examples, which, in fact, show the importance of the necessary technical and institutional conditions. While water pricing has not been that effective, its effectiveness can be enhanced with the proper level and structuring of water rates. For instance, in Israel, marginal cost pricing followed within either the block rate structure or the tier rate system has been successful in reducing water consumption by 7 %. Similarly, pricing policy, when combined with supply regulations either directly or through water rights, can also be very effective. For instance, the Krishna Delta farmers in Andhra Pradesh received 40 % less than the normal supply during the drought of 2001-2004. Interestingly, they have not only managed well with this lower supply but also reported a 20 % improvement in the yield (Reddy 2008). Although this case shows the efficiency and water saving benefits of an accidental supply reduction during drought, it does demonstrate the potential of direct supply regulations in canal regions. The experience in cases such as Australia and California in USA shows that, the effectiveness of water pricing in demand management can be attributed to the supporting institutions such as volumetric allocation, water rights and water markets.

Water Markets

In his critical review and evaluation, Palanisami (2008) highlights both the opportunities and challenges involved in using prevailing water markets as a demand management option in irrigation. He has compiled extensive empirical evidences on the efficiency and equity roles of water markets both in the groundwater and tank regions. But, at the same time, he also notes the negative social and resource effects due to the monopoly tendencies and groundwater depletion. While there is scope for considerable net positive effects of water markets on water use efficiency, he reckons it to be rather small for two major reasons. First, although water markets are observed widely, the area they cover or influence are small and they occur mostly in groundwater regions mainly on a sporadic basis. The estimated area served or *influenced* by water markets varies widely in a range of 15 to 50 % of the total irrigated area in the country. But, given their seasonal character, transitory nature and concentration in few regions, the actual area affected by water markets is likely to be close to the lower bound of this range. Second, since these markets operate without any volumetric limits or other regulatory framework, there is only very little incentive for increasing water use efficiency or water saving. Although water rates vary across markets, the dominant practice of fixing them based mainly on pumping and other operational costs reduce their role in reflecting the scarcity of water.

Due to the size, coverage and nature of functioning, the ability of water markets to perform their economic and efficiency roles is considerably limited in the Indian context. On the other hand, there are evidences for the increasing depletion and economic loss of production due to groundwater mining. In the case of inter-sectoral water markets around peri-urban areas, where water is moved directly from irrigation to urban water supply, there can be serious livelihood issues when urban migration is low and urban-based livelihoods do not increase concurrently in the long-run. Moreover, as Palanisami (2008) argues, this problem is not due to water markets per se but due to the technical and institutional conditions in which these markets operate. Specifically, he mentions the absence of volume-based water rights, spatial issues limiting competition and regulatory framework, including energy supply and pricing regulations and community involvement in local water withdrawal decisions. One can also add here the distorting role of land tenure that tends to link water control with land ownership, especially when there are no volume-based water rights. Similarly, the absence of well-spacing and depth regulations also leads to the crowding of wells in agriculturally productive regions. The successful cases of water markets in countries such as USA, Australia and Chile are provided to underline the importance of supporting institutions such as volumetric allocation, water rights and water regulations to protect equity and environment.

Water Rights

Against a detailed conceptual and legal analysis of water rights within a new institutional economics framework, Narain (2008) evaluates the potential and prospects for its utility and applicability as an option for managing irrigation demand. For water rights to be effective and enduring as an institutional system for managing water, in general, and irrigation, in particular, he suggests the necessity of converting the abstract notion into an operationally applicable practical tool with a clear delineation and quantification of the volume of water. This is not going to be easy in view of the understandable legal, technical, institutional, and political

challenges. But, at the same time, there are also considerable potentials for creating a volume-based water rights system as there are growing compulsions from the emerging water demand-supply realities and the attended water-based conflicts at various levels. The arguments also make it clear that the costs and difficulties involved in establishing a water rights system can be more than offset by the potential but definite long-term benefits for the society. Considering the existing legal and institutional potentials and the emerging realities on the resource and technology sides, the development of water rights system will not be as difficult or costly as it is made out to be in current public discourse. In fact, water right systems of various forms are already in operation both at the macro and micro levels in India.

Based on the review of the literature, legal and policy documents and field level perspective of water rights, Narain (2008) concludes that while there is a clear need and basis for establishing water rights systems, it will, however, be unrealistic to contemplate a single form of water rights systems applicable to all contexts. Diverse forms of water rights are needed to suit the location and context-specific realities, though there are common principles of equity, legal pluralism and negotiation. Besides the lease-based water rights issued by government in the Gangetic Delta regions and the macro-level rights implicit in sectoral priorities, there are also semi-legal and informal rights linked to land such as the groundwater rights—based on the legal principle of easement, and canal water rights—based on the location-related principle of fixed-tenure (Saleth 2007). But, the most important ones, which are socially recognized, locally managed, and operating on a larger scale, especially in the north-western and eastern states are the water rights based on time (as in *Warabandi* system) and on volume (as in *Shejpali* system).³ Narain (2008) provides field evidences for their role in facilitating negotiation, water allocation and use efficiency.

Although the semi-formal and locally-managed water rights systems have an effect on water allocation and use efficiency, their impacts are not that large to perceptibly influence water demand. Obviously, this is mainly due to the absence or ineffectiveness of supportive institutions, particularly the absence of legal and institutional mechanisms for monitoring, sanction and enforcement at the top and technical and organizational arrangements to facilitate a more accurate and responsive water allocations based on time, volume or both. In view of this institutional and technical vacuum, there is neither sufficient incentives for efficient use nor adequate compensation for water saving. Unless this serious gap is addressed quickly, these water rights, though helpful in water allocation, cannot be effective in demand management. For performing this economic role, these local water rights systems should be structures within a ‘public trust framework’, where the user groups, officials, and stakeholder at different levels of the system could work together within a framework of regional, sectoral and tributary and outlet level water quota system (see Saleth 2007). The transaction costs of creating this framework are obviously high because it entails tremendous information, technical and organizational demand as well as an extraordinary level of bureaucratic and political commitment. Yet, the demand management impacts water rights system cannot be ensured without this framework.

³ Notably, both the time and volume-based water rights are linked to farm size, as they are determined in proportion to land owned or operated. But, there are instances such as the *Pani Panchayat* system, where even landless persons also have water share, which they can sell. In this case, the shares are based not on land but on family size (see Saleth 1996).

Energy Regulations

Energy regulations, covering both the price and supply of electricity and diesel for irrigation purposes, are relevant for influencing water use mostly in groundwater regions, though they are also relevant even in canal areas involving lift irrigation. Malik (2008) evaluates the potential ability and actual impact of these regulations on demand management using an extensive but in-depth review of available literature and empirical evidences. The evaluation suggests that the efficacy of energy regulation as a tool for demand management depends on their intrinsic nature and enforcement as well as a number of related farm and region-specific factors such as well ownership and depth, farm size, cropping pattern, groundwater marketing possibilities and the groundwater hydrogeology itself. Energy regulations involving relatively higher and metered or use-based tariff will be more effective in controlling water withdrawals as compared to the ones based on fixed and flat rates. Similarly, regardless of the rates, direct supply regulations involving rationed and fixed hours of supply will be more effective, provided farmers do not have multiple wells, resort to illegal use of power with phase converters, or substitute or complement electric and diesel power. Considering the scope for bypassing supply regulations, monitoring and enforcement mechanisms, particularly with local involvement as well as a coordinated regulation of electric and diesel pricing and supply are critical.

There are limits within which energy pricing can be increased, and such limits are set by the economic theory and political feasibility. While the efficient use of energy and water will require the tariff to reflect the opportunity cost or, at least, the cost of alternative energy sources, political considerations lead to tariffs that not even reflect fully the production costs. Therefore, in order to achieve the financial goals in the energy sector and the efficiency goals both in the energy and water sector, there is an urgent need for a major change in the tariff level and structure, especially in the irrigation sector. Citing other studies (e.g., Saleth 1997; Bhatia 2007), Malik (2008) argues that for energy regulations to be effective in affecting water withdrawals, the tariff level and structure need to reflect the value of marginal productivity of energy, discriminate crops, consumption levels and locations, and be accompanied by supply rationing. But, changes in the power tariff level and structure, though critical, are not sufficient given the critical roles played by institutional and technical conditions involved not only in the transmission and distribution of energy for agricultural uses, but also in determining the access to groundwater itself.

Energy regulations do have the potential to influence water withdrawal and irrigation demand and also to improve the efficiency and financial viability of the energy sector itself. But, these roles cannot be expected to be automatic under the current conditions of tariff level and structure, bureaucratic management and unregulated groundwater access conditions. There is a need for major reforms both in power and water sectors. Malik (2008) outlines some key components of these reforms. First, considering the practical limits to which power rates can be raised and also the difficulties for them to effectively influence water withdrawal directly, it is reasonable to use them mainly to achieve the financial goals. Second, the policy of metered rates varying with consumption and crops has to be combined with supply regulations so as to directly influence water withdrawal. Third, the successful experiences in China and US and also in the piloted experiment in Gujarat suggest that the state electricity boards have to bulk distribute power to local organizations such as panchayats (an elected governance

body at the village level) and rural electricity cooperatives for them to retail power among users and collect charges. Finally, besides these changes related to the power sector, there are also changes needed in the water sector, especially the strict enforcement of spacing and depth regulations as well as the whole host of institutional and technical aspects related to establishment of legally sanctioned but locally enforced and managed volumetric water rights. When these conditions are created, energy regulations can be a powerful tool within an overall strategy of irrigation demand management.

Water Saving Technologies

The water saving technologies cover not only the methods related to water application (drip, sprinkler and micro-irrigation) but also those related to crop choice and farming practices. Unlike other demand management options, this option has a direct and immediate effect on water consumption and irrigation demand. Having reviewed the available evidences on the extent and impact of water saving technologies, Narayanamoorthy (2008) shows that these technologies can raise water use efficiency to the level of 60 % (sprinkler) to 90 % (drip) in irrigation. Besides the obvious savings in water that may depend on the extent the saved water is available for use elsewhere, these irrigation methods also provide additional savings in terms of energy and labor costs. Empirical studies in India establish that these irrigation technologies save 48 to 67 % of water, 44 to 67 % of energy costs, and 29 to 60 % of labor costs. Overall, private benefit-cost ratio, which depends on the value of water productivity and the underlying role of crop prices, is impressive, ranging from 1.41 for coconut to 13.35 in crops such as grapes. In view of these economic and productivity benefits, these technologies remain highly viable in a range of crops from sugarcane, banana and grapes to even field crops such as wheat and bajra (Narayanamoorthy 1997; Kumar et al. 2004). Since these technologies are scale-neutral, they are also beneficial to farmers even with less than one hectare (Narayanamoorthy 2006). Notably, much more than the private benefits are the social benefits in terms of water savings and input use efficiency (see Dhawan 2000).

Unfortunately, despite the enormous scope and the impressive performance in terms of both private and social benefits, the spread of water application technologies is rather slow and their application is largely confined to a few states and crops. For instance, the total area under drip irrigation is not more than 500,000 to 600,000 ha. Over 85 % of this area is also confined to the groundwater dependent hard-rock states, i.e., Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh. Although the technical and economic viability of this irrigation method is established, as many as 80 crops, more than four fifths of the current application is restricted to vegetable and horticultural crops, including mango and citrus. Notably, coconut, banana and grape together account for approximately half the area under drip irrigation. The issue of low level of application and extent of coverage also applies equally to other water saving technologies related to the selection of water conserving crops and farm practices such as crop spacing, use of plastics and deficit irrigation. The common reason for this low level of adoption is the absence of binding incentives, which emerge not just from the expected benefits of adoption but also from the resource-based compulsions reflecting the real scarcity value of water. Under conditions of unregulated water withdrawals, the latter never enters into the irrigation use decision of farmers.

While it is true that the water saving technologies have the most direct and immediate impacts on irrigation demand, the major problem is that these impacts are limited mainly due to the limited extent of their application and the limited environment within which they are operating at present. Narayanamoorthy (2008) elaborates, then, the policy measures needed both to expand their coverage and also to improve the supportive institutional arrangements. One of the main problems with irrigation technologies such as drips and sprinklers relates to the need for high initial investment. Although state subsidy can be helpful, this is not the only factor in view of the role of other factors such as extension and the need for the involvement of the technology firms as well as other actors such as the sugar factories in the targeting and active promotion of adoption. In this respect, beside the subsidy directed to farmers, it is also necessary to extend tax relief or other incentives for the technology firms and sugar factories. Equally, if not more important, however, is the need for other direct and indirect regulation on the water resource side such as water rights and energy regulations that will reflect the scarcity value of water to the farmers. Field studies reveal that the availability of cheap canal water and unregulated groundwater supply do not provide the farmers with the much needed economic compulsion for adopting the drip irrigation technologies. At the same time, adjustments in farm price and input policies are needed to bolster water conserving crops and farming practices.

User and Community Organizations

User organizations as well as community organizations play a major role in water allocation and demand management in the irrigation sector. They cover both the formal ones such as WUAs and *panchayats* as well as the implicit and informal ones such as those in *Shejpali* and *Pani Panchayats* systems, including those promoted by NGOs and other stakeholders in rural areas. Although the general attention is focused mainly on WUAs and canal irrigation contexts, other organizations and their roles in groundwater irrigation and energy distribution are also equally important. However, a careful evaluation of the WUAs, which are created and promoted under various forms of irrigation management transfer programs in the canal regions of many states, can provide an indication of the overall status and ability of user and community organizations in demand management, either directly or indirectly in terms of facilitating other options. Venkata Reddy (2008) has made such an assessment based on a critical review of the available literature and field evidences on the status, problems and prospects of WUAs, particularly in the canal irrigation sector.

As in the case of other options, the two most important factors that will determine the extent of demand management impacts of user organizations are their area coverage and their design and effectiveness. Despite user participation policy being promoted since the command area development programs of the 1960s and the user organizations being currently promoted actively in almost all states in India, the number of formal WUAs created so far and the extent of area under their influence remain extremely low. According to Palanisami and Paramasivam (2007), the total number of formal WUAs in the country is only about 15,000 and the area they cover is not more than about 500,000 ha. Obviously, these figures do not cover the 800 WUAs created in Rajasthan and also many informal and implicit water-related organizations involved in the *Shejpali*, *Pani Panchayats* and *Warabandi* operating in parts of Maharashtra, Orissa, Punjab and Haryana. While *Warabandi* system covers most canal

areas in Punjab and Haryana, there are no clear estimates for the number and area coverage of the other informal systems, especially for Maharashtra. However, according to the estimates for Orissa, there were 13,284 *Pani Panchayats* covering a total area of over 800,000 ha in 2002 (R. Reddy 2008). Even risking a rough estimate, the total areas under the *Shejpali* and *Warabandi* systems cannot be more than 3 to 4 million ha, representing only a fraction of the total canal irrigated area in India.

Much more serious than the low area coverage are the weak design and operational effectiveness of the user organizations. In view of their central institutional role, user and community organizations are where the whole effort to promote demand management strategy is to begin first. Unfortunately, these organizations, especially the WUAs, as they exist today, are designed more to focus on the limited roles of local maintenance, cost recovery and water distribution rather than the broad and long-term roles of being the organizational basis for developing higher levels of economic and institutional functions. As a result, the ability of WUAs to influence real water allocation and demand management is considerably limited. This does not, however, deny their positive roles in cost recovery, system maintenance and service quality in some contexts. In this respect, it is also important to note that the current policy of Maharashtra to introduce bulk water rights at the sectoral and tributary levels and involve local user organizations to retail water is likely to strengthen the kind of institutional role that is needed for demand management.

Similarly, one cannot also deny the effective role of informal organizations, which are well documented by Venkata Reddy (2008), Ratna Reddy (2008) and Narain (2008) in the context of different states. Although their impacts are highly location-specific and also confined only to a few regional pockets, the key for policymakers is to learn the social and resource-related incentives behind these success cases and try to replicate in the case of formal organizations. While having democratic elections and improving farmers' participation are important, much more important and challenging are the policy and institutional aspects of creating effective incentive systems for collective action. In this respect, the creation of volumetric water rights and volume-based water pricing, for instance, can create the necessary incentives for collective action and water use efficiency. This is an interesting case of structural linkages among the demand management options, where the effectiveness of user organizations depends on other institutional options such as water rights and pricing, which, in turn, depends on the effectiveness of the organizational aspects.

Demand Management: Analytics of Institutions and Impacts

The central message of the review of demand management options is rather clear. Although some of the options have immediate effects and some others have the potential to influence water allocation and use, these effects are rather too meager to have an impact of the magnitude that is needed for generating a major change in water savings and allocation. The two central problems limiting the impacts of demand management are their limited geographic coverage and operational effectiveness. Concerted policies are also lacking in really exploiting their demand management roles. All these options are pursued as if they are separate and essentially in an institutional vacuum because the necessary supporting institutions are either missing or dysfunctional in most contexts. To see why the demand management options are effective

and to know how their effectiveness and performance can be improved, we can develop an analytical framework capturing the linkages and dynamics among these options and their underlying institutional structure.

Although the demand management options appear to have important differences in terms of the nature, mechanics and the gestation period of their impacts, there are fundamentally important operational and institutional linkages among them. Operationally, these options are not independent but linked due to their mutual influences on each other. Similarly, there are also intrinsic linkages among the institutions that support each of these options. A clear understanding of these operational and institutional linkages is so vital not only for designing an integrated strategy for demand management but also to determine its effectiveness and impacts on water management and economic goals. For this purpose, we can use Figure 3 depicting the analytics as well as the institutional ecology of demand management options and their joint impact on sectoral and economic goals.

Before proceeding, it is instructive to note few key aspects of Figure 3. First, the institutions and their linkages noted for each of the options are not exhaustive but only illustrative to highlight some of the most important and immediate ones among them. This also applies to the effects or impact pathways identified both in the sectoral and macro- economic contexts. Second, since the institutions and their linkages form together the ‘institutional ecology’ of demand management, Figure 3 does capture the ‘institutional structure’. But, the ‘institutional environment’ of demand management, as defined by the joint role of hydrological, demographic, social, economic and political factors, though not a role of hydrological, demographic, social, economic and political factors, though not explicitly specified, actually operate beneath Figure 3 and, hence, will have major effects on the entire system presented therein. From the perspective of the demand management strategy, the elements defining the institutional environment are the exogenous factors, whereas the elements forming the institutional structure are the endogenous factors.

Despite its limited coverage, Figure 3 is able to place irrigation demand management in the strategic context of water and agricultural institutions as well as in the larger context of water management and economic goals. As can be seen, there are five analytically distinct but operationally linked segments. The first segment shows the sequential linkages among demand management options, where the options that form the necessary conditions for other options and those having the most intense linkages with others are shown. The next segment captures the joint effects of these options on the irrigation sector, where the water savings effected through an improved irrigation efficiency lead to either/both expanded irrigation with existing supply or/and increased water savings. The third segment shows the sectoral and economy-wide effects of the initial effects on the irrigation sector, which are captured through increased water transfers and higher agricultural production and productivity and converted finally into the food, livelihood, water supply and environmental benefits. The remaining two segments relate to the institutional dimension of demand management and cover respectively, the immediate institutional structure and the fundamental institutional environment. Notice that the institutional structure covers not only water-related institutions but also those related to agriculture, market and technology. Although the institutional environment is not specified in Figure 3 to avoid clutter, it plays a critical role in terms of providing the economic, resource-related and political compulsions both for the adoption of the demand management options and for the creation of their supportive institutions.

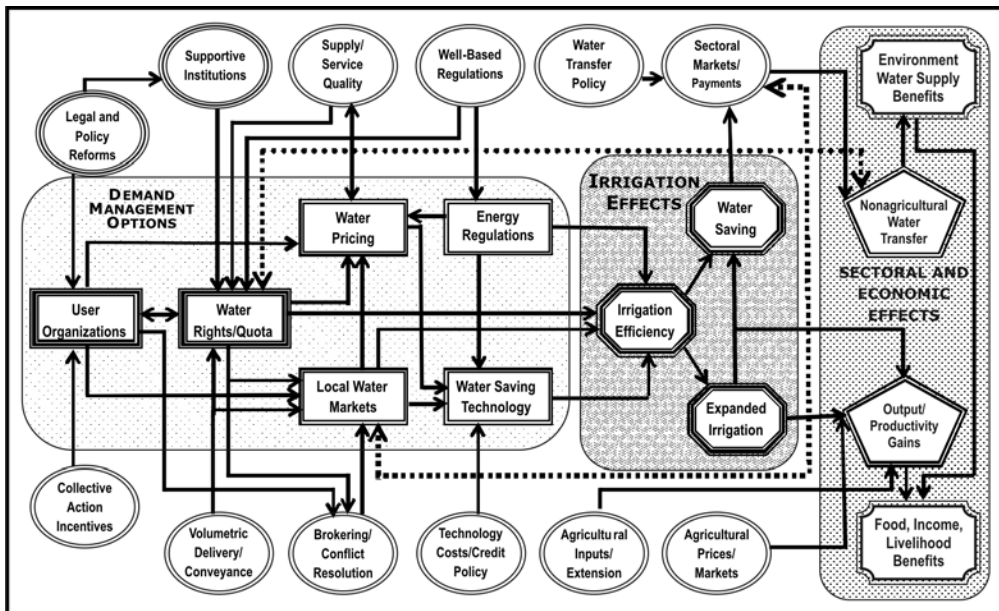
Figure 3. Demand management options: Inter-linkages and institutional environment.

Figure 3 highlights several important points. While all the demand management options are important, the sequential linkages among them suggest that some are obviously more important than others. As noted already, this is either due to their role of being the necessary conditions for others (e.g., user/community organizations) or due to the extent of linkages with others (e.g., water rights/quota system). The options also differ in terms of their nature and magnitude of their impacts on irrigation efficiency and, hence, on water saving and productivity. For instance, the direct effects of user organizations, water pricing and energy regulations will be neither immediate nor substantial partly because of the longer gestation period involved, and partly because its ultimate efficiency effects depend on the effects of related options and the existence and effectiveness of supportive institutions. But, water saving technologies will yield more immediate efficiency benefits, though the extent of such benefits depends on their geographic scale and crop coverage.

Obviously, the options also differ in terms of the institutional, technical and political requirements for their adoption and implementation. For instance, while it is easy to create user organizations, it is more difficult to create the necessary conditions such as the incentives for collective action and the establishment of the volumetric delivery, water quota and loss-free conveyance systems. Thus, the ability of an option to manage depends not just on how efficiently it is designed and implemented but also on how well is it aligned with other options and how effective are the supportive institutional and technical conditions. This fact highlights another strategic feature of the options. Considering the fact that institutions, including water institutions, are defined by the interactive roles of legal, policy and organizational aspects (Bromley 1989; Saleth and Dinar 2004), all options, except water saving technology, are also institutions in themselves. In this sense, the linkages among user organizations, water rights, water markets, water pricing and energy regulations are actually part of the larger institutional setting of demand management. Major institutional issues are involved both in terms of the

functional linkages among the options as well as in terms of the structural linkages within the supportive institutional structure.

It is also clear from Figure 3 that the institutional structure for demand management covers not only the institutions that are directly related to individual options but also those that are related to farm input and extension delivery systems, agricultural markets and price and investment policies. Responsive input and extension systems, favorable market and price conditions and well planned investments in volumetric delivery systems and user organizations are vital for the performance of demand management options. Since these sectoral and macro economic policies affect the returns of farm level water saving initiatives, they determine the level of economic incentives and technical scope for the adoption and extension of demand management options. Just as the demand management options cannot operate effectively in the absence of supportive institutions, so cannot the institutions in the absence of these sectoral and macro policy measures. But, unfortunately, the way the demand management options are operating at present suggests that there is a clear disconnection between these options and their institutional and policy environment. Indeed this is the epicenter of all problems related to the poor performance of demand management options at present in India.

From an impact perspective, it is clear that the overall performance of a demand management strategy depends on the way it is designed and implemented. In this context, the strategy has to exploit well 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 with a volumetric water rights system and are supported by effective user organizations. There are also second round institutions that can emerge through the interface among water rights, water markets and local organizations. They relate not only to the conflict resolution roles of user and community based organizations, but also the water brokering and water delivery-related technical activities of other private agencies that are expected to thrive under mature institutional conditions. Likewise, water pricing policy can be more effective, not only in cost recovery but also in influencing water use, if it is combined with volumetric delivery, use based allocation structures and improved system performance and service quality. Similar results can be expected also with other options, when they are aligned with other options and supported well with relevant institutional and technical conditions.

The ultimate impact of demand management can be measured in terms of the nature and scale of water savings obtained within the irrigation sector. Even when water savings are substantial, the social impact can still be low, unless the saved water is properly reallocated either within agriculture or to other sectors. The economic and welfare impacts of such reallocation can be enhanced with additional but higher level institutional and policy aspects such as sectoral water markets and agricultural input and price policies. Thus, the final impact of demand management options within irrigation depends not only on the scale and gestation period of their sectoral impacts but also on the facilitative roles of macro-level institutional and policy aspects. Besides the issues of scale and gestation period, there is also another major issue related to the inevitability of vast uncertainties both in the full implementation and in the expected benefits of demand management options.

Towards a Demand Management Strategy

The overview of the current status and performance of the demand management options, particularly in the light of the analytics of the institutional ecology and impact of demand

management presented in Figure 3, makes it clear what are the missing elements in the current policy in this respect. To be real, a concerted policy for demand management in irrigation is conspicuous for its absence both at the national and state levels. Instead, what is being witnessed is a casual and *ad hoc* constellation of several uncoordinated efforts in promoting the demand management options. In most cases, these options are pursued lesser for their demand management objectives than their other goals such as cost recovery and management decentralization. Even here, the policy focus is confined to only few options such as pricing, user organizations, energy regulations and, to a limited extent, water saving technologies. Although several policy documents and legal provisions clearly imply water rights system, there are no explicit government policies either as to its formal existence or its implementation, except for the recognition of the need for volumetric allocation and consumption based water pricing. This is also true for water markets, though their existence and operation across the country is well documented. Considering the critical importance of water rights and water markets for their direct effects on demand management and their indirect effects in strengthening other demand management options, it is important that they are formally recognized and treated as the central components of a demand management strategy.

As we contrast the present status of demand management policy and the ideal demand management approach evident in Figure 3, we can identify several key points useful for the design and implementation of a well coordinated and more effective and demand management strategy. The functions linkages and the institutional character of the demand management options clearly underline the need for the strategy to treat these options as an interrelated configuration functioning within an institutional environment, characterized by the overall legal, policy and organizational factors. Since the changing economic, technological and resource conditions will tend to alter the political and institutional prospects for demand management, it is important to align the policy for it to benefit from the potential synergies from institutional environment as well. Given such an overall character and thrust of the strategy, the next step is to create technical conditions and strengthen the institutions—both formal and informal ones. The technical conditions include, for instance, the modernization of water delivery system, introduction of volumetric allocation and installation of water and energy meters. Similarly, the institutional conditions will include, among others, the public trust framework for the joint management of users, officials, state, and communities, the creation of a separate but an embedded structure of sectoral, regional, and user level water rights within the overall supply limits at the respective levels, conflict resolution mechanisms and incentives for collective action.

The institutional and policy requirements for demand management identified above are varied and wide ranging. Considering their extent and coverage, what is needed is nothing short of some fundamental changes in the existing institutional arrangements built around the supply-oriented paradigm of water governance. This fact clearly underlines the logical link between the implementation of the demand management strategy and the necessity of broad water sector reforms. Indeed, demand management forms the spearhead around which water sector reforms are to be planned and implemented. While the strategic and institutional logic of designing demand managed strategy in itself as part of a larger program of water sector reforms is clear, its implementation is certainly not easy and quick. But, neither the stupendous nature of the task nor the heavy economic and political costs involved in transacting such a change in the current context can be a source for alarm or complacency.

There are well-tested reform design and implementation principles that can assist policymakers in overcoming the technical, financial and political economy constraints and,

thereby, effectively negotiating the demand management strategy and the institutional reforms. The reform design and implementation principles are simple yet powerful when used carefully within a well-planned program and time frame. These principles relate to the prioritization, sequencing and packaging of institutional and technical components based on impact, costs and feasibility considerations. Besides these design-related principles, there are also principles related to implementation, which cover strategic aspects such as timing, coverage and scale. As can be seen, these principles essentially try to exploit the basic features of institutions such as path dependency, functional linkages and institutional ecology, in addition to the inherent synergies and feedbacks that institutions receive from the larger physical, socioeconomic and political environment. The theoretical rationale and the institutional basis for these principles are explained by Saleth and Dinar (2004 and 2005), and how they have been applied in the practical context of reforms in selected countries and regions are discussed by Saleth and Dinar (2006). Here, we can discuss briefly how these design and implementation principles can be used for the planning and implementation of the demand management strategy and its underlying institutional reforms with minimum transaction costs and maximum effectiveness.

As can be seen in Figure 3, there are sequential linkages among the demand management options as well as among the institutions. For instance, we have seen user organizations remain the basis for the operation of water rights, water markets and water pricing (and also for energy regulations). Similarly, water rights are critical for the effective functioning of water markets and could also provide the incentives for the application of water saving technologies and improve the effectiveness of even energy regulations. Clearly, since the user organizations are the foundation for the emergence and operation of other institutions and do not involve much political opposition, they should receive top priority from the long-term perspective. But, in the short-term, the promotion of water saving technologies with the immediate and direct impact should receive priority. Since the establishment of a water rights system involves major legal, technical and political challenges, the focus here should be in creating some of the basic conditions for its emergence, such as the modernization of the water delivery systems and introduction of a volumetric allocation. Along with their roles in facilitating the eventual introduction of water rights system, these conditions will also have direct roles in improving the effectiveness of water pricing. Besides these ways of sequencing and prioritizing demand management options and their institutional components, there are also instances for packaging programs such as the system modernization to be combined with management transfer and improved supply reliability and service quality to be accompanied by higher water rates.

Since the design principles involving sequencing, prioritizing and packaging work on the sequential linkages and path dependent nature of institutions, they help to reduce the transaction costs of creating each of the subsequent institutions. Also, in view of the institutional ecology principle, when a critical set of institutions are put in place, other institutions or new roles for existing institutions can develop on their own. For instance, when volumetric allocation is introduced, it would be possible to negotiate limits for water withdrawals, which can eventually lead to the emergence of water quota systems. Similarly, when water rights are in place, real water markets centered on established water entitlements can emerge. With these emergent institutions, the roles of user organizations will also expand considerably to include new functions such as monitoring and enforcement, forum for negotiation and conflict resolution and brokering and facilitation of water markets. More importantly, all these institutional changes will tend to expand the application of demand management options and reinforce their effectiveness and impacts on water allocation and use. The main point to note

here is the importance of identifying the key institutional and technical elements that will form the core components of reforms. This can be done with an understanding of the technical needs, operational linkages, financial costs and feasibility criteria, using a framework similar to the one in Figure 3.

While the design principles do affect implementation, the principles related to the timing, coverage and scale have a more strategic role. This is because they work on the synergies and feedbacks emerging from a larger environment within which the institutional structure is operating. These synergies and feedbacks can relate both to exogenous factors such as macro- economic crisis, energy shortage, droughts and floods, political change and the influence of external funding agencies as well as to endogenous factors such as water scarcity, status of water finance and the physical conditions of water infrastructure. Appropriately seizing these opportunities with proper timing is critical for the success and effectiveness of reform programs. Beside the anticipation and choice of the right time, the issue of time is also significant for another important but least appreciated reason. This relates to the selection of a suitable time frame for the execution of the demand management strategy and its institutional program. Since institutional change is only incremental and slow, a longer time frame involving, say, a 10-year period is to be considered. But, within this frame, time dated reform initiatives with clear prioritization and financial allocations can be planned for sequential implementation. The issue of scale and coverage is mainly determined by financial and technical considerations. Although there are economies of scale in undertaking demand management reforms, this policy cannot be ideal in all contexts. Ideally, it would be useful to prioritize regions and areas where different demand management options and initiatives can be introduced. For instance, while water pricing policy and energy regulations can cover a larger area, it is useful to target scarcity areas so that these options can have a significant impact.

Concluding Remarks

The urgent need and compelling rationale for demand management in the irrigation sector can hardly be overstated, especially given the binding limits for supply expansion and the persisting levels of water use inefficiency. But, unfortunately, the present status and performance of individual demand management options leave much to be desired. While there are cases of limited success in efficiency improvements, especially in the case of demand management options such as user organizations, water saving technologies and water markets, they are too few to have the magnitude of efficiency and water saving benefits that are needed at present. The overview of the performance of demand management options clearly shows how their extent and effectiveness are constrained by several institutional, technical and financial factors. But, a much more serious issue is the absence of a clearly articulated policy for water demand management both at the national and state levels, even though demand management has been very much in policy discourse for a long period. Even though there are policies for promoting user organizations, water saving technologies, water pricing or energy regulations, they are implemented mostly in an ad hoc or partial manner.

The formulation of a demand management policy cannot be considered as a ceremonial need because it is the policy statement that provides the basis for the much needed financial and political commitments for implementing demand management programs. Such a policy can also represent a formal shift from the outdated supply-oriented paradigm that has governed water development, allocation, use and management so far. Since an effective demand management

strategy can both expand irrigation and also release water for other productive uses even at the current level of water use, it is logical to divert, at least part of the investments that are currently going into new supply development. Although some of the demand management initiatives have a long gestation period, this may not be as high as that which is associated with new water development projects, especially considering the delay caused by environmental problems and inter-state water conflicts. Besides the direct returns from demand management investments, there are also long-term effects since demand management options and their institutions can enhance the efficiency and sustainability benefits not only in the irrigation sector but also in the water economy as a whole.

An analytical framework similar to the one presented in Figure 3 can help to understand the analytics and dynamics of impacts of a demand management strategy. As we have shown, this framework provides considerable insights on the operational linkages among the options and functional linkages in the underlying institutions. A demand management strategy delineated in the lights of these linkages, formulated within a more realistic time frame and implemented with the design and implementation principles can be more practical and effective in achieving the efficiency and water saving goals within the irrigation sector. Broadly, this strategy involves a sequencing, prioritization and packaging of demand management tools and also their institutions. Similarly, the principles involving the issues of timing, scale and coverage can also be used for planning the implementation of the demand management strategy. While implementing the strategy, areas and regions can also be prioritized in terms of their relative feasibility and also the available financial resources for investment on demand management. The central idea is to achieve immediate efficiency benefits as much as possible while gradually paving the way for institutional and technical foundation for similar benefits in the long term. The approach of gradual, sequential and consistent implementation of demand management strategy within a well-planned time frame is likely to neutralize possible resistance, minimize transaction costs and maximize long-term impacts.

While India has to go a long way in formulating and implementing a demand management strategy as discussed here, one cannot be that pessimistic given the recent trends of institutional changes observed in India (see Saleth 2004). Although the observed changes are slow, partial and inadequate, their direction and thrust are on the desired lines. Several states have raised the water rates and there has also been a gradual and steady improvement in cost recovery. The issues of volumetric allocation and water entitlements have also been receiving increasing public and policy attention in recent years. In Maharashtra, the policy of volumetric allocation on a bulk basis has been introduced. Many policies that were once considered as anathema, such as water markets, privatization and de-bureaucratization are already a reality in India's water sector. There are also constant pressures from factors both endogenous and exogenous to the water sector (e.g., the physical limits for supply augmentation, food security compulsions, water supply challenges and energy issues) for further changes in water policies and institutions. Since the path dependency properties of institutions will ensure that it is costlier to return than to status quo than to continue to proceed with the reform path, the institutional environment is going to favor the formulation and implementation of the demand management strategy sooner than later. Obviously, there is a clear policy demand for more research-based studies for exploring still further the design and implementation properties of irrigation demand management strategy.

References

- Amarasinghe, U.A.; Shah, T.; Singh, O.P. 2007a. *Changing consumption patterns: Implications on food and water demand in India*. Research Report 119. Colombo, Sri Lanka: International Water Management Institute (IWMI).
- Amarasinghe, U.A.; Shah, T.; Turrall, H.; Anand, B.K. 2007b. *India's water future to 2025-2050: Business-as-usual scenario and deviations*. Research Report 123. Colombo, Sri Lanka: International Water Management Institute.
- Bhatia, R. 2007. Water and Energy Interactions in India. In *Handbook of Water Resources in India*, eds. John Briscoe and R.P.S. Malik. New Delhi, India: The World Bank and Oxford University Press.
- Bromley, D.W. 1989. *Economic Interests and Institutions: The Conceptual Foundations of Public Policy*, New York: Basil Blackwell.
- Dhawan, B.D. 2000. *Drip Irrigation in India*. New Delhi, India: Commonwealth Publishers.
- Dinar, A.; Saleth, R.M. 2005. Issues in Water Pricing Reforms: From Getting Correct Prices to Setting Appropriate Institutions. In *International Yearbook of Environmental and Resource Economics*, eds. Tom Tietenberg and Henk Folmer. New Horizons in Environmental Economics Series, Volume IX. Cheltenham, U.K. Edward Elgar Publishing Pvt. Ltd.
- Government of India (GOI). 2007. *Agricultural Statistics at a Glance 2007*, Directorate of Economic and Statistics, Ministry of Agriculture, New Delhi.
- Kumar, D.M.; Singh, K.; Singh, O. P.; Shiyani, R.L. 2004. *A study of water- saving and energy-saving micro irrigation technologies in Gujarat*. Research Report 2. Anand, India: India Natural Resource Economics and Management Foundation.
- Malik, R.P.S. 2008. "Energy Regulations as a Demand Management Option: Potentials, Problems, and Prospects." Colombo, Sri Lanka: International Water Management Institute (*computer script*).
- Ministry of Water Resources. 2000. *Annual Report-1999-2000*, Government of India, New Delhi, India.
- Narain, V. 2008. "Water Rights System as a Demand Management Option: Potentials, Problems, and Prospects." Colombo, Sri Lanka: International Water Management Institute (*computer script*).
- Narayanamoorthy, A. 1997. Economic viability of Drip Irrigation: An Empirical Analysis from Maharashtra. *Indian Journal of Agricultural Economics* 52 (4): 728-739.
- Narayanamoorthy, A. 2006. Economics of Drip Irrigation in Sugar Cane Cultivation: An Empirical Analysis. In *Managing Water Resources: Policies, Institutions, and Technologies*, eds. V. Ratna Reddy and S. Mahendra Dev. New Delhi, India: Oxford University Press.
- Narayanamoorthy, N. 2008. "Water Saving Technologies as a Demand Management Option: Potentials, Problems, and Prospects." Colombo, Sri Lanka: International Water Management Institute (*computer script*).
- Palanisami, K.; Paramasivam, P. 2000. "Participatory Irrigation Management (PIM): Lessons from Water Users Associations for Tamil Nadu," Centre for Agriculture and Rural Development Studies. Coimbatore, India: Tamil Nadu Agricultural University.
- Palanisami, K.; Paramasivam, P. 2007. "Irrigation Sector in India: Trends, Issues, and Prospects," Coimbatore, India: Tamil Nadu Agricultural University (*computer script*). p. 32.
- Planning Commission. 2001a. *Approach Paper to the Tenth Five Year plan (2002-2007)*, Government of India, Planning Commission, New Delhi.

- Planning Commission. 2001b. *Ninth Five-Year Plan: Irrigation, Command Area and Flood Control*, Government of India, Planning Commission, New Delhi, (available at: <http://www.planningcommission.nic.in>).
- Palanisami, K. 2008. "Water Markets as a Demand Management Option: Potentials, Problems, and Prospects." Colombo, Sri Lanka: International Water Management Institute (*computer script*).
- Palanisami, K.; Paramasivam, P. 2007. "Irrigation Sector in India: Trends, Issues, and Prospects," Coimbatore, India: Tamil Nadu Agricultural University, (*computer script*). p. 32.
- Reddy, M. V. 2008. "User Organizations as a Demand Management Option: Potentials, Problems, and Prospects." Colombo, Sri Lanka: International Water Management Institute (*computer script*).
- Reddy, V. R., 2008, "Water Pricing as a Demand Management Option: Potentials, Problems, and Prospects." Colombo, Sri Lanka: International Water Management Institute (*computer script*).
- Saleth, R. M. 1996. *Water Institutions in India: Economics, Law, and Policy*. New Delhi, India: Commonwealth Publishers.
- Saleth, R.M.. 1997. Power Tariff Policy for Groundwater Regulation: Efficiency, Equity and Sustainability. *Artha Vijnana* 39 (3): 312-322.
- Saleth, R. M. 2004. *Strategic analysis of water institutions: Application of a new research paradigm*. Research Report 79. Colombo, Sri Lanka: International Water Management Institute.
- Saleth, R.M. 2007. Water Rights and Entitlements in India. In *Handbook of Water Resources in India*, eds. John Briscoe and R.P.S. Malik. New Delhi, India: The World Bank and Oxford University Press.
- Saleth, R.M.; Dinar, A. 2004. *The Institutional Economics of Water: A Cross Country Analysis of Institutions and Performance*. Cheltenham, U.K: Edward, Elgar.
- Saleth, R. M.; Dinar, A. 2005. Water Institutional Reforms: Theory and Practice. *Water Policy* 7 (1): 1-19.
- Saleth, R. M.; Dinar, A. 2006. Water Institutional Reforms in Developing Countries: Insights, Evidences, and Case Studies. In *Economic Development and Environmental Sustainability: New Policy Options*, eds. Ramon Lopez and Michael Toman. New York, USA: Oxford University Press.