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Promoting irrigation demand management in India: options, linkages and strategy

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Abstract

Against the backdrop of a discussion on the rationale, logic and scope of irrigation demand management in India, this paper provides a brief overview of the status, effectiveness and technical and institutional requirements of six demand management options, that is, water pricing, water markets, water rights, energy regulations, water saving technologies and user organizations. The paper then develops a framework that captures the analytics of irrigation demand management in terms of both the impact pathways of and the operational linkages between the options and their underlying institutions. Using this framework, the paper also outlines a strategy for irrigation demand management that can exploit the inherent synergies between the options and align them well with the underlying institutional structure and its environment. After discussing how such a strategy can be effectively promoted within the institutional and political constraints facing countries such as India, the paper concludes with the policy implications of irrigation demand management.

Keywords: Demand management; Energy regulations; India; Institutions; Irrigation; Markets; Pricing; Technologies; User organizations; Water rights

1. Introduction

The symptoms of an increasing 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 permanent feature of the water sector in India. Water demand is growing fast owing to a rapid population growth and economic activity, but water supply is not growing at the same rate because of the serious financial and physical limits of supply augmentation. Although the currently developed water resources (i.e. 644 billion cubic meters (bcm)), constitute only 57% of the ultimate utilizable potential (1,122 bcm), it is difficult to add supply beyond this level owing to growing environmental concerns and inter-state water conflicts.

From official data, the total demand is projected to go from 694–710 bcm by 2010 to 973–1,180 bcm by 2050 (Ministry of Water Resources, 2000). Recent research studies predict that if this trend continues, nine

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basins which have four-fifths of the total water use in India will face physical water scarcity by 2050 (see Amarasinghe *et al.*, 2007a). For a heavily populated, monsoon-dependent and rural-based country such as India, water scarcity of this magnitude will have devastating food, income and livelihood consequences.

Considering the water demand and supply prospects for India, the usual supply-side solutions cannot be an exclusive basis for managing water crisis. A durable strategy calls for a large scale promotion of different demand management options, particularly in the irrigation sector that accounts for four-fifths of water withdrawals but shows just 40% use efficiency (Amarasinghe *et al.*, 2007b). These options include six of the most important water allocation and management tools like water pricing, water markets, water rights systems, energy tariff and supply regulations, water saving technologies and user and community-based organizations. Based on a review of some recent literature on the subject, this paper reviews the present status, effectiveness and supportive requirements of these demand management options in the particular context of the irrigation sector in India. Using an analytical framework that captures the operational linkages inherent both among the options and their underlying institutions, this paper also outlines a strategy for irrigation demand management and discusses how this strategy can be promoted within the technical, financial, institutional and political constraints facing countries like India.

2. Objectives and scope

The overall aim of this paper is to discuss the options, issues and strategy for promoting irrigation demand management in India. Its specific objectives are to: (i) set the basic rationale, logic and scope for demand management; (ii) provide a short overview of the status and effectiveness of and the technical and institutional requirements for different demand management options; (iii) indicate the key differences and common features emerging from the practical experiences of these options; (iv) present an analytical framework that can capture both the impact pathways of and the operational linkages among the options and their underlying institutions; (v) outline a generic strategy for irrigation demand management that can exploit better the inherent synergies among the options and align them well with the underlying institutional structure and its environment; (vi) discuss how such a strategy can be effectively promoted within the technical, financial, institutional and political economy constraints faced by countries like India and (vii) conclude with practical insights and policy implications.

Although there are a variety of demand management options with regard to the scope and focus, here we consider only six options. As noted already, the review of the status, effectiveness and requirements of these demand management options is also confined specifically to the irrigation sector. However, the general implications, especially those related to their operational linkages and institutional dimensions, can also be relevant in the non-irrigation context. Similarly, although the paper deals with the irrigation demand management options in the particular context of India, most of the discussions, especially the analytical and policy aspects of irrigation demand management strategy, are also relevant for other similarly placed developing countries. The paper is structured, more or less, in line with the listed set of objectives.

3. Demand management options: logic and focus

Although the adoption of demand management options is rather limited and slow in India, an increasing reliance on these options in future is inevitable, especially in the irrigation sector and in basins where physical water scarcity is already evident. This is not withstanding the practical difficulties and political resistance associated with the large scale adoption of demand management options in irrigation sector. These difficulties obviously relate to the enormity of the public and private commitments and investments needed to underpin demand management policy together with the necessary technical and institutional conditions.

Political resistance comes from the generally held perception that demand management policy is going to reallocate water physically on a large scale at the cost of irrigated agriculture. In reality, however, demand management aims mainly to set the basic conditions for a long-term improvement in the productivity and efficiency of irrigated agriculture. Water reallocation occurs not through a simple physical diversion within a "command-and-control" framework but through an overall improvement in the use efficiency and productivity of water within a voluntary and compensation-based framework.

The changing physical and economic realities of the water sector provide a strong rationale for water promoting irrigation demand management. For instance, the total water withdrawal for all uses at the national level in 2000 is estimated to be 680 bcm. As can be seen in Table 1, even at this level of water withdrawals, many important basins are already facing physical water scarcity (i.e. water withdrawal exceeding 60% of the potentially utilizable resource). But, if the "business-as-usual" path of water management and water use continues, water demand is expected to increase by 22% by 2025 and 32% by 2050 (Amarasinghe *et al.*, 2007b).

With such demand growth, more and more basins are likely to face physical scarcity. Since this physical scarcity is likely to raise the financial and environmental costs of new projects, even some of the technically feasible supply augmentation options are going to be economically costly and politically difficult. Many basins in India are expected to be in this predicament of physical, economic and financial scarcity by 2050, if not before[1]. As these basins account for three-fifths of the country and also cover agriculturally the most important basins, including the Indus, Ganges, Cauvery and Krishna basins, the physical and economic water scarcity in these basins will have serious food, income and livelihood as well as political ramifications.

As can be seen in Table 1, the irrigation sector accounts for 89% of the total water withdrawals at the national level with a similar dominance also being evident in most of the basins in the country. But, the actual consumptive use—the portion that is actually used for the net evapotranspiration of crops—is only 41% at the national level and varies from 12 to 59% across the basins, depending obviously on crop and land use patterns as well as on project and farm level irrigation efficiency. The difference between this consumptive use and the total water withdrawal provides the physical basis for efficiency gains and water savings through the implementation of demand management options. Note that this is "real" water savings capable of releasing a substantial amount of water elsewhere in other sectors or in other regions[2].

[1] Financial scarcity refers to the condition where water resources, even when they are available for development on technical and economic grounds, cannot be developed owing to the enormity of investment needs and the inability of the state to mobilize investment of that magnitude.

[2] By separating water use efficiency at the field level from that at the basin level, a distinction is made between "real" and "paper" water saving. The former releases water for uses outside the basin whereas the latter does not lead to any water release because the saved water from filed use efficiency is either lost to the system owing to evaporation and drainage or reused within the basin. Since water saving is reckoned here in terms of net evapotranspiration and calculated at the macro level, it relates actually to the "real" and not the "paper" water savings.

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

River basins	Water withdrawal			NET[‡] as % of irrigation withdrawal (%)	Gross irrigated area		
	Total bcm[*]	As % of potentially utilizable resources[†] (%)	Share of Irrigation (%)		Total (Mha)	Ground water share (%)	Groundwater abstraction ratio[§] (%)
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[‖]	29	112	88	59	3.2	89	132
WRF2[‖]	14	26	52	34	0.9	40	22
EFR1[‖]	20	63	92	35	1.9	26	17
EFR2[‖]	33	95	86	37	2.2	54	46
All basins	684	61	89	41	75.9	61	48

[*] Total includes withdrawals for irrigation, domestic and industrial sectors.
[†] Figures more than 100% also include recycling.
[‡] NET is the net evapo-transpiration of all irrigated crops.
[§] Relates total groundwater withdrawals to the total groundwater recharge and return flows.
[‖] WFR1 = west flowing rivers of Kutch, Saurashtra and Luni; WFR2 = west flowing rivers from Tapi to Kanayakumari; EFR1 = east flowing rivers between Mahanadi and Pennar; and EFR2 = east flowing rivers between Pennar and Kanyakumari.
Source: Amarasinghe *et al.* (2007b).

Admittedly, it will not be possible to realize the entire potential for water savings owing to various physical, technical, economic and institutional reasons, but it is certainly possible gradually to achieve, say, a 20–40% of this potential with proper targeting of basins and regions for concerted demand management policies and investment.

In view of the possibility of having a greater technical control over 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, this too, mainly through policy and institutional changes. In contrast, efficiency improvements in canal regions mostly require investments and technologies in a massive redesign of water conveyance and delivery systems, although policy and institutional changes are also essential to enhance and sustain the efficiency gains. As a result, efficiency gains are relatively more immediate in groundwater areas and would also involve a relatively lesser public investments in physical structures. This fact, taken with the dominant (i.e. 60%) share of groundwater in total irrigation, makes it

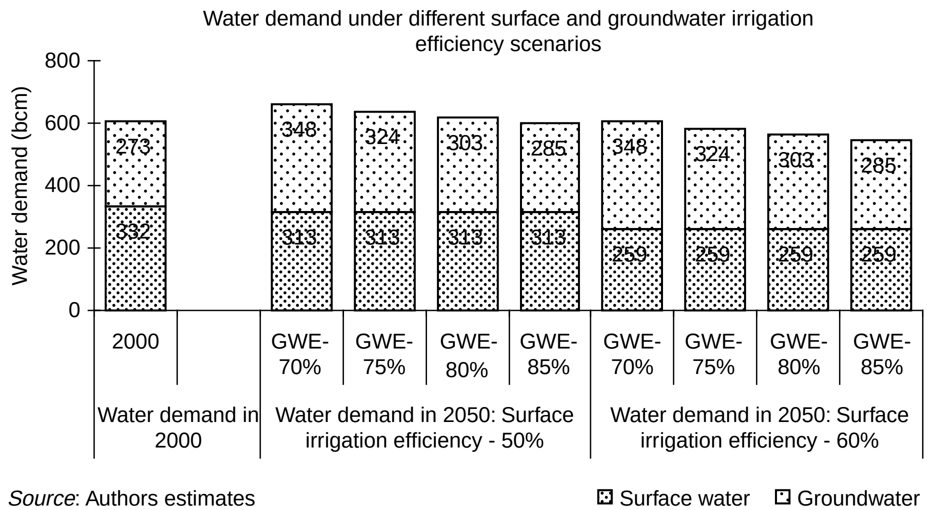

Fig. 1. Irrigation efficiency and water demand scenarios. *Source:* Amarasinghe *et al.* (2007a).

possible to realize the overall irrigation efficiency targets with greater attention to groundwater areas, particularly those with severe depletion problems.

Improvements in irrigation efficiency, apart from their immediate impact on farm productivity, will also have direct effects on irrigation water demand. As shown in Figure 1, if the irrigation efficiency in the canal regions is raised from its current level of 40–50% and the irrigation efficiency in groundwater areas is raised from its present level of 60–80%, the future irrigation demand, even with a larger irrigated area, will not exceed its present level. But, if the canal irrigation efficiency is raised by an additional 10%, that is to 60%, the total irrigation demand will decline to the tune of 43 bcm. In addition, if groundwater irrigation efficiency is also raised concurrently by an additional 5%, that is to 85%, then, the total irrigation demand will decline by as much as 63 bcm (Amarasinghe *et al.*, 2007b). Notably, this reduced irrigation demand, which represents the total water savings from improved irrigation efficiency, is close to the total non-irrigation demand of 79 bcm in 2000. 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 with the implementation of demand management strategies involving the judicial application of options such as water pricing, water markets, water rights, energy regulations, water saving technologies and user organizations.

Besides the macro logic based on the supply–demand gap, there is also a food and efficiency-based rationale for promoting irrigation demand management in India. For instance, given its current level of food consumption and projected population of around 1.6 billion, India is expected to have a food demand of about 400 million tones (Mt)—about twice the present food production—by 2050 (Amarasinghe *et al.*, 2007a, b). Unless an increase in water productivity is not realized, meeting this food demand would require the extension of irrigation to an additional area of 60 million hectares (Mha). Such an expanded irrigation is not easy to achieve entirely through the usual supply-side approaches such as supply augmentation and system improvement because of the obvious limits to adding new supplies and the increasing claims of non-irrigation needs. A still stronger argument for demand management comes from the pervasiveness of water use inefficiency found in the irrigation sector itself, which actually represents the "hidden water potential" to be realized. Simple estimates suggest that if it is possible to raise water use efficiency by 10 to 20% over a five-year period, the irrigation sector can release up to 10 to 20 Mha of additional irrigation (Saleth, 1996). That is, demand management is also a supply augmentation option.

Some of the demand management options are context-specific for focus and coverage whereas others are applicable in a more generic context. For instance, water pricing is applicable essentially in canal regions. Similarly, the option of energy regulations is confined mainly to groundwater contexts, although they may also be relevant in canal regions involving water lifting. This is also true in the case of the options involving both the water markets and water saving technologies, as they occur predominantly in groundwater regions[3]. 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 impact on water demand whereas others have only indirect and gradual effects[4].

Notably, the six options also differ considerably in terms of the practical and political economy conditions for their adoption and implementation. On this count, water rights are the most difficult, followed by water pricing and energy regulations. But, the options involving water markets and user organizations are relatively easier to adopt, although they do face implementation and regulation challenges. Water saving technologies, though politically benign and non-controversial, require however, favorable agronomic conditions and credit policies. The adoption context, investment need, impact gestation and political feasibility are key factors that determine the relative scale of adoption and impact of different demand management options.

4. Demand management options in India: an overview and synthesis

Before dealing with the analytics of impact pathways and institutional underpinning of demand management options, it is instructive to provide a brief overview of each of them, particularly to highlight their status, ability and scope in the Indian context[5]. This option-specific overview is also helpful in understanding the issues and challenges that are to be overcome for enhancing the individual and joint coverage and effectiveness of different demand management options.

4.1. Water pricing

The ability of water pricing to influence water use is severely limited both by the nature and level of water rates and by the lack of supportive institutional and technical conditions (e.g. volumetric delivery, water rights and enforcement systems). Current water rates are tuned more to cost recovery than to

[3] Water saving technologies using micro-irrigation such as sprinklers and drips are rare in canal and other surface water-based areas. However, there is evidence that sprinkler irrigation can be adopted in conjunction with intermediate water storage structures in farms. But, water saving technologies involving crop choice and farm practices (e.g. tillage and land leveling practices and intensive cultivation methods) are applicable both in canal and groundwater regions.

[4] For instance, water rights and water saving technologies have a more direct effect on water demand, the options involving user organizations and energy regulations have only an indirect effect.

[5] This overview draws from detailed option-specific status papers (see Malik, 2009; Narayanamoorthy, 2009; Narain, 2009; Palanisami, 2009; Reddy, 2009a, b) commissioned by IWMI under Phase III of its Strategic Analyses of India's River Linking Project. For the full version of these papers and their synthesis, see Saleth (2009).

influence water use. Even this cost focus is also restricted to operation and maintenance costs and, in most states, the water rates were able to cover no more than 20% of these costs. These lower rates are more to do with political factors than with willingness issues, as farmers' are willing to pay more, especially with an improved supply and service quality. Apart from the lower level, the nature of water rates also makes them ineffective both in cost recovery and water allocation. Since water rates are charged in terms of area, crop and season, they fail to create enough incentive for water use efficiency. While water rates in groundwater areas are relatively higher, they are also related more to average pump costs than to water productivity. Under these conditions, it is far fetched to expect the present water pricing policy to play the economic role of water allocation.

Although Indian experience shows that water pricing is largely ineffective in influencing irrigation water use, there are interesting examples, which show the importance of the necessary technical and institutional conditions. For instance, in Israel, marginal cost pricing followed either within the block or tier rate system has been successful in reducing water consumption by 7%. In the case of the Krishna Delta, Andhra Pradesh, India, farmers received 40% less than the normal supply during the drought of 2001–04. Interestingly, not only did they manage well with this lower supply but also realized a 20% improvement in yield (see Reddy, 2009b). This case does demonstrate the potential benefits of supply regulations in canal regions. In the cases of Australia and California, the effectiveness of water pricing in managing demand can be attributed largely to the supporting institutions such as volumetric allocation, water rights and water markets.

4.2. Water markets

There is an extensive empirical literature on the nature, operation and impact of informal and localized water markets operating in many groundwater and tank areas in India. Based on a review of the evidence, Palanisami (2009) concludes that water markets contribute significantly to use efficiency and equity, but they also have notable negative effects owing to monopoly tendencies and aquifer depletion. From an overall perspective, although they have net positive effects, the size of these effects is rather small. There are two major reasons. First, while water markets occur widely, the area they cover or influence is small. The estimated area served or influenced by water markets varies widely from 15 to 50% of the national irrigated area. But, given their seasonal and transitory nature and concentration in a few regions, the actual area affected by water markets is likely to be close to the lower figure. Second, as these markets operate without any volumetric limits or other regulatory framework, there is only a very little incentive for use efficiency or water saving. Although water rates vary across markets, the usual practice of fixing them based mainly on pumping costs reduces their effectiveness in reflecting the actual scarcity value of water.

As a demand management option, water markets operating at present can be considered to have only a marginal role. Owing to their size and dispersed nature, as well as the institutional and technical conditions in which they operate, the efficiency gains and water savings-induced by water markets cannot be expected to make much of a dent in groundwater demand. But, as Palanisami (2009) has argued, water markets can potentially alter water demand when they operate within a volumetric water rights and regulatory framework, including well-spacing and depth regulations, energy pricing and supply regulations and community involvement in water withdrawal decisions. In fact, the success cases of water markets in countries such as USA, Australia and Chile clearly underline the importance of supporting institutions and a regulatory framework. While the institutional context is critical for determining the demand management performance of water markets, their contribution can be enhanced even by promoting other demand management options such as the energy price and supply manipulations and crop and water technologies. This shows how the linkages between demand management options can improve mutual performance.

4.3. Water rights

For water rights to be effective and enduring as an institutional system for managing water in general and irrigation in particular, the first step is to convert the abstract legal notion into an operationally applicable volumetric framework (Narain, 2009). Since effectively enforced water rights provide a physical limit to individual water use, they generate powerful economic incentives for water use efficiency. Although water rights are an effective option for demand management, establishing them is not that easy for a diverse country like India. But, India does have a vast institutional potential for creating water rights systems both by building on existing systems and by creating new ones in select areas. Various forms of rudimentary water rights systems that can be developed with relatively lower inputs of time and investment are already in operation in different parts of the country (see Saleth, 2007; Narain, 2009). The important ones are the *Shejpali* (water roster), *Pani Panchayats* (water councils) and *Warabandi* (time and turn-based water allocation) systems[6].

Although the semi-formal and locally managed water rights systems have an effect on water allocation and use efficiency, their impact is not large enough to influence water demand perceptibly. 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 national and regional level, and technical and organizational arrangements to facilitate a more accurate and responsive water allocations based on time, volume, or both at the field level. Owing to this institutional and technical vacuum, there is neither sufficient incentive for efficient use nor adequate compensation for water saving. Unless this serious gap is addressed quickly, these water rights, although helpful in water allocation, cannot be effective in demand management. To perform this economic role, these local water rights systems should be structured within a "public trust framework", where the user groups, officials and stakeholder at different levels work together within the framework of a regional, sectoral and tributary and outlet level water quota system (see Saleth, 2007). While the transaction costs of creating this framework are obviously high, the demand management impact of water rights cannot be ensured without this framework.

4.4. Energy regulations

Energy regulations, covering both the price and supply of energy sources used for irrigation purposes, can significantly influence water withdrawal and use, especially in groundwater regions. Evaluating energy regulations as a demand management option, Malik (2009) concludes that much depends on their

[6] Water rights are based on time under *Warabandi*, on flow-based volume under *Shejpali* and irrigation needs under *Pani Panchayats*. 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, in the *Pani Panchayat* system, the rights are based on water shares, which are defined by family size not by land. Notably, in the *Pani Panchayat* system, even the landless have water shares, which they can sell implicitly through sharecropping arrangements (see Saleth, 2007).

intrinsic nature and enforcement as well as a number of farm and region-specific factors such as farm size, well depth, crop pattern, water selling and the groundwater hydro-geology itself. Energy regulations with a relatively higher and metered tariff can be more effective compared to ones involving only fixed and flat rates. Similarly, direct supply regulations involving fixed supply hours will have more impact than the rates regardless of their levels and structure[7]. While an efficient use of energy and water requires the tariff to reflect the opportunity cost or, at least, the cost of alternative energy sources, political considerations lead to tariffs that do not even reflect fully the production costs (Saleth, 1997). For tariff levels to reflect the economic value of energy and water, they have necessarily to vary by crops, consumption levels, locations and even the time of use (Bhatia, 2007; Malik, 2009).

The potential for energy regulations to influence irrigation demand cannot be automatic under the current conditions of tariff level and structure, bureaucratic management and unregulated groundwater access conditions. Malik (2009) has outlined some guidelines to ensure the demand management roles of energy regulations both in the water and energy sectors. First, given the practical limits to which power rates can be raised and also the difficulties for them directly to influence water withdrawals, they are useful mainly for achieving energy cost recovery. Second, the policy of metered rates varying with crops and consumption also has to be combined with supply rationing so as to influence water withdrawal directly. Third, successful experience in China, the USA and also in the Gujarat state in India suggests that the state electricity boards only have to distribute power in bulk to local organizations (e.g. *panchayats* (village councils) and electricity cooperatives), which, in turn, will retail power and collect charges. Finally, changes are also needed in water regulations, especially those relating to spacing and depth regulations and the establishment of locally managed and formally recognized volumetric water rights. This is an instance of how energy and water regulations can mutually improve their impact. When these changes occur, energy regulations can be much more powerful both as a cost recovery and as a demand management mechanism.

4.5. Water saving technologies

The water saving technologies cover not only those involved in irrigation application (drip, sprinkler and micro irrigation) but also those related to farm practices such as water saving crops, crop spacing, use of plastics and deficit irrigation. Unlike the other options, this option has both a direct and an immediate effect on water consumption in irrigation. Water saving technologies can raise irrigation water use efficiency to 60 (sprinkler) to 90 (drip)%. They not only save water by 48–67% but also 44–67% of energy costs and 29–60% of labor costs (Narayanamoorthy, 2009)[8]. Sprinkler and drip systems are scale neutral (Narayanamoorthy, 2006) and economically viable for as many as 80 crops (Narayanamoorthy, 1997; Kumar *et al.*, 2004). Despite this, the total area under these technologies in India is not more than 5–6 lakh hectares (ha) and over 85% of this area is confined only to four states, that is, Maharashtra, Karnataka, Tamil Nadu and Andhra Pradesh (Narayanamoorthy, 2009). The low area coverage is also a problem for water saving farm practices.

[7] This is so provided farmers do not have multiple wells, resort to the illegal use of power, or substitute or complement electric and diesel energy sources.

[8] Their private benefit–cost ratio, which depends on productivity and crop prices, is also impressive, ranging from 1.41 for coconut to 13.35 for grapes (Narayanamoorthy, 2009). Notably, their social benefits in terms of water and energy conservation are also significant (Dhawan, 2000).

Given their direct and immediate impact on irrigation demand, water saving technologies, especially those based on sprinkler and trip systems, are indeed very effective as a demand management option. But, the main problem is that their demand impact is confined only to the limited area where they are adopted. As a result, the resultant water savings are too small and too thinly spread to have a major impact on local or regional water demand. Obviously, the major step for enhancing the demand management impact of irrigation technologies is to expand their area coverage through suitable policies and institutional changes. For instance, a targeted policy of subsidy, particularly in areas facing groundwater depletion, can provide the financial incentives for adopting the irrigation technologies. Similar incentives are also needed both for their developers and dealers as well as for their potential promoters with leverage such as sugar factories. However, the effectiveness of both the subsidy policy as well as the demand management impact of the technologies can be ensured only when they are accompanied by direct and indirect regulations on water withdrawals such as volumetric water rights and energy regulations that will help to reflect the real scarcity value of water to the farmers.

4.6. User and community organizations

User and community organizations not only cover the formal water use associations (WUAs) but also those underlying the informal and semi-formal water allocation systems such as the *Shejpali*, *Pani Panchayats* and *Warabandi*[9]. As a demand management option, these organizations can contribute to water savings both indirectly by promoting farm level water use efficiency and directly by controlling outlet and system level conveyance losses. Their actual contribution, however, depends on their area coverage and operational effectiveness. Despite being promoted ever since the 1960s, there are only about 15,000 registered WUAs in India covering an area of just about 0.6 Mha (Palanisami & Paramasivam, 2000). These figures do not, however, cover the area under the informal and semi-formal systems[10]. But, as a rough estimate, their area coverage can be placed at around 4 Mha. Adding these figures and allowing a margin of error, the combined area coverage of various forms of user organizations can be estimated to be about 6 Mha, forming just a fraction of the canal irrigated areas in India.

The formal WUAs, as they exist today, are tuned more to perform the limited roles of system maintenance and cost recovery than to play their larger economic and institutional functions (Reddy, 2009a)[11]. Since their design features are weak, they are unable either to promote demand management on their own or to play an ideal role as an organizational framework promoting other demand management options. This also applies to the organizations under *Warabandi*, despite their turn and time-based system of water distribution. In contrast, informal organizations, especially under *Shejpali* and *Pani Panchayats* are relatively more effective thanks to their rudimentary system of volume-based

[9] While the former two systems are observed in the states of Maharashtra and parts of Orissa, the latter is operating mainly in the states of Punjab, Haryan and parts of Uttar Pradesh.

[10] While *Warabandi* covers most of the canal areas in the northwester parts of India, there are no clear national level estimates for the number and area coverage of the other informal systems. However, there are estimates for the state of Orissa, where there were 13,284 *Pani Panchayats* covering an area of 8 lakh ha in 2002 (Reddy, 2009b).

[11] In this respect, it is important to note that the current policy of Maharashtra to introduce bulk water rights at the distribution levels and involve WUAs in retail water is likely to strengthen the kind of institutional role that is needed for irrigation demand management.

and individual-specific water rights (Reddy, 2009a, b; Narain, 2009). Despite their problems with low area coverage and localized impact, these informal organizations do demonstrate the central role of volumetric and user-specific water rights in strengthening the demand management role of user organizations. In fact, there is a two-way linkage between water rights and user organizations because an efficient water rights system is also predicated on the existence of an effective user organization serving the necessary organizational and enforcement rules. This is another interesting case of structural and operational linkages between the demand management options.

5. Analytics of demand management: institutions and impacts

The review of demand management options, though brief, does suggest a few key points with important analytical and policy implications. While these options have considerable demand management potential, their actual effects on water saving and use efficiency are too meager and also very thinly spread to have any major impact on local and regional irrigation demand. The two main problems limiting their impact are their limited area coverage and operational effectiveness, both of which are due to the lack of concerted policies and supporting institutions. Despite the differences in terms of the nature, mechanics and gestation period of their impact, the options have fundamental operational and institutional linkages between them. Operationally, they are not independent but linked to each other owing to their mutual influence. There are also intrinsic linkages between the institutions which support each of these options. An understanding of these linkages is vital for designing an integrated strategy for demand management that can strategically exploit these linkages so as to enhance the individual and collective performance of the options. To see this more formally, we can use Figure 2 which depicts 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 a few key aspects of Figure 2. First, the institutions and their linkages noted for each of the options are not exhaustive but only illustrative mainly to highlight only some of the most important linkages among the options. This is also true for the impact pathways identified both in the sectoral and macro economic contexts. Second, since the institutions and their linkages taken together form the institutional ecology of demand management, Figure 2 does capture the "institutional structure". But, the "institutional environment" of demand management, as defined by the interactive roles of hydrological, demographic, social, economic and political factors, although not explicitly specified, actually operate beneath the entire system presented in Figure 2. 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 2 is able to place irrigation demand management both in the strategic context of water and agricultural institutions as well as in the larger context of sectoral and economic goals. As can be seen, there are five analytically distinct but operationally linked segments. The first segment shows the sequential linkages between 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 induced through an improved irrigation efficiency lead to either/both an expanded irrigation with existing supply or/and an increased water savings. The third segment shows the

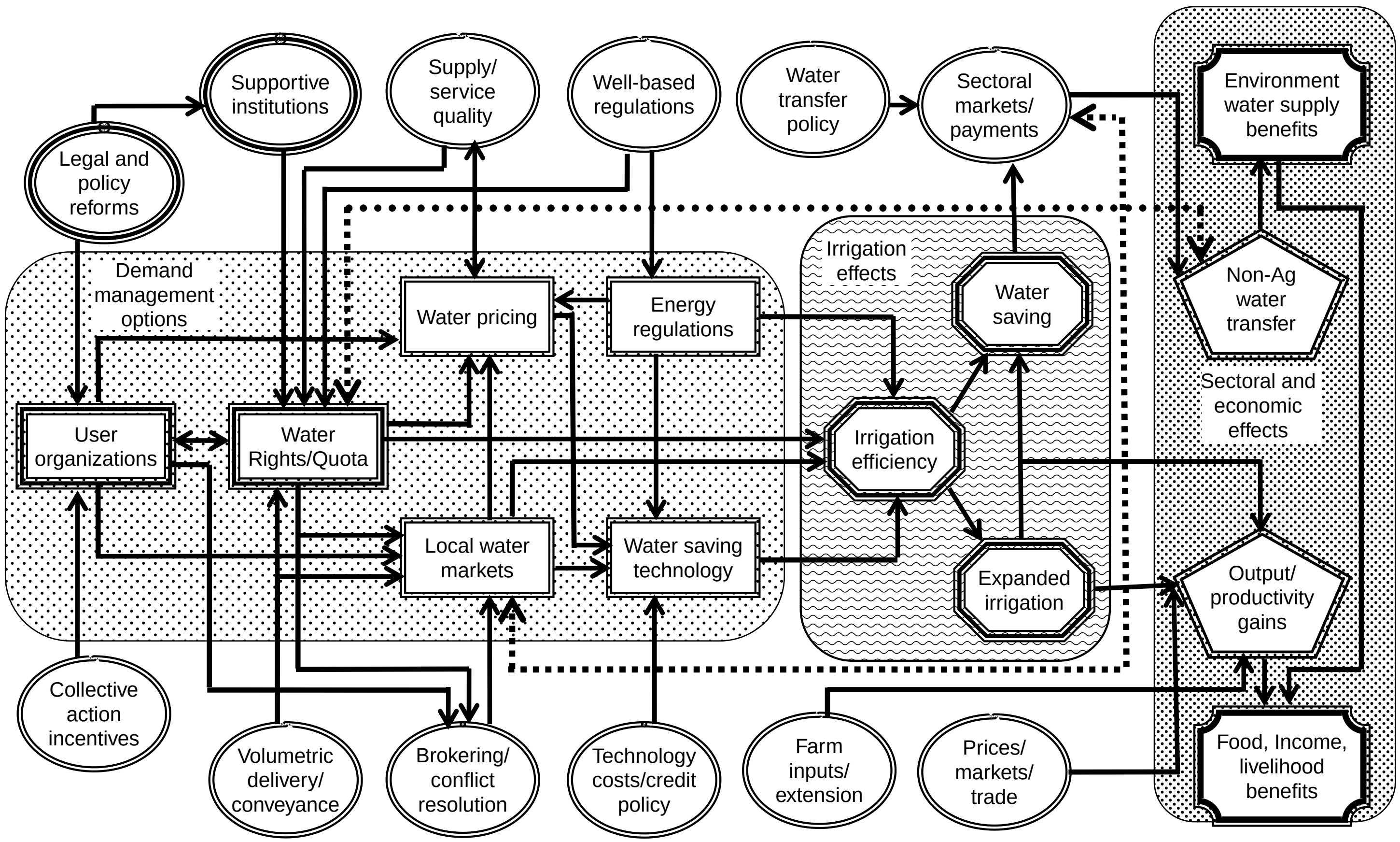

Fig. 2. Analytics of irrigation demand management: impact pathways and institutional structure.

sectoral and economy-wide consequences of the initial effects on the irrigation sector, which are captured in terms of increased water transfers and higher agricultural output and productivity and converted in terms of 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[12].

Figure 2 highlights several important points. While all demand management options are important, the sequential linkages between them suggest that some are obviously more important than others. This is either due to their role as 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 the nature and magnitude of their impact 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 effect depends on the effects of related options and the existence and effectiveness of supportive institutions. But, water saving technologies will yield more direct and immediate efficiency benefits, although 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 influence irrigation demand depends not just on how efficiently it is designed and implemented but also on how well its alignment is with other options and how effective are the supportive institutional and technical conditions[13].

Considering the fact that institutions, including water institutions, are defined by the interactive roles of legal, policy and organizational aspects (Bromley, 1989; Saleth & Dinar, 2004), all options, except water saving technology, can also be viewed as institutions in themselves. In this sense, the linkages between user organizations, water rights, water markets, water pricing and energy regulations are actually part of the larger institutional setting of demand management. There are also institutional underpinnings both in the functional linkages among the options and in the structural linkages within the supportive institutional structure. The institutional structure for demand management covers not only the institutions that are directly related to individual options but also those related to farm input and extension systems, agricultural markets, agricultural pricing and trade policies and investment policies[14]. In this context, responsive farm input and extension systems, favorable market and prices conditions and well planned investments in volumetric delivery systems, system improvement and user

[12] Note 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 explicitly specified in Figure 2 to avoid clutter, it is critical for providing the economic, resource-related and political compulsions both for the adoption of demand management options and for the creation of their supportive institutions.

[13] Thus, the ability of an option to influence irrigation demand depends not just on how efficiently it is designed and implemented but also on how well it is aligned with other options and how effective are the supportive institutional and technical conditions. This fact highlights another strategic nature of the linkages between the options.

[14] It is important to note that current pricing, procurement and trade policies favouring crops such as rice and sugarcane lead to considerable distortions in cropping patterns and hence, agricultural water demand. Obviously, a basic change in these policies as well as a redesign in water infrastructure to demand-based water release in canal areas are necessary to underpin an effective water demand management strategy.

organizations are vital for the performance of demand management options. 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 demand management options.

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 that will exploit well the functional and structural linkages between the options and also benefit from the synergies of sectoral and macro economic policies. For instance, the efficiency and equity benefits of water markets can be increased many fold when such markets operate within a volumetric water rights system and are also well supported by user-based management and enforcement mechanisms[15]. 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. Similar results can also be expected with other options, when they are aligned with their counterparts and supportive conditions. The ultimate impact of demand management can be measured in terms of the size of water savings in the irrigation sector as well as the social benefits from the reallocation of these savings either within agriculture or to other sectors.

6. Towards a demand management strategy

In reality, a concerted policy for irrigation demand management is conspicuous for its absence at the national and state levels in India. Instead, what India has is a casual and *ad hoc* constellation of several uncoordinated efforts. Notably, these efforts are confined only to options such as pricing, user organizations, energy regulations and water saving technologies. Even here, the focus is more on other goals such as cost recovery, energy saving and user participation than on demand management *per se*. Although several policy documents and legal provisions clearly imply the need for water rights, there are no explicit government policies for their formal creation. This is also true for water markets, although their existence and operation across the country is well documented. Considering the critical importance of water rights and water markets in terms of 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 postulated in Figure 2, we can identify several key points that are useful for the design and implementation of a well coordinated and more effective demand management strategy. The functional 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 structure characterized by 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 so that it can benefit from the potential synergies

[15] New institutions and expanded roles for existing institutions can also emerge in the interface of water rights, water markets and local organizations. They relate not only to the conflict resolution roles of user and community organizations but also to the water brokering and water delivery-related technical activities that are expected to thrive under mature institutional conditions.

of the institutional environment as well. Given the overall character and thrust of the strategy, the next step is to create the technical conditions and strengthen the institutions—both formal and informal ones—necessary for supporting the demand management options[16].

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 for crafting the demand managed strategy as part of a larger program of water sectors 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 current context can be a source for alarm or complacency.

There are well tested reform design and implementation principles that can assist policy makers in overcoming the technical, financial and political economy constraints and, thereby, effectively negotiate the demand management strategy and the institutional reforms[17]. These reform design and implementation principles are simple yet powerful when used carefully within a well planned reform 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 covers such 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 as well as the inherent synergies and feedback that institutions receive from the larger physical, socio-economic and political environment. We can indicate here how these design and implementation principles can be used to plan and implement the demand management strategy and its underlying institutional reforms with minimum transaction costs and maximum effectiveness.

As shown in Figure 2, there are sequential linkages both between the demand management options and between the institutions. For instance, 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 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 in the long term. But, in the short term, the promotion of water saving technologies with immediate and direct

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[16] The technical conditions include, for instance, the modernization of water delivery systems, introduction of volumetric allocation and installation of water and energy meters. Similarly, the institutional conditions will include, among others, the development of a public trust framework for the joint role of users, officials, state and communities, the creation of a separate but embedded structure of sectoral, regional and user level water rights within the overall supply limits, and the establishment of negotiation and conflict resolution mechanisms at different levels, see Saleth (2007).

[17] The theoretical rationale and the institutional basis for these principles are explained by Saleth & Dinar (2004, 2005) and how they have been applied in the practical context of reforms in selected countries and regions is discussed by Saleth & Dinar (2006).

impact should receive priority. Since the establishment of a water rights system involves major legal, technical and political challenges, the focus here should be mainly on the creation of the basic conditions for its emergence, such as the modernization of the water delivery systems and introduction of 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. Apart from these ways of sequencing and prioritizing demand management options and their institutional components, there are also instances of packaging programs such as combining system modernization and improved supply reliability with management transfer and accompanying service quality with higher water rates.

Since design principles involving sequencing, prioritizing and packaging work on sequential linkages and the 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 operating within 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 impact on water allocation and use[18].

While design principles do affect implementation, the principles relating to the timing, coverage and scale have a more strategic role. This is because they work on the synergy and feedback emerging from the larger environment within which the institutional structure is operating. This synergy and feedback can relate both to endogenous factors such as water scarcity, status of water finance and health of water infrastructure as well as to exogenous factors such as macro economic crisis, energy shortage, droughts and floods, political change and the influence of external funding agencies. Seizing the reform opportunities provided by them 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 less 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 should 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. While the there are economies of scale in undertaking larger reforms, it is ideal to prioritize regions (e.g. those with excessive groundwater depletion, institutional potential and agronomic and technical conditions) where different demand management options can be introduced.

[18] The main point to note here is the importance of identifying the key institutional and technical elements that will form the core components of the 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 2.

7. Concluding remarks

The urgent need and compelling rationale for irrigation demand management in India and similarly placed other countries can hardly be overstated. Unfortunately, the present status and performance of individual demand management options leave much room for improvement. Certainly, there are cases of the limited success of efficiency improvements in the case of options such as user organizations, water saving technologies and water markets. But, they are too few to have the magnitude of efficiency and water saving benefits that are needed at present. The reasons for such a poor performance of demand management options go far beyond the institutional, technical and financial constraints. Although water demand management is very much in the policy discourse for a long period in India, a clearly articulated demand management strategy is conspicuous by it absence both at the national and state levels. This is notwithstanding the existence of a set of separate and *ad hoc* policies used to promote user organizations, water saving technologies, water pricing and energy regulations with partial and scattered implementation.

What is needed is not the formulation of a just demand management policy as a ceremonial statement but as a formal statement with a strong political and financial commitment to move beyond the simple supply-oriented paradigm that governs water development, allocation, use and management at present. 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 demand management initiatives have a long gestation period, this may not be as high as that associated with most of the 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.

Although the hypothesis underlying Figure 2 is not tested, an analytical framework similar to the one in Figure 2 can help in developing and implementing an integrated strategy for water demand management. Such a strategy can exploit well both the operational linkages between the options and the functional linkages between the underlying institutions. A demand management strategy delineated in the light of these linkages and implemented in the context of design and implementation principles can be more practical and effective in achieving efficiency and water saving goals within the irrigation sector. Broadly, this strategy involves a sequencing, prioritization and packaging of different demand management options and of their underlying institutions. Similarly, the principles that involve the issues of timing, scale and coverage can also be used to plan the implementation of the demand management strategy. The central focus is to achieve as many as possible immediate efficiency benefits even while gradually creating the institutional and technical foundation for demand management in the long run. From a political economy perspective, this approach is also likely to neutralize possible political resistance, minimize institutional transaction costs and maximize long term social benefits.

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References

Amarasinghe, U. A., Shah, T., Turral, H. & Anand, B. K. (2007a). *India's Water Future to 2025–2050: Business-as-usual Scenario and Deviations*. Research Report No. 123, International Water Management Institute, Colombo, Sri Lanka.

Amarasinghe, U. A., Shah, T. & Singh, O. P. (2007b). *Changing Consumption Patterns: Implications on Food and Water Demand in India*. Research Report No. 119, International Water Management Institute, Colombo, Sri Lanka.

Bhatia, R. (2007). Water and energy interactions in India. In *Handbook of Water Resources in India*. Briscoe, J. & Malik, R. P. S. (eds). The World Bank and Oxford University Press, New Delhi.

Bromley, D. W. (1989). *Economic Interests and Institutions: The Conceptual Foundations of Public Policy*. Basil Blackwell, New York.

Dhawan, B. D. (2000). *Drip Irrigation in India*. Commonwealth Publishers, New Delhi.

Kumar, D. M., Singh, K., Prakash Singh, O. & Shiyani, R. L. (2004). *A Study of Water- Saving and Energy-Saving Micro Irrigation Technologies in Gujarat*. Research Report 2, India Natural Resource Economics and Management Foundation, Anand, India.

Malik, R. P. S. (2009). *Energy Regulations as a Demand Management Option: Potentials, Problems and Prospects*. International Water Management Institute, Colombo, Sri Lanka (Computer Script).

Ministry of Water Resources (2000). *Annual Report 1999–2000*. Government of India, New Delhi.

Narain, V. (2009). Water rights system as a demand management option: potentials, problems and prospects. In *Promoting Irrigation Demand Management in India: Potentials, Problems and Prospects*. Saleth, R. M. (ed.). International Water Management Institute, Colombo, Sri Lanka, pp. 127–146.

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*. Ratna Reddy, V. & Mahendra Dev, S. (eds). Oxford University Press, New Delhi.

Narayanamoorthy, N. (2009). Water saving technologies as a demand management option: potentials, problems and prospects. In *Promoting Irrigation Demand Management in India: Potentials, Problems and Prospects*. Saleth, R. M. (ed.). International Water Management Institute, Colombo, Sri Lanka, pp. 93–126.

Palanisami, K. (2009). Water markets as a demand management option: potentials, problems and prospects. In *Promoting Irrigation Demand Management in India: Potentials, Problems and Prospects*. Saleth, R. M. (ed.). International Water Management Institute, Colombo, Sri Lanka, pp. 47–70.

Palanisami, K. & Paramasivam, P. (2000). *Participatory Irrigation Management (PIM): Lessons from Water Users Associations for Tamil Nadu*. Centre for Agriculture and Rural Development Studies, Tamil Nadu Agricultural University, Coimbatore.

Reddy, M. V. (2009). User organizations as a demand management option: potentials, problems and prospects. In *Promoting Irrigation Demand Management in India: Potentials, Problems and Prospects*. Saleth, R. M. (ed.). International Water Management Institute, Colombo, Sri Lanka, pp. 147–169.

Reddy, V. R. (2009). Water pricing as a demand management option: potentials, problems and prospects. In *Promoting Irrigation Demand Management in India: Potentials, Problems and Prospects*. Saleth, R. M. (ed.). International Water Management Institute, Colombo, Sri Lanka, pp. 25–46.

Saleth, R. M. (1996). *Water Institutions in India: Economics, Law and Policy*. Commonwealth Publishers, New Delhi.

Saleth, R. M. (1997). Power tariff policy for groundwater regulation: efficiency, equity and sustainability. *Artha Vijnana*, *39*(3), 312–322.

Saleth, R. M. (2007). Water rights and entitlements in India. In *Handbook of Water Resources in India*. Briscoe, J. & Malik, R. P. S. (eds). The World Bank and Oxford University Press, New Delhi.

Saleth, R. M. (ed.) (2009). *Promoting Irrigation Demand Management in India: Potentials, Problems and Prospects*. International Water Management Institute, Colombo, Sri Lanka.

Saleth, R. M. & Dinar, A. (2004). *The Institutional Economics of Water: A Cross Country Analysis of Institutions and Performance*. Edward, Elgar, Cheltenham, UK.

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*. Lopez, R. & Toman, M. (eds). Oxford University Press, New York.

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