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Vishal Narain
Annasamy Narayanamoorthy *Editors*

Indian Water Policy at the Crossroads: Resources, Technology and Reforms

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Chapter 1
Introduction: Towards a Discursive Analysis of Indian Water Policy

Vishal Narain

Abstract This chapter presents an overview of the chief contributions of the chapters presented in this book. Over the years, Indian water policy has evolved to take cognisance of new and emerging pressures on water resources. Both local and global actors have had a role to play in this. International discourses of integrated water resource management, gender, neo-liberalism and decentralization have had a bearing on how water resource policies have been framed and water issues problematized. While emerging research has been able to throw some light on the nature of policy processes, the paper makes a more deliberate case for a discursive analysis of public policy to pave the way to understanding the nature and direction of water reforms in the country.

Keywords Public policy • Governance • Reforms • Narratives • Discourses

This book is a collection of chapters that examine critical issues and debates surrounding the governance and management of water resources in India. Recent decades have seen several paradigmatic shifts in the management and governance of water resources in the country. Focus has shifted from predominantly technical and hydrological issues to emphasise the social, economic and managerial. New paradigms such as Integrated Water Resource Management have come to influence how water is viewed as a resource with several dimensions, even as concerns are voiced over the relevance of this paradigm and its operationalization in Indian – and South Asian – contexts. Gender mainstreaming has acquired new emphases, though the gap between rhetoric and practice has tended to persist. The debates on issues of water rights, equity and justice have acquired new dimensions; the imperatives to address these issues seem to have become stronger. Increasingly, water scholars

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have sought to explore the relationships between the technological, hydrological and social dimensions of water management.[1]

The genesis of new paradigms influencing water resource policy and governance is a process in which both global and local actors have had a role to play (Narain et al. 2014; Narayanan et al. 2014). Donors and funders have played a critical role in influencing the nature and direction of what are popularly called "water reforms". They have played a key role in propagating new discourses around water resource management. A case in point is the neo-liberal discourse propagated by the World Bank and other international agencies that paved way for a greater role for the free market in the allocation of water resources. The neo-liberal discourse was founded on the narrative of the weak and inefficient state, and the free market was seen as a natural and obvious alternative. While the state was seen as playing a key role in the allocation and management of water resources in the country till the late 1980s, the neo-liberal discourse paved the way for a greater role for the free market in the period after that. Operationally, this created space for new actors in the governance of water resources. This took the form of outright privatization, for instance, and spawned debates regarding its equity and justice dimensions (Urs and Whittel 2009). Autonomous forms of water markets have nevertheless functioned for several decades in the form of water tankers meeting the demand – supply gap for drinking water in cities, as well as groundwater markets meeting the needs of smallholder irrigators. Both these forms of markets have, however, functioned outside any regulatory environment, raising questions about their equity, efficiency and sustainability implications (Shah 1993; Dubaash 2002; Prakash 2005).

Along the continuum of state and market based allocation of water, a distinct space was created for user or community based organizations for water management. This emphasis stemmed from a realization that communities were capable of crafting their own rules for resource appropriation and management (Ostrom 1990, 1992). The positive evidence generated by farmer-managed irrigation systems in India provided the basis for the underlying narratives for policies for decentralization in irrigation management. This narrative was propagated by donors and funders; NGOs played their part in mobilising communities for irrigation management, while lobbying with state governments to put in place appropriate policies (Narain 2003; Shashidharan 2000). Thus, the social engineering paradigm took shape, based on the premise that institutions for collective management of water could be "designed" or "engineered", often along the lines of models or prototypes.[2]

In the late 1990s, this culminated in serious efforts at establishing water users associations in irrigation management. The IndianPIM, Indian Network for Participatory Irrigation Management, gave a call for speedy upscaling and replication of water users associations, as if it were a 'one size fits all' panacea for the ills of the irrigation sector (Narain 2003). However, by the turn of the millennium, the euphoria surrounding water users' associations seemed to have considerably died

[1] As an example, see Roth and Vincent (2013). See also Narain (2003), Prakash (2005), Mehta (2005) and Dubaash (2002).

[2] For a discussion on the importance of models for irrigation management transfer in debates on irrigation reform, see Mollinga (2001). See also Parthasarathy (1998).

down. Several factors were found to limit the effectiveness and success of water users' associations,, including limited attention to the implications of design or the technology of irrigation systems in irrigation management transfer programmes, the perpetuation of unequal power structures in the functioning of water users' associations, poor consideration of the implications of WUA formation for water rights and entitlements, the influence of local politics, and resistance within the bureaucracy to support WUA formation (Narain 2003, 2004, 2008; Mollinga 2001; Jairath 1999; Parthasarathy 1998).

In more recent years, several new subjects have come up surrounding the question of appropriate forms of water governance. These concern the role of regulatory authorities as well as the functioning of public-private partnerships. Public-Private partnerships are seen as a way of augmenting state resources, providing new technology and expertise as well as a way of overcoming the slack and inefficiency of state enterprises. Public-private partnerships provide a legitimate way of involving private enterprise, especially where outright privatization may not be politically expedient. Critics, however, argue that public-private partnerships provide a form of disguised privatization, or 'privatization by the back-door'.

While there have been experiments both with public-private partnerships as well as with privatization, the latter has met with more explicit resistance. This resistance stems from the inability of the market to deliver a good as basic as water to those who are unable to pay for it (Urs and Whittel 2009; Kulkarni 2014). Water problems are rightly clubbed as "wicked problems", denying clear-cut solutions or outcomes (Gyawali 2014; Mosse 2009). This 'wicked nature' stems from the multi-dimensional nature of the resource – from its possessing economic, social, cultural and political values all at the same time.

While there has been a recent nod of approval from the judiciary on the subject of the inter-linking of India's rivers, this proposal presents a very good example of polarised views on what constitutes the "right way" to solve India's water problems. The proposal for inter-linking of rivers has been founded on the narrative that India's water problems are predominantly of a physical nature and that solutions lie in ameliorating the imbalance in the availability of water, transferring water from surplus to deficit basins. Water scholars have nevertheless challenged this narrative, asserting that the scarcity of water is a social construction as much as a physical one (Mehta 2005). In the context of the inter-linking of rivers, little attention has nevertheless been paid to the rights and equity dimensions of the water transfers envisaged; debates on the justice dimensions have stayed confined to issues of relocation and rehabilitation of displaced communities.

While IWRM, or Integrated Water Resource Management, has been the dominant mantra or buzzword in water management in recent decades, there remains a critical issue of deconstructing its components and depoliticising the discourse, while placing it in the Indian context to study its applicability and relevance. On many other subjects, such as water rights reform, the level of discourse has remained somewhat static. While the rationale for a property rights structure has been built on grounds of equity, efficiency and sustainability, questions are still raised on its practicability. New research – including that presented in this book, however, suggests that recent technological interventions may lower the transaction costs of administering a water rights structure, even in Indian conditions where the large number and geographical spread of water users is known to raise the transaction costs of administering such a system (Kumar et al. 2011).

The debate on the efficacy of different approaches to regulate groundwater has continued in the Indian water governance literature. Groundwater irrigation received a big spurt after the green revolution boom of the 1960s. The high-yielding varieties of crops that the green revolution technology demanded required timely application of water. This could not be provided by canal irrigation systems, that operate under state operated irrigation schedules. Besides, canal irrigation systems in India are protective irrigation systems, aiming to supply water thinly over a large number of farmers and a large geographical area (Jurriens et al. 1996). They are designed to meet a fraction of the irrigator's crop water requirements, as against the goal of productive irrigation. This created a stress on groundwater irrigation, that irrigators use for the greater control that it provides on water availability.

However, indiscriminate exploitation of groundwater has created a problem of steadily falling water tables, especially in the context of India's agriculturally important states. This has implications for sustainability of the green revolution itself, but also has wider equity implications, as falling water tables place the resource out of the reach of the smaller and marginal farmers. There has been an on-going debate among scholars of water governance in India on the appropriate ways of arresting the problem of groundwater depletion, and this debate shall likely continue, even as climate change presents additional stresses on the resource.[3] Other important subjects of debate in the realm of Indian water policy over recent years have been the limited effectiveness of policies for combating water pollution, the persistence of a gap between the rhetoric and practice of gender mainstreaming and limited attention to issues of equity and social justice in water planning.

1.1 Changing Paradigms and Debates in Indian Water Policy

This book seeks to present the current debates on these and other subjects shaping the governance of water resources in the country. It takes stock of new policy developments in India's water sector, what the experience with their implementation has been, and where important weaknesses still lie. From this perspective, this books seeks to contribute to the growing body of scholarship around water resources policy in India in particular, and water Resources policy in South Asia, more generally.[4] Authors make an effort to present a road-map for the future, while discussing the potential of alternative approaches to addressing the emerging challenges of India's water sector.

[3] See, for instance, Shah (2013).

[4] As recent contributions to this body of work, see Narain et al. (2014); Prakash et al. (2013); Narayanan et al. (2014). See also Ballabh (2008) and Lahiri-Dutt and Wasson (2008).

1.1.1 The Challenges of Groundwater Management, Water Rights Reform and Other Regulatory Approaches

As noted earlier, groundwater has assumed an increasingly important role in India's irrigation and agricultural development. It provides 50 % of irrigation in India and accounts for about a third of total food crop production in the country (Shah 2009). With growing dependence on the resource, however, groundwater has become at once a critical and threatened resource, with 'competitive deepening' emerging as a major issue in select regions, and climate change acting as a further multiplier (Shah 2009, 2013). There has been a debate spanning over four decades now in the country on appropriate approaches to regulate groundwater extraction. Authors have debated the potency of various measures, ranging from spacing and licensing norms, credit and electricity restrictions to the institution of a property rights structure (Shah 1993; Narain 1998, 2000; Saleth 1996; Kumar et al. 2011). A case has been made for enabling and participatory approaches to address this problem, as against technocratic and engineering-focused control –based approaches (Moench 1994).

Reviewing the current challenges in groundwater management in India and the potential of alternative approaches to tackle them, Nitin Bassi (Chap. 3) advocates the enforcement of private and tradable water rights in groundwater as a means to bring about increase in farm outputs, while reducing aggregate demand for water. This, he suggests needs to be complemented by a pro rata pricing of electricity in the farm sector, and an improvement in the quality and reliability of supplied power.

Maria Saleth (Chap. 9) looks more closely at the subject of a property rights structure for water. While the case for a property rights structure has been made in the Indian water governance and policy debate for several decades, Saleth provides support in favour of the administrative and technical feasibility of instituting such a system, much on lines of the arguments made by Nitin Bassi in this book. He cites evidence in the form of different kinds of water rights systems functioning in the country, while emphasizing the absolute necessity of formalizing such a system in the interest of equity, efficiency and sustainability, especially in a context where expansion of water supply faces major economic, financial and technological constraints. He cites evidence in the form of various systems of water rights functioning under different socio-technical regimes in the country, and suggests that their existence – often for decades and centuries – is evidence that a water rights system is consistent with what may be called an Indian water ethos. It seems then the core issue with regard to the functioning of a water rights system may be understanding the relationship between water rights systems that already exist on the ground and how they may articulate with a new water rights system that may be imposed through conscious policy intervention.

V Ratna Reddy's analysis of the potential of different regulatory instruments and demand management of water (Chap. 10) suggests the limitations of the commonly used instruments like pricing, supply regulation, direct and indirect policy regulation. He argues that these regulations have had a limited impact on account of the complex socioeconomic and resource systems, but also because of a lack of synergy or mutual complementarity among the different policy instruments. He calls for greater synergy in the use of different policy instruments such that they do not work at objectives counter to each other. He further argues that policies for demand management of water have paid little explicit attention to the equity dimensions of water use and access. While community based approaches to regulate the use of groundwater have had some positive effect, they have remained little more than pilots in the absence of policy support or an enabling environment to scale them up.

1.1.2 Gender and Integrated Water Resource Management in India

IWRM (Integrated Water Resource Management) emerged as a new paradigm challenging the technocratic focus of water management over the previous decades. IWRM emphasizes integration across uses, sectors and disciplines while taking cognizance of gender and equity concerns (Mollinga et al. 2006). The major critique around IWRM has been the lack of political edge in the way it has been conceptualised and implemented (Kulkarni 2014). An overemphasis on River Basin organizations and formal organization structures without an understanding of the local institutional context in which the paradigm of IWRM is to be implemented are known to have severely limited the relevance of the paradigm to the South Asian context (Mollinga et al. 2006).

Tushaar Shah and Barbara van Koppen, critically analysing the relevance of the paradigm to Indian contexts (Chap. 2), note that IWRM, in its present form, presents itself as a package of interventions of a ''one size fits all' nature around demand side management; the 'copybook' nature of IWRM reforms has been shaped by the global water discourse driven by international organizations. In developing countries in which these reforms have been experimented with, there was little effort to tailor the reform packages to local contexts. Hence, these reforms failed to address the pressing water management challenges that these countries were confronted with. The IWRM package, further, offers no guidance on what to do with the plethora of water institutions in the country. These reforms, they further note, also do not respond to the priorities of the poor in developing countries.

The current paradigm of IWRM, advocating direct demand management, is therefore at odds with the informal nature of water economies characterizing India and other countries at early stages of their development paths. The transformation of an informal water economy into a formal one, further, takes place through a long process of economic growth. Urbanization and occupational diversification are key processes characterising this transition. However, Shah and van Koppen suggest that the IWRM package may still be relevant to formal and urban sectors of India's water economy.

Gender mainstreaming has been an important component of the global discourse on IWRM. Gender, referring to the socially defined roles of what it constitutes to be male or female, is a social construction whose meaning is contested and negotiated (Zwarteveen 2013). Gender mainstreaming in water has been understood to be a slow and difficult process (Kulkarni 2014; Joshi 2014; Ahmed 2008). Changes in policy approaches to water management are known to have made little dent on the perverse niches created by the intersection of caste, class, gender and race in which women often find themselves (Joshi 2014). In her analysis of water and gender relations in this book, Seema Kulkarni (Chap. 5) traces the evolution of the gender discourse in the international water and development agenda and looks at the changing trajectory of policy efforts at mainstreaming gender in India. She argues that the rhetoric of gender would remain little more than a rhetoric unless it is located historically and understood as a set of complex relations between the different genders, defined identities and embedded in hegemonic power relations cutting across caste, class and race that serve the interests of state, capital and patriarchy. She notes that while in many cases the creation of formal spaces for women to participate and influence decision-making in water management has facilitated their empowerment, very often the creation of such formal spaces has made little difference, as women continue to be entrenched in unique niches created by the intersection of caste, class and race.

Ahmed (2008) rightly notes that it may not be possible to link all water resource planning in one national or country level IWRM strategy as proposed by advocates of IWRM. IWRM may indeed seem rational for some countries in Africa or Europe to develop; there is too much diversity and the need for context specific approaches is critical for a nation like India. However, IWRM does provide a lens to look at water resources holistically (Ahmed 2008; Shah and Prakash 2014). Gender analysis provides one of the means to do so. It is necessary however, more broadly to understand how water intersects with and transforms gender relations at different institutional levels or social contexts (Ahmed 2008; Kulkarni 2014; Joshi 2014).

1.1.3 Expanding Access to Clean Water and Sanitation

Aidan Cronin, Anjal Prakash, Praveen Sridhar and Sue Coates (Chap. 4) review the progress made in India in the expansion of access to safe water supply and sanitation. They challenge the notion of water scarcity being a predominantly physical phenomenon and emphasize instead the role of institutional factors in shaping water scarcity, much on the lines of Mehta (2005). Though there are important positive recommendations towards expanding the access to water in the 12th Five Year plan, political will and systematic implementation of the proposed reforms, they argue, will be necessary. Recent policy efforts emphasize decentralization; however, on account of paucity of resources and poor devolution of powers to the lower levels, local bodies remain limited in their ability to manage effectively. Though policy initiatives have sought to create a wide variety of institutions at the local level, many of them are not accountable at the community level. Thus, decentralization poses new challenges for power and accountability in local governance.

Prakash Nelliyat (Chap. 8) undertakes a comprehensive review of the challenges of water pollution in India and observes that water pollution has not been a major topic of political debate yet, and therefore, political instruments have been scarcely implemented. Emission-based standards have not been very effective so far, since they are rarely monitored and only occasionally enforced. He also argues that it may be incorrect to adopt western water quality objectives that are inappropriate to the level of development and economic state of the adopting country. Though India has attempted to solve the water pollution issues through legislative and policy measures with huge budgets over a period of time, significant progress has not been achieved in this direction. He advocates an overhaul of the policy approach to combating the problem of water pollution, using a mix of strategies such as policy advocacy, governance and enforcement, stakeholders' Initiatives and capacity building, the use of economic instruments and better coordination among line departments.

1.1.4 Technological Solutions and the Inter-linking of Rivers

Perhaps no subject has received as much critical attention, or been the subject of so much debate in the context of India's water governance as the proposal for the linking up of our major rivers. At the heart of these proposals has been the narrative that the transfer of water from India's water surplus basins to her deficit basins provides the key solution to her water problems. The debate on these proposals has been characterized by polarized views among their proponents and opponents. On the one hand has been the technocracy that seems to propagate the narrative that the solution to India's water woes lies in large-scale engineering solutions. This narrative has been challenged by the opponents of large-scale engineering solutions on grounds of the high social, ecological and environmental costs of such projects. On the one hand, the river-linking project in India has been criticised for the reductionist foundations of the paradigm that seeks to assert man's prerogative to control water (D'Souza 2002, 2003). On the other hand, it has been criticised for its failure to consider the systemic nature of the relationships between water, habitat, society and biodiversity (Bandopadhyay and Parveen 2004). This has created space for a balanced and informed debate on the subject.

In this backdrop, Upali Amerasinghe and Tushaar Shah (Chap. 7) take a critical look at this contentious proposal. They draw on a wide range of studies to assess the validity of various claims made with regard to the social, economic, hydrological and environmental facets of these transfers. They conclude that not withstanding the strong judicial attention that the proposal has received, the idea of a National River Linking Project may have come a decade or two too soon; the underlying assumptions behind the proposal for the inter-linking of rivers have changed since when the proposal was first conceptualized. The project, they conclude, is too large to conduct a holistic analysis leading to a complete assessment of its costs and benefits. There is too little data available in the public domain. They also cite several studies to challenge some of the claims made by the proponents of these proposals. These relate to the intended impacts of the proposals on water and food security as well as employment generation.

Narayanamoorthy (Chap. 11) reviews the potential of different water saving technologies in India; his analysis suggests that the water saving gains can be substantial through a concerted effort at the adoption of these technologies. While the efficiency gains from the adoption of micro-irrigation are substantial, further research is needed to examine the social and institutional conditions that will facilitate the adoption of these technologies in Indian contexts as well as the social profile of the users of these technologies.

1.1.5 Independent Regulatory Authorities: Balancing Autonomy and Control

The subject of Independent Regulatory Authorities (IRAs) has generated much debate in India, especially with regard to questions of regulation and autonomy in the water sector (Warghade and Wagle 2014; Rao and Badiger 2014). Sachin Warghade (Chap. 6) examines critically the evolution of IRAs in the country. The functioning of IRAs raises important questions regarding both accountability and autonomy in the water sector; however, Warghade raises more basic questions regarding their appropriateness to Indian settings. He proposes that a decentered approach, with a strong knowledge component and backed by a pro-people normative framework may lead to a more effective and comprehensive framework for water regulation in India.

1.2 Indian Water Policy and Governance Research for the Future

As noted earlier in this chapter, South Asian Water Resources scholarship has experienced an upsurge in recent years; given the present pattern of societal developments, water problems will become more severe in the years ahead (Mollinga 2008). In this context, a call is made for a pluralistic and integrated framework for formulating and implementing water policies in South Asia (Prakash et al. 2013). A case is made to listen to the multiple voices that are emerging in understanding water; it is argued that it is necessary to create space for dialogue among civil society and citizens (Lahiri-Dutt 2008). This is necessary particularly in the wake of a greater role for actors other than the state, notably civil society, in influencing water policy, both in terms of content as well as the processes of policy formulation (Narayanan et al. 2014; Narain et al. 2014).

The chapters in this book suggest that the dominant modes of water policy analysis in the country have witnessed a change. This is perhaps in the wake of a call for more reflective thinking on the types and modes of critique in light of a persistent deadlock in transforming dominant approaches to water resources development and management (Mollinga 2008). As noted earlier in this chapter, water scholars are increasingly turning their attention to the relationships between the hydrological, technological, economic and social dimensions of water management; rather than seeing them in isolation. Issues of gender and equity are gaining prominence in discourses on water management, breaking conventional polarizations that have characterised the debate and discourses on the subject.

Within the broad realm of policy studies, the contributions in this book, speak to the prescriptive dimensions of water policy.[5] Further research should unpack more explicitly the process dimensions of water policy in India, focusing on a discursive analysis of public policy. There is increasing recognition of the processes of contestation in water policy formulation and implementation (Saravanan and Ip 2013). Further research should capture the role of competing narratives and discourses on the framing of water policies, as well as the role of different interest groups in propagating and perpetuating these. The analysis of the 'ethnographies of the state', for instance, provides one entry point (Sangameswaran 2013).

There is growing recognition of increasing stress on water resources. Several writings in the Indian water literature, including some contributions in this book, paint a 'scare scenario' with regard to the country's water future. An important implication of the on-going process of democratization of water governance in the country, however is that coupled with the multiplication of stresses on water, this will create a more visible demand for platforms for negotiation, conflict resolution and dialogue across different categories of users and uses. This could happen at various levels: rural-urban/periurban, regional and transboundary. Research should document the creation of such platforms, as well as the role of power and politics in shaping their functioning. In some contexts, such as those of urbanization shaping rural-urban water flows,[6] such research should challenge implicit biases in water resources planning and address imbalances in the allocation of water both from equity and sustainability perspectives.

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[5] For a discussion on the prescriptive and process dimensions of public policy, see Hogwood and Gunn (1984).

[6] See, for instance, Narain et al. (2013).

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Chapter 2
The Precept and Practice of Integrated Water Resources Management (IWRM) in India

Tushaar Shah and Barbara van Koppen

Abstract Integrated Water Resources Management (IWRM) has been advanced as a response to growing problems of water scarcity in the developing world. While the precept of the IWRM process is unexceptionable, its practice has meant a package of interventions. The trouble with the 'IWRM package', and indeed the global water governance debate as a whole, is its intent to transform, all at once, a predominantly informal water economy into a predominantly formal one—something that would normally be the result of a long process of economic growth and the transformation that comes in its wake. In the IWRM discourse, formalizing informal water economies *is* improving water governance. But evidence across the world suggests that there is no shortcut for a poor society to morph its informal water economy into a formal one; the process by which this happens is organically tied to wider processes of economic growth. When countries try to force the pace of formalization, as they will no doubt do, interventions come unstuck. Interventions are more likely to work if they aim to improve the working of a water economy while it is informal.

Keywords Informal economy • Governance • Institutional arrangement • Economic growth • Groundwater

2.1 IWRM: A Response to Water Scarcity

Water scarcity has emerged, especially during the past decade, as an important theme in discussions on India's socio-economic future. Indeed, by 2025, by many accounts, much of India is expected to be part of the 1/3rd of the world destined to face

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absolute water scarcity (Seckler et al. 1999; Cosgrove 2003; Cosgrove and Rijsberman 2000; Rosegrant et al. 2002). The intensification of water scarcity is expected to play out in myriad different ways with variegated consequences. A major consequence will be the deepening of 'water poverty', a phrase used to indicate difficulty people face in securing adequate and reliable access to water for productive and consumptive uses. A related concern is also the deterioration of water environment, reflected in drying up of wetlands, deterioration in water quality, desertification.

Global discussions over the past decade have resulted in a variety of viewpoints about how best developing countries can cope with this imminent condition. At one extreme, researchers suggest that crying need is for honing even more than in the past the social capacity of communities and societies to *adapt* to water scarcity (Ohlsson and Turton 1999; Wolfe and Brooks 2003). However, a more widely shared view is the urgent need to make a transition from water resource *development* mode—in which countries like India have been steeped since 1830s when Arthur Cotton rebuilt the grand anicut on Cauvery—to water resource *management* mode by embracing Integrated Water Resources Management (IWRM).

At one level, IWRM is a philosophy. Global Water Partnership (2000) for instance defines it as "a process which promotes coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems". This is hard to find fault with. However, at an operational level, IWRM even though fuzzy (Biswas 2004), is centrally about *integrated* and *direct* management of sectoral and aggregate water *demand*, something which is absent in most developing countries. As distinct from the supply-side focus of public policy action in water sector—of governments as well as donors—on 'developing' the resource by investing in infrastructure, IWRM discussions emphasize the need to embrace demand-side management. In many low-income Asian and African countries where it has been aggressively promoted by international agencies in recent years, the 'IWRM package' has basically included a clutch of following instruments:

- ***A National Water Policy*** so that there is a cohesive, well-understood normative framework to guide all players in the sector.
- ***A water law and regulatory framework*** for coordinated action for sustainable water resources management;
- ***Recognition of the River basin as the unit of water and land resources planning and management*** *and creation of River Basin Organizations* in place of territorial/functional departments;
- ***Treating water as an economic good*** *by pricing water resource as well as services*, especially outside life-line uses, to reflect its scarcity value so that it is efficiently used and allocated to high value uses;
- ***Creation of water rights***, ***preferably tradable***, *by instituting a system of water withdrawal permits*;
- ***Participatory Water Resource Management*** with involvement of women so that 'water becomes everybody's business'.

In dozens of developing countries, adopting IWRM has essentially meant implementing variations of the above package. India's various enunciations of National Water Policy, including the latest in 2012 (Government of India 2012) have sworn by several of these principles. In Sri Lanka, for instance, the 2001 draft water policy and water law provided for establishing state ownership of all water, the institution of water use rights through withdrawal permits, pricing of water in all uses, transferable water permits to encourage trade in water rights, replacement of existing water organizations by river basin organizations (Samad 2005). Embracing the above, it is implied in the IWRM discourse, will help alleviate *water poverty* by improving access to water and minimizing environmental ill-effects associated with current patterns of water resources development in developing countries like India (Lawrence et al. 2003). Among several things, IWRM involves working to improve the potency and effectiveness of three pillars of the water institutional framework: water policies, water laws and water administration in managing the water affairs of a society through a new emphasis on direct water demand management (see, e.g. Bandaragoda and Firdousi 1992; Merrey 1996; Frederiksen and Vissia 1998; Holmes 2000; Saleth 2004; Saleth and Dinar 2004).

This new class of concerns has put on the backburner an earlier class of yet-to-be-resolved concerns about the limitations of 'supply side initiatives' with which India and many other developing countries struggled during the 1970s through the early 1990s. These had to do centrally with the need for and the efficiency of appropriate water infrastructure and services, promoting their financial and social sustainability, improving the performance of irrigation, and water supply and sanitation projects along several dimensions and at multiple levels: techno-economic efficiency; cost recovery; spatial and social equity in access to project benefits; investment in operation and maintenance, and so on. There were major issues of institutional reforms in public irrigation projects as well as rural and urban water supply and sanitation projects with emphasis shifting back and forth between reforming the bureaucracy to user-participatory management to public-private partnerships. In these discussions, the focus of analysis and action was squarely at the level of the user, community or a project; and the concerns of researchers and practitioners were about techno-economic efficiency, equity, socio-economic and environmental sustainability of infrastructure investments. Even before these issues have begun to get resolved, the IWRM paradigm has begun to shift the locus of policy discussions from improving *water infrastructure and services* at community and project levels to improving the management of *water resources* at the level of river basins.

2.2 Water Poverty: Is It Caused by Water Scarcity?

A critical implicit assumption underlying the IWRM discourse is that water poverty—reflecting lack of access to water for productive and consumptive needs for communities—is a result of the water scarcity and the failure of water institutions and policies to counter it. If this is indeed the case, then, embracing IWRM can be a big answer to water poverty of nations. But is this really the case?

The Water Poverty Index (WPI) covering 147 countries published by researchers from Keele University and Centre for Ecology and Hydrology, Wallingford, UK in 2003 provides a readymade global data base to explore the relationship between water poverty and water scarcity (Lawrence et al. 2003; Sullivan and Meigh 2003).[1] Table 2.1 below summarizes the results of multiple regression results that underpin our discussions in the above paragraphs. The data set for 147 countries used is the one compiled by Lawrence et al. (2003). The regressions use the WPI and component indices as dependent variables; Human Development Index (HDI) as well as Purchasing Power Parity (ppp) _-adjusted GDP are from UNDP 2003. Figures in round brackets below B-coefficients are standardized B-coefficients and represent the relative significance of included explanatory variables in explaining the variations in the dependent variable. Figures in square brackets are values of the t-ratio; for the sample size of 147, any value of t-ratio above 2.0 is significant.

Table 2.1 Determinants of water poverty of countries

	Dependent variable	Intercept	B-co-efficient for				
			Index of water resource availability (0–20)	Human development index (0–1)	Index of GDP/capita (PPP adjusted in '000 US$) (0–1)	Square of GDP per capita in US$)	R^2
1	Water poverty index (0–100)	17.761 (12.261)	1.086 (0.433) [13.048]	43.283 (0.796) [24.022]			0.842
2	Water poverty index (0–100)	20.646 [12.765]	1.205 (0.482) [12.508]		39.574 (0.764) [23.65]		0.788
3	Index of access to water (0–20) (WAP index)	−3.491 [−3.743]	0.037 (0.029) [0.691]	24.307 (0.867) [20.95]			0.754
4	Index of access to water (0–20) (WAP index)	−1.862 [−1.845]	0.103 (0.080) [1.721]		22.22 (0.831) [17.863]		0.691
5	Index of water environment (0–20)	7.215 [12.331]	0.138 (0.292) [3.962]		3.804 (0.388) [5.273]		0.227
6	Index of water environment (0–20)	15.09 [10.806]	0.149 (0.314) [4.773]		−23.778 (−2.425) [−5.191]	21.638 (2.842) [6.082]	0.387

[1] The approach and methodology used by these researchers were similar to those used for computing the Human Development Index (HDI) (see, UNDP 2000). The index was constructed by combining five component indices that cover water resource endowments, access to water, human capacity, water use efficiency, and quality of water environment. Each of the five component indices was given equal weight to generate the Water Poverty Index that takes values in the range of 0 and 100, the higher the value, lower the water poverty.

Like the global discussions, the authors of WPI too subscribe to the 'water-scarcity-determining-water-poverty' hypothesis when they say their aim was to 'express an interdisciplinary measure which … indicates the degree to which water scarcity impacts on human populations' (Lawrence et al. 2003). But is this hypothesis borne out by global database painstakingly compiled by the WPI authors themselves? A regression of WPI run on water resources per capita of the 147 countries suggests no direct relationship between the two. It might be argued that the real indicator of water poverty is "Water Access Poverty (WAP)" sub-component of the WPI suggestive of the levels of 'water welfare' achieved. However, the correlation between WAP index and water resource endowments too was found to be low. For nearly every level of per capita water resource endowments, we find countries which are at the bottom as well as top of the WAP index. A least-square line fitted to WAP index and per capita water resource endowment of countries turns out to be virtually flat, suggesting no relationship of quantitative significance between water endowments of nations and the water welfare of their citizens. Laos, Nicaragua, Cambodia, Bangladesh, Sierra Leon have much higher per capita water endowments compared to Egypt, Saudi Arabia, UK and Mauritius; yet the former are far more 'Water Access Poor' than the latter.

These analyses show that while water availability has only a weak relationship with overall socio-economic development, WAP index is strongly related to the HDI. The higher the HDI of a country, lower the water poverty, *regardless* of a country's water endowments. Our analyses support an even bolder hypothesis that WAP is strongly and positively related to per capita GDP (adjusted for ppp) (see regression 4 Table 2.1).

In exploring the relationship between the quality of environment and levels of economic development, researchers have already postulated and tested the 'Environmental Kuznet's Curve' which would suggest that as countries begin from low levels of economic development, the quality of their environment first declines as intensive economic growth uses natural resources as 'factors of production' (Bhattarai and Hammig 2001). However, as levels of living improve, growing demand for 'environmental amenity' generates pressures to seek avenues for economic growth that are light in the demands they make on scarce natural resources—what Gleick (2002) calls 'soft water path'. If this were true, an index of environmental quality would show an inverted U relationship with levels of economic growth. Our analyses based on data from 147 countries supports this inverted U relationship in regression 6 in Table 2.1 (note: the higher the value of the index, lower the quality of water environment). It suggests that as levels of material well-being improve for a majority of a country's people, need for clean water environment becomes a concern for the majority rather than just the environment groups, governments and international donors.

In regressions 1 and 2, besides HDI and GDP respectively, water resource endowment is statistically significant and has a large standardized B-coefficient, likely because water resource endowment is a component of WPI. In regressions 3 and 4, where WAP—the true measure of water welfare of a country—is the dependent variable, however, water resource endowment variable turns insignificant and its standardized

B-coefficients are very small, too. These suggest that water resource endowments have no relationship with the water poverty of nations. In these regressions, HDI and GDP per capita emerge as the key determinants of WAP with large t-ratios as well as standardized B-coefficients. Regression 5 suggests resource availability as well as GDP are significant determinants of water environment; but the overall fit of this regression improves greatly (as suggested by the increase in R^2 in regression 6 when the squared value of GDP is added; it emerges as highly significant, turns GDP co-efficient into a negative value thus suggesting better fit for a U-shaped relationship).

2.3 IWRM in an Informal Water Economy

There is a need to unpack this apparently neat relationship between water poverty and overall economic growth. Many people find it hard to accept these results because it apparently leads them to conclude that low-income countries like India have little or no scope to improve their water resources management; and that economic growth is the only path for them to reduce their water poverty. A more logical conclusion to draw from this analysis is that, in order to be effective, water resource management strategies of nations have to be *context-specific*; and the defining aspect of the context that matters is the position of a country in the evolutionary process of economic development rather than its water resource endowment (see also, World Bank 2005). This analysis raises questions about the usefulness of the one-size-fits-all frameworks—such as the IWRM paradigm—that dominate global discussions about how developing countries can put their water sectors in order. Use of economic pricing and withdrawal permits to encourage efficient allocation and use of water, transforming irrigation bureaucracies into river basin organizations for Integrated River Basin Management, enforcing laws to regulate groundwater pumping and controlling non-point pollution of aquifers are some of the stock policy reforms that are commonly recommended because these help orderly functioning of water economies in industrialized countries; however, evidence is mounting that many of these reforms are unimplementable in developing countries.

The constraint developing countries run into in implementing these arises from the highly *informal* nature of their water economies; and this has nothing to do with their water scarcity or abundance but has everything to do with their being at early stages of overall economic development. By definition, an informal economy is that part of the economy that remains outside formal mechanisms of governance—law, policy and administration (Fiege 1990). Incorporation of informal economies into what economic historian Douglass North (1990) called the 'modern transactions sector' occurs gradually as part of overall processes of economic growth. Until substantial proportion of a sectoral economy gets formalized, it would be well nigh impossible to bring it meaningfully within the ambit of formal structures of direct governance. In the context of developing countries like India, paradigms like IWRM—advocating direct demand management—are then fundamentally at odds with the highly informal nature of their water economies.

Take the case of India. Government documents claim that protected water supply[2] covers 95 % of the country's rural habitations. Yet a large nation-wide survey in 1998 that reached out to some 130,000 rural and urban households showed a different picture (NSSO 1999a: report 449) showed that nearly 80 % of India's rural households surveyed self-supplied their domestic water requirements—from domestic or irrigation wells, tanks, ponds, streams, etc—and were not in contact with *any* service provider or public or community agency in the formal sector. For urban households, the opposite held with over 75 % of the households 'connected'—which suggests that as India urbanizes, growing proportions of its population would come into contact with formal water service providers. Comparing the data across states suggests that in poorer states like Bihar and Uttar Pradesh, all or most rural households self-supply their domestic water, where as in somewhat better-off states such as Haryana, Punjab and Goa, domestic water supply gets increasingly 'formalized', suggesting that even rural households begin getting connected to some public water supply system as village economies grow, regardless of water resource endowments. Studies in six Indian cities during 2003 showed that economically strong households were much more likely to be connected to public water supply systems and poorer ones either self-supply or rely on informal sector service providers (Londhe et al. 2004).

The picture with irrigation is no different. Many researchers have shown that although under the control of government bureaucracies, at the grassroots levels, India's canal systems are barely functioning anarchies, with informal institutional arrangements ruling the roost. Even if we assume that farmers served with irrigation by canals are in some sense connected to the 'formal water economy', the National Sample Survey of 2002 (NSSO 2003) of 4646 villages throughout India showed that government canals have increasingly lost out in relative share of irrigators: over 80 % of sample villages used irrigation mostly from wells but also from tanks, and streams without being connected with, or under *direct* administrative influence of, either the irrigation bureaucracy or any other formal agency. This is village-level data; but much other evidence can be adduced from household level surveys in support of the fact that there is a great deal more irrigation going on in India than is acknowledged; and over 4/5th of this is in the informal sector. Similar impression emerges about the ownership and management of village water infrastructure. The NSS 54th round of survey (NSSO 1999b, report 452: 46) in 1998 of 78,990 rural households in 5110 villages throughout India suggests that 90 % of water infrastructural assets used by survey households were self-managed (and owned) by households; only around 10 % were owned and/or managed by government or local community organizations.

This predominantly informal nature of India's water economy raises questions about the reach of the 'three pillars' of water governance: water policy, law and administration. It also raises questions not so much about the need for but about the practicality of implementing water pricing, basin level water allocation, and water legislation in

[2] Which presumably means water supply through a local community-based or municipal body that takes some responsibility of quality.

the Indian context. How to collect a water service price or a water resource fee or use river basin agencies to allocate water amongst sectors and users if by far the majority of users self-provide their water needs without being connected to any formal agency? Likewise, how does any administration effectively enforce a groundwater law if 20 million farming households owning irrigation wells are strongly opposed to it, and the rest are indifferent or weakly opposed to it, especially when the administration is an instrument of a State that styles itself as a democratic welfare state?

2.4 IWRM Experience in Asia and Africa: Lessons for India

It is not surprising then that IWRM type policy interventions that many governments in Asia and Africa have adopted under the influence of global water discourse have produced doubtful outcomes, besides deflecting them from addressing here-and-now supply-side issues in their water economies. During the past decade, the government of Sri Lanka has made two bold but abortive attempts to push through aggressive IWRM-style reforms in the water sector. The latest draft water policy and water law provided for: (a) establishing state ownership of all water, (b) institution of water use rights through withdrawal permits, (c) pricing of water in all uses, (d) transferable water permits to encourage trade in water rights, (e) replacement of existing water organizations by river basin organizations—in sum, copybook IWRM reforms. The media and civil society however took to the turf bitterly opposing the very logic underlying the proposed reforms (Samad 2005). The government withdrew the reforms in a hurry; however, little thought was given to how exactly would their provisions be implemented had the new water policy and law got passed.

Many South East Asian countries—notably, Thailand, Indonesia and Vietnam—however, faced no such opposition from media and civil society and swiftly passed water laws that incorporated key IWRM instruments including formation of river basin organizations, registration of water users and issue of withdrawal permits as a mechanism for creating tradable water rights, participatory management of irrigation systems through service contracts between agencies and users, and so on (Molle 2005). Molle, however, found little match between the reality of the water economies of these countries and the reforms borne out of ‘a global water discourse largely driven by international organizations’. His review of the experience with IWRM in Mekong led him to emphasize “a gap between formal and state-centered initiatives and reality on the ground, which proceeds at a different pace. Lessons learned elsewhere are certainly important but cannot be adopted indiscriminately and must not be allowed to crowd out the emergence of endogenous and condition-specific solutions.” In brief, IWRM came unstuck.

A similar feeling was echoed in a 2005 African Water Law workshop about donor-induced IWRM style water policy reforms in many African countries (see Shah and van Koppen 2005). With the onset of the 1990s, many African countries took to IWRM wholesale. Almost everywhere, thinking about improving the functioning of the water economy involved little effort to fit policy reforms to the local reality. Almost everywhere, water reforms: (a) declared water as state property, (b) instituted water withdrawal permits, (c) made water pricing mandatory for all but domestic uses, and (d) led to the formation of river basin organizations with water allocation mandate in water economies where the bulk of the water diverted is (and most of the water users are) in the informal sector with little or no direct contact with formal water agencies.

Institutional reforms take a long time to sink and produce desired impacts; in Africa, however, evidence is already piling to suggest that IWRM reforms seem to have done little to improve anything; instead, they created undue tension, hassle and in extreme cases, dispossession of the poor. In particular, the Workshop identified four problems:

(a) the aims that the water reforms seemed designed to achieve did not reflect the current water sector priorities of the countries as viewed by national policy makers, civil society and citizens;
(b) reforms touched only a small formalized segment of the water economy and a tiny proportion of water use and users; as a result, their impacts on the water sector were neither deep nor broad;
(c) however, they threatened disintegration of customary laws and institutions evolved and used by communities; these are never ideal, but they are time-tested, robust and perform their basic functions well; and
(d) they also created serious distortions, threatened dispossession of large numbers of poor, and created new vested interests; these potentially deleterious impacts were limited only by the fact that almost everywhere reforms failed to stick, laws remained largely unenforced, water prices remained uncollected.

What, then, went wrong with Africa's and Mekong countries' water reforms? Several things, it seems. Many countries just copied laws made elsewhere, just as several states in India have blindly copied Andhra Pradesh's law on participatory irrigation management, and Pakistan Punjab has copied the water law of the state of Colorado in the USA. In Africa too, countries did a 'copy and paste', for example, of parts of the South African National Water Act. Without consultation, public participation, and a serious attempt to fit reforms to the context, the impact of these reforms was bound to be negative if at all. And now, Ghana is having second thoughts on its reform strategy and going back to the drawing board.

In Africa, as in some Asian countries like Sri Lanka, international agencies and global thinking rather than analysis of local context and need has had a powerful influence on the design of water sector reforms. Tanzania is a case in point; its 1991 water policy identified water development and provision as a key national policy goal and argued for more water storage creation. However, creating new storage and infrastructure was anathema to international donors; so Tanzania ended up doing what donors would support: stock textbook IWRM, which included state ownership of water resources, water withdrawal permits, water tax, legal institutional reform, river basin organizations, Water User Associations (WUAs), but no attempt to get what its people need most, more and better-managed infrastructure. Tanzanians all along had plans to build storages but were secretive about it for the fear of donor reprimand. In implementing the first phase of the IWRM project, however, the leadership figured that reforms could not deliver what Tanzania's rural communities need badly, i.e., better domestic water supply systems, improved irrigation water control and better hydraulic infrastructure rather than water withdrawal permits, water pricing and catchment organizations.

The only African country where water reforms have produced semblance of improved governance of water resources is South Africa, which has emerged as a model, exemplifying IWRM type water sector reforms in an emerging economy context. South Africa is interesting because of its first-world-third-world duality. In terms of income inequality, South Africa is next only to Brazil. 54 % of South Africa's water use is in agriculture; and 95 % of its farm lands are owned by a small minority of white commercial farmers. In the Olifants, one of South Africa's most developed basins, 95 % of rural water resources is used by only 0.5 % of the population, white commercial farmers. The Gini coefficient for rural water use is as high as 0.96 (Cullis and Van Koppen 2005).

South Africa's ground-breaking water law (chapter 4 of the Act: section 21) specifies the following uses and brings them within its IWRM mandate: (a) taking water from a water resource; (b) storing water; (c) engaging in a stream-flow reduction activity, such as forestry; (d) control activities. E.g., irrigating with wastewater; (e) discharging of wastewater into a water source through a pipe, canal, etc.

All those using water for the above purposes have to register, pay water use charge and a water resource management charge. South Africa has all of 62,000 authorized, billable water users (or registered primary diverters) that account for 11 billion m^3 of water allocation for commercial agriculture, 5 billion m^3 for industry and municipal uses, and 9 billion m^3 for forestry. The Government of South Africa generates around 2 billion rand/year (USD 0.35 billion/year) as income from water tariffs. Managing these 62,000 users has been far from easy: it is difficult to ascertain actual volumes used; some users did not register and some registered use could be unlawful under existing water law. Many commercial farmers have extended their irrigated areas unlawfully, posing that they are using their water allocation more efficiently. A critical issue for officials is whether to rely on voluntary compliance or evolve a system of policing.

Interestingly, however, the South African IWRM leaves 95 % of its people out of its ambit. All of 2.3 billion m^3—about 10 %—of total water use is allocated to the so called schedule-1 users, mostly rural black South Africans, who include some 18 million primary diverters of water for domestic use, irrigating tiny food plots and small vegetable gardens. Their water use is neither subject to licenses nor billable. If anything, everyone agrees, the crying need is to increase the access to and productive use of water by these users; yet the entire edifice of IWRM practices is unable to meet this need.

It is not that South Africans are not trying; but they have just begun reforms in black South Africa and find the going tough. 18 million rural South Africans, *de facto* still partially ruled by 800 chiefs and 13,000 village headmen with their customary law and traditional institutions constitute a diffuse informal water economy where self or community provision galore. Under the National Water Policy of 1997 and Water Act of 1998, South Africa was to be covered by 19 Catchment Management

Agencies (CMAs). Only two fledgling CMAs have been formed so far with a far more modest role than was originally envisaged. Moreover, for the five poorest Water Management Areas it is increasingly recognized that a CMA will never be financially viable at all, and could become, at best, business units within government. Formation of CMAs, turning over of small-holder irrigation systems to WUAs, promotion of appropriate technologies—central to improving the lives of the vast majority of South Africans—remain major challenges that the country's water reforms are yet to begin to meet. These are also the challenges facing India, Bangladesh, Nepal and numerous poor countries. IWRM is working in European South Africa, but the African South Africa has to begin at the beginning.

The lesson India needs to learn from the experience of all these countries is centrally about the gap between the precept and practice of IWRM. There can be little questioning the basic IWRM premises such as that water should be priced to reflect its scarcity value, that it is best managed at basin level, that reform of property rights will promote its efficient and sustainable use. The question is how to make these stick in water economies that are predominantly informal. All the evidence we have suggests that these work best where:

(a) primary water diverters are large, body corporates and few in number;
(b) most water users are supplied by organized service providers; and
(c) capital accumulation in terms of infrastructure creation is already high.

In contrast, IWRM-style demand management reforms would fail to stick where: (a) most of the country's households are primary water diverters; (b) most self-supply their water requirements directly from a natural source; and (c) capital accumulation in water infrastructure is very low.

All in all, the IWRM paradigm neither responds to the priorities of the poor in poor countries, nor does it resonate with their ground conditions which make implementing water pricing, reform of property rights, allocating water at basin level work. The key factor often ignored is the number of primary diverters of water from nature. In rich countries, these are often just a very small number of body corporates—water companies, utilities, municipalities, co-operatives—who serve the water needs of all users that are no longer primary diverters. In low-income countries with high level of income inequality such as Brazil and South Africa, IWRM works well in the rich, modern, formal segment of the water economy but can actually leave the poor worse off by destroying their traditional institutional arrangements while replacing them by poorly functioning modern ones. In most other low income countries where a majority of users are obliged to self-provide their water because of absent or poorly developed water infrastructure, IWRM deflects attention of policy makers in these countries from what ought to be their key priority—which is to deliver improved and better managed water infrastructure and services.

A core value of IWRM is people's participation in water resources management: its popular slogan 'make water everybody's business' is illustrative. In reality, in countries like India, the fact that diverting water from natural water bodies is everybody's business makes IWRM impossible to implement. A condition necessary and sufficient for effective implementation of IWRM type demand management is that diversion of water from nature is the business of relatively few, large users and service providers who can be brought within the ambit of public policy with relative ease.

Contrast the informal water economy of a typical Indian district with the highly formalized water economy of a typical European country, such as say Switzerland (Luis-Manso 2005). 70 % of Switzerland's population is urban; the country is facing continuous reduction in industrial workers and farmers. 15–20 % of the Swiss population was linked to public water supply as far back as in the eighteenth century, more than India's is now; today, 98 % of the Swiss population is linked to public water supply networks and 95 % is connected with waste-water treatment facilities. At US$468, per capita water bill the Swiss pay annually is higher than the per capita total income of Bangladesh. All its water users are served by a network of municipal, corporate, co-operative water service providers. It has stringent laws and regulations about water abstraction from any water body which can be done only through formal concessions. However, these concessions are held only by a small number of *formal* service providing public agencies; as a result, their enforcement entails little transaction costs. It is not surprising that IWRM instruments work perfectly in such a highly formalized water economy.

2.5 Economic Development and the Organization of a Water Economy

Water institutions that exist or can be externally catalyzed in a country depend, besides several other factors, on the stage of formalization of its water economy which in turn depends upon the overall economic evolution of that country. Figure 2.1 presents a clutch of empirically verifiable hypotheses—a set of iron laws of economic development[3]—about how the economic organization of a country's water economy metamorphoses in response to economic growth and the transformation of society that comes in its wake. Regardless of its water endowments, as a low-income economy climbs up the economic ladder, the organization of its water economy undergoes a transformation in tandem with the transformation of the society as a whole. The foremost driver of this transformation is urbanization and occupational diversification. As the proportion of rural and agrarian population declines, agricultural water demand eases. With urbanization and economic growth, self-provision of water is increasingly replaced by service providers. In poor economies, implicit costs of water acquisition—in the form of labor spent in fetching water—are high, especially for the poor; with economic growth, labor costs decline but monetary cost of buying water service increases. In affluent countries, scientific and economic resources devoted by the society per km^3 of water diverted are much higher than in poorer countries.

[3] Scott Roselle used this phrase recently to refer to the unexceptionable tendency of agricultural population ratios of countries to fall as their economies grow. But I think this also applies to other responses to economic development as outlined in Fig. 2.1.

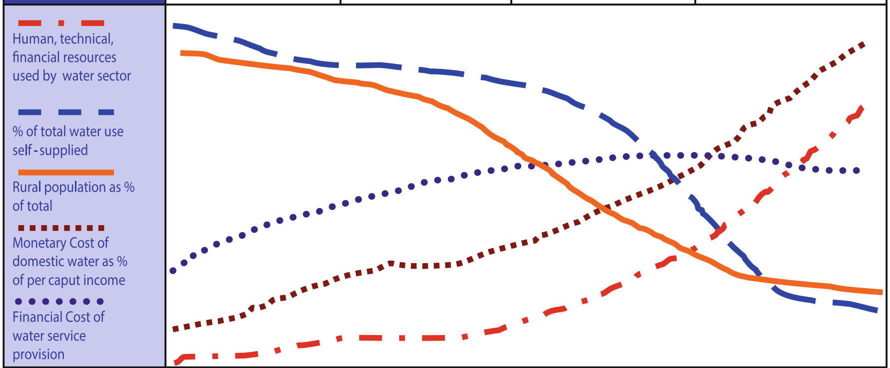
	Stage I: Completely Informal	Stage II: Largely Informal	Stage III: Formalizing	Stage IV: Highly Formal Water Industry
% of water users in the formal sector	<5%	5-35%	35-75%	75-95%
Examples	Sub-Saharan Africa	India, Pakistan, Bangladesh	Mexico, Thailand, Turkey, Eastern China	USA, Canada, Western Europe, Australia
Dominant mode of water service provision	Self-supply and informal mutual-help community institutions	Partial Public Provisioning but self-supply dominates	Private-public provisioning; attempts to improve service and manage the resource	Rise of modern water industry; High Intermediation; self-supply disappears
				
Concerns of the Governments	Infrastructure creation in Welfare Mode	Infrastructure and Water services, especially in Urban areas	Infrastructure and service in towns and villages; Cost recovery; Resource protection	Integrated mgt. of water infrastructure, service and resource; Resource protection
Institutional Arrangements	Self-help; mutual help and feudal institutions dominate	Informal Markets; Mutual help and community management institutions	Organized service providers; self-supply declines; informal institutions decline in significance	Self-supply disappears; all users get served by modern water industry.

Fig. 2.1 Transformation of informal water economies in response to overall economic growth

Along with these changes, water institutions too undergo profound change. In very poor societies, self-provision of water by households is ubiquitous; in much of Africa, we do not find local, informal markets even for pump irrigation service that are widespread in South Asia. Countries at somewhat higher level of economic growth witness limited local specialization in water services provision in an informal manner. As economies grow still further, local specialization—and informal institutions associated with these—disappear as large, professionally run corporates take over the role of procurement, processing and retailing of water. Thus, the informal water institutions we find in India, Pakistan and Bangladesh—such as, say, pump irrigation markets, urban tanker water markets—are unlikely to be found in Australia or Spain because those countries have outlived the need for these by creating specialized water institutions at a higher level that their citizens need and can now afford. Likewise, water institutions that are standard in industrialized countries—high net-worth water companies managing a city's water supply system—would not begin to work until Dhaka as a water service market evolved, at least, to Manila's or Jakarta's level.[4]

[4] If accounts of the travails facing global water companies like Vivendi and Thames Water who are forced to wind up even in these increasingly affluent east- Asian cities is any guide, we must

For much the same reasons, it is difficult to find a country in say Sub-Saharan Africa with a modern water industry of the kind we find in a European country. South Africa may be the exception that proves this rule: white South Africa—inhabiting its towns or operating large, commercial farms in the countryside—is served by what approximates a modern, formalized water sector. However, the former homelands, where half of South Africans live, are served by a water economy even more informal than India's.

We have so far discussed IWRM paradigm's errors of commission. However, its major error of omission is that it offers no guidance on what to do with a plethora of water institutions that developing countries already have. The here-and-now challenge of water governance in low-income countries like India is one of understanding and working with groundswells of spontaneous institutional formations which have emerged and sustained to create value for water users. Informal, decentralized pump irrigation markets today serve 1/3rd of India's gross irrigated areas (Mukherji 2005), as much as the share of all public irrigation projects. There is a booming culture fishery in the making in small common property ponds and tanks throughout India providing livelihoods and improving nutrition of millions of rural households. New technologies and stocking material created the potential for a boom; however, it is the myriad changes that have occurred in the institutional arrangements for leasing of small water bodies that have energized this boom. Where state governments dogmatically adhered to the communitarian ideal, the boom has remained muted; where they have adopted an entrepreneur-friendly approach, the culture fishery economy has boomed. In the famous Sardar Sarovar Project on river Narmada, planners had planned that the government would build lined minors going up to each Village Service Area (VSA) commanding 200–600 ha; a WUA will build subminors and distribution network within each VSA by mobilizing local resources. As it has turned out, planners proposed; and farmers have disposed. Of the 1100 odd VSAs so far covered, not one has a WUA that built the distribution system. However, this has not stopped irrigation in the SSP command; thousands of farmers have invested in diesel pumps and rubber pipes; pump irrigation markets have sprung up everywhere. According to some, this is certainly not the best solution; planners do not like this irrigation anarchy; but then farmers do not like to lose precious farm land and invest own funds for building a distribution system (Talati and Shah 2004). Groundwater depletion is one of the most complex challenges India's people and water policy makers face. However, the responses of the IWRM theoreticians have tended to differ from those of the people who are at the receiving end: the former think primarily in terms of ways to reduce groundwater draft through laws and regulations; people have steered clear of demand restriction but have instead mobilized local resources to increase supply. Rural communities in western India—notably, Saurashtra and eastern Rajasthan—have taken to water harvesting and decentralized groundwater recharge in a big way as a mass movement. In southern states, there is growing tendency to convert irrigation tanks into percolation tanks by sealing the

conclude that South Asian cities have a long way to go before they can afford water supply systems of European or North American quality (see, *The Economist*, August 15–21, 2004).

sluice gates of tanks. In Gujarat, the government has been able to effectively regulate overall groundwater draft for irrigation, not by pricing groundwater and power, or creating tradable water rights or making new groundwater laws, but by intelligent rationing of farm power supply (Shah and Verma 2008; Shah et al. 2008).

Developing countries like India are then confronted with a policy dilemma of whether to pursue an unachievable ideal—such as the IWRM—or to work with what they have. Recent discussions in the field of New Institutional Economics (NIE) help us to explore this dilemma because it addresses the question 'why economies fail to undertake the appropriate activities *if they had a high pay-off*' (North 1990). India's water sector is replete with situations where appropriate activities can potentially generate a high pay-off and yet fail to get undertaken. An institutional change creates a 'structure' of pay-offs with gains varying across different groups of agents, and therefore, inviting different 'intensities' of responses. A small group of agents each threatened with large loss may put up a stiff resistance to a change that is beneficial for the society as a whole, and vice versa. In NIE, transaction costs are seen to include: (a) costs of search and information; (b) costs of negotiation, bargaining and contracting; and (c) costs of policing and enforcement of contracts, property rights, rules and laws. For a policy or institutional intervention, all these three increase *directly* with the number of agents involved as well as the strength of their preference for or against the intervention. All the three costs come into play in determining the 'implementation efficacy' of an institutional intervention because each depends on the number of agents involved in a transaction, which in an informal water economy is large.

A great deal of what policy makers and researchers consider desirable institutional change—such as making and enforcing groundwater regulation, metering farm electricity connections, instituting participatory irrigation management, reforming water rights all of which would be part of the IWRM package—are extremely difficult to implement on the ground because the transaction costs of doing so are high for implementers and pay-offs are low, even negative, for the water users. In contrast, a plethora of institutional arrangements in the informal sector address various priorities of users, offering them high pay-offs and entailing low transaction costs; yet the State is largely oblivious, even suspicious, of them.

2.6 Summary and Conclusion

The trouble with the 'IWRM package', and indeed the global water governance debate as a whole, is its intent to transform, all at once, a predominantly informal water economy into a predominantly formal one—something that would normally be the result of a long process of economic growth and the transformation that comes in its wake. In the IWRM discourse, formalizing informal water economies *is* improving water governance. But evidence across the world suggests that there is no shortcut for a poor society to morph its informal water economy into a formal one; the process by which this happens is organically tied to wider processes of economic growth. When countries try to force the pace of formalization, as they will no doubt do, interventions come unstuck. Interventions are more likely to work if they aim to improve the working of a water economy while it is informal.

Improving water governance worldwide is a work in progress. Countries like the United States, Spain, Australia, and Mexico struggled with orderly governance of their agricultural groundwater economies for decades before developing countries like India have had to worry about these problems. And their experience is valuable capital from which the latter societies can draw important lessons. The pioneer countries' experience does not offer readily applicable solutions, given developing countries' early stage of economic growth, vast number of small, dispersed water abstractors, and a highly informal, atomistic irrigation economies. The solutions would work in portions of water economies, such as urban areas and industrial sectors, that are already formal or easy to formalize. Here, water pricing and regulation must certainly be the way to go. But in a diffuse, atomistic irrigation economy, more inventive approaches are called for. The lesson that developing countries need to draw from the pioneer countries is the value of actively engaging with the expanding but unregulated atomistic irrigation economy.

Three distinctive aspects set India's water economy apart from the pioneer countries. First is the transaction costs, with millions of dispersed users directly withdrawing water from nature. Using pricing, tradable water rights, or even policing and administrative regulation here is infinitely more difficult in logistical terms than in most other countries.

Second is the agrarian poverty aspect. Over the past three decades, small-holder irrigation based on groundwater revolution has provided more relief—if not a lasting solution—to millions of the region's agrarian poor than most public policies and programs (Shah 2009). Until population pressure on agriculture eases, public policy will involve tightrope walking to balance conflicting objectives. The government will simultaneously persist with the power subsidies responsible for groundwater depletion and implement watershed development intended to recharge aquifers. This apparent incoherence is symptomatic of the dilemma of water governance in India. Efforts to cope with or alleviate depletion through supply-side strategies will tend to be preferred over aggressive demand-side strategies that threaten livelihoods.

Finally, the large numbers of dispersed users over a vast countryside present not only a constraint but also a great opportunity for land and water care that sparsely populated countries do not have. The institutional environment here can often achieve more by joining forces with farming communities and institutional arrangements than by taking a command-and-control position. Rogers and Hall (2003: 10) ask, "can the state steer the society?" In most developing countries "which typically have a strong society and a weak state," the challenge of steering lies in the state's making common cause with the multitudes. The mass-based groundwater recharge movement in Saurashtra is but one example of what the state can do in partnership with people. The trouble with regulatory zeal is that it puts the institutional environment and the people in rivalrous relationships when they should be comrades-in-arms.

Bearing the experiences of the pioneer countries in mind, India needs to look within to find ways of turning Prisoner's Dilemma outcomes in Coase outcomes. In so doing, they can derive useful guidance from the original IWRM philosophy—which emphasized participation and dialectics, enjoined societies to move from a resource development to resource management, highlighted the insight that a natural resource cannot long remain both scarce and free, and encouraged a process for evolving water governance structures tailored to the local context. By so doing, India may not tame the anarchy in its water economy, but it can achieve a better compromise between its conflicting priorities—providing succor to its agrarian poor, and protecting its natural resources and environment.

Finally, the IWRM paradigm must not be allowed to obfuscate India's key priorities for years to come, which is making good, sensible investments in improving water infrastructure and services; and making these investments work. We also need to bear in mind that as the world's largest user of groundwater, India's water economy has a unique dynamic of its own which demands a unique strategic response. Finally, as India urbanizes and gets richer, highly formalized segments must emerge especially in cities; direct demand management of the IWRM variety is the ideal framework for managing these formal segments, and we should vigorously pursue IWRM in these formal segments of our water economy.

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Chapter 3
Groundwater Depletion in India: Potential of Alternative Approaches and Policy Instruments

Nitin Bassi

Abstract Since the advent of green revolution in late 1960s, groundwater played an important role in the agricultural and economic development of India. However, large expansion in well irrigation due to policies of promoting private tube well construction, rural electrification programme and subsidies on electricity and diesel for agricultural use resulted in groundwater over-abstraction largely in north-western, western and peninsular India. As most of the measures to regulate groundwater overuse in India have met with little success, this chapter examines the viability of alternative institutional and economic instruments for sustainable groundwater irrigation. Analysis suggests that the enforcement of private and tradable property rights in groundwater can bring about a significant increase in farm outputs, with a reduction in the aggregate demand for water in agriculture. It will also bring about more equitable access to, and control over, the water available from groundwater for food production and thus ensure household-level food security. This has to be complemented by the pro-rata pricing of electricity in the farming sector, with improved quality and reliability of the supplied power.

Keywords India • Groundwater over-exploitation • Groundwater legislations • Water rights • Energy pricing

3.1 Introduction

In India, groundwater has become a mainstay of rural economy supporting agricultural development and providing food security to millions of people. Following diffusion of green revolution technology in late 1960s, the area of irrigated cropland using groundwater has expanded rapidly with farmers making extensive use of

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groundwater in irrigated agriculture. It came as no surprise that between 1993–1994 and 2006–2007, irrigation structures (dug wells and tubewells) pumping groundwater increased from 8.9 to 18.7 million. At present, groundwater nearly sustains 60 % of the net irrigated area and about 2/3rd of irrigated food production depends on irrigation from groundwater wells (Kumar 2007). Almost all major agricultural states in India heavily depend on groundwater for irrigation. In Tamil Nadu, Maharashtra, Madhya Pradesh, Rajasthan, Uttar Pradesh, Punjab, and Gujarat, groundwater caters to more than 60 % of the net irrigated area (CGWB 2006).

It has been estimated that crop yield in groundwater irrigated areas is higher by one third to one half then those irrigated by surface sources (Dhawan 1995). Productivity of groundwater irrigation is more than that of surface water because it is reliable, available at the point of use, requires minimum conveyance infrastructure, and has high application efficiency (Dhawan 1989). Thus in order to optimize crop yields and maximize profits from agriculture, farmers intensively use groundwater. Though it contributed significantly to agricultural and economic development of the country, of late it has thrown many challenges for the management and governance of this resource (Singh and Singh 2002). Overdraft of groundwater beyond the recharge potential resulted in water scarcity across many regions in India. Out of 5842 number of assessed administrative units, nearly 802 are over-exploited, 169 are critical, 523 are semi-critical and 4277 are safe.[1] Further, 71 assessed units are completely Saline.[2] In Delhi, Gujarat, Haryana, Himachal Pradesh, Karnataka, Punjab, Rajasthan and Tamil Nadu, number of over-exploited and critical administrative units are significantly higher (i.e. more than 15 % of the total assessed units) (CGWB 2011).

With this context, this chapter discusses the extent of groundwater overexploitation in India, various existing institutional arrangement for groundwater management and the role of alternative approaches and policy instruments in promoting sustainable use of groundwater for irrigation.

3.2 Extent of Groundwater Overexploitation in India

Groundwater use for irrigation in India has increased steadily and surpassed canal irrigation in the early 1970s (Fig. 3.1). Since mid-1960s, it is actually energized irrigation (through electric and diesel operated pumps) that has increased more. Between 1961 and 2002, number of electric pumps increased from mere 0.2 to 10.3 million, and diesel pumps increased from 0.2 to 6.5 million. The expansion of energised irrigation is attributed to: (1) government programs to promote private tubewells, supported by soft loans to farmers and rural electrification (Scott and Sharma 2009); (2) the general shift to a flat rate electricity tariff for agricultural use in most states (Janakarajan and Moench 2006; Scott and Sharma 2009); and (3) diesel subsidy. Such ambitious interventions led to overdependence and overuse of

[1] An administrative unit is categorized as: overexploited if the stage of groundwater development is more than 100 %; critical if it is between 90 % and 100 %; semi-critical if it is between 70 % and 90 %; and safe if it is below 70 %.

[2] Saline units are those where the entire assessment area is having poor quality groundwater.

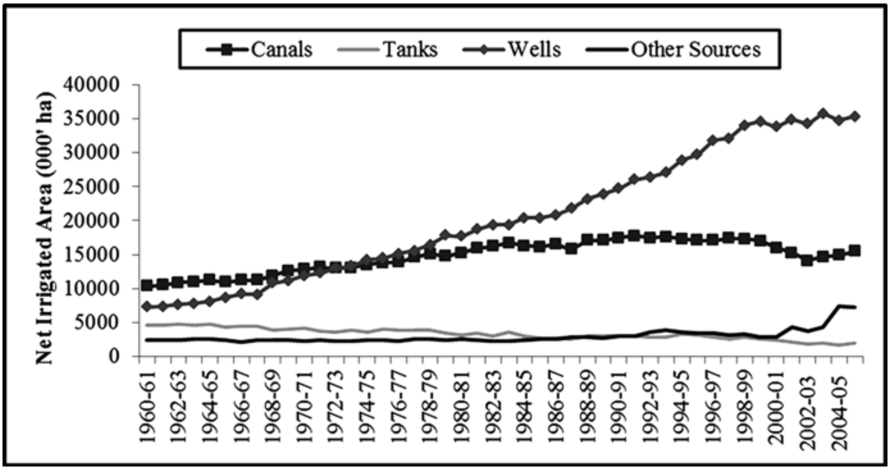

Fig. 3.1 Source wise net irrigated area (Source: Author's own analysis using data tables from Indiastat)

groundwater for irrigation in many parts of the country. This resulted in declining groundwater level, reduction in supply, saline water encroachment (Singh and Singh 2002; Narayanamoorthy 2010), drying of the springs and shallow aquifers, increased cost of lifting, reduction in free flow and even local subsidence at some places (Singh and Singh 2002). Lack of well-defined ownership rights in groundwater too contributed to its unsustainable use.

As a consequence of overuse of groundwater for irrigation, 37 % of the total assessed administrative units in Karnataka, 37 % of the total units in Tamil nadu, 49 % of total units in Haryana, 59 % of the total units in Rajasthan and 75 % of the total units in Punjab were found to be overexploited (CGWB 2006). These figures are much above the average figure (which is 15 %) of the country's total overexploited administrative units. However, it is argued that the current assessment of groundwater over-exploitation did not provide a clear picture of the actual extent of over-exploitation in both absolute and relative terms. It tends to underestimate the magnitude of groundwater overexploitation in India, which can be assessed from the negative social, economic and ecological consequences of over-development (Kumar and Singh 2008). From that perspective, many districts in Madhya Pradesh, Andhra Pradesh and Tamil Nadu could be actually over-exploited, though the official figures show that they fall under "safe", "semi-critical" or "critical" categories. The regions which have serious problems are alluvial Punjab, both the hard and alluvial areas of Gujarat, and the hard rock areas of Maharashtra, Tamil Nadu, Karnataka, and Andhra Pradesh.

Nonetheless, large-scale overexploitation of the groundwater resource has serious consequences for the Indian subcontinent where hard rock (consolidated) formations cover almost 70 % of the total area. In these hard rock areas, mainly in water scarce Western and Peninsular India, recharge of aquifers is comparatively low and often occurs at places having fissure or cracks or weathering in the rock formations. In general groundwater potential of hard rock areas is poor (Fig. 3.2), though relatively high yields may be obtained in restricted locations under favorable

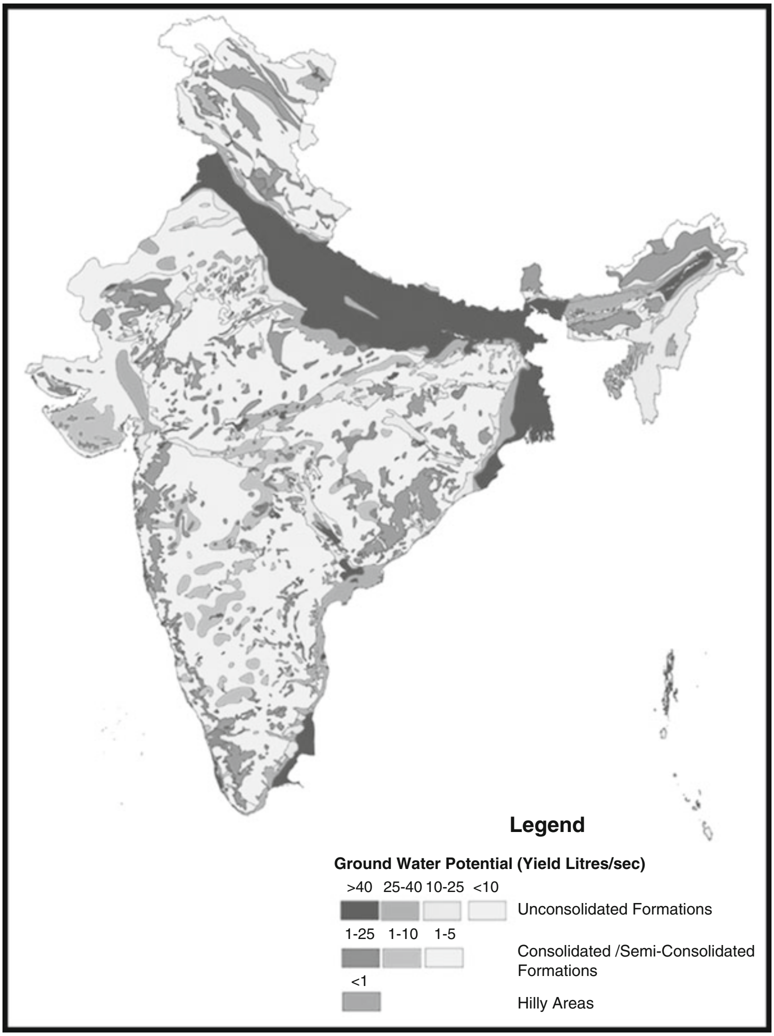

Fig. 3.2 Ground water potential in different hydro-geological settings, India (Source: CGWB 2006)

circumstances of topography and rainfall (NIH 1999). Therefore any form of over-exploitation seriously affects the groundwater availability and contributes to well failures in these regions (Bassi 2011).

Over the years, though the total number of irrigation wells in the hard rock regions has increased, there is a simultaneous increase in abandoned or failed wells (Fig. 3.3). Further, in some states, increase in number of wells has not contributed to corresponding increase in groundwater irrigated area. For example in Tamil Nadu, it was found that with the increase in number of wells there is no major increase in groundwater irrigated area after 1980s (Janakarajan and Moench 2006). Similarly,

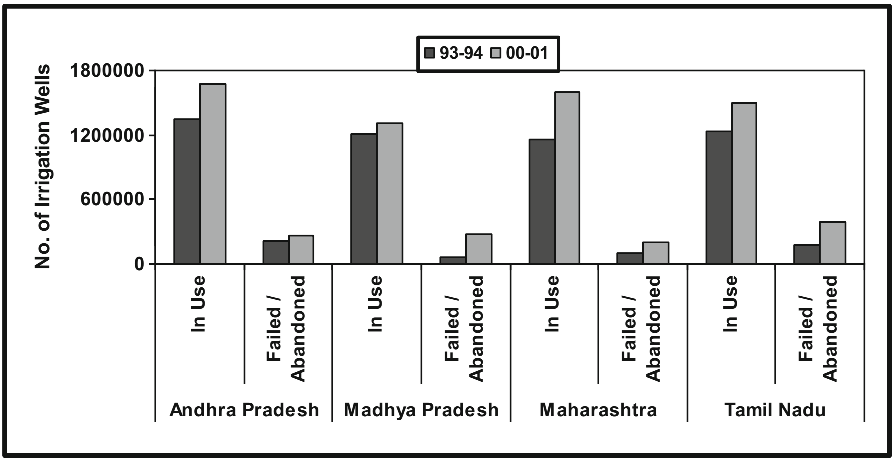

Fig. 3.3 Well failures in hard rock regions, India (Source: Author's own analysis using data from minor irrigation census and Indiastat)

in five districts of Madhya Pradesh namely Balghat, Chhindwara, Shahdol, Jhabua and Betul, the average command area of energized wells was observed to be declining almost consistently after mid 1970s (Kumar 2007). On the other side there are areas in the Gangetic river basin, mostly comprising alluvial aquifers in Bihar and West Bengal, with comparatively less development of groundwater resources (39 % and 42 % respectively). The reasons are: (1) small and fragmented land holdings; (2) low number of water extraction mechanisms; (3) high cost of energy; and (4) low investment capacity of small and marginal farmers (Sharma et al. 2008). Along with economic water scarcity, these are the areas which also face scarcity of arable land. As a result, development of groundwater for irrigation and overall agricultural growth is very low in this water rich eastern part of India (Kumar et al. 2011).

3.3 Institutional Arrangements for Groundwater Management in India

In context of groundwater management, institutional arrangements include formal laws dealing with groundwater, irrigation laws and their regulations, and informal norms regarding groundwater development and use (Kemper 2007). Some past legal attempts include Bombay Irrigation (Gujarat Amendment) Act of 1976 (on well depth restriction), Pondicherry Groundwater (Control and Regulation) Act of 2002 (on well spacing restriction) and Andhra Pradesh Water, Land, and Trees Act of 2002 (dealing with well registration and ban on well construction in notified villages). More recent is the Maharashtra Groundwater (Management and Development) Act 2009 which envisages several restrictions such as, ban on the construction of wells; prohibition on groundwater pumping from the existing deep-wells (more than 60 m deep); stipulation on deep-wells users to follow the groundwater use plan and crop plan.

In pursuance of these legislations, many direct and indirect measures were adopted for groundwater management in India. These include: artificial recharge in areas facing problems of overdraft; direct regulation of groundwater abstraction; indirect regulations through well financing and other leverages; local management of groundwater by user groups; and establishment of cooperative property rights in groundwater. However, most of these measures have met with little success and have been ineffective in arresting groundwater depletion (Janakarajan 2002; Kumar 2005). Moreover, the 1992 Model Groundwater Bill which advocates well permits, water metering, and withdrawal limits has not been properly adopted by any state so far (Saleth and Dinar 2000). But of late, direct institutional instruments; such as establishment of water rights and effective enforcement of legislations, and indirect economic instruments; such as power rationing (Scott and Shah 2004; Shah et al. 2008) and pro rata electricity pricing (Gupta 2002; Kumar 2005; Kumar et al. 2011), for managing groundwater demand are being increasingly advocated.

3.4 Can Water Rights and Energy Pricing Emerge as Better Options?

The spatial and temporal variation in both water availability and demand is very high in India. In eastern regions, such as states of Bihar, Eastern Uttar Pradesh and West Bengal, though water resources are abundant, irrigation demand is very low. Further, problems of water logging due to rising groundwater levels caused by flooding and excessive irrigation from canals are encountered (Shah 2001). On the other hand, demand for water is extremely high in water scarce arid and semi-arid regions of Gujarat, Rajasthan, Tamil Nadu, and Maharashtra, where groundwater is the major source of water for all purposes. Pumping regulations in these areas facing overdevelopment problems through groundwater legislation, control of institutional financing for well development, and restrictions on power connections for pumps have been ineffective (Janakarajan 2002; Kumar 2000).

It is argued that even an imperfect system of groundwater rights will have more sustainable benefits than a most perfectly designed power tariff structure (Saleth 1997). Many other scholars in the past have also suggested establishment of property rights as a means to build institutional capability to ensure equity in allocation and efficiency in use of water across sectors (Saleth 1994; Narain 1998; Kumar 2000). Other institutional mechanisms, such as groundwater legislations, to check and control overdraft have fallen flat due to their social and political implications. The issue of effective water rights is particularly important for irrigation water which has significant implication for agricultural sustainability (Saleth 1994).

Scott and Shah (2004) claimed that strict rationing of power supply to agriculture in India is having an unintended consequence of limiting the rate of groundwater exploitation. Further based on power reforms in Gujarat, Shah et al. (2008) argued that metering electricity use by tubewells and charging farmers at rates based on power consumption is detrimental to the marginal and landless farmers who largely depend on groundwater markets and hence, unlikely to happen in near future. Therefore best intermediate strategy is to provide good quality rationed power but at a common flat rate tariff to all tubewells regardless of whether metered or not metered. Citing example from water rich eastern state of West Bengal, Mukherji (2007) supported the view that high flat-rate electricity tariff encourages development of water markets whereby the water buyers, mostly small and marginal farmers, benefit from access to irrigation. But these views do not hold true in case of western and peninsular India which are water scarce and already facing increased problem of groundwater depletion due to continuing subsidized energy regimes for groundwater pumping. Researchers have indicated that energy rationing but without metering and unit pricing have failed to motivate farmers to use water and electricity efficiently (IRAP 2010). For instance, in Gujarat where *Jyotigram* scheme of rationalized power supply to farm sector was launched during 2003–2006, agricultural power consumption has actually increased from 9,571 million units in 2002–2003 to 11,009 million units in 2006–2007 (Data Source: Gujarat Electricity Board). Whereas, Kumar (2005) showed that unit pricing of electricity influences groundwater use efficiency and productivity positively. In fact, Kumar et al. (2011) has provided empirical evidence that raising power tariffs in the farm sector to achieve efficiency and sustainability of groundwater use is both socially and economically viable.

3.5 Water Rights as an Instrument to Manage Groundwater

In India, groundwater property structure has remained relatively unchanged since colonial era (Aguilar 2011). Based on the 'dominant heritage' principle implied in the Transfer of Property Act IV of 1882, the Easement Act of 1882 deems groundwater to be an easement connected to the land and grants landowners an unrestricted right to use the groundwater below the land (Saleth 2010). Since the land and well ownership is heavily skewed, there is an inherent inequality in access to groundwater (Kumar 2007). A formal system of water rights can mitigate this inequity in groundwater access and can also promote its sustainable use (Rosegrant and Binswanger 1994; Saleth 1994).

Over-exploitation occurs when users ignore the effects of their actions on the resource and other users when pursuing their own self interests (Johansson et al. 2002). For instance, in Gujarat, where there are well developed informal groundwater markets, water is sold without considering the limits of the resource. Though the allocation of purchased water may be more efficient than in absence of such markets, the groundwater level is nevertheless being drawn down (Kemper 2007). Under such scenario, absence of well-defined private property rights can be a major source of uncertainty about the negative environmental impacts of resource use, leading to its unsustainable use (Pearce and Warford 1993; Kay et al. 1997; Kumar 2003). Once the resource becomes scarce, well defined groundwater use rights can become a key mechanism to control over-abstraction (Kemper 2007). Saleth (1994) notes that the more robust, though politically and administratively harder, options such as the institution of a water rights regime could effectively limit and regulate both individual and collective water withdrawal and use from sub-surface sources. Well-defined groundwater use rights entitle individual users to an abstraction allocation at a certain point in time (Kemper 2007). However, the water rights administrative agency has to ensure that water rights granted will not result in annual pumping quantities that exceed safe yield (Peck 2003).

If the rights are allocated only to use water, it can create incentives to use it even when there is no good use of it. Therefore, water rights have to be tradable (Frederick 1993). Also, transferability and exchangeability of water rights are crucial to capture and reflect the scarcity value of water through price signal and guide water allocation accordingly (Saleth 1994). Well-defined tradable rights (especially in context of developing countries) formalize and secure the existing water rights enjoyed by water users; economize on transactions costs; induce water users to consider the full opportunity cost of water; and provide incentives for water users to internalize and reduce many of the negative externalities inherent in irrigation (Rosegrant and Binswanger 1994). Thus, the highest value of water use is taken into account and provides an incentive to users for more efficient use and reallocation of surplus water to a higher valued use (Kumar 2003; Kemper 2007). Empirical evidences from the functioning of groundwater irrigation institutions in north Gujarat show that under a system of fixed volumetric water use rights, farmers prefer to grow mustard, which is less water intensive, in larger area as compared to wheat, though the earlier one has much lower land use productivity than wheat, but getting same water use productivity (Kumar 2000, 2005). Further, volumetric pricing of water and its rationing as found in the shareholders of tube-well partnerships, farmers allocate their entitlements for growing crops that give higher economic returns from every unit of water used for crop production (Kumar 2005). But for a tradable groundwater use right to resolve overexploitation of groundwater aquifers, a definite proportion of the aquifer volume needs to be reserved to achieve a certain stabilization (Kemper 2007) on sustainable yield considerations (Kumar 2005).

Further, there is a need to separate rights to groundwater from right to land as it has constrained the potential for inter-sectoral allocation. Considering that agricultural use accounts for more than 80 % of water use, the modest transfer of water from agriculture could meet growing urban and industrial demands. As evident from other parts of the world, the infrastructure required for such inter-sectoral water transfers would cost much less than the large hydraulic infrastructures planned to meet growing water demand for domestic and industrial uses (Mohanty and Gupta 2002).

3.6 Pricing Energy for Limiting Groundwater Use

It is a common knowledge that users have an incentive to use a resource more efficiently when it is priced appropriately (Kemper 2007). In case of groundwater, energy pricing is important in developing economies like India where energy subsidies to agriculture are estimated between USD 1.9 billion and USD 6.5 billion per year. Further, the electricity subsidies to agriculture in India are estimated to be 26

% of the gross fiscal deficit. These range from 80 % in Madhya Pradesh and Haryana to 50 % in Andhra Pradesh, Gujarat and Karnataka, and to about 40 % in Rajasthan, Punjab and Tamil Nadu (Bhatia 2005). These are also the states which are experiencing tremendous groundwater over-abstraction for irrigation. Hence, the 'pro poor' subsidies regime has affected both groundwater situation and the state finances alike; and has already turned 'anti-poor' in several regions of Peninsular and Western India where the aquifers are already over-exploited and only the rich and large farm owners can afford to abstract water.

Earlier, many researchers have suggested rational pricing of electricity as a potential fiscal tool for sustainable groundwater use in India (Moench 1995; Saleth 1997; Kumar 2005; Kumar et al. 2011). Many argue that a flat rate based pricing structure in the farm sector creates an incentive for farmers to over-extract it, as the marginal cost of extraction is zero (Kumar 2005). Some researchers have argued that since the price at which groundwater is traded in regions like north Gujarat reflect the scarcity value of the resource, tariff hike would not have significant impact on groundwater use (Mohanty and Ebrahim 1995). However, such arguments are contested on the ground that the actual annual demand for irrigation services in hourly terms is much smaller in comparison to the total amount of groundwater the well owners can pump out during a year and that they are not confronted with the opportunity cost of using excess water for irrigating their own fields (Kumar and Singh 2001). Nevertheless, some scholars continue to advocate that the flat tariff regime with power supply rationing and supply management is the highly rationale, sophisticated and scientific pricing regime (Shah et al. 2007). But field studies suggest that power rationing with good quality supply but without metering and unit pricing has failed to arrest groundwater over-exploitation (IRAP 2010).

It is quite true that the policies with regard to water and electricity pricing are guided by strong political and economic considerations (Moench 1995). Once a subsidized regime is set, it is politically very difficult to return to energy prices that actually reflect the cost of energy to state (Kemper 2007). But the recent past has seen some remarkable success in introducing metering, and charging a power tariff based on actual consumption in some states. These include West Bengal (Mukherji et al. 2009), Uttarakhand (Bassi et al. 2007), and Gujarat (Kumar et al. 2011). In many Indian states farmers have been crying foul over the deteriorating power supply, which is free or highly subsidized, and instead were demanding a good quality power supply with a price. A field research study undertaken in Madhya Pradesh confirmed that it is actually small and marginal farmers who have been affected most by the subsidized power driven groundwater overexploitation as they have limited resources and access to groundwater (Bassi et al. 2008). It was further analysed that the aggregate net returns per farmer for small landholders were 41 % less than the large landowners. Similarly, aggregate net returns per well for small landholders were 39 % less than the large landowners (Fig. 3.4).

Citing the case of the aquifers of the Lower Jordan River Basin, Venot and Molle (2008) argued that any substantial increase in volumetric charges is unlikely to enable regulation of groundwater abstraction and would further decrease the income from low-value or extensive crops. They emphasized that significant reduction will

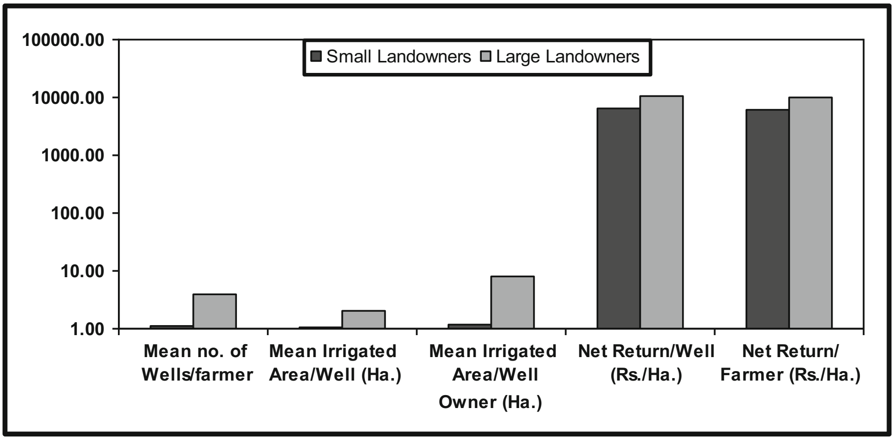

Fig. 3.4 Well irrigation characteristics and returns, Bagli block, Madhya Pradesh (Author's analysis of primary data)

only be achieved through policies that reduce the number of wells in use. However, the empirical studies carried out so far on the issue of energy pricing on groundwater use in India show that the introduction of consumption-based pricing of electricity and an increase in unit charges, if combined with improvement in the quality of power supply, will lead to greater agricultural income and a reduction in use of groundwater (IRMA/UNICEF 2001; Kumar 2005; Kumar et al. 2011). Scott and Shah (2004) held that a zero or flat-rate tariff provides no incentive to limit pumping; however, the increases in metered tariff required for elastic demand behaviour are likely to be significantly higher than are acceptable to either farmers or politicians (also refer to de Fraiture and Perry 2002). However, empirical studies in North Gujarat (Kumar 2005) and in South Bihar, Eastern UP and north Gujarat (Kumar et al. 2011) established that the levels of pricing at which demand for electricity and groundwater becomes elastic to tariff are socio-economically viable.

Some researchers have also questioned the feasibility of installing meters at such a large scale because of the huge transaction cost involved in it (Shah et al. 2007). However they were found to be rather excuses used by officials and other functionaries of electricity departments to cover up the revenue losses due to poor operational efficiencies, resulting from transmission losses and distribution losses, including thefts (Kumar 2009). With the advent of pre-paid electronic meters which work through scratch cards (Zekri 2008) and work on internet or mobile technology and remotely-sensed meters (Kumar et al. 2011), the transaction cost of metering can be minimized to a great extent. The use of remotely-sensed meters can also avoid the huge transaction cost of metering. The technology used in these meters enables them to be installed in places where tampering by farmers and meter readers will be difficult, yet where readings can be easily obtained. This is now used for measuring electricity consumption by agro wells in West Bengal (Mukherji et al. 2009).

But, such fiscal instruments are required in regions experiencing over-draft. In India, overdraft appears to be occurring in regions which experience low to medium rainfall with high aridity (Kumar and Singh 2008). Metering and pro rata pricing of electricity may not be required in those regions which have abundant groundwater, if the issue of cost recovery in electricity supply can be addressed through other modes of pricing. The reason is that metering is essentially an economic decision and the benefits of metering have to justify the efforts involved (Arghyam/IRAP 2010). In water-abundant regions, the social and economic benefits of groundwater conservation through metering may not be very significant. Therefore, in those regions, the pricing structure should be designed in such a way that it encourages greater use of groundwater for boosting agricultural production. But caution should be exercised, to see that it does not create negative effects on equity in distribution of energy subsidy benefits. The flat system of pricing, based on the connected load of the pump set, can be a good basis for pricing electricity in groundwater abundant areas (Kumar et al. 2011).

3.7 Conclusion and Policy Implication

The number of groundwater wells in India has almost doubled during the last two decades. Further, incidence of well failures has been on rise especially in regions characterized by poor specific yield and groundwater potential. These instances give clear signs of aquifer depletion which requires some immediate solution. However, existing state regulations concerning groundwater management have been able to achieve little. Additionally, compliance with age old colonial laws and policy of providing free or subsidized energy supply for irrigation use has resulted in over-exploitation of aquifer and misuse of abstracted groundwater. Though started as a pro-poor policy initiative, energy subsidies are quickly turning into pro-rich policy initiatives by allowing resource rich farmers to continue more pumping.

Enforcement of private and tradable water rights in groundwater can together bring about a significant increase in farm outputs, with a reduction in aggregate demand for water in agriculture. It will also bring about more equitable access to, and control over, the water available from groundwater for food production and ensure household-level food security. In this formal regime, small farmers and the poor will gain water rights, which would empower them, and can serve as additional collateral (Mohanty and Gupta 2002). This has to be complemented by the pro rata pricing of electricity in the farm sector, with improved quality and reliability of the supplied power. Flat tariff regimes, whether rationed or managed, can do little to control groundwater and energy use in agriculture. Therefore, metering and pro rata pricing of electricity has to receive priority, especially in naturally water-scarce regions which also experience groundwater over-draft. Whereas, in the groundwater-abundant eastern region of India, the pricing structure in the farming sector should be designed in such a way that it encourages greater use of groundwater. However, in such areas there is a limit to agricultural growth as availability of per capita arable land becomes a constraint.

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Chapter 4
Drinking Water Supply in India: Context and Prospects

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Abstract India has made significant progress in developing its water resources and the supporting drinking water infrastructure. In fact, it has met the water target for its MDG commitment and in doing so has contributed significantly to the global achievement of this target. However, rapid development, increasing population and variable resource distribution has led to the current demand for water outweighing supply.

Large budgetary outlays since independence and a high political focus on drinking water have resulted in the country supplying water through improved sources to 92 % of its citizens. Improved sources, as per Joint Monitoring Program definitions, do not reflect the safety of the water supplied. Also improved sources do not result necessarily in improved health and nutrition outcomes due to other factors; the principal being poor sanitation and hygiene. This chapter will, therefore, deal with water along with sanitation and hygiene.

Like any other basic service, to be delivered efficiently the institutions responsible for them play a crucial role. Clear delegation of responsibilities is essential for this. This is not the case in India today with numerous institutions with duplicate roles and also significant gaps. In addition, inadequate institutional performance, lack of appetite for reforms and ineffective implementation of existing provisions have affected the performance levels for water supply, in both the rural and urban contexts. Besides the institutional challenges, other factors affecting water supply in India include political will, environmental sustainability (including climate change), social dynamics, technological appropriateness and economics.

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In spite of a sizeable water resource base and vast land resource, India continues to struggle to meet its drinking water requirements. This paper examines the landscape challenges and opportunities for improved drinking water supply in India. Positive developments can be seen in the recommendations for the 12th Five Year plan but will require systematic implementation of reforms and a strong political will.

Keywords Drinking water • Policy • Supply • India

4.1 Introduction

India has lost more than 600,000 children under 5 years in 2010 due to diarrhea and pneumonia (UNICEF 2012a); almost 30 % of the global total. Water, sanitation and hygiene (WASH) plays a critical role in combating these killers. Eighty-eight percent of diarrhea deaths are linked to incomplete water and sanitation service provision (Fewtrell et al. 2007). Stunting is thought to contribute to over a third of under five deaths globally (UNICEF 2012b). India has the largest number of stunted children in the world with over 40 % moderately or severely underweight (NFHS-3 2006). Stunting depends on food intake, the general health status of the child and the physical environment; WASH cross-cuts all these aspects and it has been estimated that 50 % of malnutrition is attributable to water, sanitation and hygiene (Fewtrell et al. 2007). A recent study (WSP 2010) estimates that inadequate sanitation causes India 'considerable economic losses', equivalent to 6.4 % of India's gross domestic product (GDP) in 2006 (US$53.8 billion). These are all unacceptably high figures for a country of India's standing and ambition.

India has about 16 % of the world's population as compared to only 4 % of its water resources. With the present population of more than 1.2 billion, the per capita water availability is down to around 1,170 cu m/person/year (NIH 2010). Despite these constraints, it is to India's credit that the provision of safe drinking water has taken great strides. India has contributed more than any other country to those gaining access to improved drinking water sources in the world, 522 million between 1990 and 2010 and has met the Millennium Development Goal for water (WHO/UNICEF 2012). These numbers are commendable but when the data is looked at in more detail, it is clear not all have benefitted equally. This is a key issue that has to be addressed as equity has been highlighted in the 12th Five Year by the Planning Commission of India (Planning Commission 2010, 2011).

Drinking water fits into the broader water sector. This sector is complex, interlinked and requires a holistic systems approach to develop a full understanding ranging from political, environmental, social, institutional and economical (UNICEF, FAO and SaciWATERs. 2013). This is true in all countries, but especially with the competing interests and priorities at play in developing countries and middle income countries like India.

Given this need for a holistic approach, this chapter unpacks the challenges and then develops the future possibilities. The chapter is divided into five sections. After the introduction, Sect. 4.2 traces the history and institutional setting of drinking water in India so that a clear picture of how the sector has evolved is conveyed. Section 4.3 discusses the present institutional and service delivery structure of water supply in India while Sect. 4.4 focuses on the present status of water supply and sanitation. Section 4.5 maps the challenges of the sector in supplying water for all.

4.2 History of Indian Water Supply Policy and Implementation

The journey of planned efforts in water supply and sanitation in India began in 1949 when the Environmental Sanitation Committee, Govt. of India, recommended a goal of supplying safe water to 90 % of the country's population over the next 40 years. In 1950 the Constitution of India listed water as a State subject. Article 47 of the Constitution conferred the duty of providing clean drinking water and improving public health standards to the State Governments. This set the background for governing and managing water in the successive Five Year Plans. This evolution of thinking and planning is grouped into four groups, called First to Fourth generation programs (Sridhar 2012) and the corresponding milestones are illustrated in Fig. 4.1.

These generations of programs focus on rural water supply and sanitation. Urban water supply scenario has been different from the rural in a way that the progression of planning efforts as well as institutional structures shows a distinct trajectory. Figure 4.2 illustrates developments in urban water supply over the years. The timeline of developments in both – rural and urban – water sectors is provided to suggest a comprehensive way of looking at the developments in these areas rather than examining separate programs in isolation. A wider temporal perspective offers context and insight into why a particular program was launched.

4.2.1 Rural Water Supply and Sanitation

First Generation Programs The first Five Year Plan (1951–1956) allocated approximately 1.5 % of the total budget to water and sanitation. The allocation remained roughly the same until 1969 when the National Rural Drinking Water Supply Program (NRDWP), was launched, with technical support from UNICEF. The effort mainly comprised drilling bore wells and building piped water infrastructure. The fourth Five Year Plan (1969–1974) saw a near doubling of budgetary allocation. During this plan the Accelerated Rural Water Supply Program (ARWSP) was launched in 1972. This goal of this program was to increase the pace of drinking water supply coverage which had grown at a sluggish pace until this time. ARWSP made significant progress in the next decade, during which the budgetary allocation to water and sanitation also peaked at 4.15 % under the Sixth Five Year Plan (Fig. 4.1).

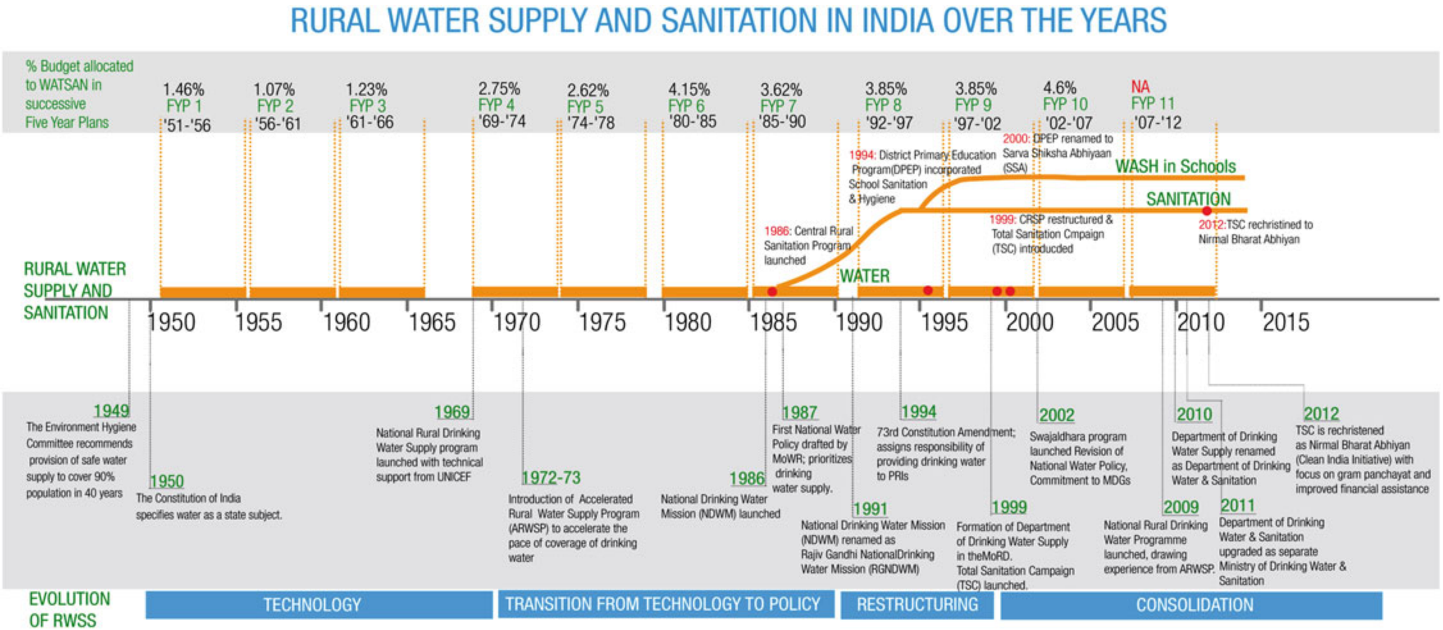

Fig. 4.1 Timeline of rural drinking water supply and sanitation in India (Sridhar 2012)

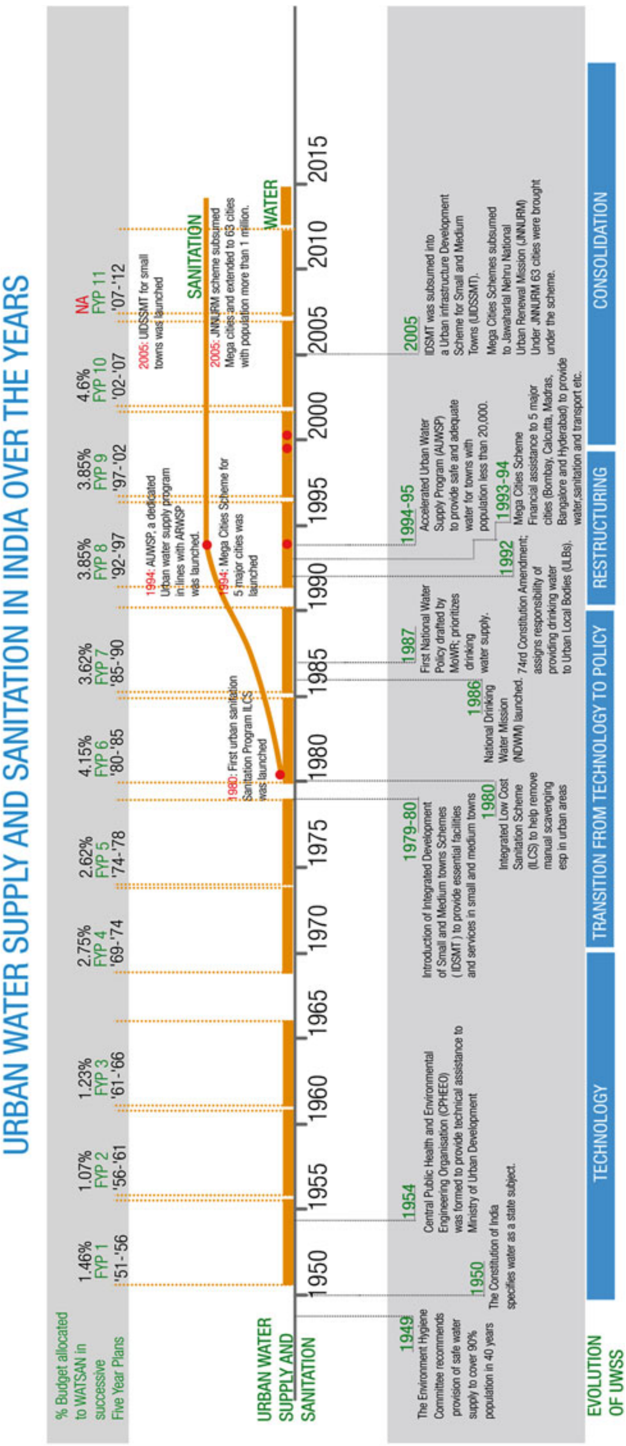

Fig. 4.2 Timeline of urban drinking water supply and sanitation in India (Sridhar 2012)

Second Generation Programs A national level apex committee was setup in 1981 to define policies to guide India to provide access to safe water in all its villages. This lead to formation of National Drinking Water Mission (NDWM) in 1986 followed by first National Water Policy in 1987 by the Ministry of Water Resources. Additionally, a Technology Mission was launched in 1986–1987 in which appropriate technology intervention, water quality, human resource development and support were introduced in Rural Water Supply sector. The Technology Mission was later renamed as Rajiv Gandhi National Drinking Water Mission (RGNDWM) in 1991 (Fig. 4.1).

Third Generation Programs The National Water Policy was revised in 2002. Villages that did not have adequate sources of safe water were prioritized and level of service in partially covered villages was planned to be improved, under this revision. In the same year India committed to UN Millennium Development Goals to halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation, from 1990 levels. The *Swajaldhara* program was launched in 2002 which changed the way in which water and sanitation services were supported in rural areas. *Swajaldhara* decentralized service delivery responsibility to *Panchayati Raj* Institutions (PRIs) and users. This new approach advocated for communities to be consulted and empowered in the planning process via a participatory approach; and from this to enter into a cost sharing agreement with the local authorities. For the first time users agreed to pay an upfront tariff for water use, that was significantly increased to cover the operation and maintenance costs. *Swajaldhara* continued till 2009 when the National Rural Drinking Water Program (NRDWP) was introduced. NRDWP drew on experiences from ARWSP and continues until now.

Fourth Generation The Rural Water Supply sector today appears remarkably different in its approach and prioritization of issues, in comparison to the earlier generations. A significant difference lies in the shift from top-down and technology driven approaches to a decentralized one which lays greater emphasis on aspects like sustainability, equity and community participation. Ensuring sustainability of water, its availability in terms of pot ability, adequacy, convenience, affordability and equity are given priority in the latest programs. All this is to be achieved while ensuring decentralized approach which involves PRIs and community organizations.

As in other areas of governance the 73rd and 74th Constitutional Amendments were a landmark development in water sector. Now, with the amendments Panchayati Raj Institutions were given the responsibility of providing drinking water. The Department of Drinking Water Supply was renamed as Department of Drinking Water and Sanitation in 2010, which was later upgraded into the Ministry of Drinking Water and Sanitation (MDWS) in 2011. A dedicated Minster solely in charge of MDWS was appointed in 2012.

Meanwhile, sanitation developed separately from drinking water, with the launch of Central Rural Sanitation Program (CRSP) in 1986, though was planned and implemented in conjugation with drinking water programs. By the 1990s although progress was being made in water, sanitation coverage remained abysmally low. To give increased impetus to progress and address known bottlenecks, in 1999 the Total Sanitation Campaign (TSC) was launched. This program is a restructured version of the CRS. TSC also included a component of building water and sanitation facilities in schools. TSC evolved into *Nirmal Bharat Abhiyan* (NBA) in 2012, with increased household subsidy and linkage with the rural employment guarantee scheme.

It can be said that in rural water supply and sanitation the focus was on technology until the lack of policy was felt. Policies affected a comprehensive approach to the sector but the gaps remained unaddressed. These gaps included sanitation, community engagement and increasing emphasis on demand over supply. Attempts to address these over the two decades have been through restructuring of departments, decentralization of local level planning as well as responsibilities from the centre to the lower levels of the democratic structure. More recently the importance of community engagement, gender, flexibility in central funding along with increased financial outlays have helped raise the profile and priority of the sector, especially sanitation.

4.2.2 Urban Water Supply and Sanitation

About 32 % of Indian population is urban spread across 474 urban agglomerations across the country, 31 of these have a population in excess of one million. Presently 97 % of population has access to improved water supply and 58 % has access to sanitation. Urban water supply was separated from rural water supply and given exclusive attention with the formation of Central Public Health and Environment Engineering Organization (CPHEEO). This organization was to assist Ministry of Urban Development in its functioning. CPHEEO began to conduct PHE trainings specifically to produce professionals trained in water supply and sanitation. Sanitation in urban context was seen in association with water but its introduction as a focus area happened much later in rural context. To remove the practice of open defecation and manual scavenging in urban areas Integrated Low Cost Sanitation (ILCS) was introduced in 1980. Improvement of infrastructure to address basic needs of smaller urban agglomerations and to avoid migration from smaller habitations to bigger habitations Integrated Development of Small and Medium Towns (IDSMT) was initiated in 1978. But in spite of these programs little progress was made in the state of urban water and sanitation. Part of the reason for this was allocation of funds. The rate of urbanization over years was not proportional to the funds allocated to deal with water and sanitation demand. The other reason was that the Urban Water Supply (UWSS) did not have exclusive and targeted programs to attend to the requirements of water and sanitation that emerged in the urban areas. The practice was to always club it with larger urban programs in infrastructure and planning. Accelerated Urban Water Supply and Sanitation Program (AUWSP) was an effort to give water and sanitation a focused attention and Mega Cities Scheme was initiated to address the overall basic needs of metros. Both IDSMT and AUWSP were subsumed into Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) and Jawaharlal

Nehru National Urban Renewal Mission (JNNURM) with improved budgetary allocation and increased scope to schemes. These programs have helped introduce wide ranging changes in planning, implementation as well as maintenance of water and sanitation services in urban areas. But this has yet to achieve the scale of results required; also due to the variety of structural challenges (administrative, political, and social) that are constantly at play and affect the state of water and sanitation in urban areas and which are further described below.

4.3 Water Supply Institutional Structure and Delivery Mechanisms

Governing water resources and their use, along with servicing basic needs (drinking water, sanitation and health) to over 1.2 billion people, requires an extensive system of institutions at various levels aided by numerous special purpose agencies (Fig. 4.3). The federal structure of India requires that there is clarity in responsibilities at Centre, State, and sub-State levels. It is important to understand the institutional structure and related responsibilities to fully comprehend the water landscape and in identifying the critical points in the decision making to implementation chain.

4.3.1 Rural Institutional Structure

The Central government is the facilitator of the entire process; its role is to set policy, guide investments in the sector, help States with funding, training, research, quality monitoring and human resource development. Under the aegis of MDWS, the National Scheme Sanctioning Committee (NSSC) sanctions funds to States. The sanctioning process is closely monitored and heavy emphasis is placed on financial expenditure. Impact of these funds is less closely scrutinized.

The States plan, design and execute water and sanitation programs. The State governments are supported by various departments including Public Health Engineering Department (PHED), Rural Development Department, Water Boards and PRIs. It should be noted that States may have different institutional setups in accordance with the local context. In some states water supply and sanitation programs are supported by PHED, whereas in some it is the Panchayat and Rural Development Department and in some it is the Rural Development Department. At a lower level PRIs play a crucial role in the process as most of the implementation and ground action takes place here. Going further, the PRIs are required to takeover planning of the programs at the village level.

The highest sanitation authority at the State level is the State Water and Sanitation Mission (SWSM) which is aided by a State Level Scheme Sanctioning Committee (SLSCC), Capacity and Community Development Unit (CCDU) and State Technical Agency (STA). The Water Supply and Sanitation Organization (WSSO) works

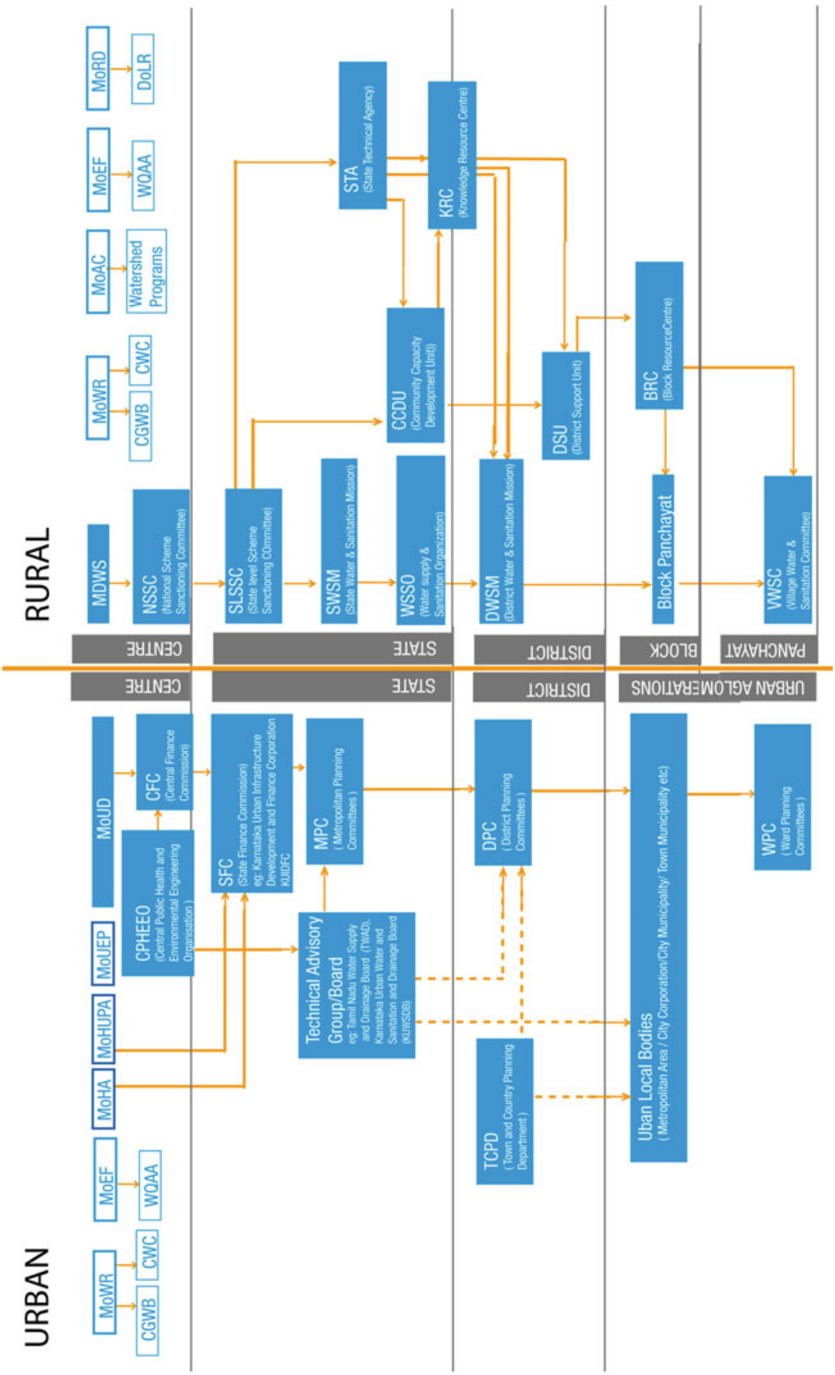

Fig. 4.3 Institutional setup in the water and sanitation sector (Sridhar 2012)

under the SWSM (Fig. 4.2). WSSO provides software support to district and blocks in areas like water quality monitoring, surveillance, evaluation, behavioral change and capacity building activities. At the district level the District Water and Sanitation Mission (DWSM) is constituted under the supervision and guidance of *Zilla Parishads*. DWSM's role is to facilitate communities (at the PRI level) to plan, implement, operate and manage schemes in their areas. Similar to the support units at state level, DWSM is also supported by District Support Unit (DSU) to fill in technical knowhow and capacity building (Fig. 4.2). Key Resource Centers (KRCs) provide capacity building on key technical areas from State to District level.

The Block Panchayats plays an intermediary role between DWSM and village. In 2010 Block Resource Centers (BRC) were introduced to augment support at the village level. BRCs provide continuous handholding to Gram Panchayats and village communities to achieve the goals that are set at the village level. Finally, at the lowest level Village Water and Sanitation Committees (VWSC) operate. As the entire system is decentralized, VWSCs should be independent units which make decisions and plans according to their local context and requirements. The resource and financial requirements are fed into the institutional system.

The system then works to meet these requirements and focus efforts towards meeting the goals set by the Centre, State, District and the Village, ideally in consultation with each other. Achieving adequate WASH coverage is not possible independently and requires convergence. This implies that the agencies responsible for planning, design and implementation must act in consultation with each other and ensure coordination at field level. As previously outlined, access to drinking water is determined by water availability and this issue spans several ministries. Water Resources (surface and ground water) is governed by Ministry of Water Resources (MoWR). In rural areas, monitoring of ground water is undertaken by the Central Ground Water Board (CGWB). Ground water is replenished by watershed development programs in some states and watershed development falls under Ministry of Agriculture and Cooperation's purview (MoAC). The Water Quality Assessment Authority (WQAA) is the responsibility of Ministry of Environment and Forest (MoEF). These links imply that all these ministries have to be involved in the sustainable provision of drinking water. Several ministries besides MDWS, including Ministry of Health and Family Affairs and Ministry of Women and Child Development, are required to achieve universal access to safe sanitation and ensure good health via adoption of best hygiene practices.

4.3.2 Urban Institutional Structure

Unlike rural water supply urban water supply does not have a clear organizational structure. At the highest level, the responsibility of provisioning urban water supply and sanitation services rests with the Ministry of Urban Development (MoUD). Ensuring these services for the urban poor is under the remit of the Ministry of Urban Employment and Poverty Alleviation. Other National Ministries that share the responsibility and also contribute financially towards urban water and sanitation are Ministry of Housing and Urban Poverty Alleviation, and Ministry of Home Affairs. Two other ministries that have a role to play in urban water and sanitation are Ministry of Water Resources which allocates resources to meet urban demand and Ministry of Environment and Forests, which also influences the decision on utilization of the resources used to meet urban needs.

A coherent and comprehensive institutional structure to deliver water and sanitation services in urban areas is not evident, though the 74th Amendment of the Indian Constitution intended to empower Urban Local Bodies (ULBs) to deliver basic services required in their regions. As a part of this, Central Finance Commission was set up through which finances are allocated to States to renew their urban localities especially small and medium scale towns to contain migration to bigger cities.

Similarly, at the State level, State Finance Commission is advised by both CPHEEO and technical advisory boards in allocating funds to ULBs. Further down from this level to district and ULB, every state has its own structure to deliver services. In some states like Karnataka the State sets up engineering cells (Karnataka Urban Water and Sanitation and Drainage Board) to advise ULBS to plan their water and sanitation services. Likewise, Tamil Nadu has Tamil Nadu Water Supply and Drainage Board that advises ULBs and also executes the services for them. In municipalities like Rajkot, the municipality takes up the responsibility to plan and implement the water and sanitation services. With these examples it should be noted that overall there is no single, uniform structure that is followed by all urban agglomerations countrywide.

The 74th Amendment mandates a structure where the State Finance Corporation provides funds to urban agglomerations through Metropolitan Planning Committee and eventually to ULBs though it has been observed that this process is often not followed by the states (Planning Commission 2001).

4.4 The Current Drinking Water Supply and Sanitation Scenario in India

4.4.1 Rural

The Joint Monitoring Programme or JMP (WHO/UNICEF 2012) estimates that 97 % of urban areas and 90 % of rural areas in India have access to an improved source of water (Fig. 4.4). JMP defines an improved drinking-water source is one that by the nature of its construction adequately protects the source from outside contamination, in particular with faecal matter. Indeed, the global MDG for drinking water has been met thanks to the considerable contribution of India.

However, access to improved drinking water quality does not take into account the safety of the water supplied (Bain et al. 2012). Hence, this value of 92 % of the population accessing improved water is impacted upon when the issue of water quality is considered. Microbiological (principal health threats from bacteriological

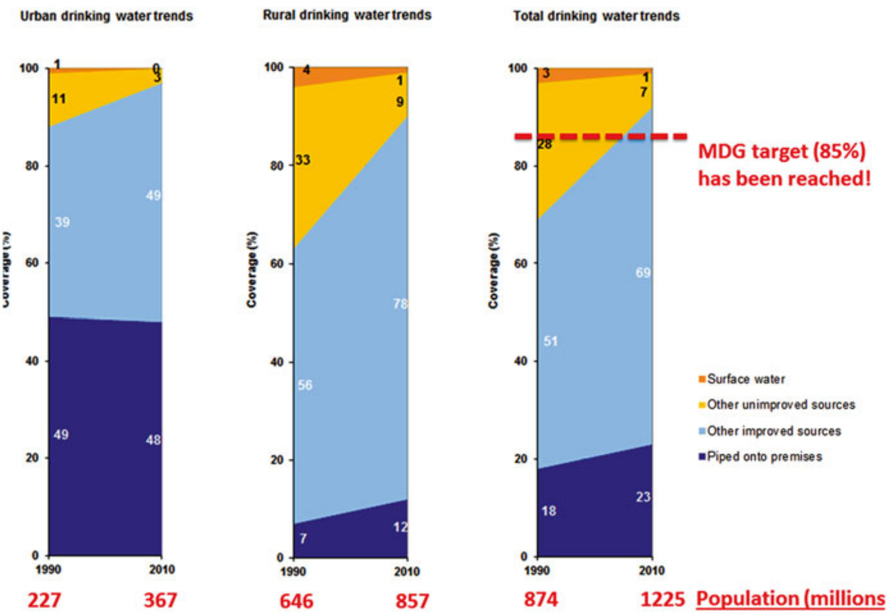

Fig. 4.4 Drinking water provision in India 1990–2010 (WHO/UNICEF 2012)

and viral pathogens) and chemical contamination (Arsenic and Fluoride are the main health concerns from geogenic pollution; anthropogenic pollution is also severely impacting on water quality) has resulted in water sources posing serious health problems, especially to the most vulnerable segments of the population.

Groundwater has traditionally been thought to be a safe source, especially from microbiological contamination. A UNICEF study conducted across 60 districts of India in 2007 found that from a total of 11,800 water sources tested 40 % were non-compliant for bacteria testing parameters respectively (MDWS 2011a). Sanitary surveillance, simple risk assessment forms filled out at water sources; indicate that this comes, not surprisingly, from the high levels of open defecation and poor operation and maintenance. Fluoride has been detected across 188 Districts in 19 States and Arsenic across 54 Districts in 8 States (MDWS 2011b). Needless to say, the at-risk populations in both cases are in the millions.

Another key issue behind these statistics is that of who is gaining access (Mudgerikar and Cronin 2012). Sixty-five percent of the richest quintile of India have piped water on premises while it is only 2 % of the poorest quintile; in rural areas 32 % of the richest quintile have piped water on premises while it is 1 % of the poorest quintile (NFHS-3 2006). Scheduled Tribe (ST) household access to piped water is lower than the India average (24 % as opposed to 44 %); the corresponding value for Scheduled Castes (SCs) is 41 %. STs and SCs are also disproportionally with lower access to sanitation than the Indian average (75 % and 63 % respectively as compared to the national average of 50 % from Census 2011). In terms of sanitation, though progress has been made India will miss the MDG target (Fig. 4.5).

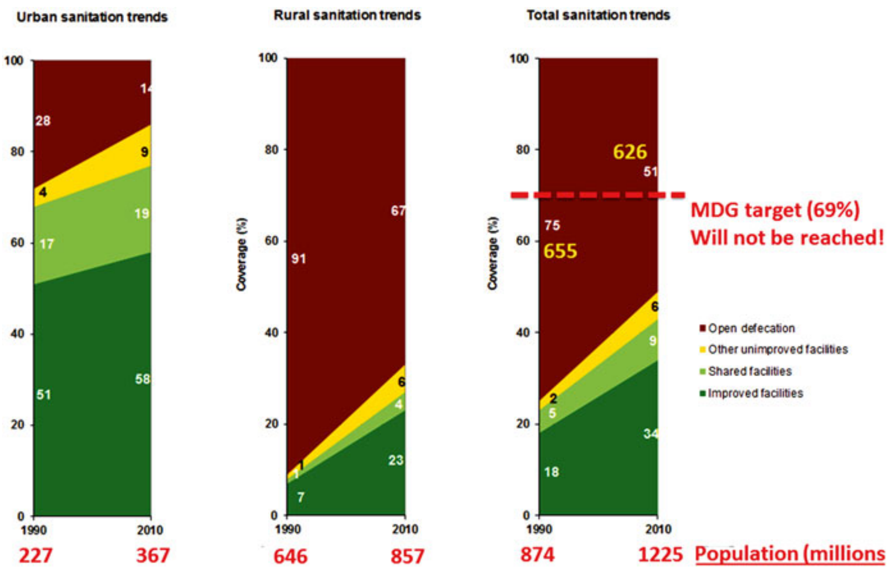

Fig. 4.5 Sanitation provision in India 1990–2010 (WHO/UNICEF 2012)

4.4.2 *Urban*

India is rapidly urbanizing and now almost one third of the population lives in urban areas. Associated with the rise in urbanization, WASH access for the urban poor is an issue of concern. Although the 11th Five Year Plan (2007–2012) considered the census slum population (42.6 million, 14.88 %), it is also mentioned in the document that 'almost 30–40 percent of India's urban population lives in slums' (Planning Commission 2008).

Water supply is not uniform across all cities or states. The average per capita water supply for Class I cities of Tamil Nadu is 79.9 l and for Maharashtra, it is 310.09 l, whereas the average per capita per day water supply for Class II cities of the state is 106.74 l. Among the Class II cities of Maharashtra, water supply ranges between 34.5 LCPD in Malkapur to 464.94 LCPD in Anjangaon. Such variations are common across all the cities and states of the country. One of the major reasons for wide variation in per capita water supply is the poor management of the water supply system. Levels of system losses through 'unaccounted-for water' or 'non-revenue water' are often as high as 50 % in Indian cities and represent large financial and environmental losses to cities and their economies. A study of four cities of Madhya Pradesh revealed that this Non-Revenue Water (NRW) ranged between 31 % and 49 % in Bhopal, between 37 % and 43 % in Jabalpur, and between 36 % and 66 % in Gwalior; based on the study, city-specific water demand management strategies were developed to minimize water losses and to increase revenue for municipal corporations (UN-HABITAT 2006).

Discharge of untreated sewage is the most critical water polluting source for surface and groundwater in India. Estimated sewage generation from Class I and Class II cities is about 38,000 million l per day (80 % of the water supply) and only 31.5 % of the generated sewage can be treated per day on the basis of the installed capacity. Estimated sewage generation by Class I cities is 35,558 MLD and sewage treatment capacity is only 32 % of the total sewage generated. Estimated sewage generation from Class II cities is about 2,697 MLD and the treatment capacity is only 8 % of the generation. Thus, 70 % of untreated sewage from Class I cities and 92 % from Class II cities contaminates surface and groundwater on a daily basis. Location is the deciding factor for source and availability of drinking water. It is reported that 50.7 % of urban households have access to piped water supply at home but access in non-slum and slum areas is 62.2 % and 18.5 % respectively.[1] Further, the disparity on the basis of tenure status is more severe and, generally, households of the non-notified slums are totally deprived from piped water supply in a dwelling unit (Fig. 4.6). The disparity in access to improved not shared (individual) toilet facility between slum and non-slum households is clearly visible. Also clear is the urban–rural sanitation divide, as well as social group disparities (Fig. 4.7).

In India, empirical observations indicate that there is a vicious cycle of relationship between the insecurity of housing tenure and access to basic services. Tenure security is defined by housing conditions and employment status. In general, those living in slums are considered as poor. But, among the slum dwellers, there is a hierarchy of tenure security. Basic services such as housing, water and sanitation, electricity, education, health and above all employment and access to credit also play a vital role in the overall development and enhancement of quality of life of the poor people living in slums. But, basic services, such as water and sanitation are not available to the slum dwellers living in 'illegal' housing or what is called 'slums with insecure land tenure'. Hence, land tenure has a very significant link with access to basic services and therefore poor and most needy are left out of the formal systems of water supply (Darshini and Shah 2009).

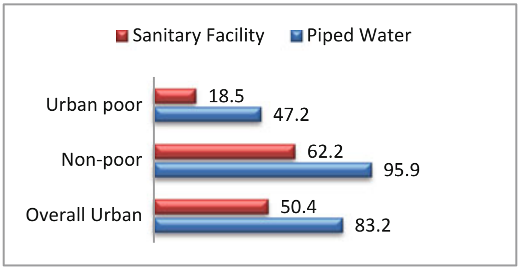

Fig. 4.6 Status of piped water supply and sanitary facility for urban poor and non-poor

[1] '*Key Indicators for Urban Poor in India*', available at http://www.uhrc.in/name-CmodsDownload-index-req-getit-lid-99.html (accessed 16 October 2011).

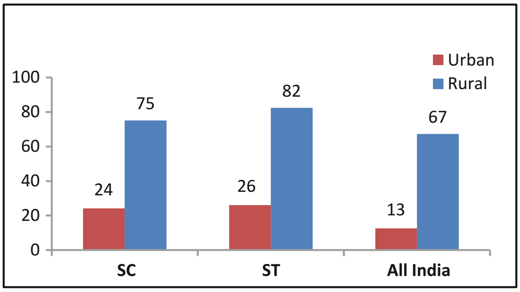

Fig. 4.7 Open defecation rates (%) across scheduled caste (SC), scheduled tribe (ST) and the all-India national average, analysed from Census (2011)

4.5 Challenges in Ensuring 'Water for All'

The previous section showed that the present framework for managing water has not yielded its desired policy outcomes in terms of supplying water to all and catering to the needs of the poor and marginalized. Approaches on water seem isolated and not integrated. Responsibilities for service delivery have been shifting to local bodies – urban local bodies (ULBs) and Panchayati Raj Institutions (PRIs). However, most of the time, these local bodies are unable to manage due to paucity of manpower, and lack of awareness and understanding of planning a water resource development and management activity. In most states, institutions created for water management at the community level are not accountable and therefore do not have any legal identity. They also lack capacity in merging multiple programs and schemes. The question therefore is this: What can be done to change the situation? In this section we outline some of the challenges that need to be addressed in a coordinated fashion to further the goal of supplying water for all.

4.5.1 Economic Challenges

It is also imperative to take into account that people cope with declining water availability in a variety of ways. A recent study of the costs of coping with inadequate water supply in Delhi found that the true total costs of water supply are already 'privatized'; on average, the private coping costs are Rs 262 per month (when capital costs are included) versus a monthly water bill of only Rs 141 per month (Misra 2005). Indeed, the provision of availing a consistent 24 × 7 supply to water at higher cost might not appeal to the elite group which already has ensured supplies by means of bore wells, water storage tanks or pumps. Managing this water scarcity situation is an immense challenge due to the socio-economic set-up of the country. Another study, a water balance study of municipal water supply conducted in four cities of Madhya Pradesh (UN-HABITAT 2006) suggests that the available water supplies theoretically translate into per capita availabilities ranging between 150 and 70 liters per capita per day (lpcd). But at the consumption end, the availability remains low, due to substantial non-revenue water which is estimated to range among cities between 28 % and 45 %. The study reveals that the present water supply problems can be attributed to lack of governance and inadequate monitoring infrastructure rather than to scarcity of water resources. The financial and institutional assessments suggest that the reporting on revenue is inappropriate with poor estimates of collection efficiency, revenue and expenditure and over reliance on the government for financial support.

Competing uses also reflects in the economic domain. A key player with ever increasing water demands is industry. Industries are a large promoter of economic growth and as India strives to maintain and accelerate its impressive GDP growth, the demand for water in the industrial sector is also bound to increase. India is the tenth most industrialized country in the world with about 88 industrial clusters scattered across the country (CPCB 2009). Water is an integral component in industrial infrastructure and hence its importance in sustaining the GDP cannot be undermined. As mentioned before, the industrial sector accounts for only 2 % withdrawal of the total freshwater resources of the country. According to the projected water demand for 2030, the demand from industry will quadruple to 196 BCM (13 %), pushing overall demand growth close to 3 % per annum (Addams et al. 2009). An analysis on water use in industry, making a case for the underestimation of water use by the industries in India (CSE 2004) argues that water use efficiency in Indian industries is significantly lower in comparison with other developing countries in the world.

4.5.2 Political Challenges in Ensuring Water as a Human Right

Water is an immensely political issue due to the nature of the resource. This resource interacts with a highly inequitable society marked with class, caste and gender differentiation. Techno-managerial reforms in the water sector have been unable to tackle the fundamental issues of inequity in water supply.[2] In this light, the right to water issue becomes important. India is now a signatory to the 2010 United Nations (UN) declaration of water as a right. A rights-based approach to water means that communities have the opportunity to participate in decision making on water-related projects and plans, and have access to information concerning water, such as safe hygiene practices and water quality data. Ensuring right to water means that the obligation to guarantee that everyone has access to safe clean water rests with governments.

[2] Prakash and Sama (2006) document one such experience from Gujarat where water access is intertwined with caste and gender relationships. The authors observed 'that power structure and social and economic hierarchy go hand in hand and unless the issue of resource inequity is tackled through policy and advocacy means, the real issue will not be solved'.

All stakeholders, especially the state, market, community and civil society, are critical to resolving the challenges faced in the water supply landscape in India today. The prime role of the state is to formulate people-centric policies thus ensuring parity. Also, to bring in strong directives for those violate the existing laws and regulations. The market is seen by many as a profit-making entity that may compromise on the issue of equity and sustainability. Under strong state regulations, markets do play a positive role in water service delivery, research and development, and also water-related technological solutions. There is no single entity known as 'the community' as it is divided by socio-economic class, caste, tribe, age, gender. Models exist for the community's self-regulation, which needs to be seen in an overall framework of people-centered development with more political and financial powers for the community to implement water-related projects. The role of civil society becomes important here as it helps community capacity building thus enabling community members to manage resources in a decentralized resource management framework. Their role in having a close watch on the water management process is also important for equitable water distribution and sustainable management of the resource.

Community involvement in a structured process is essential to achieve this, right from the planning to implementation level (for example Biswas 2012). However, the problem is twofold; on one side, the authorities lack planning, and the community, too, is not actively getting involved in water supply projects. Wherever the gaps from both ends have been met, the water supply projects have been successful. Other related issues are gaps in technical capacity at the level of the resource, delivery, distribution and O&M, lack of information about the policies and plans, and political interference.

4.5.3 Environmental Challenge of Dealing with Water Availability and Scarcity

With an estimated per capita availability of 1,588 cu m/capita/year (CWC 2010), India does not fall under the category of a water scarce country per se, rather it can be termed as a country under 'water stress'.[3] However, India faces a large gap between current supply and projected demand, amounting to 50 % of demand or 754 BCM (Addams et al. 2009). Any analysis pertaining to water resource management in India would be futile without incorporating the spatial and temporal variations in the distribution of the resource. Erratic distribution of rainfall, results in to floods and droughts in various areas of India. While theoretically it might be feasible to divert water resources from surplus to deficit regions, the ecological sustainability

[3] According to the UN an area experiences water stress when annual water supplies drop below 1,700 cubicmetres (cu m) per person. When annual water supplies drop below 1,000 cu m per person, the population faces water scarcity, and below 500 cu m 'absolute scarcity'.

and affordability of such an exercise puts constraints on its implementation. Even in the areas where water is made available it is important to revisit the sustainability of such supply by looking into service indicators and customer feedback rather than mere technical supply indicators. Further, climate change is now become one of the developmental challenges for nations across the world. Climate change has an altogether different connotation for a country like India due to its varied topography, consisting of diverse bio-geographical features including forests, coasts, mountains, mangroves, islands. Further, the dependence of people, especially the poor, on the natural resource base also makes them more vulnerable to such changes. The Lower Bhavani Project in Tamil Nadu, is a clear example, where the most significant uncertainty factor is rainfall variability (UNWATER 2012). This has led to water scarcity and a highly unpredictable situation for the farmers without canal supply to endure and adapt to seasonal fluctuations in water availability.

Water pollution is adding to India's water woes with almost 70 % of surface water and an increasing percentage of groundwater being contaminated by biological as well as chemical, organic, inorganic and toxic pollutants (MoWR 2000). The sources of such pollution include point sources such as industrial effluents and domestic waste, and non-point sources such as agriculture. The health implications of poor water quality are enormous, and water and sanitation related diseases are responsible for 60 % of the environmental health burden in India (Planning Commission 2008). Water quality is another major concern. The presence of pathogenic microorganisms in drinking water is an extremely important parameter of water quality given the crucial role water plays in healthy lives. The world over, unsafe drinking water, along with poor sanitation and hygiene, are the main contributors to an estimated four billion cases of diarrheal disease, causing more than 1.5 million deaths, primarily among children under 5 years of age (WHO 2011). Surveys have estimated that over one third of rural ground water sources in India may be microbiologically contaminated, much of this contamination is preventable and proper operation and maintenance of water sources coupled with safe sanitation practices (MDWS 2011a). Indeed, improving environmental sustainability of water and energy was been cited as one of the top ten interventions that India needs to accelerate growth, in order to reach its economic potential (Goldman Sachs 2008). As is evident from the gap between sewage generation and sewage treatment capacities of major cities, there is an immediate need to build appropriate infrastructure. There is legislation that addresses the prevention and control of pollution – for example, the Water Prevention and Control of Pollution Act of 1974, Water Cess Act of 1977 (amended in 1988 as the Water Prevention and Control of Pollution Cess Act), and the umbrella legislation, the Environment (Protection) Act or EPA (1986). Recently, the Right to Information (RTI) has also been used by activists and people as a potent legislation to deal with discrepancies in the water sector. Although the Indian government is working more proactively on the increasing threat of water pollution, it will take very significant political will for these actions to translate into concrete measures resulting in improved water quality.

4.5.4 The Challenges of Equity and Distribution in Water Supply

One of the major constraints often cited for India in achieving developmental goals is the pressure of an ever-increasing population; it has now reached over 1.21 billion (Census 2011). The per capita water availability during this period has decreased from 2,309 cu m in 1991 (Sharma and Bharat 2009) to 1,588 cu m in 2001 (CWC 2010). Considering the projected population growth in 2025, the per capita water availability can further decrease to under 1,000 cu m. Despite the National Water Policy (NWP) assigning the highest priority to drinking water, providing adequate and safe drinking water to every household in the country remains an onerous task.

A projected 40 % of the population will be living in the urban areas by 2030 with higher purchasing power. This will increase calorie intake putting greater pressure on existing water resources. There exists a huge disparity between the water consumption patterns of the rich and the poor.[4] Access to water is governed by power relations in society with the poor often being differentially excluded from this process. The efforts to augment water supply and 'manage the scarcity' often concentrate on the technical and managerial aspects thereby reinforcing existing inequalities. It is imperative to consider the relational aspect of water scarcity and the differential consumption patterns as the scarcity experienced by a poor person with reference to basic livelihood needs should not be clubbed with the luxury needs of the urban rich.

Provision of water supply and sanitation for increased population in urban areas and provision of infrastructure in peri-urban areas are some of the challenges faced by the government. At the moment, the policies are either geared towards urban or rural areas with different institutional setup for delivery of services. The peri-urban areas in this case face greater challenge as they face the brunt of urbanization and lose their water security to fulfill increasing urban demand for 24 × 7 water. In many areas, tankers fetch water from peri-urban areas and supply them to urban domestic and industrial use. Prakash (2012) documents the case of Hyderabad where tanker economy is thriving at the cost of peri-urban water security. Due to large influx of population mainly because of the expansion of the city as an Information Technology (IT) hub, the peri-urban areas have been losing out on water access to the more powerful urban population with high paying capacity. These areas are witnessing change in two ways. First, they cater to the rising urban economic class that is ready to pay for constant water supply through the sale of water fueled by an informal water tanker economy. Second, peri-urban areas and their citizens are at the receiving end of the waste water produced by cities, and suffer the consequences in the form of polluted rivers, industrial and domestic waste and a damaged urban ecosystem. This trend has led to immense water insecurities due to a combination of

[4] A study by Water Aid in Delhi reveals that in one particular locality, '92 per cent of water supplied goes to 20 per cent of population and the remaining 80 percent of population gets 8 per cent of the total piped water supply'. See Water Aid (2006: 58).

issues –urban growth induced water scarcity; myopic planning that is not based on available environmental resources; lack of recognition of community water rights and lack of regulation for the protection of diminishing surface water resources.

The final key issue to be considered under social challenges is gender. Rural and urban women of almost all age groups are engaged in collection of water for household needs, including water for livestock. Women balancing pots of water on their heads while travelling vast stretches is a common sight in rural India, as is the serpentine line of women standing in queues in urban slums to collect water from a single tap! Indeed, water collection is a responsibility that primarily rests on women. The average distance travelled by women every single day in rural and peri-urban India has been a subject of countless surveys, and the fact that this indeed affects their overall health and decreases productive work hours is established in many research studies.[5] The girl child's educational and overall self-development status suffers a serious setback in a society where they are considered inferior to the male child by getting involved in water collection and other household chores constrained by water supply. Although the policy discourse has recognised this role of women, it has not come without its own peril. Women's role in government water schemes has largely been reduced to water collectors while undermining their potential for involving them in the decision-making process. As per the NRDWP guidelines, the members in VWSC should be selected to represent various groups of society and 50 % of which should be women especially those belonging to SCs, STs and OBCs. The efforts were made to involve more and more women in the programmes at a policy level. However, in reality and on the ground, these provisions are hard to implement because of strong gender bias. The technological interventions which do not take into account the social, economic and familial constraints of a society with respect to women, may lead to unfair outcomes for them.

4.5.5 Institutional Issues

India has a significant governance deficit when dealing with changing water scenarios. Severe water shortages have led to a growing number of conflicts between users in the agricultural and industrial sectors, as also the domestic sector. The pressures and drivers that stem from demographic, socio-economic, industrialization and urbanization processes could have been better dealt with, if there as a sharp vision for governance of water. Governance of water is divided between the central and state authorities, with categorization of rules and responsibilities, yet it is seen that the overall sustainable vision for water development, conservation and management remains missing. There is a dire need for convergence of laws and legislations; there exist too many laws and this in turn dilutes the water issue. The coordination and synchronization between departments/implementers and regulators is fragmented leading to each department doing things without coordination with other

[5] See, for example, Seaforth (2001).

departments, and sometime at cross purposes. The regulatory bodies have not been strict in controlling, for example, appropriation of water bodies, industrial pollution. Also, there is lack of data disaggregation and aggregation in important decision making by the body involved in water planning. Data is generated by different bodies and is sometimes contradictory in nature. The importance of data and its input into management and regulation have been stressed for the 12th Five Year Plan (Shah 2013). Much stronger political will is equally essential in finding sustainable solutions to water problems and reducing the current governance deficit in water (UNICEF, FAO and SaciWATERs 2013).

4.6 Conclusions

Here we have traced the sector development in India, both in urban and rural areas, and have outlined the issues currently holding back progress. India has had significant challenges to date in managing water. Emerging challenges such as climate change are going to further transform the water management scenario rapidly. This chapter shows that the present framework for managing water has not yielded its desired policy outcomes in terms of supplying water to all and catering to the needs of the poor and marginalized. Approaches on water seem isolated and not integrated. Responsibilities for service delivery have been shifting to local bodies – urban local bodies or ULBs and PRIs. However, most of the time, these local bodies are unable to manage due to paucity of manpower, and lack of awareness and understanding of planning a water resource development and management activity. In most states, institutions created for water management at the community level are not accountable and therefore do not have any legal identity. They also lack capacity in merging multiple programmes and schemes. The question therefore is this: What can be done to change the situation? Would treating water as a basic human right change the way we look at water governance? While there is some recognition of right to water in international human rights, as well as in the Indian constitution, at the level of state legislation and policies in India, different dimensions of right to water do not get much support. This is true even of cases like Maharashtra, where a particular version of rights (for example, entitlement to water) has been put forward. In addition, there has to be stronger disincentive for polluting the water source which accentuates the scarcity situation while polluting freshwater resources. Thus, infrastructure for waste water management needs urgent intervention. The structure and mechanism for conflict resolution between the sector and states need urgent attention. Unless these concerns are met, the right to water, even if it is guaranteed, will not bring fundamental change in the way water is conserved, managed and delivered.

Given the multiple problems that the water sector faces, it is necessary to re-think the approach to planning and implementation of the water projects. Since water is used for multiple purposes, involving potential users from the start of a project should be made central to program implementation but it must be asked if the current institutional set-up has the necessary manpower and skills to do this. The governance structure around water has undergone considerable change with a view to be more participative rather than techno-centric, though there is considerable scope for capitalizing still on this policy shift and this really is the key to sustainable services delivered with quality and equity.

Disclaimer The views expressed herein are those of the authors and do not necessarily reflect the views of UNICEF, or the United Nations

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Chapter 5
Gender and Water in India: A Review

Seema Kulkarni

Abstract This chapter provides an overview of key issues in the area of gender and water. It gives an overview of different debates around women and environment and shows how these have shaped the discourse and practice around gender and water. The chapter then goes on to discuss the reforms in the water sector at the global level and how this has impacted the discussions around gender and water. A comprehensive review of literature is done in the context of India which covers the various writings and actions in the area of gender and water. The review specifically looks at gender and equity issues in the areas of rivers, dams and displacement, water for production and domestic water.

The chapter argues for going beyond the politics of representation and developing new agendas and creative forms of engagement with people's movements- more specifically women's movements, farmers movements and unions working on the question of growing informalisation of the economy, greater accumulation of capital, increasing injustices and disparities in everyday living- to see the linkages between land, water, rivers, natural resources and livelihoods.

Keywords Ecofeminism • Gender • Domestic water • Water for production • Dams and displacement

5.1 The Historical Context

The early 1970s witnessed a global environmental crisis with a model of limitless growth at the cost of nature. This was increasingly being challenged with questions around sustainable development raised by environmentalists the world over. Among these were also strong feminist voices questioning the unsustainable paradigm where women and mother earth were exploited. Eco-feminist thought primarily

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developed as a response against destructive nuclear power, anti nature development paradigms evolved as a powerful challenge in the first world context forcing debates on zero growth development. In the developing world however the context was different and a zero growth model could not be conceived of in the midst of poverty. Environments and their conservation had thus to be seen in the context of the millions who depended on nature for their survival.

Subsequently a large body of literature developed around the theme of Women, environment and development both in the developed and developing world, primarily as a response to the crisis on nature and its people. Actions and writings around these themes were a wakeup call for governments. The World Commission on Environment and Development (WCED), better known as the Brundtland commission was set up in 1983, which came out with the report "Our Common Future" (1987). This was followed by the Earth Summit in 1992 at Rio. The Summit marked a new momentum in the women and environment debates. Since then there have been several summits and conventions on issues related to sustainable development.

In a sense 1992 can be considered as a marker for work around gender and water emerging globally. Its roots of course lay in the rich body of work coming as a response to environmental degradation, and the limitless growth in the first world countries since the late 1970s and more so in the 1980s and 1990s. Deep Ecology, social ecology, ecofeminism (Merchant 1983; Salleh 1990, 1991; Mies 1986; Mies and Shiva 1993), political ecology (Blaikie 1985), feminist political ecology (Rocheleau et al. 1996), feminist environmentalism (Agarwal 1992) etc contributed significantly to literature and actions around gender and water.

Ecofeminist thinking however had a lasting impact on actions, programmes and writings around gender and the environment. There is however no one single ecofeminism but several ecofeminisms broadly classified as cultural and social ecofeminism. Cultural ecofeminism has been critiqued for its biological determinism which sees a close and inherent association between nature and women. Since the survival of both is so intricately linked, women are seen as the nurturers and regenerators of nature. These positions drew heavy criticisms from social ecofeminists as well as other feminists for essentialising both women and nature, for seeing them without the complex web of relations in which they are bound with each other and the larger society. Social ecofeminists or feminist environmentalists understood the relationship between women and the environment as based in a material relationship. Women's reproductive work of collecting fuel, fodder, water brings them in close connection with the environment and hence their knowledge and experience becomes crucial in the management and regeneration of nature. At a macro level the work of Maria Mies (1986) is crucial as it looks at exploitation of nature, women's labour and other subsistence workers from the developing world as a systematic process of entrenching new patriarchies and capitalist accumulation on a world scale (Mies 1986).

What is important for us is how these debates informed the women and environment related actions and policies and vice versa. In the developing world contexts early actions and writings on gender and environment were framed within the oil crisis of the early 1970s, the increased dependence on wood fuel and women's burden in collecting wood fuel. Women were thus seen as victims of this degradation facing the brunt of degrading forests, depleting water resources. Large scale forestry programmes were planned to address this concern and by the 1980s there was a realization that most of these had failed since there was no community participation; this understanding led to programmes being planned with communities participating in forestry management and community was understood as women because of their close relationship to nature. The widely acclaimed Chipko movement from India in a sense changed the discourse with women being projected as the protectors of forests hugging trees to save them. This significantly contributed to the framing of women as the solutions to the problem of degrading environments (Shiva 1989). Thus from victims women were now being viewed as solutions to the crisis. Guha's (1989) ethnographic work which traced the long history of the movement, its Gandhian tradition gave a different view to the Chipko movement by pointing towards the shortcomings of an essentialist interpretation of Chipko which ignored history.

Learnings from this body of work led to formulations which tried to locate the environment and gender question within broader frameworks by addressing the dynamic and complex relationship of nature, and genders, diversity and development (Agarwal 1992; Green et al. 1998; Jackson 1993; Rocheleau et al. 1996). The backdrop of this discussion is important for us to locate work around gender and water which was largely informed by these debates.

5.2 Global Policy Changes in Water

In Dublin in Ireland in January 1992 the International conference on water and environment for the first time stressed the importance of women's participation in water management. Strangely it was the same conference which also clearly laid the basis for commoditization of water. All of the four principles[1] were accepted and were recommended to the countries across the globe at the Rio Earth Summit held later in the same year. Participation through decentralised planning and management and cost recovery through pricing were considered as important measures in water management in the post Dublin era. It also marked a clear shift from a

[1] The four principles Principle 1: Fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment.

Principle 2: Water development and management should be based on a participatory approach, involving users, planners and policy-makers at all levels.

Principle 3: Women play a central part in the provision, management and safeguarding of water.

Principle 4: Water has an economic value in all its competing uses and should be recognized as an economic good.

technocentric approach to water management to one which recognized the need for institutional restructuring and economic reform. Following this were the World Water Forums since 1997. The first one was in Morocco, Marrakech in 1997 where the main theme was to develop the "Vision for Water, Life and the Environment in the 21st Century." It was in the second world water forum held in 2000 at the Hague that gender issues got firmly entrenched with the formation of the Gender and Water Alliance or the GWA (genderwateralliance.org). International agencies acknowledged the need to involve men and women in planning for water (UNDP 2003). As part of the Global Water Partnership formed in 1996, country water partnerships were set up in different countries and many in South Asia had Women and Water networks that emerged from the country partnerships. Much has happened since at the global level in terms of recognizing water as a human rights issue on the one hand and commoditizing it on the other, however gender remains a stated but unaddressed cause. The rhetoric on gender will remain a distant dream unless it is located historically and understood as a set of complex relations between the different genders, defined identities and embedded in hegemonic power relations (cutting across caste, class and race) that serve the interest of state, capital and patriarchy.

5.3 The Gender and Water Literature: An Overview

Much of the documented work on gender and water emerges in the post Dublin period. A fall out of this was a spate of programmes designed to include women in water management, largely at the micro level institutions planned around domestic water. Most national and state governments brought in women's participation in their policy documents guided largely by agendas set by multilateral agencies. Feminist writings approached the question by highlighting the contradictions between recognizing women's contribution as significant on the one hand and turning water into an economic good on the other (Cleaver and Elson 1995; Green and Baden 1995; Zwarteveen 1998).

Framing women as being connected closely with nature and thus as privileged knowers and placing undue burden of water management and conservation on women drew heavy criticism from feminists. These critiques brought out the instrumental approach to women's participation in water. They also pointed to flaws in understanding women and communities as homogenous without addressing the structures (caste, class, race and other differences), identities and discourses that determine access to water (Ahmed 2005; Joshi and Fawcett 2005; Kulkarni et al. 2007; Rocheleau et al. 1996).They called for a more nuanced approach to understanding gender and water, locating it in the larger political ecology framework. In a nutshell then, we have literature that supports the essentialist view of women's close association with nature and hence water and that which counters this view by saying there is nothing inherent and essential in the association. Within the realm of these debates policy makers and to a great extent uncritical practitioners continue to understand women as instruments to address the water crisis, especially at the micro level.

It is indeed a difficult task to take complete stock of gender and water issues in the Indian context in one article here. The first challenge is to organize the multifarious and overlapping writings on this topic in any compartments. But a broad categorization that seems useful for this particular review looks at writings and work around (a) rivers, dams and displacement (b) domestic water and (c) water for production. Again these are not mutually exclusive categories but would help us unravel the different meanings around water and its relation to gender. We already have two good books, namely, 'Flowing Upstream', edited by Sara Ahmed (2005) and the more recent one 'Diverting the Flow' edited by Zwarteveen et al. (2012) in the Indian and South Asian context which are devoted to gender and water and they become important references for those interested in this topic.

The second challenge is to bring readers to appreciate the rich and path breaking work by feminists in unpacking the basic concepts of gender, sex, labour, social/gender relations, division of labour, productive and reproductive labour, intersection of gender with caste, class race and other forms of social and economic discrimination. Rather than going into an elucidation of this work here I would like the water readers to refer to some basic writings on gender and patriarchy in the Indian context (Geetha 2002; Chakravarti 2006; Menon 2012; Mohanty 2004; Ghosh 2009) that show that gender is a social construct that intersects with other hegemonic structures like caste, class, race etc to create unequal power relations which greatly disadvantage women especially so from disadvantaged social groups. It is an organising principle that creates identities which determine how we are perceived and expected to think and act. Gender relations are thus social relations between the different genders that reflect the distribution of power. They also determine the work we do and the work that gets valued or not. Productive work is considered as valued work, which creates surpluses and is largely done by men it is believed while reproductive work is largely unpaid work that is significant from the point of view of subsistence and welfare of the household. Much of this work is done by women and is not recognized as work and less still as work that contributes to accumulation of capital. These images, symbols and meanings around gender and gender relations get firmly entrenched and carried forward through institutions like family, marriage, state, religion and markets for example. With this as a historical context we can now see how and why gender mainstreaming in water is not only about changing water policies but about bringing about a paradigmatic change in our understanding of water and gender.

5.4 Rivers, Dams and Displacement

Rivers have several meanings in India; they are the source of life and livelihood and have a strong religious and cultural meaning in people's lives. In the Indian context reference to rivers has often been as female. Feldhaus (1995) points out how waters in rivers are attributed with feminine properties in folk as well as classical material in rural Maharashtra as elsewhere in India. She points to not only the purifying powers of the rivers but also their fertilizing properties. Her work discusses the folklore around rivers in Maharashtra, which she shows is linked to different goddesses of fertility and fecundity. They depict the different cycles of life i.e birth, growth and death. Feldhaus gives several references from the Vedas that refer to river in the feminine and describe the beauty, benevolence and the rage of the river.

Lahiri Dutt's work also discusses through an ethnographic work on the Bengal deltaic rivers how the images around rivers in these regions are constructed as feminine with qualities such as benevolence, nourishing and yet at the same time fearsome and frightening (Lahiri-Dutt 2006). She further goes on to show how natures are constructed within ideological frameworks and the construction of feminine rivers also reflects the gender relations within society that encompass love, hate and fear of women. Lahiri's work brings out the close relationship between the symbolism associated with nature and with women. She argues how this is used to the disadvantage of subaltern groups in this case women, as an "anchoring platform" to reproduce inequalities.

Shiva's work for example in Staying Alive (1989) points out how irrigation development, or damming rivers, to be more specific "violates cycles of life in rivers." and leads to drought and women's exploitation. She says "violence to the water cycle is one of the worst but invisible form of violence …. destroying the feminine principle and sustaining power of water and destroying women's knowledge and productivity in providing sustenance".

This literature informed by cultural studies looks at water not as part of the physical environment but also very much part of our social and cultural lives. While one strand tends to essentialise women by invoking the feminine principle the other uses this imagery to show how these symbols are selectively used to power over women and nature.

Construction of water scarcity and thus the justification for creating large dams has been one of the critical areas of work in water. Displacement caused due to submergence affects social and cultural lives of people in a significant way. Literature around gendered dimensions of large dams has received very little attention, despite the fact that several anti dam protests have seen women in the lead. Large dams change the entire landscape of a place by bringing in tenurial changes and property ownerships. It changes the way informal arrangements in resource sharing took place prior to the project. Women are most affected by these changes as it puts them in vulnerable positions. They lose out on their status in the community and their bargaining power becoming more prone to abuse. Literature has also shown how new formalized institutions in fact have a male character to them. Interestingly women are at the forefront of these struggles, but do not seem to benefit very much from them in terms of addressing gender inequities. These struggles however display the strong urge of women to change the course of dominant understandings around development (Mehta 2009; Lahiri-Dutt 2012). The Narmada movement and the lesser known movements in South Maharashtra are testimony to this. These are struggles against dispossession from land and water and the livelihood rights of people. But they also raise questions about the change that these projects bring about in their lives in terms of the social and cultural meanings that the rivers held for them.

5.5 Domestic Water: Female Domain

Documented examples of water for domestic use abound in the literature around gender and water. Several of these documented examples are also from regions where there have been stronger NGOs or organisations working on women, SHGs and rural livelihood issues. Women's collectivisation around water for domestic use stems from their role as providers of household care. Thus lack of water for drinking and domestic use implies hardships for women in performing their role as providers of care and nurture. We therefore find several examples where women have come together and responded to crisis of domestic water in very creative ways, either through engagement with the state, or through acquiring new skills in water harvesting, conservation, repair and maintenance and management. There are also examples of how women's collectives have through participatory processes resolved the water crisis of their villages. It may not be possible here to take stock of all the examples around drinking and domestic water, simply because there are a large number of such examples both documented and undocumented. For example noted socialist leader from Mumbai, Mrunal Gore was fondly remembered as Paniwali bai or water lady because she led several struggles for water, price rise and basic amenities in urban slums, and women were in the forefront of these struggles. As early as 1968 she fought for the right for water and other civic amenities for slum dwellers in Mumbai (Gavankar 2003). Numerous such tales abound in history where women have collectivised for water, largely to reduce their burdens of going through hardships to collect scarce water from long distances. Women's struggles around domestic water need to be understood in the context of the established system of division of labour where women's work includes domestic work of caring, cleaning, fetching water, fuel, fodder, cooking etc. or what is often referred to as reproductive labour in feminist work. In fact gender and water often gets equated with women and domestic water largely neglecting women's work with productive water. For example women's extensive labour in different stages of irrigated agriculture or use of water for tanning and other village industries hardly gets accounted as work related to water. Feminists have critiqued this division of water domains where domestic is considered as the female domain and productive water as the male. The established division of labour extends to the water sector as much as to any other dimension of work (Zwarteveen 1995, 1998; Kulkarni et al. 2007). Productive water involves commodity production, marketing and cash exchanges thereby giving an economic value to water, whereas domestic water remains as a consumption resource with no evident economic value. Feminists have pointed out that it is in fact these 'domestic' tasks of women that contribute to surplus generation and capital accumulation. However this analysis has not been systematically applied in the context of water.

Some of the well documented and visible examples of work around gender and water are those initiated by well established NGOs and organisations, such as Utthan, SEWA and Tarun Bharat Sangh to name a few.

In the Bhal region of Gujarat which has scanty rainfall and saline groundwater, women under the banner of Utthan formed a coalition called Mahiti and demanded solutions for clean and adequate water. The Gujarat water supply board thus agreed to approving a project to promote decentralised rain water harvesting structures, such as plastic lined ponds, roof top water collection tanks and similar such local solutions to address the water problem (*utthangujarat.org, accessed 11 june 2013)*. Sewa trained its women members in hand pump repairs so that they are equipped to deal with problems that arise due to failure of hand pumps. These trained women not only work as barefoot water technicians but in turn have also trained several women to deal with similar crises (Iyenger 2000; Ahmed 2000).

Tarun Bharat Sangh (TBS) in Rajasthan has been working for more than two decades now on revival of traditional water structures in Rajasthan and the idea of water parliaments has been a much acclaimed one. Increasingly TBS is engaging with women through the establishment of Mahila Jal Biradaris which is a village level collective that identifies the key reasons for the crisis and also looks for possible solutions for addressing it. Documented reports show that such processes have contributed to addressing water scarcity and reducing the drudgery of women (Field work discussions with TBS staff 2010).

In 2007 with a severe drought affecting the Bundelkhad region a local group Parmarth mobilised rural dalit women through its informal initiatives of pani panchayat and jal sahelis with the aim of conserving traditional water bodies and preparing water conservation plans for some of the districts in this region. For dalit women to come forward and challenge the caste ridden society, this was indeed a challenge. With a network of 2000 women across 60 gram panchayats in three districts of Bundelkhand they have not only addressed the water question but importantly also challenged the caste and patriarchal order of society and established right to water as a human right (Singh 2012).

These and many more examples from the rural context occurred in the post 1990s, which coincided with the Dublin principles of course, but also with increasing scarcity and mismanagement of water due to the extractive and iniquitous policies of the early 1970s especially with relation to ground water. All of these examples challenged the mainstream thinking around women and water. Utthan's experiment is important from the point of view of women's collectives being able to counter the conventional wisdom of the water departments to invest in large centralised pipeline projects which have not necessarily found answers to certain kinds of local problems such as this one. Both SEWA and TBS examples become important as they challenge the static understanding around gender roles as providers of care and nurture. While in SEWA women take on the role of technicians, which is otherwise considered as a male domain, in TBS women analyse, think together and find solutions again understood to be a male trait and prerogative. In both cases women take on new roles, challenge stereotypes and yet continue performing their old tasks as well. New work simply gets added on. How do we understand these examples- as using women as solutions to the problem and burdening them or as an opportunity to discuss the age old feminist question of division of labour. Unfortunately most gender and water interventions stop at the solution and do not use the space provided to challenge gender roles and division of labour thereby burdening the already overburdened women. Much of the gender and water work as we can see remains isolated from feminist politics despite the challenges it posed to water paradigm as well as to gender stereotypes.

5.6 Water for Production: The Male Domain

In the post 1980s reforms were being brought into public sector irrigation across the globe. Poor uptake of irrigation, failure of the governments to maintain and sustain irrigation systems both physically and financially were some of the evident triggers for this reform. Thus transferring irrigation management popularly known as Irrigation Management Transfer (IMT) and transferring operation and maintenance to the farmers, were the key elements of the irrigation reform process.

Gender was not on the radar of irrigation thinking since its objectives were clearly geared towards sustainable management of the systems and the increased efficiency of irrigation and crop productivity. Women were not considered as users and farmers were typically male. Thus in the initial years one finds little writing and thinking on gender and irrigation. Some of the early assessments of the IMT programmes were done by IWMI (then IIMI) Colombo which clearly showed that IMT was a mixed bag of experiences. Some were positive and many not so positive. However much of this analysis was within the framework of normal irrigation thinking guided by efficiency, productivity and financial recovery improvements (Vermillion 1997).

Critical writing on how the shifts in water policy impacted women in the context of irrigation also emerged around the mid-nineties. These writings pointed to the commoditization of water and a gradual erosion of water rights especially for women (Zwarteveen 1997, 1998; Kulkarni et al. 2008). However there were also cautionary articles pointing to the need to not ignore the agency of women and men in these changing contexts. Jackson (1998) argues the need to look at the subjectivities of women and their embodied livelihoods to understand the ways in which women relate to water (Jackson 1998).

Some of the early writings on role of women in irrigation also came from IWMI's gender group and it highlighted both the role of women in irrigation and also the impact of IMT on female farmers. These studies showed that a water user is not a neutral homogenous category, but there are differences between male and female water users since roles in farming are different. The authors thus argued that the impacts of IMT vary significantly across different groups of users (Zwarteveen and Neupane 1996).

Despite these differences women were not identified as farmers and were excluded from farmer organizations. Their interests were thus marginalized and this exclusion, the studies concluded, is constraining and may have serious impacts on women's well being (Merrey 1997).

Researches done in different parts of Africa and Asia also showed similar findings in terms of women's exclusion from irrigation planning, in some cases these exclusions were related to ownership of land and in others simply because of a lack of formalized policies of inclusion of women in different for a to allow for better allocation of irrigated lands (van Koppen 1998). Extensive researches were done to identify and typify women farmers across different regions of the globe and provide a tool base for assessment of indicators for improvement of gender performance (van Koppen 2002).

In the Indian context IMT was largely known by the name of Participatory Irrigation Management. Although there are historical evidences of community managed irrigation systems that can be traced to centuries ago the formal idea is as recent as the twentieth century. In fact Maharashtra and Gujarat had formed water users associations as early as the 1930s. Although there was little response then, the PIM movement in India geared up towards the late 1980s with the first formal Water Users Association being formed in Maharashtra, in Ahmednagar district on one minor canal of the Mula Major Irrigation Project in 1989 (SOPPECOM 2004). Since then there has been leapfrogging in India with several states by the end of 2012 making PIM mandatory (Shah 2011).

Literature in the context of gender and irrigation is very sparse in the Indian context. Broadly it can be classified as literature that came from (a) critical understanding of irrigation as a modernizing project, increasing undue burdens of the laboring classes and (b) from experiences gained through including women in the PIM process.

Critical writings on irrigation and women's role came in the late 1980s and early 1990s. As mentioned earlier Shiva's writings brought out the destructive powers of irrigation through the damming of rivers- on both rivers and women. Agarwal and others have contested these views but in a different way shown how irrigated agriculture in fact hinges on the availability of cheap female labour thereby leading to their exploitation. In her study she showed how among the Garo tribes irrigation led to privatization of land and subsequent displacement of women from critical role in agriculture (Agarwal 1994). Agarwal and Shiva essentially show how development of irrigation in fact commoditised agriculture and displaced women from subsistence agriculture. This was also lucidly brought out by Ramamurthy in her study of WUAs in Andhra Pradesh where she shows how irrigation as a modernizing strategy has led to increased agricultural productivity and surpluses and in the process altered the sexual division of labour, workloads and labour processes of women across castes and classes to the disadvantage of women (Ramamurthy 1991). Studies in Maharashtra have also shown how irrigation, resultant sugarcane cultivation has led to intensified alcoholism amongst men and subsequently increased violence against women (Seshu and Bhosale 1990).

The other set of writings around gender and water in irrigation come from groups working in the public irrigation sector. This was partly as a response to donor agendas which in turn were also largely influenced by critical work around gender and water. Much of this work was within the framework of providing women with facilities that are directly related to their current roles of cleaning, cooking, washing etc. Thus bathing steps in canals or clearly demarcated spaces for washing and cleaning were some of the policy and programmatic prescriptions in the context of gender and irrigation (Shah 2002). This work pointed out that women's priority concerns and needs are around domestic water i.e. cooking, bathing washing i.e around the reproductive needs and not so much around the productive needs despite the fact that they were served by the canal. However it also brought out how women make multiple uses of a water system. Much of this literature emerged from practitioners working in the irrigation sector guided largely by the understanding that participation is a means to an end and in this case the end is clearly that of improving irrigation efficiency. Women are simply an add on. It also comes from disciplinary understandings that seldom challenge the existing social order. So neither are the goals of irrigation seen beyond efficiency and nor are women seen beyond their role of nurture and care for the household. The same organizations that set out with these understandings of irrigation and women also changed their objectives over time with exchange of new perspectives and ideas. A significant example in this regard is that of Aga Khan Rural Support Programme (AKRSP) in Gujarat which has been working on PIM extensively. Recognising that canals were used for multiple purposes such as washing, bathing, livestock and of course irrigation, the organisation decided to rethink canal management. They introduced women's nominal membership to the WUA committees irrespective of ownership to land in commands. Women were thus recognised as users of water. AKRSP fought against the rules of the Irrigation department and brought women onto committees. The experience has been positive and AKRSP has documented the change this action has brought about in women in terms of their active interest in management activities, participation in agriculture and farming related trainings, but above all the confidence in dealing with Irrigation officials and talking to them of their problems (Vasavada 2005).

However around the same time or a little earlier there were writings in India looking at lift irrigation schemes and women's participation in it from a feminist perspective. These writings looked at empowerment and changing gender relations as a result of irrigation and related interventions (Ahmed 1999). Sadguru foundation working in tribal areas of Gujarat in its lift irrigation interventions involved women in decision making. Despite the restrictive rules of the government in terms of including women in the executive committee of the lift co-operatives, Sadguru went ahead and formed the committees with nominal membership of women. Later in 1996 the law was amended to include three women on the executive committee of the Lift Irrigation co-operative. According to Sara Ahmed's study of three lift co-operatives of Sadguru, women's lives have changed substantially. In her study she brings out the positive impact of women's participation in the scheme and the role they played in resolving conflicts related to water sharing and water rotation. She has also documented changes in women's self perception, confidence and importantly mapped the changes in gender roles that were brought out so vividly after Sadguru's participatory exercise to map changes in sexual division of labour.

In Jharkhand with support from Professional Assistance for Development Action (PRADAN) an innovative programme around women's participation in Community managed lift irrigation schemes (CMLI) was initiated. Initially designed to be the male irrigators programme in the dry areas of Jharkhand, the CMLIS were later controlled by all women WUAs linked to the SHGs. When managed by the men farmers, WUAs it was reported were not effective as water charges were not being collected, and maintenance was not being done apart from several other problems in running the scheme effectively. When Pradan decided to finally close down these schemes, they thought of using the rich SHG experience with women and asked women if they would be able to manage the WUAs. After considerable inputs in terms of organising the WUAs around the existing SHGs, training the women in O&M, all women WUAs were formed and full charge of these WUAs was then taken over by the women, cutting across different SHGs. The successful management of this activity, enhanced the self esteem of women and their confidence grew (Sarkar and Sarkar 2005).

Earlier still from the late 1980s to early 1990s there were new ideas being discussed in non party political groups in Maharashtra which looked at water as a means of production and thus calling for sharing this resource in an equitable manner. Shramik Mukti Dal (SMD), a left thinking group articulated this in the form of right to assured water for livelihoods at an affordable cost. SMD worked out through intensive field based experiments the quantum of water that a household of five would require annually in a drought prone region. The demand was also expressed in terms of a per capita requirement to ensure that women are not excluded from this right in a household context irrespective of landholding. In principle thus SMD included the rights of women and landless in the context of water. The operationalisation of this right was of course a far more complex matter. Thus when the organization after a long struggle against the sand mafia planned and implemented its first people's dam- Baliraja, it ensured sharing of water rights not only on a household basis but made separate allocations within the household for women. This was exemplary and radical and addressed the gender question in the broader framework of societal change and gender justice. A few experiments were initiated on a few plots where one tenth of an acre was carved out for women and they began cultivating it using some of the water allocated as a household resource. This initiative needed a concerted effort for it to see its fuller development (Joy and Paranjape 2005).

In Karnataka the example of women's collectivisation in Kolar district of Karnataka where rural women were organised since the mid 1980s by Grama Vikas is significant. Kolar district has about 4500 traditional tanks which were constructed and managed under royal patronage. Most of these tanks were filled with silt and were no longer able to fulfil the water requirements of the communities living in the area. Women spoke about this to Gram Vikas and thus Grameen Mahila Okkuta (rural women's collective) was formed. With a strong mobilisation they were able to pressurise the government to repair and desilt these traditional tanks which then became a significant source of water (Joy and Paranjape 2005).

NGO efforts in involving women in decision making in PIM were seen across the country through the 1990s. In Orissa PIM was introduced in the mid nineties through a state level policy. Thereafter formation of water users associations (WUAs) and transferring of management of irrigation to these WUAs became a targetted programme of the Irrigation department. In the initial stages there were no special efforts made to involve women in these WUAs. Aunli command of Angul district was one of the early experiments in irrigation to involve women in planning and decision making (Dalwai undated). This was possible because interestingly 67 % of women owned land in this canal command. Men had not responded to the governments call to form a WUA, but women saw the potential and collectivized to form the WUA and an all women's executive committee that took and implemented key decisions. This example is very important and marks a milestone in the history of women and irrigation in India (cited in Joy and Paranjape 2005).

Following on this in the mid 1990s a different kind of an experiment was initiated in Khudawadi village of Osmanabad district of Maharashtra. On a medium irrigation project of this drought prone region a WUA was formed on one minor canal of the Kurnur Medium Irrigation project with the initiative of SOPPECOM. Frustrated with their experience with the Irrigation department for more than 20 years since the completion of the irrigation project, farmers in Khudawadi responded to SOPPECOM's initiative of forming a WUA and entering into an agreement with the department. In this case however the farmers at the behest of SOPPEOM also added a new component of extending equity beyond the command area by including landless women as beneficiaries of irrigation water. The WUA thus agreed to a 15 % share of their water quota for landless women to use water outside the command areas. Lands were thus leased in by the women's collectives; storage ponds were constructed to lift the canal water and use it on the leased lands to grow fodder and fuel and some food.[2] In several ways this action countered the conventional thinking that irrigation is male and that it is limited to canal command (Kulkarni 2005).

Efforts on expanding the notion of equity in the irrigation sector continued and this is reflected in the writings in the post 2002 period. Stronger critiques of irrigation policies and programmes from a feminist perspective were gradually emerging on the gender water scenario in India (Kulkarni 2005; Kulkarni et al. 2007; Vasavada 2005). These critiques were also informing programmes and policy issues in the irrigation sector. They challenged the notion that women's realm is restricted to the domestic and the productive is for the men. These alternative frameworks have raised considerable questions regarding the conventional and instrumental roles expected of women in the water sector.

All of these examples where diverse groups of women stood up in a primarily male domain are noteworthy. Examples from Orissa, Jharkhand, Gujarat and Karnataka, indicate women's overriding considerations for survival and livelihoods and hence the need to take on challenges that men do not. These experiences do empower them and create some spaces to negotiate power within the households as was evident from the work in Sadguru. However, to conclude that water intervention alone led to these changes would be rather presumptuous. Examples from Maharashtra aim to change the discourses around water and gender. The SMD example particularly is making an effort to address the issue beyond water by looking at structures, identities and also the mainstream discourses around both water and society.

Two significant findings emerged from these early experiences (1) women play a significant role in irrigated agriculture and (2) despite this they are excluded from

[2] Details of how the negotiations were worked out can be found in Looking back … in flowing upstream.

formally or informally being represented in water users associations and involved in planning and decision making.

These findings helped in policy advocacy and mainstreaming some of these ideas in the field. It also led to stronger advocacy to define women as a category worthy of notice in irrigation and the need to bring them in decision making committees of the WUAs (Kulkarni 2005; Vasavada 2005).

PIM legislations brought in the recent years did introduce some changes in its governance structures. With the introduction of quotas in the managing committees for women and in some states[3] joint membership of men and women from land holding families within command areas have at least legally created a space for women in irrigation. The potential is large and some efforts are being made to use this space in Maharashtra and elsewhere. However, women's lack of participation in irrigation goes beyond the hitherto lack of legal or formal spaces. It goes back to the construction of irrigation as a male activity and the farmer as a male entity. It overlooks the labour of women in both the reproductive and productive terrains which contribute towards household survival.

While formal representation was being seen as an important demand by gender water advocates different studies since the late 1990s also showed how formal representation does not necessarily bring women into active decision making (Meinzen-Dick and Zwarteveen 1998); (Kulkarni 2011). In 1997 Ruth and Margreet's study on women and irrigation in the context of South Asia shows that despite some of the formal spaces granted in policies women are rarely able to use these spaces due to the iniquitous structures. As recently as in 2011, a study done by SOPPECOM, Utthan and TISS on decentralization, gender and water, points to women's lack of participation in decision making especially in the irrigation sector. It shows that despite formal representation women are simply not able to participate effectively as a result of past histories of patriarchy and caste (Kulkarni 2011; Kulkarni and Joy 2012).

In irrigation, of course formal representation remained limited to women who own lands in the command areas of these irrigation projects. Participatory Irrigation Management laws restrict membership of WUAs to owners or holders of land within the command areas of canals. This is the first level of exclusion and so far there has not been any headway in this regard. Madhya Pradesh is the only state which has made some progress by including spouses of land holders and owners in canal commands as members of WUAs. Thus in general the demand for recognising women as farmers and with a legitimate right to assured water has not been acknowledged by policy makers.

Right to water for production often becomes a tricky issue in the context of water for women especially because it is so closely linked with access to land. Studies around landownership have shown that not more than 11–12 % women own land (Agarwal 1994). Secondly mobilising women for water rights which are largely usufruct rights is complex as women are divided across social groups such as that of

[3] Madhya Pradesh PIM Act includes spouses of landowners and holders to become members.

caste, class, religion and across households. Identities around social groups and households are stronger, especially when it comes to livelihood resources.

As we can see much of the research and practice in the area of gender and irrigation has largely focused on making women visible through documenting gendered work patterns, which provides a case for improving their rights over water use and their representation in water related institutions like the water users association. While this body of work has been very useful in establishing a case for women and recognizing them as stakeholders in the sector, it has neglected some of the central issues of critiquing irrigation, its association with men and technocracy and the resultant exclusion of the weak or the powerless. Presence of women in water management is not only about ensuring that they enter the predefined formal spaces in irrigation decision making, but also how these pre-defined boundaries of thinking and practice can change. A comparison between both the sectors has shown us how the drawing of these boundaries has in fact served to maintain and strengthen the existing gender hierarchies and identities that foreclose options for change, how policy and programmatic changes are also constrained by the imagery and belief systems that surround irrigation thinking. As recent literature (see Zwarteveen 2008 for example) points out, exploring this relationship is perhaps what lies at the heart of understanding the power relations within the sector.

This has also led to developing another aspect of gender and water which focuses on men, masculinities and water (Zwarteveen 2008). This body of work looks at the association between masculinity and professional water performance and brings out how power and politics in water appear as self evident, static and gender neutral. It thus argues for the need for going beyond representation of women to critically looking at the nature of water knowledges. An initial exploratory study in the Indian context in this regard was done in the field of women as water professionals. This study done by SOPPECOM at the behest of SaciWATERs (SOPPECOM 2009) looked at mainly women engineers and other managerial level women professionals working in the water sector mainly with government departments across South Asia. The study clearly brought out the low numbers of women professionals in water bureaucracy and this linked to their understanding of water as a technocentric and masculine subject. It was also evident from the way water priorities were set (emphasis on infrastructure over participation), work allocations were decided (site work for men and desk work for women or financial and design planning for men and the administrative work for women) and of course infrastructure was available (no toilets and child care facilities in offices for example). Such studies would help unpack the gender question in the context of water in a qualitatively different way by understanding irrigation as a masculine and hegemonic discipline that constrains participation of women and other discriminated groups. The focus would then be to rethinking irrigation and revisiting our ideas around different genders, castes, class and power dynamics within and among them.

5.7 Concluding Remarks

While grassroots initiatives related to gender and water have responded to everyday crises related to water and social injustice, policies to address gender equity in the water sector have often been in an awkward relationship with the ground realities where gender and other forms of social discrimination pervade all aspects of life. They are simply not able to capture the social barriers that cause unequal access to water and an undemocratic decision making process.

A considered approach to gender or caste question in water would call for a critical analysis of the constraints imposed on women's and men's access to resources by social structures, the gendered divisions of labour and a water paradigm that brings in new reallocations and altered social and labour relations which firmly entrench new forms of discrimination.

Learnings from over two decades of work around this question urge us to give fresh insights to the question. While a social justice agenda that brings in representation of women and socially disadvantaged groups in decision making and access to basic livelihood water would be an important policy measure, there is a need to go beyond this policy rhetoric and address several other stakeholders through engaging them in creative ways of addressing inequities in water.

That there is a need to restructure both the water sector as well as our understanding of what constitutes the notion of women and gender relations has been stated on several forums. Policy suggestions based on this understanding have seen the inclusion of women and other socially disadvantaged groups in water institutions but has not improved their access to the resource (SOPPECOM 2002).

So while policy advocacy within water remains an important area of intervention, it's time that new agendas and creative forms of engagement are available for people's movements- more specifically women's movements, farmers movements and unions working on the question of growing informalisation of the economy, greater accumulation of capital increasing injustices and disparities in everyday living- to see the linkages between land, water, rivers, natural resources and livelihoods. There is a need to cut across sectoral understandings around natural resources since they are being appropriated by capital with active connivance of the state to the disadvantage of the socially and economically discriminated groups. There is a need to bring in interdisciplinarity in research and activism. It might be worthwhile for example to explore how (a) reallocations of water are modifying tenure, labour and consumption relations and identities, in particular focusing on caste, class and gender divisions and identities; (b) identifying new possibilities and proposals for influencing water decision making and water activism to arrive at forms of water allocation that are fair – in terms of how incomes and benefits as well as costs and risks are shared among different (groups of) people at different and across scales – and sustainable.

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Chapter 6
Independent Regulatory Agencies in Water Sector in India: Debate and Discourse

Sachin Warghade

Abstract The rise of the 'regulatory state' in developing countries has remained an understudied phenomenon. It is characterized by arm's length regulation, achieved by creation of Independent Regulatory Agency (IRA). The diffusion and transplantation of IRA models, from developed country context into a developing country context, is a critical juncture for analyzing the emergence of regulatory state in developing country. This paper reviews the debate generated in India when such transplantation began in a politically sensitive and ecologically complex sector like water. This is done by placing the local debate in the wider international discourse on IRA.

The review shows how different mechanisms of institutional isomorphism – coercive isomorphism, mimetic isomorphism, and policy learning – can be used to explain the structure and substance of regulation being adopted in India. Reforms through isomorphism raise concerns on the appropriate rationale for IRA in water sector. Review of the related laws suggests that the conventional credible commitment rationale is inadequate to explain the emergence of these IRAs. Political uncertainty, the root-cause of credible commitment rationale, needs to be explored as an appropriate rationale for IRA for ensuring development and implementation of long-term, integrated and consistent policy framework on water resources. But this requires proper sequencing of reforms in which the evolution of normative framework precedes creation of new institutions like IRA. The paper further reviews the normative aspects, such as equity and efficiency, to show how reconciling of seemingly contrasting principles is a huge challenge in developing an effective regulatory model. Finally the paper presents the idea of 'decentered regulation' and 'sunshine commission' as the two alternative propositions relevant for the developing country context.

Keywords Water regulation • Independent regulatory agency • Institutional transplantation • Regulatory state • Developing country

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List of Abbreviations

IRA	Independent Regulatory Agency
MWRRA	Maharashtra Water Resources Regulatory Authority
WRA	Water Regulatory Authority

6.1 Introduction

The phenomenon of creation of Independent Regulatory Agencies (hereafter referred as IRA) in water sector is a recent development in India as compared to its counterpart in other utility sectors such as electricity or telecom. The proposal for establishment of such Water Regulatory Authorities (hereafter referred to as WRA) at the state-level has its origin in the reform agenda driven by international financial institutions such as the World Bank (Warghade and Wagle 2014). Now it has become an internal reform agenda of the Central Government. For example, the 12th Five Year Plan of India includes a section on WRAs and it also proposes a model bill for adoption by the states. The 13th Finance Commission also earmarked a grant which the states could avail on the condition that they would establish a WRA. The process began with the establishment of the Maharashtra Water Resources Regulatory Authority (hereafter referred as MWRRA) in 2005. The MWRRA Act became a model for adoption by other states. Apart from the State of Maharashtra, such regulatory authorities have been established in other States such as Arunachal Pradesh (2006), Uttar Pradesh (2008/2014), Andhra Pradesh (2010), Jammu and Kashmir (2010), Rajasthan (2012), and Madhya Pradesh (2013).[1]

An IRA is a statutory body empowered to undertake important regulatory functions. Various regulatory functions, such as determination of water tariff, are delegated to IRA. Most important characteristics feature of an IRA is that it serves as an arm's length body. Autonomy is accorded to the regulator, though in varying degrees, to carry-out the functions independent of their political principals. A typical IRA comprises members who are experts in the respective field. Members are not officers serving in the government but may have worked for government in the past. It is often a quasi-judicial body with powers equivalent to the civil court. The orders of such an authority are legally enforceable. The State Electricity Regulatory Commissions in India or the Telecom Regulatory Authority of India are typical examples of an IRA.

[1] Following laws have been passed till date for establishment of IRA at state-level: The Maharashtra Water Resources Regulatory Authority Act 2005, The Arunachal Pradesh Water Resources Regulatory Authority Act 2006, The Uttar Pradesh Water Management and Regulatory Commission Act 2014 (the Act of 2008 was revoked and replaced by the Act of 2014), Andhra Pradesh Water Resources Regulatory Commission Act 2010, The Jammu and Kashmir Water Resources Regulation and Management Act 2010, The Rajasthan Water Resources Regulatory Authority Act, 2012 The Madhya Pradesh *Jal Viniyaman Adhiniyam* (Water Regulation Act) 2013.

The WRAs established in India are representative of the typical IRA. For example, they are constituted by members having expertise in water engineering or water economy. The MWRRA, which is the longest functioning WRA in India, is empowered to make autonomous decisions on water tariff and other regulation issues mentioned in the law. WRAs in other states have generally followed the model laid down by MWRRA with some state-specific variations. For example, the WRA in Uttar Pradesh has to recommend a cess on beneficiaries of flood control measures undertaken by the government. The WRA in Andhra Pradesh and Madhya Pradesh have been assigned advisory role. In their current form, they resemble the 'advisory regulator', which is seen as a transitional model of regulation before moving towards an IRA model (Brown et al. 2006, p. 99). But the overall direction to move towards economic efficiency through independent regulation is evident from these different state-level regulatory laws.

There is a wider discourse in the international literature on IRA as a component of regulatory reforms. There is a need to understand this discourse in relation to the debate that the WRA has generated in India. This paper presents a review of this debate by placing it in the context of the international discourse on IRAs.

6.2 The Rise of Regulatory State

The development of WRAs can be understood in greater depth by locating the phenomena in the context of the rise of 'regulatory state' (Majone 1994, 1997; Moran 2002; Minogue and Carino 2006; Dubash and Morgan 2013). Regulation has emerged as the central mode of governance in developed countries. In the context of Europe, the transition from the interventionist and welfare-oriented governance to predominantly regulation-oriented governance is characterized as the rise of 'regulatory state' (Majone 1997). This is seen as the outcome of coming together of important processes, viz., privatization of public sectors, deregulation of business activities, and regulation by arms-length bodies such as the 'independent regulatory agency' (IRA). This transition to regulatory state is now taking place in developing countries, although with its own characteristic features (Minogue and Carino 2006; Dubash and Morgan 2013). Hence, the debate around the WRAs in India needs to be located within this larger discourse on the regulatory state.

Delegation to an IRA is one of the characteristic features of the regulatory state. These IRAs are often categorized as non-majoritarian institutions of the government that posses specialized public authority. Members of an IRA are neither directly elected by the people, nor directly controlled by elected officials (Thatcher and Sweet Stone 2002). This is the ultimate step in delegation in a representative democratic set-up and hence becomes a very crucial and often controversial feature of the regulatory state (Gilardi 2001).

The WRAs being established in India represent this particular form of institutional reforms. Their spread in India can be viewed as part of the phenomena of diffusion of IRAs in different sectors and in different countries. The IRA as a regulatory model was first established in USA and later spread to Europe. Studies suggest that the majority of the diffusion in UK and Europe started in 1980s coinciding with the Thatcher era of privatization. A comprehensive dataset has been developed on diffusion of IRAs in Western Europe, Latin America and other OECD countries (Jordana et al. 2011; Gilardi 2008). Although there is no concrete data-set, there are references to diffusion of IRA models in Asia and Africa (Estache and Goicoechea 2005, pp. 138–150). Starting mainly from financial sector (banking, securities, insurance), the IRA model has spread to utility (electricity, water, telecom, gas), general competition and also to social sector (food safety, work safety, health, pension, environment).

In India, the diffusion of the IRA model is happening across different sectors and different states. Starting from the financial sector (like the Reserve Bank of India) the IRA model is now adopted in various sectors such as electricity (the Central and State Electricity Regulatory Commissions), telecom (the Telecom Regulatory Authority of India), and general competition (Competition Commission of India). The state-level WRAs, that are being set up in India, are the new additions to this existing list of IRAs. This could be seen as the beginning of the rise of the regulatory state in water sector. This signals a dramatic shift in Indian water policy and governance.

6.3 Institutional Transplantation

Scholars identify 'institutional transplantation' of the regulatory models as one of the key features of the regulatory state in developing countries (Minogue and Carino 2006; Dubash and Morgan 2012; Dubash and Morgan 2013). The mechanisms of transplantation or diffusion will provide valuable insights into the nature of regulatory reforms in water sector.

The diffusion mechanisms have been studied by scholars of institutional theories (Peters 1999; Gilardi 2004). An important component of this is the theory of sociological isomorphism, which asks the question of why a similar form of institution emerges in absolutely different political or social context (Peters 1999). For example, why relatively similar forms of regulatory authorities, such as IRA, emerge across the developed and developing countries in financial, utility and other sectors including water? This is a relevant question considering that the WRAs have similarities with IRAs in electricity and other sectors in India. Also the water regulatory model that emerged in different states in India is relatively similar to the model first established in Maharashtra. The institutional theory explains this in terms of various mechanism of diffusion or isomorphism. The two mechanisms relevant to our case are: coercive isomorphism and mimetic isomorphism.

Coercive isomorphism is due to the pressure exerted from other organizations on which the policy makers or government are dependent for various reasons. In the current water case, it is clear that the Maharashtra model of WRA has its genesis in the World Bank supported project in which the funding was provided under the covenant of establishment of IRA. Similarly the conditional grant provided by the Central Government under the 13th Finance Commission acts as an external pressure on the states to adopt the regulatory model. Considering the fiscal constraints at the state-level, on raising funds for development and management of water resources, these external pressures on the government to adopt IRA models in return for funds leads to coercive isomorphism.

Apart from the coercive forms, there are evidences of mimetic forms of diffusion in case of WRA. In mimetic isomorphism there is a tendency to mimic or imitate models from other places in belief that they represent the 'best practices' model. This is seen in case of MWRRA, which is considered as model for replication by other states. For example, the law for establishment of WRA in Arunachal Pradesh is a ditto copy of the MWRRA Act.

One of the variant of the coercive and mimetic isomorphism is the mechanism of diffusion through 'policy learning' (Peters 1999). Here it is assumed that the organizations would learn from the experiences of others and will adapt the models as per the suitability to the local context. There are evidences showing that the MWRRA law was accepted after a deliberative process conducted in the form of consultations and scrutiny by legislative committee (Warghade 2013). There have been some changes in the model after this consultative process. Most importantly, 'equity' emerged as an important principle in the MWRRA Act. For example, the law accepts 'equity' as the principle for determination of water allocation and entitlements. This is in contrast to the principle of 'efficiency' that forms the key consideration in establishment of an IRA. The integration of equity related considerations in the otherwise efficiency-focused regulatory model can be seen as the outcome of the 'policy learning' rather than coercive or mimetic diffusion. However, the law also provides for creation of water markets, seen as a necessary institutional reform for ensuring efficient water allocation. Water markets as the mechanism of efficient water allocation is modeled around similar mechanisms existing in countries like Australia and Chile. So although the incorporation of equity principle can be seen as a process of policy learning the transplantation of market-based model for water allocation can be seen as the outcome of coercive isomorphism.

The influence of the mechanism of 'policy learning' is found to be limited to the substantive values that guide the functioning of the regulator, such as the incorporation of principle of equity. The overall structural features of the IRA, such as the reliance on apex-level arm's length regulatory bodies, still continues as the key feature of the water regulatory model. Hence, the debate around WRAs can be categorized into the 'structural features', i.e., the organizational structure related to autonomy, and the 'substantive values', i.e., the principles that will guide the functioning of the regulatory.[2] From the earlier discussion, it is found that mode of diffusion through policy learning is influential for determining the substantive values,

[2] In the regulatory literature, the 'structural features' mentioned here is termed as 'regulatory governance' (Brown et al. 2006; Levy and Spiller 1994) and the 'substantive values' is termed as 'regulatory substance' (Brown et al. 2006) or 'regulatory incentives or content' (Levy and Spiller 1994).

while the structural features of the IRA are largely influenced by the coercive and mimetic mechanism of diffusion.

The combination of these diffusion mechanisms will lead to confusion. It represents a case of creation of an institution – originally meant for economic efficiency – for the purpose of equity and other social goals. The problem is that IRA, while regulating based on equity and other social goals, might end-up encroaching on the patently political function associated with redistributive principle. Dubash and Morgan, already warn about situations where adoption of models from the developed countries into developing countries might lead to dissonance in the regulatory design (Dubash and Morgan 2013). This can be described as a mismatch of structure of regulatory governance (structural features) and regulatory substance or content (substantive values).[3] The regulatory policy related to WRA points towards such a dissonance, the root cause of which lies in the higher influence of coercive and mimetic mechanism of policy diffusion as compared to the mechanism of policy learning.

6.4 Rationale for IRA in Water

The coercive and mimetic nature of the institutional transplantation has raised several concerns related to the relevance of the IRA model in the Indian context. The rationale for an IRA in water sector in India is highly debated among scholars and civil society actors (Prayas 2007; Warghade and Wagle 2013).

One of the important structural features of the IRA is that powers are delegated to it without direct political control. So it becomes important to dwell on the question of the rationale for delegating powers to an IRA. There exists a detailed discussion in the international literature on the functional rationale for delegation to such autonomous bodies (Thatcher and Stone Sweet 2002; Gilardi 2001, 2004, 2008; Levy and Spiller 1994). One of the key arguments is related to the characteristics of natural monopoly, seen in network-based utilities such as water and electricity. Due to the economies of scale it is beneficial to have a single service provider in such sectors. But this might lead to monopolist behavior by the service provider. Hence, the government intervenes through regulation of various aspects of services such as tariff, quality, and access. If government regulates by itself the private investors fear that political uncertainty due to electoral and other compulsions might erode their investments and future returns. In this situation, delegation to an independent, apolitical, and expert-based organization increases the credibility of the commitment given by political representatives to the private investors. Thus, 'credible commitment' rationale is most prominent in situation of privatization of natural monopoly sectors.

[3] Using the terminology of 'regulatory governance' and 'regulatory substance/ content' as used by Levy and Spiller (1994), and Brown et al. (2006).

In response to this, the scholars in India have argued that, in absence of large-scale privatization of water utilities there is no case for an independent regulation in water. Although water has the characteristics of natural monopoly, it is a resource distinct from electricity and other such utility services. Hence, even the case for privatization in water sector needs to be first developed and established before accepting an independent regulatory model. Privatization should not be taken for granted considering the unique features of water as a life-sustaining and ecological resource (Prayas 2007).

This brings to light the problem of sequencing of policy and institutional reforms in relation to creation of an IRA. The question is whether the substantive policy framework precedes the creation of institutional form for giving effect to that policy. One of the distinctive feature of regulatory reforms in developing countries is the incomplete or absence of privatization in different sectors (Minogue and Carino 2006). In contrast to the post-privatization regulatory reforms seen in developed countries, the regulatory reforms in developing countries, like creation of IRA, go in tandem with the efforts to privatize the sectors. Hence, the institutional form (like IRA) is created without an adequate discussion and debate on the policy decision to privatize the sector. This aspect related to sequencing and timing of reforms has created confusion related to the purpose and design of the regulatory. For example, the Electricity Act of 2003 was a package comprising both the provision for allowing private sector investments and provisions for regulation by an IRA. This makes the regulatory model of IRA as controversial as the privatization proposal. The problem with this is that the rationale for IRA cannot be discussed irrespective of the privatization policy. This limits the scope of discussion on the alternative forms of regulation and rationale for IRA in a non-privatization scenario. Even in completely privatized sector like electricity, the IRAs are found to be regulating mainly the state owned utilities because of absence of large-scale privatization. Hence, the debate around the rationale for IRA needs to be widened beyond the privatization paradigm.

A closer look into the legislations related to WRAs provides evidence of this non-privatization scenario of regulation. Unlike the Electricity Act, the WRA laws shun away from clearly providing for private sector participation. The first WRA law in India, the MWRRA Act, in fact negates any such possibility even in future by limiting the level of cost recovery from tariff to operation and maintenance cost. Recovery of capital cost or fair returns on investment through water tariff is not a possibility as per the existing provisions of the MWRRA Act. But at the same time, the WRA law in Jammu and Kashmir, and Uttar Pradesh includes a provision for licensing of water service providers without actually mentioning the word 'private' service providers. This shows the reluctance to clearly incorporate the privatization agenda in the IRA laws and instead find out means to create spaces for privatization in future. Scholars have argued that the WRAs in India seem to be the thin end of the wedge of privatization (Prayas 2007).

It is important to note that, although the WRA laws shun away from incorporating the reforms for utility privatization there are several urban water service projects undertaken for utility privatization. Similarly in irrigation, case of proposed dam privatization in Maharashtra was brought before the MWRRA. The government department promoting the privatization was reluctant to bring the proposal under the regulator's purview. It was only after a petition filed against the process of privatization that the regulator finally issued an order for regulation of some aspects of this privatization projects.[4]

Overall it is found that neither 'regulation of privatization' nor 'regulation for privatization' seems to be the articulated rationale for WRAs in India. The ongoing privatization initiatives in water sector are emerging as cases of 'unregulated privatization' even after creation of IRAs. This is emerging as one of the key features of the regulatory reforms in water sector in India. This is also not a hybrid model where the privatization process is regulated by a contract that is overseen by an IRA.[5]

If privatization is not on the current agenda of creation of IRAs, the question of the rationale for IRAs in water sector gets more complicated. One of the alternative rationales is to overcome the 'political uncertainty' in policy areas requiring long-term vision and consistency (Warghade and Wagle 2013). The political uncertainty arises due to the possibility of undue political intervention in the broader policy direction and in the functioning of the state-owned utility. Uncertainty looms over the continuity of the policies adopted by policy makers after change in the ruling government. Partisan politics and politics of patronage are some of the factors that contribute to the uncertainty. Various compulsions of electoral politics are at the core of such political uncertainty.

Overcoming such political uncertainty could be one of the important rationales for creation of IRA in water sector, especially for evolving and implementing long-term policy framework. Change in government might lead to change in water policies with the effect of absence of long-term, integrated, and consistent approach to policy and its implementation. Delegating such policy functions to an IRA, which works irrespective of the political functionaries, could be seen as a counter measure to inconsistent and random changes in policy. Once the long-term vision and policy framework is laid down through political and legislative route then the independent regulatory could play an important role by distancing itself from the political and executive wing of the government and focusing on bringing consistency and continuity in policy implementation. So the 'credible commitment' rationale, which was found highly relevant for protecting private investors, is important for the sole reason of protecting public interest associated with achieving consistency in the evolved long-term policy direction. However, this again is associated with the issue of sequencing of policy and regulatory reforms. It is expected that the policy framework in form of the substantive principles is laid down before the choice of the regulatory institution is made.

[4] Refer Case 1 of 2008 before MWRRA. For details of the petition refer to: Wagle, S., Warghade, S. 2009. Independent Water Regulatory Authorities in India: Analysis and Interventions, Prayas: Pune. Also refer the order by MWRRA on this petition available at: http://www.mwrra.org/Order%20No.%201.pdf.

[5] Refer Brown et al. (2006) for details on such hybrid models.

6.5 Substantive Values: Equity and Efficiency

Going beyond the privatization debate, scholars have argued that even if we accept that a regulatory is necessary what is more important is the 'normative framework' that will guide the regulatory processes and decision making (Prayas 2007; Iyer 2009; Joy and Paranjape 2009). It is observed that there is no framework of guiding principles in the existing water laws in India (Iyer 2009). Hence, developing such a framework is important before deciding on the appropriate institutional structure such as an independent regulator. It is in this context, that the recently drafted 'National Water Framework Law' becomes an important instrument that would provide the required normative principles for regulating water sector.[6] While the process of enacting this national framework law is still in its nascent stage, there are important insights to be gained by looking at the substantive principles that the water regulatory laws and their implementation have espoused.

The WRA laws throw open the important debate around 'equity Vs efficiency'. Although the water regulatory laws do not clearly provide for privatization of water services there are adequate evidences to show that genesis of the regulatory model lies in the economic efficiency rationale (World Bank 2005). There are two contributing principles found in the WRA laws in this respect. First is the 'cost recovery' principle and other is the 'efficient water allocation' principle.

6.5.1 Cost Recovery Principle

Cost recovery through water tariff has not been an important issue on the agenda of the policy makers in India. Water supply has been highly subsidized. Water charges are largely determined based on political considerations rather than financial considerations. There was no legally mandatory provision for cost recovery. The WRA laws in India for the first time are trying to institutionalize this principle by empowering the regulator to determine tariff based on cost recovery. For example, the MWRRA is empowered to determine tariff based on recovery of cost of operations and maintenance.

Experience of electricity regulation in India clearly shows that once the regulatory is delegated powers in this regard, tariff setting is undertaken periodically as a routine procedure. Even after political interventions in the form of providing subsidies, the routine tariff determination process has led to gradual and consistent increase in the average electricity tariff. A similar process will be established in the water sector once the regulators begin the periodic tariff setting process. Even if WRA laws currently cap the recovery level to operations and maintenance costs,

[6] The draft law was produced by a group, constituted under the 12th Five Year Plan process, and headed by Prof. Ramaswamy R Iyer http://www.planningcommission.nic.in/aboutus/committee/wrkgrp12/wr/wg_wtr_frame.pdf.

with the IRA law in Jammu and Kashmir adding cost of project, there is clear indication that tariff setting will become a routine and periodic process with higher chances of gradual and consistent increase in water tariff. How the objectives of equity and efficiency are addressed in such cases becomes highly important.

The experience of implementation of first such tariff regulatory process in Maharashtra, initiated in 2007, has thrown light on several dimensions of the equity and efficiency debate (Prayas 2013). Reduction of cross-subsidy in terms of higher tariff charged to industrial water users as against other sectors, mainly agriculture, is seen as an important regulatory policy for enhancing the efficiency of the sector. In this process initiated by MWRRA, the initial attempts of reduction of cross-subsidy were highly objected to by water users during the regulatory consultations. The active participation and concrete demands made by agriculture and domestic water users resulted into a highly 'social tariff system' in Maharashtra. Affordability and other social considerations have been accepted in the tariff formula along with concessions accorded to various disadvantaged groups like tribal communities, project affected people, small and marginal farmers, rural water users and others. This shows how an independent regulatory process, when conducted in participatory manner, has the potential to tilt the debate towards equity. As the cross-subsidizers, mainly the industrial water users, start participating in the process the demand for efficiency will also gradually come into the debate and there will be an opportunity to reflect and arrive at the right balance of both the principles.

6.5.2 Efficient Water Allocation

In contrast to the experience in water tariff, the regulatory process around water allocation in Maharashtra suggests a very different picture. As per the principal law the MWRRA is empowered to determine water allocation. Through this legislation, the political functionaries accorded powers to the regulator to determine allocations based on the principle of equity. But the same political functionaries were found to be bypassing the powers of the regulator by reallocating water from agriculture to industrial use without due cognizance of the MWRRA Act. The principle of equity, as provided in the law, was not followed while making these reallocation decisions. When farmer groups and civil society organizations opposed the reallocation and demanded adherence to the equity principle as given in the regulatory law, the political functionaries amended the law with the effect of revoking the equity principle and also the related powers of the regulator (Wagle et al. 2012).

Data shows that huge amount of water was reallocated by the political functionaries to several industrial projects such as Special Economic Zones and private power plants. In light of increasing water demands from urban-industrial sector and the dwindling potential for increasing water availability, allocation of water will be an important function in future that provides opportunity of wielding political clout and power. The delegation of water allocation powers to an IRA seems to be a threat perceived by the political functionaries. Thus, an IRA, that provided opportunity of public participation in case of tariff determination, is not seen as an acceptable form of institutional mechanism by the policy makers in case of a highly politicized issue such as water allocation.

It should be noted that the economic efficiency principle, that drives regulatory reforms, puts lot of emphasis on reallocation of water from lower to higher economic benefits. Hence, reallocation of water from agriculture to industrial use, done by the political functionaries, goes well with this economic principle. But it raises questions of due process and of consideration to equitable allocation of resources. The reallocation process in Maharashtra was a closed-door political decision making instead and not transparent regulatory process as expected in the MWRRA Act.

According to the market principle accepted in the MWRRA Act, the process of water reallocation was expected to be made operational through a system of tradable water entitlements. In such water market, the water entitlement holders can engage in voluntary transactions with non-entitlement holders in return of an acceptable compensation. But before any such entitlement system could be established or market could operate, huge amount of water is being reallocated through the political route without any consideration of the rights of the farmers. Any proposal for water market, in such a situation, will accentuate inequities in water allocation created through this inadvertent and non-transparent political route of reallocations. It will also accentuate inequities created in the past when landless and others disadvantaged sections were devoid of right to the water stored in the dams.

This discussion on water tariff and water allocation throws light on the complications associated with operationalizing regulatory principles. One of the central debates is around the question of reconciling equity and efficiency. It also throws light on the political power-play that will influence the regulatory space. Dubash and Morgan rightly suggest that the intensity of redistributive politics will shape the scope and nature of regulatory state in the developing countries (Dubash and Morgan 2013). Unless these dimensions of the existing regulatory space in a developing country are adequately understood and assimilated in the regulatory design the IRA models of regulation will remain ineffective.

6.6 Depoliticization through Expertocratic Regulatory Process

The rise of the regulatory state also signals the rise of expert-oriented deliberations and decision making. As seen from the 'credible commitment' rationale, depoliticizing the decision making process is achieved by delegating powers to arms' length bodies such as IRA. Concerns are raised by civil society actors that this will lead to complete de-politicization of sectoral policy making (Prayas 2007). This concern is highly relevant in a developing country context where there is a large section of the society which may not be able to participate in such expertocratic decision making processes. The concerns and demands of these sections would be neglected for want of voice and concrete evidences. Mobilizing analysis-based evidences will be a major hurdle for such sections to get a sound hearing in the regulatory proceedings. This brings to light an important aspect related to accountability of the autonomous regulator, especially towards the voiceless sections of the society.

There are several mechanisms created for this purpose in different models of autonomous regulation. The most direct mechanism is the official appointment of 'consumer representatives' in the state electricity commissions in India for protection of public interest.[7] The consumer representatives in this case have been empowered to receive all information pertaining to regulatory processes and also to participate and intervene in all regulatory proceedings. Another set of conditions that make the decision making favorable for pro-poor and pro-people interventions is operationalization of principles of transparency, accountability and public participation (Nakhooda et al. 2007). Such procedural matters contribute to what is termed as 'procedural accountability' of IRAs (Dubash 2008).

The analysis of the WRA laws in India shows that these aspects of 'procedural accountability' have not been incorporated adequately (Wagle and Warghade 2010). For example, there is provision for public participation while determining tariff. This helped in ensuring active participation of stakeholders in the tariff proceedings initiated by MWRRA. But there is no provision for public participation in MWRRA Act in the crucial function of determination of water allocation. Apart from members of MWRRA, there is provision in the law for appointment of 'special invitees' representing different regions of the state. But these invitees do not anywhere resemble the likes of consumer representatives. There are hardly any concrete pro-people or pro-poor interventions done by these invitees that might have influenced the regulatory actions and decision in the past.

Unless strong transparency and accountability provisions are made in the regulatory law it is not possible to avert the situation of complete depoliticization of sectoral decisions. An associated concern raised in this regard is the possibility of 'regulatory capture', a widely studied and discussed theory in the regulatory literature (Dubash 2008). Depoliticization and expertocratic procedures provide avenues for capturing of the decision making process by the intellectual and resourceful stakeholders like corporate entities. Because the avenues for political mobilization are reduced, the poor and disadvantaged sections will remain marginalized in such regulatory decision making process. Who will then represent the interest of these groups in the expert-oriented regulatory process, is a major concern that need serious consideration in the regulatory design. Measures to enhance the 'procedural accountability' form an important counter measure to thwart attempts of regulatory capture.

[7] Refer the Electricity Act 2003 (Source: http://powermin.nic.in/acts_notification/electricity_act2003/preliminary.htm).

6.7 Way Ahead

Independent regulation in the water sector is still in its experimental phase in India. The debates arising from the design and implementation of the water regulatory models in India have raised serious questions on the appropriateness of the model. This reflects on the peculiar nature of the regulatory state in the developing countries. It also reflects on the peculiar nature of water as a distinct resource. There is certainly a need to relook at the existing models and evolve more context-friendly models instead of just transplanting context-free models.

The literature provides some alternative directions with regard to regulatory models. The independent regulatory is an apex-body overlooking the whole of the sector. Such an apex-level institutional structure combined with its expert-oriented proceedings creates a tendency towards centralization of decision making. Such a 'centered' model of regulation is being challenged by several regulatory scholars. Most prominent work in this regard is the theory of 'regulatory space' proposed by Hancher and Moran (1989) (Scott 2001). The authors use the metaphor of space to suggest that regulation is shaped not by a single power-center, like an IRA, but is shaped by multiple stakeholders active in a regulatory space. The regulatory power in the space is dispersed and not concentrated. The regulatory space is further shaped by the context that exists in given place and time. The interface and interactions among various organizations is the key in understanding regulation and its outcomes. This leads us to a 'decentered' approach to regulation (Black 2002).

The decentered approach to regulation is a potential alternative approach for a developing country like India where the democratic set-up and the structural features of inequity demands for more and more decentralization of power. The evidences of this can be seen in the model bill drafted by a group constituted by Planning Commission of India on behalf of the 12th Five-Year Plan.[8] The group comprised representatives of governmental and non-governmental organizations. The draft bill, which is the outcome of this consultative process, resembles the decentered approach. It envisages a decentered regulatory space where regulatory power is not concentrated in an apex-level IRA. It recognizes and attempts to balance the multiple sources of regulatory power, held among the political functionaries, regulatory bodies, expert bodies and water users' organizations.

The implications of such a model can be two fold. One, it can provide appropriate spaces and opportunities for the disadvantaged sections to influence the regulatory process. Second, it will ensure that the political functionaries do not get a free hand on making decisions in a closed-door manner. The balance of power among stakeholders combined with the detailed process guidelines given in the model bill could serve as the step towards evolving a context-friendly decentered regulatory model. However, considering the complex web of regulatory stakeholders and

[8] Refer 'The Model Bill for State Water Regulatory System Act, 2011'. The relevant document can be accessed on the following link: http://planningcommission.nic.in/aboutus/committee/wrkgrp12/wr/mb_wtrgrnd_181011.pdf.

processes that the bill proposes, there is a need for moderation of some of the aspects of the bill while adapting the same to specific state-level context. This moderation is necessary to reduce the administrative and regulatory burden that might make it infeasible to operate on ground.

Another arena to look for alternative models is the 'sunshine commission' model originally developed and practiced by Charles Adams, one of the earliest thinkers on regulation in USA (MCraw 1984). In the 1870s, Charles Adams pioneered the thought of a very different form of independent regulation which he called 'sunshine commission'. Adams argued that continuous learning and knowledge building on a particular sector is not possible at the level of the legislatures because of their short tenures in a particular sector of governance. There is a need for a permanent and independent analytical expertise within the government which can be developed through an independent commission.

Apart from undertaking study and disclosure, Adams emphasized on the role of regulator "as sort of lens by means of which the otherwise scattered rays of public opinion could be concentrated to focus and brought to bear upon a given point" (MCraw 1984, p. 15). He proposed a 'Sunshine Commission' which would "shed the cleansing light of disclosure on the hitherto secret affairs of business corporations" (ibid). Discouraging direct intervention through tariff setting, Adams emphasized on regulation through publication and disclosure. Enlightenment was seen as an essential prelude to action. Avoiding the confrontationist approach in regulation, Adams followed the strategy of enlightment, assistance, and prodding in the Massachusetts Board of Railroad Commissioners (1869), the first important IRA in USA which Adams not only founded but also worked as its Chairperson. Moving away from this 'sunshine' approach the later commissions in USA engaged more directly through tariff setting and other regulatory functions. Adams warned that such a higher engagement will entangle the regulatory into controversies and red-tapism around rate and other regulatory interventions. This will be at the cost of losing out on the larger role of bringing the "interests of the public and corporation into identity" (ibid).

Considering the diversity in conception of water as a resource and the plurality of values attached to water in India, the idea of the 'cleansing light' of knowledge and a lens for bringing together the 'scattered rays of public opinion' to focus on key common interests, seems to be worth exploring. There are several government authorities engaged in data collection and dissemination but the approach is far from Adams 'sunshine commission'. The notion of water as a common resource and the process of evolving a common interest that could drive policy and regulation cannot be institutionalized without a facilitative role of such a commission. This brings in focus the argument developed by Dubash and Morgan on regulatory models as the potential harbingers of 'repoliticization' mainly due to their procedural component (Dubash and Morgan 2013). A decentered approach, with a strong knowledge component (sunshine commission), and backed by a pro-people normative framework may be a good starting point for building an effective and comprehensive alternative framework for water regulation in India.

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Chapter 7
River Linking Project: A Solution or Problem to India's Water Woes?

Tushaar Shah and Upali A. Amarasinghe

Abstract The public discourse on the National River Linking Project (NRLP) has been hopelessly lopsided—with the protagonists of the project unable to take on the antagonists on either their rhetoric or their analytics. This paper contributes to the discourse by presenting a balanced analytical point of view from a series of studies conducted by the International Water Management Institute and its partners. The studies have analyzed the drivers and assumptions used to justify the NRLP and have assessed hydrological, financial and social implications of the NRLP water transfers. These studies find that the underlying assumptions have either changed over time or have flaws and alternative options are not given the consideration these need and deserve. Given these and many other factors, the hydrological, financial and social benefits and cost, if implemented in its present form, are mixed. However, the paper also argues that the idea of NRLP may have come a decade or two soon; and that a slew of upcoming contingencies shall not only change the tenor of the debate around inter-basin water transfers but even make a compelling case for them, even if in a different form than the present proposal.

Keywords River linking project • NRLP • River basin • Water transfers • Storage • Irrigation • Groundwater

7.1 Introduction

For a long period, the notables in India have argued that the answer to the drought-proneness of western and peninsular India lies in the flood-proneness of the east, and vice versa. Few grand proposals of linking rivers evoked the imagination and

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enthusiasm of water stressed Indians from time to time. At the forefront were, Sir Arthur Cotton's plan of linking rivers in southern India in the nineteenth century, Dr K. L. Rao's plan of linking Ganga and Cauvery in the 1970s, and Captain Dastur's plan of lateral Himalayan canal linking Ravi and Brahmaputra and an interconnected Garland Canal girdling peninsular in the later seventies. In addition, the latest is the grandiose scheme to link Himalayan rivers and river in peninsular India—those currently under discussion as National River Linking Project (NRLP). In the early 1990s, the National Water Development Agency (NWDA) was entrusted to start detailed planning for a mega-scheme of NRLP under the national perspective plan for water resources development (NWDA 2012a).

Implementing mega-schemes, which require pre-feasibility, feasibility, and environment impact studies, is a long drawn out process. Many proposals do not even go beyond the drawing board, as the planners themselves dismiss ideas as too grandiose. Nevertheless, in 2003, acting on public interest petitions, the Supreme Court of India has decided that the time had come for the nation to pull its act together on the waterfront, and enjoined the Government of India to complete all planning required to complete the NRLP by 2016. President Abdul Kalam too endorsed the idea and vigorously argued that the government should plunge headlong in its implementation without wasting time unduly in studies.

The ruling National Democratic Alliance government at that time—constituted a high-powered, multi-disciplinary task force to embark upon the NRLP project forthwith in deference to the Supreme Court's injunction. However, a groundswell of opposition to the project emerged from environmental groups and civil society organizations with a battery of arguments representing a variety of perspectives. Most of these did not even address the benefit-cost issues but questioned the basic model of water resources planning and management through large-scale dams and canal networks ('the disease of gigantism', as one antagonist referred to it) that the NRLP exemplified (Alagh et al. 2006). The interest in the project has waned since then, or at least placed in the back burner until the next major nation-wide drought.

The idea of linking Himalayan Rivers with peninsular and western ones has however proved hard to kill. Like phoenix, it rose from its ashes again in 2012, when the Supreme Court took note of it *suo moto*, and based largely on an economic analysis by the National Council for Applied Economic Research (NCAER 2008), again enjoined the government to implement the project so as to complete it by 2016! (Venkatesan 2012). The NCAER study showed NRLP's economic benefits will exceed its costs, but it is not clear whether the battery of assumptions would hold under intense scrutiny. Once again, the civil society started to express anxiety of the Supreme Court decision (Iyer 2012; Narain 2012). The responses of the Government of India to the second Supreme Court decision and on people's concerns are not clear yet.

Against this backdrop, this paper discusses major assumptions and implications of NRLP water transfers on Indian water, land and social scape. After this brief introduction, the next section, on *the NRLP project*, gives a brief technical overview of the project concept. Section 7.3 titled, *Justification of the NRLP*, discusses the economic and social justification of the project as advanced by the

NWDA. Section 7.4, *Analyses of Core Assumptions*, critique the core assumptions behind the large project. Section 7.5, *The Implication of NRLP Water Transfers*, assesses the implications of implementing such a large project. The final section discusses under what contingencies a project like NRLP would be required to address India's water woes and their implications on policy and research.

7.2 The NRLP Project

7.2.1 Himalayan and Peninsular Component

The NRLP intends to transfer water from surplus river basins to ease the water shortages in western and southern India, while mitigating the impacts of recurrent floods in eastern India (NWDA 2012a). Conceptualized in two components, Himalayan and Peninsular (Fig. 7.1), the project will build 30 link canals and approximately 3,000 storages to connect 37 Himalayan and Peninsular rivers. The canals, which are planned to be 50–100 m wide and more than 6 m deep, will handle 178 billion cubic meters (BCM) of inter-basin water transfer/per year. The Himalayan and Peninsular components will transfer 33 and 141BCM of water respectively, through a combined network of close to 15,000 km long distributary canals.

The Himalayan Component, with 16 river links, has two sub-components one linking Ganga, Brahmaputra and Mahanadi Basins (links 11–14 in Fig. 7.1), and the other comprising links between eastern Ganga tributaries and Chambal and Sabarmati river basins (links 1–10). Altogether, these transfers intend to mitigate floods in the eastern parts of the Ganga Basin, and provide the western parts of the basin with improved irrigation and water supplies. The Himalayan component needs several large dams in Bhutan and Nepal to store and transfer floodwaters from the tributaries of the Ganga and Brahmaputra rivers, and within India to transfer the surplus waters of the Mahanadi and Godavari rivers.

The peninsular component, with 14 major links has four sub-components: (1) linking the Mahanadi-Godavari-Krishna-Cauvery-Vaigai Rivers; (2) linking west flowing rivers that are south of Tapi and north of Bombay; (3) linking the Ken-Betwa and Parbati-Kalisindh-Chambal rivers; and (4) diverting the flow in some of the west flowing rivers to the eastern side. The en route irrigation under the peninsular component will serve a substantial area as proposed under the NRLP, and much these beneficiary lands are in arid and semi-arid western and peninsular India.

The 'back-of-the-envelope calculations', the best available so far, suggest that the project will altogether cost about US$ 123 billion (or Indian Rs. 560,000 crore) at 2000 prices. This includes US$ 23 billion (In Rs. 106,000 crore) for the peninsular component, US$ 41 billion (Rs. 185,000 crore) for the Himalayan component and US$ 59 billion (In Rs. 269,000 crore) for the hydroelectric component. Given that India's Wholesale Price Index in 2012 is 120 % higher than in 2000, the project cost at current prices would be more like Rs. 1.19 trillion (US$ 216 billion).

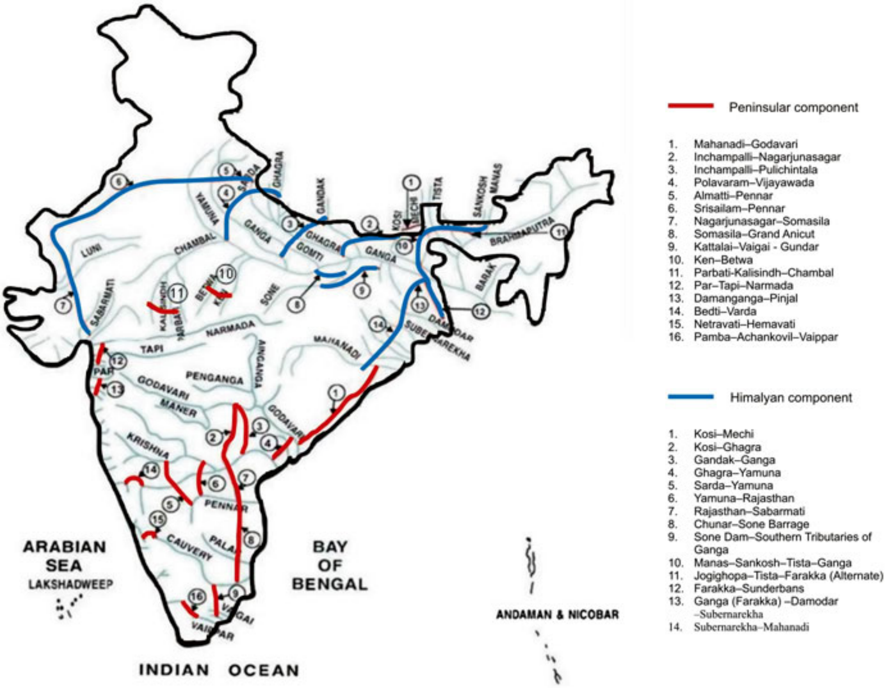

Fig. 7.1 Links of the Himalayan and peninsular components (*Source:* IWMI (2008))

NWDA claims the project will add 34 G watts (GW) of hydropower capacity, which includes 4 and 30 GW from the peninsular and Himalayan components respectively. Approximately 3,700 MW would be required to lift water across major watershed ridges by up to 116 m. It also adds 35 million hectares to India's irrigated areas, and generates an unknown volume of navigation and fishery benefits (NWDA 2012a). One worry with these numbers is their reliability. Water infrastructure plans in India are often exaggerate estimates of likely benefits and under-estimate costs, making them appear highly desirable. As projects unroll, the actual benefits turn out much smaller and costs much higher than shown in the planning documents.

7.2.2 Grandiosity of the NRLP

The NRLP is unique in its unrivalled grandiosity. If fully implemented, it could be the largest water infrastructure project ever undertaken in the world. The NRLP will handle four times more water than China's South to North water transfer project, which is one of the largest inter-basin water transfer projects implemented in the world at present (Stone and Jia 2006). The NRLP will also handle four times more water than the Three Gorges Dam; five times all the inter-basin water transfers completed in the U.S.A; and six times more than the total transfer of the six inter-basin water transfers projects already operational in India namely, Sharda-Sahayak; Beas-Sutlej; Madhopur-Beas Link; Kurnool- Cudappa-Cana; Periyar- Vegai Link; and Telgu Ganga.

The cost of the NRLP could be three times the cost of China's South–north water transfers scheme, six times the cost of Three Gorges Project, and twenty times the estimated costs of the Red-Dead connection in the Middle East. The project will require a larger investment than the sum total of all irrigation investments made by the governments of colonial and free India since 1830. The actual cost could most likely be several times more than the present US$ 123 billion 'guest estimate', when it considers the cost of land acquisition and rehabilitation and resettlement.

Although enjoined to complete by 2016, the way irrigation projects in India have proceeded during recent decades, general agreement is that this grandiose project may not fully complete even by 2050. Varghese (2003) suggests, realistically, that NRLP could be a 50–100 year project. Only nine of the 30 proposed links are independent and can be constructed and operated without the other links. In the first stage of the Project, which won government approval, a 230-km canal will transfer water from the Ken River to the Betwa River in the northern Madhya Pradesh. A dam and small hydroelectric plant in the Ken River will be located in the Panna Tiger Reserve. Work on the first component of this US$ 1.1 billion project is underway, and will alone take 8 years to complete (Bagla 2006).

7.3 Justification of the NRLP

7.3.1 Augmenting Utilizable Water Supply

The *raisons d'être* of the project is the accentuating water scarcity in western and peninsular India, low storage capacity and per capita utilizable water supply, high spatial and temporal variability of rainfall and the associated droughts and floods.

In India's 19 major river basins, only 55 % of the total renewable water resources (TRWR) are utilizable (GOI 1999). The Ganga-Brahmaputra-Meghna basins, which cover one third of the country's total land area, are home to 44 % of India's population, but drain more than 60 % of the country's TRWR. The Brahmaputra sub-basin alone drains 31 % of the TRWR, but due to geographical restrictions, only 4 % of the TRWR are potentially utilizable. In contrast, the Krishna, Cauvery and, Penner river basins and few other eastward flowing rivers cover 16 % of the land area, host 17 % of the population, but drain only 6 % of total water resources.

Due to this spatial variability of water supply, more than 200 million people have per capita utilizable water supply below 1,000 m^3/day, which, according to Falkenmark et al. (1989), indicates severe regional water scarcity. Due to over-development, some basins are physically water-scarce (Amarasinghe et al. 2005). One of the solutions suggested to deal with increasing water scarcity, is augmenting the utilizable water supply of water scarce basins by transferring waters from surplus basins.

Low reservoir storage capacity is another concern. At present, it is only 200 m^3 per person at present. These result in *economic* water scarcity, which, many fear, will impede economic growth. In comparison, other arid and semi-arid regions of the world have invested heavily in storage creation; Brazil, Australia and the U.S.A, have per capita storage capacity of 3,388, 4,717 and 5,961 m^3 respectively. Even China has increased its per capita storage capacity to 2,486 m^3. For this, and the fact that variability of rainfall is increasing due to climate change, many consider that it is imperative that India increases its storage for regulating the vast amount of runoff that otherwise cannot be beneficially utilized. The proposed NRLP water transfers will increase utilizable surface water resources by an estimated 25 % and improve water availability in water-scarce regions.

Flood and droughts inflict heavy damages. Annual floods, on average, affect more than 7 million ha of the total land area, 3 million ha of the cropped area and 34 million people, mostly in the eastern parts. Floods inflict an annual damage of well over US$ 220 million (Rs. 1,000 crores) (GOI 1999). In contrast, recurrent droughts affect 19 % of the country, 68 % of the cropped area and 12 % of the population (Nair and Radhakrishna 2005). Reservoir storages and the canal diversions in NRLP would, it is argued, reduce flood damages by 35 % (Sinha et al. 2005) and ease drought-proneness in semi-arid and arid parts. Also, NRLP will make 12 km^3 of water available for domestic and industrial sectors in these drought-prone districts. Many argue that diverting a portion of the surplus floodwater from the Himalayan Rivers into the drought-prone areas can only be a win-win proposition for the country.

7.3.2 Meeting Food Self Sufficiency

Self-sufficiency in food grains is a key plank of the NRLP justification. Lay circles consider that the report by the National Commission of Integrated Water Resources Development (GOI 1999) as the first cut justification of the NRLP's design-concept. Assuming the criticality of maintaining national food self-sufficiency and agricultural exports, the Commission projected a grain demand in the range of 425–494 million tonnes for India by 2050 and argued for the need to increase the country's irrigation potential to 160 million ha, which is 20 million more than what can be achieved without basin transfers (NWDA 2012b). The surface irrigation from NRLP alone is expected to add 25 million ha of irrigated land.

Improving rural employment is another justification for the NRLP. The rural population in India will peak at about 775 million by 2015 (UN 2004). The Commission projected that the rural population will decrease to about 610 million by 2050, but assumes that a large part of the rural population will remain agriculturally active in the future.

7.4 Analyses of Core Assumptions

7.4.1 Demographic Change

Changes in demography are critical to NRLP food and water demand projections. The NCIWRD projected the state-wise population growth by pro-rata distribution of national population projections from the 1991 population census. However, the new regional projections (Mahmood and Kundu 2009) incorporating age-size structure, HIV/AIDS and adjusted fertility and mortality estimates from the 2001 census, show vastly different emerging patterns. Although the total national population projections are not different, new projections show that many water scarce states, including Andhra Pradesh, Kerala, Karnataka, Punjab, and Tami Nadu will have appreciable decline in population trends before 2050. Haryana, Gujarat, Maharashtra, Orissa and the West Bengal too will experience a moderate decline, while Uttar Pradesh, Bihar, Jharkhand, Madhya Pradesh and Chhattisgarh will show an increase in population. Thus, unlike in the NLRP assumptions, the latter group of states—which are to cede water to southern and western states—is where pressure for farmlands and demand for irrigation will continue to be high.

Rural employment was a major driver of India's past irrigation development, the fact that NCIWRD has also emphasized. However, according Sharma and Bhaduri (2009), today's younger generation in Indian villages has different perception and priorities. There is a high likelihood that today's young rural farmers will move out of agriculture, or at least keep it as a secondary income activity, regardless of increased access to irrigation. This is more evident among rural youth who have different skills and better education. The tendency of moving out of agriculture is higher where the distance to travel to town or urban centers is less. Certainly, future generations of India will be more educated, and will be acquainted with better skills. In addition, many rural centers will become small towns and towns to sprawling urban centers. Infrastructure facilities such as access to roads, electricity, and telecommunication are also increasing. Thus, migration from full time agriculture to non-farm rural and urban livelihood will increase; especially in economically more dynamic states where NRLP proposes to transfer Himalayan water.

7.4.2 Food Self Sufficiency

The NCIWRD has projected that India will have to produce 450 million MT (or 284 kg/person/year) of food grains by 2050, and an additional 45 million MT for feed, seed and waste. However, Amarasinghe et al. (2007) have shown significant changes in food consumption patterns over the recent decades. Because of these changes, India's total grain demand shall increase from 217 million MT in 2000 to about 380 million MT by 2050. This projection includes the feed grain demand of

120 million MT, which is a tenfold increase from the present levels, a factor that the NCIWRD study has significantly underestimated. Even then, the projections of Amarasinghe et al. study (2007) s fall short of the commission's projection by 115 million MT.

The Commission also assumed that self-sufficiency in food grains as a major driver of irrigation cropping patterns and water demand. The self-sufficiency assumption was based on three concerns: (1) India has a large population and food grain is the staple food, so, no major deficits are acceptable; (2) Agriculture is the main driver of economic growth and contributes to a large share of the GDP; and (3) India's foreign exchange reserves are too low to permit large scale imports of food grains. However, all three reasons are no longer valid in a rapidly growing India: food consumption patterns are fast changing, agriculture sector contribution to GDP is rapidly decreasing; foreign exchange reserve is increasing; and imports and exports, even in the agriculture sector, are growing (Malik 2009). The only concern that demands a significant level of self-sufficiency is that large grain imports from a country of India's size could potentially impact world prices and hurt the very consumer that imports are expected to help feed.

7.4.3 Yield Growth

Many argue that the Commission took an unduly bleak view of the potential to increase food grain yields. The Commission assumed average grain yield to increase from 1.5 tonnes/ha in 1993 to 3.1 tonnes/ha by 2050. However, if India can double the land and water productivities (1.67 tonnes/ha and 0.48 kg/m^3 of consumptive water use in 2000) in 50 years, it can not only be self-sufficient but also will not require any additional irrigated land or withdrawals for food grains (Amarasinghe et al. 2010).

The moot question is: will India be unable to increase its average grain yield to 4.0 tonnes/ha, which is the present level of China, even over a 50-year period? Research suggests that a significant potential exists for larger yield growth. There is significant variation in yield even within a same irrigation system or in the same region growing similar crops (Kumar et al. 2009) or in regions of similar consumptive water use (Amarasinghe et al. 2010). Increasing the reliability of irrigation and increasing the application of inputs can significantly increase grain yields in irrigation areas. Sharma et al. (2010) showed that even small doses of supplemental irrigation during critical periods of crop growth can double the productivity in the rainfed areas.

7.4.4 Future of Irrigation

The NCIWRD's prognosis for how India's future of irrigation shapes up is the most contentious. The composition of surface water and groundwater area in 1993 was 55 % and 45 % of the gross irrigated area. The Commission assumed surface irrigation would be the dominant form of irrigation by 2050, and the composition of net irrigated area will reverse by 2050. However, the developments in recent decades show a completely opposite trend (Fig. 7.2). There has been no appreciable increase in surface irrigated area in India, although, due largely to private small-scale investments, the groundwater irrigated area has recorded a rapid growth.

Today, net groundwater irrigated area is 39 million ha, which constitutes 63 % of the net irrigated area, and contributes to 64 % of the gross irrigated area. It is therefore, largely due to this increase in groundwater irrigation that India has achieved in 2000 the projected gross irrigated area of 79 million ha for the year 2010. But, the sustainability of these trends depends on how far groundwater irrigation can grow without any surface irrigation growth?

Many contend that increase in groundwater irrigation is not possible without surface irrigation recharge. But a substantial part of groundwater irrigated area growth in the last decade took place in districts outside the command areas (Shah et al. 2003) and showed no significant spatial dependence on surface irrigation growth (Bhaduri et al. 2009). The analysis by Amarasinghe et al. (2008) shows that if the 10 million ha of net surface irrigated area from the projects under construction and another 25–35 million ha of net groundwater irrigated area are added to the present level of irrigation, the gross irrigated area will increase to about 130 to 140 million ha. This is the area required for achieving the Commission's exaggerated projections of, and the self-sufficiency targets of grains. With this increase, groundwater irrigation by 2050 will cover more than 70 % of the gross irrigated area. Such a change will significantly reduce the total surface irrigation demand due to differ-

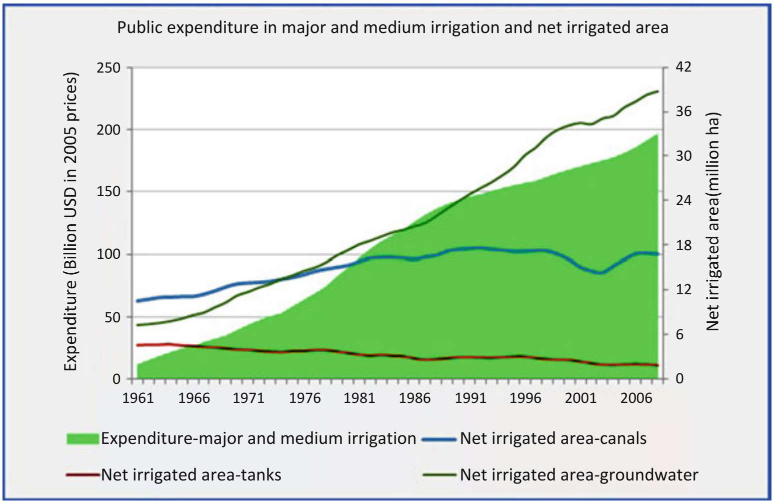

Fig. 7.2 Trends of public expenditure in major and medium irrigation and net irrigated area from different sources in India (*Sources:* Public expenditure data are from the Central Water Commission, Ministry of Water resources, Government of India (accessible via http://cwc.gov.in/main/webpages/statistics.html)). Net irrigated areas under different sources are from the Ministry of Agriculture, Government of India (accessible via the http://dacnet.nic.in/eands/)

ences of efficiencies between surface irrigation (60 %) and GW irrigation (75 %). But, can these optimistic assumptions on irrigation efficiency increase be realized by 2050? Can Managed Aquifer Recharge (MAR) in a decentralized format enable India to use its aquifers as large-scale storages in place of surface storages? These are critical questions for India's water future.

7.4.5 Irrigation Efficiency

The Commission assumed a significant increase in irrigation efficiencies—from 35–40 % now to 60 % in the future for surface irrigation, and from 65 %–70 % to 75 % for groundwater irrigation across all the river basins. The little information we have today on the variation of irrigation efficiency across river basins is not adequate to predict future directions. However, they show that groundwater irrigation efficiency is already close to or even higher than the commission's projections (Kumar et al. 2009). But the surface irrigation efficiency has shown virtually no increase over the recent decades.

It is also clear that many water saving technologies, especially micro-irrigation systems, can significantly increase water use efficiency. Narayanamoorthy (2009) showed that the efficiencies of sprinkler and drip irrigation systems range from 75 % to 90 %. And, more than 70 million ha of land can potentially benefit from micro-irrigation. Many of these technologies are more easily adopted by groundwater irrigators than canal irrigators. This too may work in favor of larger contribution from groundwater to India's food self-sufficiency.

Many water-scarce river basins approaching high degrees of closure as there are no flows to the sea on many days of the year. In these basins, projected application efficiencies of surface irrigation are low, but they have high basin efficiency due to reuse of the return flows of irrigation. Thus increasing irrigation efficiency in one location, and then using the saved water for new locations or for other purposes, would certainly affect some other water users elsewhere. We need to know more on the interactions of efficiencies at the system and basin levels before we can make firm statements on the potential improvement of efficiency in the surface systems. Or, at least we need conservative assumptions on the potential increases based on the information currently available.

7.4.6 Rain-fed Agriculture

Did the Commission's report overlook the potential of rain-fed agriculture? Surprisingly, the Commission projected only a modest growth in rain fed yields from 1.0 tonnes/ha in 1993 to 1.5 tonnes/ha by 2050. At present, rain-fed area accounts for 56 % of the grain crop but contributes only 39 % of the total production. But, by doubling the rain-fed yield to about 2.0 tonnes/ha over the next 50 years; the grain production on the existing rain-fed lands can alone be increased by

81 million metric tonnes. This kind of increase in grain production can meet a substantial part of the future food demand.

Sharma et al. (2010) find that frequent occurrence of mid-season and terminal droughts were the main causes for low yield or crop failure in rain-fed cropped lands. Small supplemental irrigation, especially during the water-stress period of the reproductive stage of crop growth, can benefit a substantial part of the rain-fed area. This requires collecting only 18–20 km^3/year of water through rainwater harvesting using small-scale structures, and will have little or no effect on downstream users.

7.4.7 Eco-system Water Needs

The Commission's water allocation to eco-system services is only 10 km^3–less than 1 % of the mean annual runoff of all river basins. Even the Commission has admitted that this is not an adequate provision. IWMI research shows that in many basins, maintaining a healthy river ecosystem requires much more minimum environmental flows (EF) (Smakhtin and Anputhas 2006).

Level of minimum EF needed depends on the natural hydrological variability of the river and the maintenance requirements under various environmental management classes (Smakhtin et al. 2007). The former is an endogenous driver of the water system and the latter is exogenous. Environmental management classes, which depend on qualitative importance assigned by people, could range from pristine (natural) condition to slightly to moderately to critically modified conditions, and the minimum EF could accordingly vary from 70 % to 15 % of the mean annual runoff.

At present, many of the water surplus river basins considered in the NRLP fall in moderately modified category (Amarasinghe et al. 2008). If eco-systems' water needs get high priority, then effective water supply that is available for potentially utilizable supply for other uses would diminish. In fact, many argue that environmental water demand should also include the needs of wetlands, for cleaning the polluted rivers, for fisheries' needs in the down streams etc. All these, and the resulting ecosystem water needs will have a significant impact on inter-basin water transfers, as the ultimate decision of the surplus or the level of closure of river basins is decided on what proportion of the utilizable water resources are required for the eco-system water needs.

7.5 Implications of NRLP Water Transfers

7.5.1 Hydrological Feasibility

Surplus water in river basins and hydrological feasibility of large water transfers is a topic that is much in discussion; it is a highly contentious topic, too. Many contest the very notion that there can be water surpluses in river basins. One such extreme view, held by Bandyopadhyaya and Praveen (2003), is that "…from a holistic perspective, one does not see any 'surplus' water, because every drop performs some ecological service all the time. ….there is no 'free surplus' water in a basin that can be taken away without a price." Shiva (2003), likewise, considers NRLP to be an act of violence against nature. Iyer (2003) is acerbic in his comments on NRLP projects: "Are rivers bundles of pipelines to be cut, turned around, welded and re-joined? This is technological hubris—arrogance—of the worst description, prometheanism of the crassest kind. The country needs to be saved from this madness."

But others argue differently. For them, some large Indian River basins have vast non-utilizable water resources, even after meeting all human and eco-system service's needs. The total renewable water resource of the Brahmaputra basin is about 584 km^3, which is about a quarter of India's total water resources. But, only about a quarter of that is potentially utilizable within the basin. Mohile and Anand (2009) showed significant non-utilizable water resources also available in Mahanadi and Godavari basins. Rapidly expanding population and increasing demand in other basins can beneficially use a part of these non-utilizable water resources, without noticeable impact on the eco-systems.

Although major donor basins have significant surpluses, Smakhtin et al. (2007) showed that the use of annual data in feasibility reports shows up more water perceived to be available than actual for transfers at some transfer sites. This study concluded that when intra-annual variability of flow is accounted, any transfers of water at the transfer sites within the Krishna river basin would affect the environmental water requirement in the Krishna delta or vice versa. Hydrological modeling of the Godavari (Polawaram)-Krishna (Vijayawada) link (Fig. 7.1) also confirms the above finding that water transfers would affect the downstream users of the Godavari basin (Bharati et al. 2008).

Most recently, the Comprehensive Assessment of Food and Agriculture (CA 2007) by IWMI and partners determined that investments in large-scale infrastructure is necessary in regions where there has historically been under-investment, such as sub-Saharan Africa and parts of Asia. That Assessment however also said that investment in large-scale irrigation, even as a component of multi-purpose projects, is generally economically unattractive. But, Kumar and Saha (2008), based on data of India's large and medium dams, shows that increasing the storage capacity through large/medium dams is important for rapid economic growth in India.

These concerns and others hint at the need to be more circumspect about large-scale water transfers worldwide. However, more recently the pendulum has begun to swing back towards investments in water infrastructure. In some countries, most notably in China, which did not have to depend on external sources to secure the necessary financing, there have been many dams constructed in the recent past. According to the ICOLD World Register, China has 4,434 large dams (ICOLD 2000), but the actual number can be as high as 22,000 according to other sources (WCD 2000). The WSSD in Johannesburg recognized hydropower as a renewable resource for power generation. And, the new World Bank water strategy (World Bank 2004) laid the groundwork for a re-engagement of the multi-lateral banks in large-scale water infrastructure. All in all, the pendulum of global opinion has gradually moved again in favor of large dams, notwithstanding all the concerns that have arisen during recent decades. This change in the worldview may influence Indian thinking about NRLP. Despite renewed attention to 'giganticism' in water infrastructure planning, the modalities to ensure that the infrastructure developed is effective and sustainable will still remain highly contentious

7.5.2 Environmental Impacts

Environmentalists are worried about the ecological impacts of the NRLP water transfers of such a massive scale. In May 2003, the Government of India's own Ministry of Environment and Forests raised 23 environmental concerns about the NRLP. Independent researchers too worry on many counts, including seismic hazard, especially in the Himalayan component (Bandyopadhyaya and Praveen 2003). Many worry also about the transfer of river pollution that accompanies inter-basin water transfers. The potential loss of forests and biodiversity, of course, are recurring themes.

When completed, some 3,000 plus storages reservoirs of NRLP, will substantially change the river flow patterns and impact sediment loads to down-stream deltas. Such reduction in sediments could shrink river delta, affecting production and mangrove ecosystems. Large numbers of reservoirs already constructed in the Krishna basin have contributed to the shrinking of the river delta (Gamage and Smakhtin 2008). Further construction under NRLP, on the one hand could only exacerbate the shrinking of delta, and on the other hand may reduce the environmental flows, which-if protected—could partially arrest the shrinking delta.

The NRLP water transfers could also have both positive and negative externalities in terms of groundwater recharge and water logging. The proposed irrigation transfers in the Godavari (Polawaram)-Krishna(Vijayawada) link could raise the groundwater water level by 2 m and improve the groundwater profile of the over-exploited blocks of the Krishna basin. Simultaneously, intensive surface irrigation could increase the risk of water logging in about 16 % of the command area (Sharma et al. 2008). Without precautionary planning, as in many other large irrigation schemes in the past (Sharma et al. 2010), disbenefits of water logging could easily offset the benefits of groundwater recharge.

7.5.3 Irrigation Benefits

The NRLP envisages many benefits: generation of hydropower, supply of much needed drinking water to several million people, and industrial water supplies to drought-prone and water-scarce cities in the west and south, mitigation of floods in the east and droughts in the west and the south, and facilitation of inland navigation. However, increased irrigation is by far the largest benefit envisaged from the project. It adds 25 million ha through surface irrigation and 10 million ha through groundwater irrigation to water-scarce western and peninsular regions. This in turn shall generate more employment and boost crop output and farm incomes. It shall also provide multiplier benefits through backward linkages such as farm equipment and input supplies and forward linkages such as agro-processing industries.

Among the many scathing criticisms that this key plank of the project has come under, the most eloquent has been from Rath (2003). Based on simple, back of the envelope calculations, Rath shows that assuming a 7 % interest rate per year, the annual capital costs and interest to recover the total capital over a period 50 years will be US$ 110/ha (Rs. 2,015/acre @ 1 US$ = 45 In Rs) in the peninsular component and US$ 334/ha in the Himalayan component. For irrigating hybrid *jawar* (sorghum) in peninsular India, the required annual capital recovery cost alone will be US$ 221/ha. Similarly, the annual capital recovery cost at 7 % interest over 50 years amounts to US$ 0.30 per watt of hydropower. At the same interest rate charged during the construction period, the three components will cost US$ 252 billion (In Rs. 1,147,873 crore), approximately double of what is now suggested. On the further assumption of a 5 % annual rate of inflation, the project will commit India to a project outlay of US$ 22 billion (In Rs. 100,000 crore) per year.

There are other concerns about such large scale investment, given the past trends of irrigation investments and benefits. The most notable trends are:

- India has invested more than US$ 24 billion (In Rs. 100,000 crore) since 1990 in major and medium irrigation, yet it has hardly increase the net surface irrigated area (Fig. 7.2). Tank irrigated area has been decreasing relentlessly
- Among southern states Tamil Nadu and Andhra Pradesh, two of the major water recipients of NRLP, have spent more than US$ 5 billion (In Rs. 22,500 crore) in major and medium irrigation since 1970, but lost more than 500,000 ha of net canal irrigated area over the same period (Amarasinghe et al. 2009);
- On the western front, Gujarat has already spent more than US$ 6 billion in the Sardar-Sarovar Project, although the planned cost of construction was only US$ 1.5 billion (In Rs. 6,840 crore). In spite of the cost over-run, only 0.1 of the 1.8 million ha of proposed area is irrigated (Talati and Shah 2009).

Ex-ante benefit: cost analyses of two link canals—Godawari (Polavaram)-Krishna (Vijayawada) and Ken-Bethwa—show similar trends. Major parts of the command areas in both links are already irrigated by groundwater or pre-existing schemes. In the Godavari-Krishna link, groundwater already irrigates 90 % of the en-route canal command. In the Ken-Bethwa link, rainfall is sufficient for the Kharif season crop cultivation, for which a substantial part of the water transfers under the link is planned. These studies show that when the canal links are considered individually, direct and indirect benefits per every cubic meter of water consumed or delivered are rather low even under most optimistic scenarios of cropping patterns (Bhaduri et al. 2009; Amarasinghe et al. 2008).

However, many of the NRLP links, such as those in the peninsular component, are inter-dependent. Water transfers to a river basin from up-stream links are a substitute for water transfers out from the basin from downstream links. These form a large project with many small components. Inocencio and McCornick (2008) have shown that large projects with many smaller schemes, with diversified cropping patterns, show better economic performance. Viewed from this perspective, similar are water transfers and irrigation benefits from the major links from Mahanadi to Godavari to Krishna to Pennar and Cauvery in the peninsular component (Amarasinghe and Srinivasulu 2009). Although irrigation benefits of some of the individual links are not financially attractive, the links taken together as a project may prove financially attractive under a diversified cropping pattern.

Of course, the above benefits are only direct and indirect financial benefits from irrigation. But, water infrastructure projects have other direct and indirect costs, including the cost of displacement of people—resettlement and rehabilitation, and the environmental impacts. The data on many of these aspects are scanty at best, and it is difficult to assess financial implications to complete a social cost and benefit of all links at present.

7.5.4 Social Costs

It is likely that NRLP shall displace *adivasi's* and poor people on a massive scale. Estimates are sketchy, but the construction of reservoirs and canals in the peninsular component alone is expected to displace more than 583,000 people, and submerge large areas of forest, agriculture and non-agricultural land. One estimate suggests that the network of canals alone would displace about 5.5 million tribesmen and farmers (Vombatkere 2003).

Many critics of large water projects often focus only on negative impacts, multi-purpose water transfers potentially can and do bring significant social benefits. Recent history of large-scale water resources projects in India and elsewhere, however, shows that despite government policies and procedures that include the necessary redress measures, displaced populations still suffer enormously. Such suffering can be moderated or reduced but only though planned and sensitive resettlement and rehabilitation programs which India has generally failed to establish so far. Samad et al. (2009) shows that enhanced livelihood opportunities in relocation sites can create longer-term benefits to compensate short-term losses.

In fact, many water transfer projects require both skilled and unskilled labor, and the training provided for the local and sometimes for the regional or national workforce, is a major advantage for future endeavors. Often, large water development projects increase access to new infrastructure: roads, which otherwise takes hours to reach to a decent mode of transport; markets, which otherwise are not even reachable for several days; clean water supply- without which people, especially women and children, trek hours to find a potable water source.

The large irrigation projects not only enhance the livelihood of the farming families in the command area, but also bring substantial multiplier effects to the region, and in some cases at the national level too (WCD 2000). The Bhakra Irrigation Project's regional multiplier is 1.7 of the direct benefits (Bhatia et al. 2007). And the Indus Basin, where irrigation is an integral part of the crop production system, meets more than 80 % of the food production deficits of other basins in India. It is not a secret that irrigation was a major factor in transforming the major food deficits in India in the 1950s and 1960s to present day food surpluses.

7.5.5 Resources Mobilization

Many critics are skeptical of the government's capacity to mobilize the kind of investable funds that NRLP demands. Budgetary provisions made so far for water development are far from enough to complete ongoing projects. During recent years, under a special 'Accelerated Irrigation Benefits Scheme', the government has been setting aside funds for the so-called 'last mile' projects(projects which are nearly complete but have been languishing for years for the lack of relatively modest funds to complete minor residual work).

Many incomplete projects dot the country, to the extent that the NCIWRD estimated at the turn of the century that India needed US$ 15.5 billion (Rs. 70,000 crores) during the Tenth Plan and US$ 24.4 billion (Rs. 110,000 crores) during the Eleventh Plan just to complete these 'last mile' projects. It is this fact that made senior researchers like Iyer (2003) to quip, "We have had great difficulty in completing even single projects successfully and we want to embark on 30 massive projects at the same time!"

These concerns relate to the small versus large storage debate. It is clear that freshwater storage at present is inadequate to address tomorrow's water needs. The situation will be more acute with the pending climate change impacts. There is evidence that increasing storage only through a combination of large reservoirs, small pond and tanks, soil moisture, groundwater aquifer and wet lands can bring the most socio-economic benefits while reducing the environmental cost (Keller et al. 2000; McCartney and Smakhtin 2010).

7.5.6 Trans-boundary Conflicts

There are trans-boundary issues of over-riding significance—within India and outside—when it comes to the actual implementation of NRLP. The Himalayan component is critically dependent on the agreement of neighboring countries Nepal and Bhutan to the proposed construction, especially of dams, in their respective territories. Bangladesh, as a downstream riparian country, will be an affected party, and its concerns need to be factored into the NRLP calculus. Under the India-Bangladesh Treaty of December 1996 on the sharing of Ganga waters, India has undertaken to protect the flows arriving at Farakka, which is the sharing point. West Bengal has only reluctantly agreed to the large allocations of waters to Bangladesh under the Ganga Treaty and has been pressing the needs of Calcutta Port. On the other hand, Bangladesh may feel threatened that a diversion of waters from the Ganga to the southern rivers will not be consistent with the sharing arrangement under the Treaty. Mamata Banerjee, West Bengal's Chief Minister recently refused to share Teesta waters with Bangladesh in an open show of defiance to Government of India's attempt to forge cooperation with Bengladesh. Inability of India to secure compliance from its own state governments weakens the scope for trans-boundary international cooperation even on a win-win formula.

Water transfers between Brahmaputra and Ganga basins and from Ganga to other rivers may require modification of existing agreements or new treaties. Bhaduri and Barbier (2008) showed that India and Bangladesh could modify existing agreements to augment water supply, which in turn may benefit both countries. However, this depends on the scale of political altruism India can muster to allocate water to the downstream user or create some kind of insurance mechanisms to safeguard rights of the downstream riparian. If India decides unilaterally to transfer water to peninsular basins, or the States decide to use more than their share, Bangladesh could incur huge environmental losses.

Existing international agreements elsewhere provide many lessons relevant to the NRLP (Gichuki and McCornick 2008). Initial agreements of water transfers are no longer functional in many inter-basin transfers, including those in the Aral Sea basin among Central Asian Republics, in Tagus and Ebro basins in Spain. Many of the conflicts arose later due to unforeseen circumstance at the planning stage. Often, initial planning did not undertake a holistic analysis of t water supply and existing uses, and future demand in different countries or basins.

Water transfers in the peninsular component too would hinge on inter-state politics, economics and agreements. Bihar may refuse to transfer Ganga water, as Lalu Prasad Yadav, a senior political leader of the State, argued that if her farmers are unable to use her water today, it does not mean they will remain unable to do so forever. But, such rejections could change if the recipient states compensate Bihar for the Ganga waters that it allowed to transfer.

7.6 Conclusion

Despite the Supreme Court order, if the fate of NRLP were to depend upon the shape of the national debate around it, the dice are heavily loaded against it. This is partly due to intensely polarized ongoing debate based on plurality of prevailing conditions and experiences. The analyses of this paper have mixed conclusions. The project is so large that it is difficult to conduct a holistic analysis leading to a social cost and benefits. The main reason for this is due to little information and data the available in the public domain. The NCAER (2008) study has evaluated the macroeconomic benefits of the NRLP project, but lacked the environmental and socioeconomic cost.

It is possible that the present proposal for NRLP has come a decade or two too soon. Many drivers and assumptions, which were conducive to the condition in the 1990s, have changed since the proposal conception, and may change further before the project undergoes feasibility analyses. Some of the changes are likely to create conditions favorable for a comprehensive solution of the kind of NRLP, although it is likely to be quite different in nature to the presently conceived form. In particular, the following seven contingencies may be important in determining how the country will plan its water infrastructure investments over the coming decade or two:

1. Just as a cash-strapped China cold-stored Mao's proposal for transfers from South to North until the mid-1990s, a US$ 2 trillion Indian economy around 2015 may take more enthusiastically to the idea of massive water infrastructure investment that amounts to more than what was invested under the current US$ 2 trillion Indian economy;
2. Economy-wide demand for the improved performance of public systems in infrastructure creation and management—in road, railways, power, etc.,—will also restore public confidence in the water bureaucracies' capacity to deliver on their promises, and ease the prevailing opposition to 'sterile gigantisms';
3. Similar economy-wide pressures to improve the rehabilitation of people affected by projects on roads, Special Economic Zones and such other dynamic infrastructure areas will raise the bar for resettlement and rehabilitation work in water infrastructure projects, alleviating the other major concerns of civil society about large water projects;
4. Increasing disposable incomes will prompt the 'median voter' to demand better water services and pay for them, transforming extant water scarcity into 'economic' water scarcity; this will improve the financial viability and sustainability of water infrastructure; it will also mean water conflicts will be resolved through price negotiations rather than through political bargaining or administrative processes;
5. Similar pressures in agricultural water demand will arise due to intensive diversification of Indian agriculture that generates higher output-value per m^3 of water; diversification will create *economic* demand for more reliable, on-demand irrigation service for which the farmers will be willing to pay substantially more than what they pay for canal irrigation today;
6. Rising energy costs will make pump irrigation increasingly unattractive and increase demand for surface water either for direct application to crops or for groundwater recharge in western and peninsular India; rising costs of fossil fuel will also make hydropower dams more attractive; and
7. Finally, rapid growth in urban agglomerations will seriously strain their groundwater-dependent water supply systems and that in turn will make inter-basin water transfers for urban water needs economically viable and politically compelling.

India may or may not implement NRLP as proposed. However, there seems no avoiding massive water infrastructure investments on a scale similar or even exceeding the NRLP. Medium- to long-term water sector planning needs to take account of the aforementioned seven contingencies. Throughout Indian history, irrigation projects on a grand scale have been constructed more as political statements by ambitious rulers rather than as economic enterprises justified by cold calculus of benefits and costs. If and when projects like NRLP is back on the drawing board and for them to be a grand socio-economic statement, their techno-economics will need to be based on the reality of India's agricultural future rather than its past.

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Chapter 8
Water Pollution: Extent, Impact, and Abatement

Prakash Nelliyat

Abstract Water pollution is an emerging challenge in developing countries like India, which try to achieve rapid economic development without adequate/effective environmental management facilities. In recent years, the pollution load discharged by different sectors (domestic, industrial and agriculture) has increased, some times beyond the carrying/assimilative capacity of the environment. Fresh water sources (rivers, lakes and aquifers) are one of the major victims of pollution, whose impact on health and livelihood of millions of poor people is critical, besides the physical deterioration of the aquatic ecosystem. Hence, pollution hampers development in a significant manner. Though various pollution management measures have been attempted over a period of time, significant progress has not been achieved. In this regard, a more realistic and integrated approach (with emphasis on appropriate water pollution policies, strict enforcement, multi-stakeholders' initiatives and cooperation, affordable technology development and application of economic instruments) needs to be implemented.

Keywords Water pollution • Integrated water resources management • Pollution management • Water policy • Multi stakeholders analysis

8.1 Introduction

The availability of good quality and adequate quantity of water is a pre-requisite for the survival of all living organisms, smooth functioning of ecosystems, enhancing communities welfare and increasing their economic activities. However, freshwater sources have been threatened, sometimes in an irreversible manner in recent times, from various sources of pollution. The growing pollution of water sources is affecting the availability of safe water for various human uses. Besides, it causes environmental and health hazards, as well as a financial burden to community and government.

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“Water Pollution is the degradation of water quality, as measured by biological, chemical or physical criteria that can make it unsuitable for desired uses, such as bathing, drinking or fishing, and can have serious effects on the health of humans and animals through contact or injection” (Manson 2002). Pollution typically refers to chemicals or other harmful substances in concentrations greater than would occur under natural conditions, to make the water unfit for use. Major water pollutants include microbes, nutrients, heavy metals, organic chemicals, oil and sediments. Heat, which raises the temperature of the receiving water, can also be a pollutant. Water pollution differs from nation to nation, with respect to the levels of economic development and pollution governance. Rapid industrial development, uncontrolled urbanization, intensive agriculture and aquaculture are the major causes of pollution in developing countries like India.

Water pollution can broadly be categorized as: (a) Point source of pollution, which occurs when harmful substances are emitted directly into the water and land, and (b) Non-point source pollution, when pollutants are delivered indirectly through transport or environmental change. Generally, the point source of pollution is easy to monitor and regulate, compared to non-point sources.

Water pollution has severe impacts on the usefulness and value of water resources, on ecosystems, fisheries, food production, health and social development, and economic activities. Water pollution can cause or aggravate tension and conflict, among various water users and even between countries (Kraemer et al. 2001). The rising water pollution leads to the real and potential loss of the overall development opportunity in an economy like India, when the poor are affected seriously. This chapter examines the water pollution scenario, its impacts, management efforts and integrated pollution management strategies in the context of India.

8.2 Water Pollution Scenario in India

India possesses 17 % of the world’s population, but has only 4 % of the world’s renewable water resources with 2.6 % of land area (MoWR 2012). In India, the pressure of economic development is changing the distribution patterns of water resources. The average availability of water is reducing steadily with the growing population, and it is estimated that by 2020, India will become a water stressed nation. There is no doubt that increasing fresh water contamination aggravates the situation.

India has been experiencing rapid urbanization and this rate has increased from 10.84 % (1901) to 28.5 % (2001) and to 31.16 (2011). Most of our cities don’t have proper schemes for the collection, transportation, treatment and disposal of liquid and solid wastes. Besides, the expansion of peri-urban areas without adequate infrastructural services is an emerging challenge.

According to Lundqvist et al. (2003), the entire population growth in the world during the coming decades will virtually occur in or be confined to urban agglomerations, and most of it in less developed countries like India. India is experiencing structural transformations, in terms of a decreasing role for agriculture, and the increasing dominance of the industrial and service sectors, especially in urban areas.

The urban population is a heavy user of land and water resources. Hence, natural resources like wetlands, agricultural land, tanks and lakes, and the associated flora and fauna have been significantly lost. Moreover, waste (both solids and liquids) generated in urban and peri-urban areas is more concentrated, and hence, more serious in terms of environmental damage (Nelliyat and Ambujam 2011). In India, the urban population has increased from 11 % (1901) to 17 % (1951) and further to 28 % (2001). Similarly, the number of towns has also increased from 1916 to 2422, to 4689, in these same respective years (Maiti and Agrawal 2005). Sanitation condition of the metro cities in India revealed that, almost universal flush toilet facility is available in Mumbai followed by 90 % in Kolkata and 89 % in Delhi. However, the matter of fact is that, more than half of this facility in Mumbai is available in a public place and not in house premises. Kolkata and Delhi might have a similar situation. Again it is unfortunate to note that about 9 % population of Kolkata and Delhi uses pit toilet. Further, what is the worst situation is that 9 % of Chennai's population does not have toilet facility at all followed by 6 % in Delhi (Maiti and Agrawal 2005).

The study done by Nelliyat et al. (2012) revealed the magnitude of urbanization and its impacts on water sources in Chennai Metropolitan Area (CMA). CMA comprises a total area of 1189 km^2. It consists of Chennai city (176 km^2), 16 Suburban Municipalities (240 km^2), 20 Town Panchayats (156 km^2), and 216 Village Panchayats (617 km^2). Chennai's growth has been rapid since the 1970s. Its population has increased from 3.5 million (1971) to 5.8 million (1991) to 9.8 million (2011) (CMDA 2007). Population projections based on the past trend showed that CMA would hold population of 12.6 million by 2026, of which Chennai city would accommodate only 5.8 million. Which means in future substantial urban growth will occur in sub-urban part of the city. According to CMDA (2007), the sewerage system in Chennai city has covered 98 % of its area. The Corporation is collecting and disposing the solid wastes. However, the sewerage network and solid waste management practices in the suburban areas are not satisfactory. The wastes are disposed in the open lands and water bodies, which lead to high level contamination of fresh water sources and its consequences on human well-being are serious.

About 29,000 million l/day (mld) of waste water is generated from India's class-I cities and class-II towns, out of which about 45 % (about 13,000 mld) is generated from 35 metro-cities alone. A collection system exists for only about 30 % of the waste water through sewer lines, and the treatment capacity exists for about 7000 mld (CPCB 2007). Thus, there is a large gap between the generation, collection and treatment of waste water. Most of the un-collected, un-treated waste water finds its way to either nearby surface water bodies or cesspools.

According to CAG (2011), only about 10 % of the waste water generated from the domestic and industrial sectors in India is treated; the rest is discharged as it is into water bodies and land. In almost all urban centres, cesspools exist, which are the breeding grounds for mosquitoes. Further, the wastewater accumulated in cesspools gets percolated in to aquifers and pollutes the groundwater. Even now, our cities have large numbers of conventional septic tanks and other low cost toilets, which contaminate the groundwater.

The industrial sector discharges around 30,730 million cubic meters of effluents, without proper treatment, into water bodies (CPCB 2006). For effluent treatment in the small scale industrial sector under government initiatives, 88 Common Effluent Treatment Plants (CETP) were constructed, having a total capacity of 560 mld. These plants would cover more than 10,000 small scale industries. But the study done by the CPCB (2006) revealed that the common effluent treatment plants are not performing satisfactorily, largely due to improper operation and maintenance.

Run-off from agriculture fields is another major source of pollution as it contains fertilizers and pesticides. Fertilizer application in the country has increased substantially: from 305 metric tonnes (1959–1960) to 20,340 metric tonnes (2005–2006) (Khurana and Romit 2008). The use of pesticides has also increased from 20,305 tonnes (1974) to 85,030 tonnes (1994) (Khurana and Romit 2008). Water quality is affected by frequent floods and droughts, and the over extraction of groundwater, particularly in the coastal areas.

In certain parts of the country, groundwater quality degradation has occurred due to natural reasons. The natural chemical composition of groundwater is influenced predominantly by the type, depth of soils and subsurface geological formations through which groundwater passes. According to CGWB (2010) the behaviour of groundwater in the Indian sub-continent is highly complicated, due to the occurrence of diversified geological formations with considerable lithological and chronological variations, complex tectonic framework, climatological dissimilarities and various hydro-chemical conditions. However, groundwater has become an important source of water for meeting the requirements of various sectors. It accounts for nearly 80 % of the rural and 50 % of the urban domestic water needs. Besides, well irrigation plays a significant role in increasing agricultural production. An aquifer is generally less susceptible to anthropogenic induced contamination and pollution when compared to surface water bodies. However, recently the trend has been changing, and anthropogenic factors such as overexploitation of groundwater, excessive use of fertilizers and pesticides in agriculture, and improper disposal of urban/industrial waste, contaminate the groundwater. Nitrates, phosphates, and heavy metals in the groundwater lead to various health disorders.

A recent study done by the CGWB (2010) through a network of about 15,500 groundwater samples indicated that well water in certain areas is found to have concentrations beyond permissible limits of some constituents, and is not fit for human consumption. The study results are summarised below.

Total Dissolved Solids – TDS – (Salinity) is the saltiness or dissolved salt content that exists in groundwater. It is mostly influenced by aquifer material, solubility of minerals, duration of contact and factors such as the permeability of the soil, drainage facilities, quantity of rainfall and above all, the climate of the area. The salinity of the groundwater in coastal areas may be due to air borne salts, originating from the air water interface over the sea, and also due to over pumping of fresh water which overlays saline water in coastal aquifer systems. The Bureau of Indian Standards (BIS) has recommended a drinking water standard of a limit of 500 mg/l for TDS, which can be extended to 2000 mg/l in the case of no alternative source. But water having TDS of more than 2000 mg/l is not suitable for drinking. This is observed in some districts of Andhra Pradesh, Delhi, Gujarat, Haryana, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal.

Chloride is highly soluble in water and moves freely through soil and rock. In groundwater, the chloride content is mostly below 250 mg/l, except in cases where inland salinity is prevalent and in coastal areas. The BIS has recommended a desirable limit of 250 mg/l of chloride in drinking water. This concentration limit can be extended to 1000 mg/l in case no alternative source of water is available. However, groundwater having concentrations of more than 1000 mg/l of chloride is not suitable for drinking purposes. This is observed in some districts in Andhra Pradesh, Delhi, Gujarat, Haryana, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, and West Bengal.

Fluoride Most of the fluoride found in groundwater is naturally drawn from the breakdown of rocks and soils or weathering and deposition of atmospheric particles. The occurrence of fluoride in natural water is affected by the type of rocks, climatic conditions, nature of hydrogeological strata and time of contact between the rock and the circulating groundwater. The presence of other ions, particularly bicarbonate and calcium ions, also affects the concentration of fluoride in the groundwater. Small amounts of fluoride (less than 1.0 mg/l) have proven to be beneficial in reducing tooth decay. However, high concentrations (1.5 mg/l and above) have resulted in staining of teeth. The BIS has recommended an upper desirable limit of 1.0 mg/l of fluoride in drinking water, which can be extended to 1.5 mg/l if no alternative source of water is available. But fluoride concentrations of more than 1.5 mg/l in water make it un-suitable for drinking purposes. This is observed in some districts of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Rajasthan, Chattisgarh, Haryana, Orissa, Punjab, Haryana, Uttar Pradesh, West Bengal, Bihar, Delhi, Jharkhand, Maharashtra, and Assam.

Iron is a common constituent in soil and groundwater. It is present in water either as soluble ferrous iron or insoluble ferric iron. The concentration of iron in natural water is controlled by both physio-chemical and microbiological factors. It seeps into groundwater mainly from the weathering of ferruginous minerals of igneous rocks, such as hematite, magnetite and sulphide ores of sedimentary and metamorphic rocks. The permissible iron concentration in groundwater is less than 1.0 mg/l as per the BIS for drinking water. Excessive iron has been found in some districts of Andhra Pradesh, Assam, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Orissa, Punjab, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, West Bengal and Andaman & Nicobar Island.

Arsenic Arsenic is a trace element found in rocks, soils, and the water in contact with them. Arsenic has been recognized as a toxic element and is considered a human health hazard. The occurrence of arsenic is mainly in the aquifers up to 100 m depth, but deeper aquifers are free from contamination. As per the BIS for drinking water, the maximum permissible limit of arsenic concentration in groundwater is 0.01 mg/l. Arsenic contamination has been found in the states of West Bengal, Bihar, Uttar Pradesh, Assam and Chhattisgarh.

Nitrate is a naturally occurring compound that is formed in the soil when nitrogen and oxygen combine. The primary source of all nitrates is atmospheric nitrogen gas. This is converted into organic nitrogen by some plants by a process called nitrogen fixation. Dissolved Nitrogen (Nitrate) is the most common contaminant of groundwater, and generally originates from non-point sources, such as leaching of chemical fertilizers & animal manure, groundwater pollution from septic and sewage discharges, etc. It is difficult to identify the natural and manmade sources of nitrogen contamination. Some chemical and micro-biological processes such as nitrification and de-nitrification also influence the nitrate concentration. As per the BIS for drinking water the maximum desirable limit of nitrate concentration is 45 mg/l. Though nitrate is considered relatively non-toxic, a high concentration in drinking water is of great concern because of increased risks of matheomoglobinemia (Methemoglobin is a form of hemoglobin that contains ferric iron and has a decreased ability to bind oxygen), particularly to infants. Excess concentration of Nitrate in groundwater has been observed in most of the states.

8.3 Impacts of Pollution

Pollution is an 'externality' issue and its impacts on human health and wellbeing are critical. The state of human health is inextricably linked to a range of water related conditions: safe drinking water, adequate sanitation, minimized burden of water related diseases and healthy freshwater ecosystems (WHO 2003). Water conveys micro-organisms, and chemical pollutants, and is a source of radiological risks. Pollutants are directly transferred to the human body through drinking water, and indirectly to the water applied to food crops and livestock, fish, etc., and through aerosols generated by air conditioning systems. Aquatic ecosystems serve as breeding habitats for insect vectors of diseases, and for snails that serve as intermediate hosts in the transmission cycle of certain parasitic diseases. When the pollution load increases in fresh water sources, millions of people are at risk (Nelliyat 2011). Further pollution will increase the financial burden of local bodies through incremental costs for pure water supply.

Historically, rural settlements managed their drinking water requirement through local sources, and quality issues did not emerge except in a few habitats due to geogenic reasons. However, the level of pollution has increased in recent times due to various anthropogenic reasons. Our country is also characterised by non-uniformity in the level of awareness, socio-economic development, education, poverty, practices and rituals which add to the complexity of providing water (Khurana and Romit 2008). Even if the government has undertaken various drinking water programmes with huge expenditure over a period, many rural settlements still lack safe and secure drinking water.

Bacterial contamination of water continues to be a widespread problem across the country, and is a major cause of health problems. During 2005, the CPCB conducted a detailed water quality analysis, and the results indicated that organic pollution (BOD and coliform) continues to be predominant in aquatic resources. It was observed that nearly 66 % of the samples had BOD values less than the acceptable limits and 44 % of the samples indicated the presence of coliform. About 70–80 % of water borne diseases in India are caused by the discharge of untreated/partially treated sewage and industrial effluents into water bodies. The health costs of water pollution are enormous. Annually 37.7 million Indians are affected by water diseases, including the loss of 75 million working days (Khurana and Romit 2008). Around 1.5 million children die of diarrhoea alone (Khurana and Romit 2008).

In India, the cost of inaction or the estimated overall environmental damage cost from pollution was $9.7 billion/year or 4.5 % of GDP in 1992. Out of the total damage cost, the health impact of water pollution was estimated to be US$5710 million (59 %) (Brandon and Hommann 1995). Water related diseases impose burdens on both the household's and the nation's economy. At the household level, the economic loss includes cost of treatment, and wage loss during sickness. Loss of working days affects national productivity. Besides, the government also spends huge money on treatment of the sick and in providing other supporting services. According to a Government of India estimate, the expenditure on health care adds up to Rs. 6700 crore (Rs. 60 per head) annually.

Pollution impacts on ecosystems (biodiversity) and various economic activities like agriculture, livestock, fisheries etc., are also of concern. The study done by Nelliyat (2012) revealed the various impacts of untreated/partially treated textile effluent discharge in a South Indian river basin (Noyyal). Since the groundwater and surface water sources are not suitable for cultivation, farmers incur heavy losses. Most of the saline sensitive crops have disappeared from the basin and the productivity of the existing crops has reduced. Water contamination has also affected the domestic water sector, and households are purchasing or fetching fresh water from distant sources. Since all the surface water sources are highly polluted, biodiversity and fisheries are affected, and fishermen have lost their livelihood options. Industries are also bringing their required water from the non-polluted/distant areas through tankers or pipelines. The annual damage cost of pollution was estimated as Rs. 448.9 million, of which Rs. 352.9 million is for agriculture, Rs. 130.5 million for domestic water supply and Rs. 1.5 million for fisheries.

Pollution impacts are also significant on fisheries and other coastal resources such as mangroves and corals. India has 7500 km of coast line. A number of urban settlements, including mega cities and industries are located on the coast. In the coming decades, this pressure will intensify further, as coastal urbanization and inward population migration increase. The considerable amount of waste generated in coastal areas is directly discharged in to the sea, leading to a significant impact on the marine environment. Municipal/domestic wastes reduce the dissolved oxygen (DO), increase hydrogen sulphide, BOD and faecal coliform. Industrial waste affects the DO, temperature, turbidity, pH and increases the BOD, COD, and suspended solids. Coastal areas are experiencing overexploitation of groundwater. Seawater intrusion induced contamination of the aquifer is a major challenge to freshwater security in coastal areas of the country (Nelliyat et al. 2009). Further, the intensive aqua-cultural practice in coastal villages has led to salinization of the groundwater.

Coastal cities in India are under the looming threat of pollution. The type and quantum of pollutants into the coastal ecosystem of India are given in Table 8.1.

In Mumbai, the river Kalu flowing through the industrial towns of Ambarnath, Ulhasnagar and Kalyan has a mercury concentration exceeding 100 ppm. Thana creek receives effluents of over 50 MLD where high mercury levels are present in the water, sediments and living organisms. In Calcutta the Hoogly river carries effluents that have contaminated fish and shell fish with heavy metals such as Ni, Cu, Cd and Zn. The sediments near Haldia have up to 10 ug/g of pesticides. These river waters are contaminated by e-coli, shigella, salmonella and other human pathogens – indication of severe sewage contamination. In Kochi, the Periyar river receives effluents from chemical industries and untreated sewage. Incidents of ulsuration in shrimp and fish, and frequent fish mortality have affected traditional fishing. In Goa, estuarine and coastal waters are "clean", though there is high sediment load from mining activities. The Mandovi-Zuari estuaries receive over 30 MLD of partly treated domestic sewage and 15 MLD of industrial effluents (Elrich 2013).

The study by Palanisamy et al. (2006) indicated that the levels of hydrological pollution of Chennai coastal zone have been increased in the recent years by an uncontrolled disposal of wastewater and pollutants due to human activities. Analysis of physical, chemical and biological parameter determinations indicated that the concentrations of dissolved oxygen (DO), biochemical oxygen demand (BOD),

Table 8.1 Pollution load in the coastal ecosystems in India

Sr. No.	Input/pollutant	Quantum – annual
1.	Sediments	1600 million tonnes
2.	Industrial effluents	50×10^6 m^3
3.	Sewage – largely untreated	0.41×10^9 m^3
4.	Garbage and other solids	34×10^6 tonnes
5.	Fertilizer – residue	5×10^6
6.	Synthetic detergents – residue	1,30,000 tonnes
7.	Pesticides residue	65,000 tonnes
8.	Petroleum hydrocarbons (Tar balls residue)	3500 tonnes
9.	Mining rejects, dredged spoils & sand extractions	0.2×10^6 tonnes

Source: Elrich (2013)

chemical oxygen demand (COD), nutrients (nitrate, nitrite and phosphate), turbidity, maximum probable number (MPN) and chlorophyll *a* (Chl *a*) reached notably high levels at all sample locations before monsoon. The concentrations of trace/toxic metals such as manganese, copper, nickel, lead, cadmium and cobalt also reached very high levels, leading to further habitat and ecological destruction.

Even if pollution damage is widespread in certain locations, its impacts are more on the socially vulnerable and poor communities due to their weak coping options. Moreover, they are less aware of the various pollution consequences. For example, when traditional drinking water sources get contaminated, the rich can buy packaged water. But the poor are not able to pay, and hence are compelled to use the polluted water.

8.4 Pollution Management

Historically, the municipalities and such civic authorities have been responsible for management of the wastes in cities. However, in recent periods due to various reasons (including erosion of authority, inability to raise revenues and inadequate managerial capabilities) urban bodies have not been able to cope with this massive task. That is why, it became necessary to launch special programmes like the Ganga Action Plan and subsequently the National River Conservation Plan, which are essentially addressed to the task of trapping, diverting and treating municipal wastewater (CPCB 2007).

India has a long tradition of institutions in water resources management, which is seen from its ancient culture to the modern legislative devices. Ancient Indian religious literature (*Vedas, Upanishads, Smiritis and Dharmas*) preached a worshipful attitude towards earth and its elements including water and enshrined a respect for nature and environmental harmony and conservation (Sankar 1998). During the British period, too environmental (water pollution) issues garnered attention through:

(a) The Indian Penal Code 1860, that contains one chapter (Chapter XIV) on offences affecting public health, safety, convenience, decency and morals.
(b) The Indian Easement Act of 1882, that guaranteed property rights of riparian owners against "unreasonable" pollution by upstream users.
(c) The Shore Nuisance (Bombay-Kalova) Act, 1893, that was enacted to check wastes and marine water pollution.
(d) The Municipal and Public Health Acts on the pattern of Local Authorities Act of United Kingdom, conferred powers on the local bodies for controlling water pollution caused by industrial effluents and for necessary action against the erring industries. Further it prohibits the discharge of any pollutant or trade effluent from factories into municipal drains, and the discharge of sewage into any watercourse until it had been treated, so as not to contaminate the water (Sankar 1998).

In the Indian Constitution, environmental protection has been emphasized. The River Boards Act, 1956 is an important legislation enacted by the Parliament. Further the 42nd Constitution Amendment Act, 1976, inserted specific provisions for environmental protection in the form of Directive Principles of State Policy and Fundamental Duties. Article 51A (g) was envisaged to protect and improve the natural environment, including forests, lakes, rivers, wildlife, and to have compassion for living creatures. For water pollution management, various initiatives have been taken by the government (Table 8.2).

8.4.1 Legislative Framework

The goal of compliance with environmental laws is to assure the average citizen, that natural resources are protected, that specific violators can be identified, and that they comply with legal provisions. This is needed in order to safeguard human health and the environment and to deter future violations (CAG 2011). The main legal provisions with regard to the prevention of water pollution in India are as follows:

Water (Prevention and Control of Pollution) Act: 1974 was the first environmental law enacted by Parliament. It defines pollution as 'such contamination of water or such alteration of the physical, chemical or biological properties of water on such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may, or is likely to

Table 8.2 Water pollution management efforts

Legislation	Policy	Programmes	Industrial water pollution (SSIs)
◆Water (Prevention and Control of Pollution) Act,1974 ◆Water (Prevention and Control of Pollution) Rules, 1975 ◆The water (Prevention and Control of Pollution) Cess Act, 1977 ◆Environment (Protection) Act, 1986 ◆Environment (Protection) Rules 1986	◆National Water Policy, 2002 ◆National Environment Policy, 2006 ◆Draft National Water Policy, 2012	◆Ganga Action Plan ◆National River Conservation Plan ◆National Lake Conservation Plan ◆Jawaharlal Nehru National Urban Renewal Mission ◆Urban Infrastructure ◆Development Scheme for Small and Medium Towns	◆Closure Policy ◆Waste Minimization ◆Common Effluent Treatment Plants (CETPs) ◆Relocation strategy

create a nuisance or render such water harmful or injurious to public health or safety, or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or of aquatic organisms'. The Act provides for the prevention and control of water pollution and for maintaining or restoring the wholesomeness of water in the country. To achieve this objective, the Act provided for establishing the Pollution Control Board (PCB) at the central and state levels. It lays down a system of consent, whereby no industry or operator process or any treatment and disposal system can be established without the prior consent of the state Board. Similarly, no industry/process can discharge sewage or trade effluents into a stream or well/sewer/land in excess of the standards. Contravention of the provisions of this Act is punishable in monetary as well as non-monetary terms.

The Water (Prevention and Control of Pollution) Cess Act, 1977 provides for the levy of cess on the use of water by various users, i.e., industry and local authorities which are entrusted with the duty of supplying water under the law. This cess was meant to augment the funds required by the state PCB for their effective functioning, in the discharge of duties under the Act. The cess is collected by the state government concerned, and paid to the central government. The proceeds are credited to the consolidated fund of India. The central government, after due appropriation made by Parliament by Law, disburses such sums of money as it may think fit to the central and state Boards, having regard to the amount of cess collected by the state government concerned.

Environment (Protection) Act, 1986 was enacted in the aftermath of the Bhopal gas tragedy in 1984; it also refers to the decisions taken at the Stockholm Conference in 1972, and expresses concern about the decline in environmental quality, increasing pollution, loss of vegetal cover and biological diversity, excessive concentrations of harmful chemicals in the ambient atmosphere, growing risks of environmental accidents, and threats to life systems. The Act is a comprehensive piece of legislation and under this, the Environment Protection Rules (EPR) was announced. The nodal agency for implementing various legislations relating to environmental protection at the centre is the MoEF. It is expected to provide directions to the CPCB on matters relating to the prevention and control of pollution, and design and implement a wide range of programmes relating to environmental protection.

Subsequently, different standards were set for emission and effluent discharge. Under EPR 1986, the Government of India notified in 1993, that the emission or discharge of environmental pollutants from industries, operations or processes shall not exceed the relevant parameters and standards specified. The general standards for the discharge of effluents cover more than 40 parameters, including colour and odour, suspended solids, dissolved solids, pH, BOD, COD, chemicals and metals. The permissible limits vary depending on where the effluents are discharged, viz., inland water surface, public sewers, land for irrigation, and marine coastal areas. These standards are based on concentrations of pollutants per unit of effluent.

8.4.2 *Policy Framework*

Besides the legal framework described above, the following policy provisions address the issues of water pollution in India:

The National Water Policy (NWP) adopted in 1987, was reviewed and updated by the MoWR in 2002. This policy aimed at meeting the challenges that have emerged in the development and management of water resources, including water pollution. The policy emphasizes that:

(a) Both surface water and groundwater quality should be regularly monitored
(b) Effluents should be treated as per standards before being discharged.
(c) Principle of 'polluter pays' should be followed.
(d) Necessary legislation should be made for preservation of water bodies from encroachment and deterioration.
(e) New techniques should be followed to eliminate pollution and
(f) Waste water should be recycled and reused.

The MoWR 2002 envisaged that in a time bound manner, (a period of 2 years) the states would frame and adopt the respective state water policies (MoWR 2002).

National Environment Policy, 2006 enacted by the MoEF, deals with water quality pointing out that improvement in the existing strategies and innovations are needed to eliminate the pollution of surface and groundwater resources. It also states that resources should be conserved, and water availability augmented by maximising retention, eliminating pollution and minimising losses. The policy emphasized the need:

(a) To develop and implement, public-private partnership models for setting up and operating treatment plants.
(b) To prepare and implement action plans for major cities for water pollution, through regulatory as well as incentive based instruments.
(c) To take measures to prevent pollution of water bodies from sources, especially waste disposal on lands.
(d) To enhance spatial planning with adequate participation by local communities, to ensure clustering of polluting industries, and to facilitate setting up of CETPs.
(e) To promote R&D in development of low cost treatment technologies at different scales.
(f) To manage pollution through pricing policies of agricultural inputs, especially pesticides and dissemination of agronomy practices.

Draft National Water Policy, 2012 indicated that "access to safe and clean drinking water and sanitation should be regarded as a right to life essential to the full enjoyment of life and all other human rights" (MoWR 2012 page no 5). The policy emphasised the following:

(a) Recycle and reuse of waste water and de-salinization.
(b) Urban water supply and sewage treatment schemes should be integrated and executed through proper pricing policy.

(c) Industries in water short regions should be allowed to either withdraw only the make up water or should have an obligation to return treated effluent to a specified standard back to the hydrologic system.
(d) Subsidies and incentives should be implemented to encourage recovery of industrial pollutants and recycling/reuse, which are otherwise capital intensive.
(e) Industrial effluents, local cess pools, residues of fertilizers and chemicals, etc., should not reach the groundwater as cleaning is complex.

8.4.3 Programmes

Ganga Action Plan (GAP) is a pioneer comprehensive attempt to address pollution at the river basin level. The Ganga originates from the Gangotri Glacier in the Garhwal Himalayas, and traversing a distance of 2525 km, flows into the Bay of Bengal at Ganga Sagar in West Bengal. The Ganga basin (861,404 km^2) is the largest river basin in India, and covers approximately 25 % of the country's total geographical area, and caters to about 40 % of the population. The utilizable water is around 30 % of India's total usable water from major river basins (ERI 2011). During the course of its journey, municipal sewage from 29 Class-I cities (population >1,00,000), 23 Class II cities (population between 50,000 and 1,00,000) and about 48 towns, effluents from a number of industries, and pollutants from non-point sources, are discharged into the river (MoEF 2004). The average population density of the Ganga basin is 520 persons/km^2, while the national average is 325. Major cities, including Delhi, Kolkata, Kanpur, Lucknow, Patna, Agra, Meerut, Varanasi, and Allahabad, are situated in the basin. These cities have large and growing populations, and a rapidly expanding industrial base (Vinod 2011). The total wastewater generation in the Ganga basin is about 6440 MLD.

For immediate reduction of the pollution load on the river Ganga a GAP was prepared by Department of Environment (now MoEF) in 1984, based on the investigation carried out by the CPCB. For implementation of the GAP, the Government of India constituted the Central Ganga Authority, under the chairmanship of the Prime Minister in 1985.

At the time of launching, the main objective of the GAP was to improve the water quality of the Ganga to acceptable standards by preventing the pollution load reaching the river. The objective of the GAP was, however, recast in 1987, restricting it to include only the restoration of the river water quality to the "Bathing class" standard (Dissolved Oxygen – Not less than 5 mg/l, Bio-chemical Oxygen Demand – Not more than 3 mg/l, Bacterial Load/Coliform Count – Not more than 10,000 per ml, Faecal Coliform – Not more than 2500 per 100 ml and pH – 6.5 to 8.5) (MoEF 2004). The GAP emphasized the 'interception and diversion of wastewater and its treatment in Sewage Treatment Plants (STPs), before discharging into river'. For implementing the plan a comprehensive institutional arrangement was created at different levels. The allotted money by the Government of India for the first stage of

GAP (1985–1992) was Rs. 451.70 crore. Until recently, an amount of Rs. 1612.38 crores has been spent on the second stage (MoEF 2004; ERI 2011).

According to Vinod (2011) GAP is one of the longest and ambitious government interventions, which has significantly influenced policies for controlling water pollution in India. However, GAP has been criticized on many fronts: inordinate delays in implementation, irregular release of funds, confusions over roles of institutions, weak monitoring, inadequacy of standards for assessing water-quality, irregular and inadequate operation and maintenance of the assets, political motivations, ‘quality’ and ‘purity’ of the Ganga water, etc. (Ahmed 1990; Divan 1995; Alley 1994; Vinod 2011). The Central Government itself has accepted that despite having spent more than 2500 crores of rupees on abatement of the pollution of the Ganga in the earlier phases, it has not been quite effective (Vinod 2011).

National River Conservation Programme (NRCP) The GAP has generated considerable interest, and set the scene for evolving a national approach towards replicating this program – NRCP – for the other polluted rivers of the country. After the completion of GAP-I, the programe of river clearing was extended to other major rivers of the country under two separate schemes (GAP-Phase II and NRCP). The Yamuna and Gomati Action Plans were approved in 1993 under GAP-II, while other major rivers were subsequently approved in 1995 under the NRCP, covering 190 towns and 39 rivers in 20 states. So far Rs. 4302.43 crores (including state government share) has been spent under this programme. The pollution load to be tackled has been estimated as 4906.53 mld (MoEF 2012a).

National Lake Conservation Programme (NLCP) Lakes are valuable ecosystems and provide a range of goods and services to humankind. They act as livelihood sources (irrigation, fisheries, washing) for millions of poor people. They are sources of fresh water and serve as habitat to many plants and animals. Lakes can moderate hydrological events, such as drought and floods, influence the microclimate and enhance the aesthetic beauty of the landscape. However, in recent times, rapid urbanization and degradation of catchments have resulted in the deterioration of lakes (decline in water quality, loss of biodiversity, eutrophication, encroachment, siltation and shrinkage). Recognizing the importance of lakes, particularly urban ones, the MoEF launched an NLCP in 2001, exclusively aimed at restoring the lakes in different parts of the country. The objective of the scheme is to “restore and conserve the urban and semi-urban lakes of the country, degraded due to waste water discharge into the lake and other unique freshwater eco-systems, through an integrated ecosystem approach”. The scheme operates on a funding pattern of 70:30 costs sharing option between the Central and the participating State Governments. Fourty-four lakes were included in this programme and the total cost was Rs. 1028.19 crores.

Activities covered under the NLCP are: (a) the prevention of pollution from point sources by intercepting, diverting and treating the pollution loads, (b) in situ measures such as de-silting, de-weeding, bio-remediation, aeration, bio-manipulation, nutrient reduction etc. with the help of successfully tested eco-technologies depending upon the site conditions, (c) catchments area treatment include forestation, storm water drainage, silt traps etc., (d) strengthening of bund, lake fencing, shoreline development etc., (e) lake front eco-development including public interface, (f) solid waste management, prevention of pollution from non-point sources by providing low cost sanitation, and (g) public awareness and public participation, capacity building, training and research in the area of Lake Conservation, and any other activity depending upon specific location (MoEF 2012b).

Jawaharlal Nehru National Urban Renewal Mission (JNNURM) The tremendous increase in urban population over the last two decades resulted in acute infrastructural deficiencies, including sanitation and solid waste management. With this consideration the Government of India estimated that over a 7 year period, (starting from 2005 to 2006) the Urban Local Bodies (ULBs) required a total investment of Rs. 120,536 crores (Rs. 17,219 crores annually) for infrastructure development. Totally 63 cities are included in this programme (7 mega cities with a population of more than 4 million, 28 medium cities with populations between 1 and 4 million and 28 small cities with less than 1 million population).

Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT) was launched in 2005 for improving the infrastructure in towns and helping create durable public assets and quality oriented services in cities & towns, enhance public-private-partnership in infrastructural development and, promote the planned integrated development of towns and cities. The targeted duration of the scheme was 7 years from 2005 to 2006. The scheme would apply to all cities/towns not included under JNNURM. The components of the scheme covered all urban infrastructure developmental projects, including water supply, sewerage, solid waste management and preservation of water bodies. The sharing of funds would be in the ratio of 80:10 between the Central and State Governments, and the balance 10 % could be raised by the nodal/implementing agencies from financial institutions.

In brief, the waste management attempts under JNNURM and UIDSSMT were a positive step in maintaining water quality.

8.4.4 Industrial Pollution Management

The government has taken some special initiatives for industrial water pollution management, particularly, the small scale industries (SSIs). The National Productivity Council estimated that SSIs were responsible for 65 % of industrial pollution and 40 % of waste generation (Yadav 2002). In India, the enforcement agencies have adopted a policy of *'closure'*, but its negative impacts on production and employment are critical. Then the MoEF in collaboration with the World Bank launched a project for *'waste minimization'* in the late 1990s. 45 waste minimization circles were set up in various sectors in different parts of the country. Unfortunately, the project has not been successful in achieving its objectives.

Out of the 300 waste minimization options identified, only 120 were implemented (Yadav 2002).

Subsequently, the Government focused on *'Common Effluent Treatment Plants (CETPs)'* where SSIs could come together, collect and treat their wastewater in a common centre. Besides, the CETPs could minimize the treatment cost and also the problem of technical know-how. During 1990–2000, more than 90 CETP projects were approved in India, with financial assistance from different agencies, including the World Bank. But now, the CETPs are facing a big problem with the operating/running costs, and industrialists are unwilling to share the cost, which ultimately has seriously affected the efficient functioning of the plants. The *'relocation strategy'* is another strategy widely discussed and some felt that this is the only solution to solve the SSIs' pollution problem in urban areas. Based on the Supreme Court's order, the Delhi Government sealed around 16,000 non-conforming industrial units and decided to relocate them. But experience shows that the relocation of units simply means relocation of pollution (Gupt 2003).

8.5 Water Pollution Control Efforts: Emerging Lessons

River cleaning and control of pollution programmes for our polluted rivers are being implemented since 1985. The programmes seek to address pollution from point and non-point sources, through the construction of STPs, low cost sanitation, electric crematoria etc. However, the data on the results of these programmes are not very encouraging. The Ganga in certain stretches, Yamuna, Gomti, Godavari, Musi, Cauvery, Cooum, Mahananda, Khan, Kshipra, Vaigai, Chambal, Rani Chu, Mandovi, Sabarmati, Subarnarekha, Tungabhadra, Pennar, Pamba, Betwa, Krishna, Sutlej etc., continue to be plagued by high levels of organic pollution, low level of oxygen availability for aquatic organisms and bacteria, protozoa and viruses, which have faecal-origin and cause illnesses (CAG 2011).

Most lakes in India are under threat from nutrient overloading, which is causing their eutrophication and eventual choking up by the weeds proliferating in the nutrient-rich water. The implementation of NLCP in conserving these lakes has had no discernible effect. Pichola, Pushkar, Dimsagar, Banjara, Kotekere, Bellandur, Veli Akkulam, Shivpuri, Powai, Rankala, Twin lakes, Bindusagar, Mansagar, Mansiganga, Rabindra Sarovar, Mirik, Kodaikanal lake, Dal lake, Durgabari lake, Laxminarayanbari Lake, Dimsagar Lake etc., have shown poor water quality. However, there have been some success stories like Nainital lake, Kotekere lake, Sharanabasaveshwara lake and Mansagar, where the water quality has improved after completion of conservation programmes (CAG 2011). Even if various strategies have been introduced for pollution management in the industrial sector, notable achievement has not been attained. Still industries play a significant role in water pollution.

Even if India has a strong historical heritage in water resource management bounded with culture and legislation, the country's performance in pollution control is not appreciable. Still many locations in the country are under pollution threat.

Only Kerala formulated a separate policy to deal with water pollution. The Water Policy of most of the states also does not give adequate emphasis on the prevention and control of water pollution. The recent study by CAG (2011) concludes that water pollution has not been adequately addressed in any policy in India, both at the central and the State levels. Besides, in the absence of a specific ‘water pollution policy’ which would also incorporate the prevention of pollution, the treatment of polluted water and ecological restoration of polluted water bodies, the government’s efforts in these areas would not get the required emphasis and thrust. Further, CAG (2011) study observed a serious failure in planning, implementation and monitoring various programs for the control of the pollution of rivers, lakes and groundwater, which are summarized below.

For ***planning*** the MoEF and the states: (a) Did not undertake a complete inventory of rivers/lakes and species associated with them. (b) Did not carry out an identification of the existing pollution levels in terms of biological indicators. (c) Had not identified and quantified contaminants, including human activities. (d) Did not assess the risks of polluted water to health and environment. (e) Did not adopt the basin level approach for the control of pollution. (f) Did not develop water quality goals, and failed to enforce them (CAG 2011).

With regard to ***implementation***: (a) Current programmes were insufficient. (b) Institutional set-up to manage various programmes was inadequate. (c) Inclusion of rivers and lakes in NRCP and NLCP respectively, was flawed. (d) 82 % of the projects undertaken under NRCP were completed after the scheduled date.

In ***monitoring***: (a) Inspection and monitoring of projects being implemented under NRCP and NLCP was inadequate at all three levels, i.e., local, state and central. (b) There was a paucity of a network for tracking the pollution of rivers, lakes and groundwater as there were inadequate numbers of monitoring stations. (c) No real-time monitoring of water quality was taking place and the data on water quality had not been disseminated adequately.

Thus, one can conclude that the programmes to control the pollution of rivers, lakes and groundwater in India have not had the desired results.

8.6 Conclusion

In developing countries, environmental management strategies are not satisfactory. Many of the responsible bodies for water-related services, have centralized structures, which inadequately deal with issues of consultation and interaction with other stakeholders, especially users have proven to have a weak effect regarding water pollution control (European Commission 2000). Besides, water pollution has not been a major topic of political debate yet, and therefore, political instruments have been scarcely implemented. But responses such as Environmental Quality Objectives (EQOs) and uniform standards have so far been on the political agenda in the western developed world (Kraemer et al. 2001). However, rigorous but phased legislation with realistic timetables, and enforcement of technical standards can act as key catalysts of change in water pollution abatement (Stockholm Water Front 2000). In developing countries like India, emission-based standards have not been very effective so far, since they are rarely monitored and only occasionally enforced. It is also incorrect to adopt western water quality objectives that are inappropriate to the level of development and economic state of the adopting country.

Past experiences has revealed that though India attempted to solve the water pollution issues through legislative and policy measures with huge budgets over a period of time, significant progress has not been achieved. The overall status of the quality of water in rivers, lakes and the ground is not satisfactory. The risks of polluted water to the health of humans, and living organisms, and the environment are critical issues.

A country like India, that possesses 17 % of the world's population with 4 % of water resources, extracts its water significantly for various developmental purposes. Huge quantities of water have been transferred from rivers and the lakes for irrigational, domestic and industrial purposes. Hence, the water flow or storage capacity of water bodies has declined substantially, and this adversely affects its waste assimilation/sink functions. There is sufficient evidence to suggest that the problem of future management of water quality, though complex, is solvable. Surely, it is not realistic to aim for zero water pollution, but a level of socially acceptable pollution, respecting the integrity of ecosystems and service provision can be reached. Hence a rethinking towards a more innovative and suitable approach is needed with an emphasis on the following strategies.

Policy Advocacy, Governance and Enforcement Precautionary and preventive approaches instead of end-of-pipe solutions need to be promoted at all decision and policy levels. Stricter action should be taken to combat corruption in the water sector. Corruption leads to ineffective implementation of water protection policies, and undermines the efficiency of pollution prevention policies (Kraemer et al. 2001). At the national and regional level, water pollution prevention policies should be integrated into non-water policies that have implications on water quality such as, agriculture and land use management, trade, industry, energy, and urban development. It is increasingly recognized that integrated water protection planning is suitable for the reduction of many forms of water pollution. Considering the negative externality issues; water pollution should be made a punishable offence. The effectiveness and power of the "polluter pay principle" should be considered. The enforcement agencies should function impartially and strictly.

Stakeholders Initiatives and Capacity Building In pollution management, the participation of the multi-stakeholders is important. Various policies, plans and strategies to protect water resources should be participatory, allowing for consultation between government, industry and the public. For effective decision making, it is necessary to improve the flow of information towards all stakeholders. Often, the lack of public awareness on the importance of water pollution prevention and low participation in improvement efforts, contributes to a deterioration of the pollution problem (World Bank 1998). According to the Commission on Sustainable Development (2000), there has been an increasing awareness of the need to strengthen technical and managerial capacity at all levels of the government and local community. At the local level, capacity building enables the community to make decisions and disseminate them to the appropriate authorities, thus influencing political processes.

Economic Instruments Recently, the emphasis on policy regarding water pollution has shifted towards environmental management, using incentives, cost-effective strategies and improved performance to achieve sustainability (World Bank 1998). The market-based strategies (charges, environmental taxes, pollution levies and tradable permit systems) should be enhanced to the utmost possible extent. Higher charges, fines and penalties act as disincentives to pollution. Besides, it brings revenue to the government that can be used to fight against or abate water pollution. Further, incentive mechanisms, such as subsidies, soft loans, tax relaxation etc., should be included in installing pollution management devices.

Technology Development/Transfer and Input Substitute In industrial pollution management, technological attempts should be made through Cleaner Production Technology (CPT) rather than end of the pipe devices like Effluent Treatment Plants. User friendly and affordable CPT should be developed with the support of industrial development agencies. Further, sophisticated pollution management technology developed overseas should be brought to India. The application of eco-friendly inputs, such as bio fertilizers and pesticides in agriculture, natural dies in textile industries etc., will reduce the pollution load discharged into the environment considerably.

Coordination Among Line Departments A complex issue like water pollution management will succeed only through coordinated efforts from different departments who are direct and indirect stakeholders in water quality issues. In this regard, the attempt of the "River Basin Board" at Palar in Tamil Nadu, was appreciable. Right now, there are multiple agencies involved in river and lake conservation, right from planning to implementation and monitoring, without proper coordination. Hence the consolidation of all activities under an umbrella agency is required for better coordination and accountability.

Integrated Water Resources Management (IWRM) Generally, fresh water sources (river, lake and aquifer) are Common Pool Resources in nature, and are experiencing the 'free rider' problem. Unfortunately, the collective efforts on water bodies' management are not effective, particularly in urban areas, and are experiencing the phenomenon of the 'tragedy of the commons'. Water quality and quantity are interlinked. The polluted water is an 'externality' issue, and its environmental and social impacts are far-reaching. In this context, pollution management should be part of IWRM, and should safeguard the interests of different water users. At present, waste water treatment plants generate huge quantities of sludge, which becomes a threat to the environment and fresh water sources. Therefore, the safe disposal of sludge is a pre-requisite for maintaining the water quality. Since fresh water is increasingly getting scarce the application/use of treated waste water for appropriate use is an effective waste management strategy. For example, the waste water generated in urban areas can be used for peri-urban agriculture and industry, after the required treatment.

In brief, in a rapidly developing countries like India, which possess more population and limited water resources, allocation and management of water for various developmental activities and preservation of biodiversity and ecosystem are huge challenges. In these circumstances, threat of pollution to the fresh water sources aggravate the problem and become an add-on challenge. Sometimes polluted river is more problematic than a river without water. When the public awareness on pollution and its impacts are limited, the cost of pollution on human health and ecosystem is huge. The victims of pollution are generally, the poor or socially vulnerable communities who are having limited coping strategy against pollution. Considering the above issues, the effective pollution management strategies need to be implemented with multi-stakeholders initiatives.

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Chapter 9
Regulatory Instruments and Demand Management of Water: Potential and Prospects

V. Ratna Reddy

Abstract This paper is an attempt to review the role of various regulatory instruments in managing water demand with specific objectives of listing out types of regulatory instruments; role of these instruments in managing water demand and attaining equity; assess existing social regulation models and draw lessons for policy. Basic regulatory instruments that are being or could be adopted in water management are broadly grouped under: (i) direct and indirect regulation, (ii) economic regulation, and (iii) social regulation.

The review of the role of regulatory instruments in managing water demand across the countries suggests that the commonly used instruments like pricing, supply regulation, direct and indirect policy regulation, etc., have not been effective. This is more so in India due to complex socioeconomic and resource systems and policy environment. Often policies are neither comprehensive nor they work in tandem. It is argued that unless policy, economic and institutional regulations complement each other, the scope for achieving sustainable and efficient water management is a far cry.

None of the regulatory instruments have equity in-built in to them. Whatever equity impacts evident seems to be rather incidental. On the other hand, social regulation appears to be more effective in achieving sustainability and equity though it requires lot of efforts working through complex rural dynamics at various levels. The reason is that appropriate policies to support or encourage such initiatives are not in place. Social regulation initiatives may remain as models rather than being adapted at a wider scale in the absence of complementary policy/legislative/legal support. Creating demand for these initiatives is as important as demand management of water. The regulatory instruments for demand management would not be effective as long as policy environment continues to be supply sided.

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9.1 Introduction

Judicious management of water resources is among the critical policy issues across the continents. The need for action in this direction is growing, as countries and communities across the globe are increasingly experiencing water stress in various contexts. Water stress often leads to civil strife and conflict. The conflicts could be traced from micro level to global level (Reddy et al. 2005). These conflicts are expected to be more frequent in future due to the increasing pressure on the resource consequent to anthropogenic as well as climate change factors. Increasing inter-sectoral competition between agriculture and other users (i.e., drinking water, agriculture, industry) and intra-sectoral competition, especially in the case of irrigation, is adding to the complexity of managing both surface and groundwater resources. These conflicts represent culmination of gross neglect and miss-management of water resources over the years. For, the problem is not due to absolute shortage of water, but due to the absence of proper mechanisms for conservation, distribution and efficient use.

In spite of rapidly increasing value for water resources, water policies continue to be supply sided. Water demand management is often ignored in the major policy formulations. In most cases the projections of water demand are in terms of crop/human/livestock water requirements that are fixed normatively in a given environmental, socioeconomic and technological conditions. Therefore, the impact of demand management approaches on the use of water is not properly evaluated. Such an approach provides a basis for evaluating whether specific investments in water management are justified (Thompson and Young 1973). The literature on water demand management indicates that water demand could be managed using regulatory instruments at various levels. However, different regulatory instruments operate and their effectiveness varies across locations depending on the economic and socio-cultural conditions. These instruments are often enmeshed or integrated in to institutional arrangements and policy initiatives. Besides, the political economy factors play an equally important role in adopting regulatory instruments.

This paper is an attempt to review the role of various regulatory instruments in managing water demand. Specific objectives include:

(i) To list out types of regulatory instruments
(ii) Assess the role of these instruments in managing water demand and attaining equity in access
(iii) Assess existing case studies and draw lessons for policy

Irrigation water management assumes paramount importance in the situation marked by water stress and in the agrarian economies like India. In these economies irrigation consumes more than 70 % of the water utilised and continues to face shortages in terms of quality as well as quantity. Drinking water sector, on the other hand, is the socially most sensitive area and needs utmost attention. Within these two sectors groundwater management is the most important policy challenge given the fact that groundwater is the single largest as well as ill managed source in terms of equity and sustainability. This review covers the experience of regulatory instruments in managing water in the context of irrigation and drinking water with a focus on groundwater.

9.2 Regulatory Instruments: Types and Nature

Lack of clarity in property rights on water requires implementation of sanctioning and enforcement of water allocation mechanisms at the policy level. Rigid and static governance structures fail the policy makers to understand the changing water scenario. Lack of information at appropriate scale is a bottleneck at the community level for adopting informed water management practices (Reddy 2012). The absence of appropriate information coupled with high economic value is making access to water a highly sensitive issue. Therefore, it is necessary to manage water in a sustainable and equitable manner. In the light of supply constraints or limited options, demand management or regulation assumes importance at different levels (national, state and community levels). Based on a review of existing literature the basic regulatory instruments that are being or could be adopted in water management are broadly grouped under: (i) direct and indirect regulation, (ii) economic regulation, and (iii) social regulation. These three groups in a way are overlapping and all of them even come under policy regulation. For, pricing is done at the policy level and most of the institutions are also initiated through policy, except some local or informal institutions. However, this grouping is for convenience and clarity. In what follows we briefly discuss these instruments.

9.2.1 Direct and Indirect Regulation

Water management in India falls within the jurisdiction of the state government that is responsible for the financing, cost recovery and management of all water resources (Saleth 2005). However, Central Government has the concurrent power to make laws with respect to any matter for any part of the territory of India. Policies or policy guidelines are often made at the central level and enforced or implemented at the state level. States also make policies on their own and implement. Direct and indirect regulation is the most commonly used instrument for regulating water demand, especially groundwater use. Direct regulations include restrictions on timing of water supply, quantum of water supply, digging new wells, well depths, etc., which are generally enforced by the administrative process (Shah 2009). Indirect regulations include restricted supply of electricity for pumping, restrictions on financing, cropping restrictions, price and procurement policies, technology policy, etc. These regulations consist of complex and multilayer framework of a range of constitutional and statutory provisions at the central and state levels.

In India water rights are based on riparian law that gives right to water based on proximity. Communities close to the water sources (rivers) have the first right. In the case of groundwater the Indian Easements Act of 1882, which mentions about the private property rights over groundwater use, forms the basis for groundwater regulation in India (Saleth 2005). Adopted from the English Common Law, which gives every owner of land "the right … to collect and dispose within his own limits of all water under the land, which does not pass in a defined channel" (World Bank 2010). Thus, groundwater is treated as an appendage to land because it is an easement connected to land and person who owns the land owns groundwater beneath the land. They have also the right to transfer the rights over groundwater with transferring the ownership of land. Given the high inequalities in the land ownership and skewed in favour of large farmers (i.e., 15 % of the households own 80 % of the land), access to groundwater is not only iniquitous but also used inefficiently resulting in unsustainable exploitation of the resource.

9.2.1.1 Surface Water

In the case of surface irrigation regulations are introduced through institutional arrangements like water user organisations (WUAs). These organisations enforce regulations with policy support. The regulatory instruments in the case of surface water systems include: crop restricts, water charges, timing the release of water, etc. In most of the countries, majority transfer units are subsections of main irrigation systems that are managed by farmer organizations while the main system continues to be managed by a government authority. Most of these transfer units in developed countries tend to be water users' associations that take over O & M responsibility directly. However, in some of the countries such as in some parts of India, USA, Mexico, Japan, and Taiwan, the farmer-elected bodies handle large-scale post-transfer governance. These countries have stronger legal systems and local institutions that are more capable of handling management at large scales of complexity. But most parts of Asia and Africa often lack legal powers of rights and ability to enforce rules. Most of the cases involve only partial transfer of control over irrigation O & M, especially for larger systems. The evidence indicates that regulations are used to achieve: (i) efficient water delivery services to suit the local needs, (ii) increase in the area irrigated and productivity, (iii) reduced financial burden on the State, and (iv) reduction in the adverse environmental effects.

Recognizing the importance of users in management to solve the main problems faced by the government in managing the irrigation systems, some States in India adopted participatory management policies though the policies differed from State to State (Reddy et al. 2005). For instance, in Bihar, the two tier WUAs exists at village and distributary channel. Entire O & M responsibilities are vested with the distributary channels and below to these WUAs. The associations are authorized to collect irrigation fees and in return they can keep 70 % of the collected amount. In Haryana, legal and government irrigation arrangements are based on precedents set by the Moghul emperors and by the British government and the basic irrigation management system is warabandi or rotational irrigation. The State is considering a policy to create WUAs at outlet level and assign full O & M responsibilities below the outlet, including maintenance of lined water courses. It is also contemplated that the WUAs collect irrigation fees in return for keeping a small commission. However, the devolution of these powers are yet to be transferred.

Gujarat has a reputation for innovation in irrigation management based on a number of well-publicized experiments since 1978. However, only in 1995 the State declared a policy of management transfer. It stipulates creation of WUAs for a block of 500-ha and transfer full O & M responsibilities for minor and smaller channels within the blocks to the WUAs. WUAs have to pay the price for water on the basis of the volume of water actually taken. The State is also planning to invite NGOs to carry out the work of creation of WUAs in cooperation with the personnel of Water Resource Department. The policy made provision for incentives, including channel repairs, rebates for prompt payment of irrigation fees, and maintenance grants Gujarat Water Users Participation Management Act, 2007 was recent when compared to Andhra Pradesh. The experience shows that these formal PIM initiatives suffer from legal and legislative support, financial sustainability; water scarcity, etc (GoI n.d.). Even the earlier experience in Gujarat indicated that generating funds for covering 100 % 100 O & M continues to be a major challenge (Parthasarathy 2000).

Maharashtra has the long history of development and management of private irrigation schemes. The irrigation department manages the State's canal systems and the basic irrigation management approach is called *shejpali* although alternatives exist. It adopted a policy to create WUAs at minor canal level (with average command of 500 ha); transfer O & M responsibilities for the minor and smaller channels to the WUAs; allocate water to the WUAs through 5-year agreements and charge WUAs for water on the basis of the volume actually taken (Volumetric pricing). This new system will replace *shejpali.* Like Gujarat, Maharashtra also envisaged incentives for farmers. In Tamil Nadu, Kerala and Orissa the present transfer of irrigation management to WUAs are creating a three-tier system of management organization including WUAs at the outlet and 500 ha command levels and a joint management committee (including representatives of the WUAs and of key government agencies) at project level, and transferring O & M responsibilities fully or partially to these bodies. It is observed that the Maharashtra experience is very similar to Gujarat as far as O&M recovery is concerned and devolution of powers (GoI n.d.).

In Andhra Pradesh, Irrigation and Command Area Development (CAD) Act that was enacted in the year 1984 imposed the creation of command area development authorities and 'Pipe Committees'. These 'Pipe Committees' proved to be quite ineffective as the delivery of water at the outlet was quite unrealistic leaving no scope to the pipe committees to effect any improvement in the distribution of water. The Pipe Committees had no role in the maintenance and their responsibilities were not defined and hence were non-functional (Joshi 1997). The State through another act in the year 1997 called "The Andhra Pradesh Farmers' Management of Irrigation" created a three-tier WUAs system at hydraulic level, Distributary Committee and Project Committee. More than 10,000 WUAs have been created with a clearly specified responsibilities and powers. A provision was also made to provide financial assistance for those WUAs that enhance water fee collections in their commands (Brewer et al. 1999). Though Andhra Pradesh experiment has been lauded as pioneering in participatory irrigation, the reform process has not been taken to its logical conclusion. Devolution of powers to the WUAs is very partial and financial sustainability and covering O& M costs remain major issues (Reddy and Reddy 2005; GoI 2007a).

9.2.1.2 Groundwater

Direct and indirect regulation is more prominent in the case of groundwater as it does not involve communities or collectives. This include regulations on number and depth of the wells, distance between the wells, regulating supply of electricity, pricing of electricity or diesel, etc. India introduced a Model Groundwater Bill during 1972 constituting a groundwater management agency at the state level, which is responsible for registrations and control of larger groundwater users. Some of the major elements of this bill include power to notify areas for control and regulation of groundwater development, grant of permission to extract and use water in the notified areas, registration of existing users in the notified areas, prohibition of carrying on sinking wells, etc. The Model Groundwater (Control and Regulation) Bill of 1992 proposes a kind of groundwater permits systems. However, it did not set any withdrawal limits (GoI 1992) and confined only in the states of Tamil Nadu, Maharashtra, and Karnataka. National Water Policy of 2002 also makes certain provisions on control of groundwater extraction.

During the late 1990s states like Andhra Pradesh, Tamilnadu, and Maharashtra have enacted groundwater legislations. These legislations imposed restrictions on groundwater exploitation by making registration of wells as well as rigging technologies mandatory. The implementation and enforcement of these legislations are yet to bear fruits due to various reasons. For, these legislations have failed to take special distribution of the resource in to account by putting all the regions irrespective of their level of groundwater development. Similarly socioeconomic equity is not taken in to account while enforcing the regulations i.e., treating those having and not having wells equally. Due to the negligence and conflict of interests of all sections of the society enforcement has received scant attention (Sharma 1995). Similarly, monitoring mechanism to ensure a particular regulation is enforced is a costly and difficult task in vast and remote regions (Kumar 2007). Given the size, spread and variety of groundwater extraction across the country it would be a big challenge to bring groundwater under a formal system of control or sanctions. The sheer size and anarchy prevailing in this regard is main bottleneck for enforcing sanctions (Shah 2009).

Limiting power supply and formal credit are the indirect ways of regulating groundwater use. A number of states in India follow power supply regulations for one reason or another. The main reason, often made explicit, for restricted power supply is supply constraint as well as reducing the burden on exchequer due to subsidised or free power supplied to farm sector. The externality of restricted power supply is regulation of groundwater use. In fact, farmers express that 'but for the limited power supply their bore wells would have gone dry', especially during drought years. The power supply restricts are usually associated with subsidies or free power. Gujarat Electricity Board does not provide new electricity connection for extraction of groundwater in over-exploited, critical and saline areas without consent of the CGWA. It has also launched Jyoti Gram Service (JGS) which put separate feeder provisions for agriculture and domestic services (Lakhina 2007). There is only 8 h/day power supply to agricultural purposes. As a result farmers are alerted every time and optimized utilization of water pumped out which reduced over-exploitation and ensure investment in demand side water management measure. Andhra Pradesh has been using 7–9 h a day power supply along with free power policy over the last 7 years.

National Bank for Rural Development (NABARD) has adopted a policy not to provide refinance wells in critical and over exploited areas. NABARD has prescribed spacing norms for different types of areas whereby minimum distance between two groundwater obstruction structures can be indicated (IRM&ED 2008). According NABARD regulation, farmers do not get credit for a new bore well if it is located within 200 m radius of an existing well. These restrictions are also imposed by other nationalized banks. However, implementation or enforcement of such regulations have their own limitations as formal credit accounts for minor share in the investment in groundwater development.

The Punjab Government has recently introduced the Punjab Preservation of Sub-Soil Water Ordinance 2008, which prohibits the planting of paddy by the farmers in the state before June 10th to conserve groundwater. The ordinance provides for the government agencies to plough the area with the standing crop of such farmers who transplant paddy before the notified date. The effectiveness of this order in dissuading farmers to sow early paddy and thereby conserve groundwater is, however, yet to be seen.

9.2.1.3 Technology

Technologies are often given little importance in the demand side management of water. Managing water demand through promotion/discouraging technology is a less explored option. This is mainly because of the reason that the area covered under water saving technologies is negligible. Promotion of micro irrigation is the most widely used across the countries. Micro irrigation such as sprinkler and drip irrigation are being promoted through subsidy in order to increase water use efficiencies. In Israel policies are designed to use only these technologies for irrigation. Of late more and more area in India is being brought under these technologies in order to tackle the scarcity conditions. These technologies are spreading to more number of crops instead of limiting to horticultural crops earlier. In Gujarat farmers use micro irrigation systems on various crops like wheat, bajra, maize, groundnut, cotton, castor and vegetables apart from number of horticultural crops while drip systems are used even on water intensive crops like sugarcane in Maharashtra (Narayanamoorthy 2003). Though these technologies are subsidised, access to subsidies is limited to few farmers making it expensive for small and marginal farmers. Community based ownership or funding of these technologies yet to take shape. Moreover, use of these systems are limited to groundwater as there is no incentive to use them in canal irrigated regions.

Similarly, water efficient crops or cultivation methods are being promoted in order to overcome water shortages or water stress. One such example is the System of Rice Intensification (SRI), which requires less water when compared to the traditional flood irrigation with same productivity per unit of land is notorious for its high dis-adaptation rates at the farmers level in the absence pricing regulations on water use. There is a need for exploring innovative regulatory mechanisms in order to promote water use efficiency.

In the case of domestic water supplies also there are technologies that can reduce water use to the extent of 50 % (Postel 1985). These include faucets, shower heads, toilet flushes, etc. Countries like Israel, Italy, USA (California, Michigan and New York states) have passed laws requiring installation of various water efficient appliances in new homes, apartments and officer (Postel 1984). Installation of these technologies in the new constructions is made mandatory for giving permission. While imposing such regulations at the user level is not only difficult but also involves high transaction costs, imposing such regulations at the industry level could be much easier. For instance banning the production of high water intensive faucets, shower heads, flushes, etc., could be achieved with policy regulation (Reddy 1996). Incentives like tax holidays or tax exemptions could be provided to those industries or products for improved water use efficiency. Combining such instruments with price instruments could result in faster adoption, as it happened in the case of fuel efficient four stroke engines of two wheelers in India. Use of such regulatory instruments in the water sector needs to be explored. In our view, these are some of the low hanging fruits, which need to be picked up.

9.2.2 Economic Regulation

Pricing of water or a complementary input like electricity or diesel, water markets and tradable water rights are some of the important economic instruments that are used. While direct pricing of water is used in the case of surface water, other instruments are more common in the case of groundwater management. Economic instruments in India include charges and taxes levied on irrigation water or volume of water withdrawn such as the 1994 Water Law in China (Wang et al. 2007), Law of the Nation's Water in Mexico (Shah et al. 2004; Scott and Shah 2004; Sandoval 2004), and Israel (Feitelson 2006). An example of taxes as an economic instrument is found in the Chennai city. Municipal water utility is paying farmers to sell bore well supplies to meet the drinking water demand in the urban areas which created incentives for the farmers for moving water to a higher-value use and reduced mismanagement in groundwater allocation. However, it is very difficult to collect and enforce such a fee in case of large resource users or poor governance environment (Shah 2009). Pricing as a demand management variable is widely studied in the case of canal water. For groundwater is rarely priced.

9.2.2.1 Surface Water

Volumetric pricing is expected to be effective in conserving water and improving water use efficiency. However, volumetric pricing is followed in very few cases. A broader issue: is volumetric pricing technically feasible in Indian irrigation systems, as metering of irrigation water has become politically sensitive issue in number of states. Besides, this is mainly due to high costs associated with fixing water meters and monitoring them. Even in the few cases where volumetric pricing is adopted, water is often under priced with little impact on water demand. In other words, as long as volumetric pricing is not equated with marginal cost pricing, pricing is not going to be an effective tool of demand management. This is mainly due to the reason that marginal cost based pricing is often found to be politically unacceptable and also may impose undue burden on the marginal sections of the farming community. In the absence of volumetric pricing water pricing on the basis of acreage is found to be the easiest way of implementation administratively.

9.2.2.2 Groundwater

Electricity pricing is more commonly followed instrument in India. Electricity has potential to regulate the use of groundwater. For instance, it is argued in the context of Western India that electricity pricing enhances groundwater use efficiency (Kumar 2005). The study estimates the levels of pricing at which demand for electricity and groundwater becomes elastic and shows that pricing is socio-economically viable. But the main difficulties lying with the price mechanism is that of implementation. There is lack of required administrative resources for metering and monitoring groundwater use and collecting user fees. During the 1970s, Government of India had faced difficulty of metering about two million wells and thus implemented flat tariff on electricity used by agriculture. At present the number of wells is over 20 million aggravating administrative difficulties and transaction costs. Besides, pricing is a politically sensitive issue, especially when populism has become the norm (Kemper 2007).

Development of private groundwater market has a long history in rural India (Pant 2005; Saleth 1994). Even though selling of water was traced out during 1920s, it was in the 1960' when systematic information started flowing (Saleth 2005). Groundwater markets are widespread in Gujarat, Tamil Nadu, Andhra Pradesh, Uttar Pradesh and West Bengal (IRM&ED 2008). However, there is no clear cut statistics about the total area under private groundwater market. Based on his studies from Gujarat and Uttar Pradesh, Shah (1993) projected that the area irrigated under groundwater markets was about 50 % of the total gross irrigated area under private lift irrigation. Whereas Shankar (1992) mentions that the actual area varies between 80 % in Gujarat to 60 % in Uttar Pradesh. A Tamil Nadu study shows that it is not more than 30 % (Janakarajan 1993). Market forms basically with mutual understanding between two adjacent farmers on sharing of water (Mukherji 2007). It serves two purposes: promoting efficient use and providing water to poor farmers who are either unable to afford wells or find it uneconomical to do so (Shah 1989, 1993; IRM&ED 2008). Markets also increase cropping intensity and demand for agricultural labour, which ultimately benefits the landless and wage labour (Fujita and Hussain 1995). But, markets ensure neither equity, especially in scarcity conditions, nor source sustainability (Reddy 2010).

9.2.3 Social Regulation

Community management of groundwater is very limited in its spread despite the fact the community management of irrigation (tank or canal) is very old. This is mainly due to the private property or open access nature of groundwater resource. Participatory approach to groundwater management in India is based on the western United States experience of the management of aquifer by the communities. This model has also been tried in Spain and Mexico where users are registered and organized into associations with a mandate to manage sustainably (Villarroya and Aldwell 1998; Sandoval 2004). Thus 'community management' implies creation of self-governing water user organisations who take the responsibility of sustainable management of aquifers through collective action (Shah 2009). The main objectives of management process are to focus on demand side management through participatory data collection, analysis and dissemination (GoAP 2007). It can also involve any mix of instruments including regulation, property rights and pricing (World Bank 2010).

Pani Panchayat or water council in Maharashtra is one of the first institutions to promote social regulation initiatives in order to improve access to water, water use efficiency and equity. Social regulations such as restricts on digging of bore wells, specified cropping pattern, water distribution, equal access to water to all households, including landless. This was adopted in a number of villages with mixed results (Deshpande and Reddy 1990). A different type of peoples' participation was found in Rajasthan. Villagers decided to stop sinking of bore wells to preserve and judiciously use the water resources at their disposal. As a result no bore well is found within the 4 km radius of the village (IRM&ED 2008). In Kerala two community managed groundwater projects were implemented for proper utilization of water for irrigation. As per the instructions two persons can irrigate their land at a time. Farmers bear electrical and O&M charges and succeed to achieve financial and source sustainability.

Check dam Movement was started in Gujarat where farmers formed village level local institutions (Gandhi and Sharma 2009). Under this system villagers undertake planning, finance and construction of a system of check dams in and around the village to collect and store rainwater to recharge the groundwater aquifers and thereby recharge the dug wells. Expected benefits are increased water table and improved agricultural income. However, there was no collective action on reducing over-extraction. Communities were self interested and every farmer in the community was free to extract whatever they want rather than focusing on collective targets for crop diversification or water use reduction.

Of late quite a few initiatives of social regulation are being tried in a number of states. Some of them are knowledge based and some combine awareness building with social regulation (GoI 2011). These include: (i) the pioneering and large scale APFAMGS programme in Andhra Pradesh aimed at involving farmers in hydrological data generation, analysis and decision making, particularly around crop-water budgeting; (ii) social regulation and water management implemented by the Centre for World Solidarity (CWS) with its partner NGOs in AP; (iii) social regulation in groundwater sharing under the AP Drought Adaptation Initiative (APDAI) involving WASSAN, in parts of AP; (iv) experiences from Barefoot College, Tilonia, with a water budgeting tool known as Jal Chitra; (v) efforts by Foundation for Ecological Security (FES) at taking a micro-watershed unit for water balance and planning groundwater use along with communities at their sites in Rajasthan, MP and AP; (vi) experiences of ACWADAM with SPS in Bagli, MP and with the Pani Panchayats in Maharashtra on knowledge-based, *typology*-driven aquifer-management strategies; (vii) training programs and drinking water initiatives by ACT in Kutch on the back of training local youth as para-professionals for improved groundwater management; (viii) research on documenting local groundwater knowledge in Saurashtra and Bihar by INREM Foundation and (ix) the Maharashtra's Hivre Bazar model of watershed development and social regulation to manage water resources.

Community based management programs should be designed with a shared focus on improving agricultural productivity, income and water conservation. Water use reductions should not be explicitly sought but realized by aligning efficient irrigation interventions with farmer incentives for higher profits. GoI (2007a) also agrees with the fact that community management "should not work well unless it serves some basic needs of farmers. According to the World Bank (2010) stakeholders" participation in the management process is necessary because it disseminates understanding of issues that can be the impetus for up-scaling of good practices in the sustainable use of groundwater. It also improves the self-regulatory capacity, counteracts corruption and facilitates the coordination of decisions relating to groundwater, land use and waste management. According to Burke et al. (1999), socio-economic, political and institutional factors are main determinates, which incentivise these stakeholders in sustainable groundwater management.

9.3 Effectiveness of Regulatory Instruments: Review of Experience

As far as the impact of ***direct and indirect regulation*** on water use and efficiency are concerned, evidence across the globe indicates that quotas are more effective in regulating demand. ***Supply regulation*** though found to be inefficient in the long run, it happens to be the most preferred option among the administrators. Quotas or supply regulations arise due to resource shortages. Less water is distributed equally among all the farmers in the years of water scarcity. During the drought years between 2001 and 2004 the Krishna delta farmers in Andhra Pradesh were provided with 40 % less supply of water when compared to normal years. Farmers not only managed with low supplies of water but also reported 20 % higher yields. This reveals the extent of water wastage and inefficiencies during normal years. Hence, quotas lead by shortages are more preferred to volumetric or marginal cost based pricing.

For instance, in Andhra Pradesh though some benefits from WUA regulations in terms of increased area under irrigation in canal systems and improved quality of irrigation is evident, the sustainability of these benefits is rather uncertain in the absence of efficient institutional structures. Equity in the management and distribution of water is not addressed. No proper incentive (positive and negative) structures were designed and placed to support rule compliance (Reddy and Reddy 2005). In Rajasthan, though more than 800 WUAs were constituted and elections were conducted almost 5 years back, the progress is very tardy. So far no devolution of powers has taken place, though the irrigation department appears to be keen in devolving the powers (Reddy 2010). In Orissa the Government claims that the PIM programme allows farmers to take decisions regarding distribution and management of water resources. In reality the programme has created a divide between the large and small& landless. Landless are not even members of the pani panchayat. The rotation of canal water use resulted in poor farmers having rabi crop only once in 2 years and increasing inequity. Consequently, people rebelled against the programme and the model has collapsed, but not before causing much misery (Das 2006). On the whole, benefits from regulations through institutional arrangements (WUAs) are mostly limited to shifting the O&M responsibilities to the farming communities. Effectively, the impacts in terms of water use efficiencies and financial sustainability are limited. And there is no evidence of improved equity.

In the case of groundwater, a model bill to ***regulate and control*** development of groundwater has been circulated by the Ministry of Water Resources to all the States/Union Territories (UTs). So far 11 States/UTs Andhra Pradesh, Goa, Tamil Nadu, Kerala, West Bengal, Bihar, Himachal Pradesh and Union Territories of Chandigarh, Lakshadweep, Pondicherry, Dadra and Nagar Haveli have enacted and implemented groundwater legislation. However, the effectiveness of their implementation and enforcement is not known.

It is often the shortage of electricity that prompts ***supply restrictions*** and reduced exploitation of water. Restricted power supply policy was observed to have little consequence in the case of large pumps and multiple wells as the effectiveness of regulations undermines not only the availability of the diesel pump-set option but also by the presence of a 'kink' in the farmers' power demands (Saleth 2005). As a result, misuse of power as well as groundwater is wide spread, as farmers leave their pumps on round the clock. The combined impact of free and limited power supply on groundwater use needs to be assessed critically.

In the case of ***credit regulation*** field research has shown that it was not very effective due to the availability of other credit avenues (mainly informal sources) at the village level (Kumar 2007). This is despite the fact that cost of credit is high for the informal sources. Credit rationing policy of the bank is also trying to curb new power connection to bore-wells and put restrictions on electric power supply. Besides, enforcement is also lax due to the pressure on banks to achieve targets.

Some success in reducing groundwater draft through regulatory measures have reportedly been made in a few water-scarce countries such as Jordan, where a quasi water policy requires measuring withdrawals from the irrigation wells, enforcement of pumping quotas and levy of volumetric groundwater fee (World Bank 2000). But, the situation is more complex in countries such as India where millions of individual private tube well owners, dispersed through the length and breadth of the country with varying groundwater availability and demand conditions, are engaged in groundwater extraction. Putting into effect such an approach and overseeing its implementation in a country of the size of India is nearly impossible. For, the number of groundwater structures in India is estimated at about 23–25 million (World Bank 2010).

Maharashtra has recently developed a groundwater management model which involves regulation of more than 1.5 million irrigation wells. It includes a ***levy of groundwater use*** and a ***ban on deep tube wells***. The Chinese, with stronger state commitment to groundwater regulation, with a more elaborate reach and local authority structures have still found it impossible to regulate groundwater overdraft in North China Plains (Shah et al. 2004). Nor have the Americans been able to implement real groundwater demand management with their elaborate structure or water rights and groundwater districts, nor have Spaniards and Mexicans with their efforts to promote groundwater user associations.

It is estimated that ***micro irrigation systems*** save 48–67 % in terms water and 44–67 % in terms of energy and 29–60 % in terms of labour. Farmers have also reported low incidence of pest attack, reduced weed growth, improvement in soil quality and increased yields. As a result net incomes have increased substantially and farmers are interested in investing on their own without any subsidy. Cost-benefit analysis of drip irrigation in Maharashtra revealed high economic viability for banana, grapes and sugarcane (Narayanamoorthy 1997). The economic viability seems to hold good even in the case of small-holdings of just 1 ha. Despite the high economic viability the spread of these technologies is limited due to high initial cost and lack of awareness. The rationale of subsidies for these technologies is valid not only for spreading of these technologies but also due to the reason that social returns are far in excess of private returns accruing to drip investors (Dhawan 2000). Besides, there is need for strong extension support for better adoption rates. The

Table 9.1 Impact of pricing on water demand

Country	Price mechanism	Impacts on water demand
Israel	Block rate tariff	7 % decline in average water use and 1 % reduction in output
Israel	Tiered system of pricing	Regulates water demand at margin
India	Price induced water scarcity	Farmers are responsive but water allocation is not efficient
Spain	Arbitrary pricing	Differential impacts due to regional, structural and institutional conditions
Sri Lanka	Arbitrary pricing	Not effective
Turkey	O&M cost recovery pricing	No improvement
Mexico	O&M cost recovery with tradable bulk water rights to WUAs	No improvement at the farmer level. But overall improvement in water use efficiency due to internal trading
China	Volumetric pricing at the WUA level	No incentive at the farmer level as the price at the farm level is based on area
France	Full financial cost recovery	Managers only discourage water use beyond subscribed amount
Peru	Volumetric Pricing	Not used to reduce water demand
USA	Volumetric pricing	Quotas were more effective in times of scarcity

Source: Compiled from Molle; Dudu and Chumi (2008) and Johansson (2005)

spread of these technologies is limited despite some state governments like Rajasthan, AP, etc., are providing up to 90 % subsidy. This could be mainly due to the absence of comprehensive policies like water pricing, pricing policies, etc.

Pricing of water as a demand management variable is expected to achieve double benefits of reducing demand and improving financial sustainability of the systems. A number of studies across the world has observed limited impact of pricing on water demand (Table 9.1). But most of the studies are clear in saying that pricing has the potential to achieve efficient allocation of water, but its effectiveness in the real world depends on a number of other factors. These include: (a) proper valuation of water resources (i.e., use value + scarcity value + existence value), (b) institutional mechanisms like water user associations to support implementations of pricing policies, (c) technologies to enhance water productivity and (d) property rights in water so that water is tradable and reallocated for other productive uses. More importantly, in most cases optimum or marginal pricing of water is neither determined nor implemented. In the absence of optimal or threshold level pricing, its impact on demand is limited. The threshold pricing that would influence demand is often high making it politically sensitive to implement. Evidence in India shows that water pricing barely covers the O and M expenditure even in the reform states where prices have been revised, let alone influencing water demand (Reddy 2003, 2010).

In the case of groundwater, water productivity impacts of pricing would be the highest when water is volumetrically allocated with rationing. An effective power tariff policy followed by enforcement of volumetric water allocation could address the issue of efficiency, sustainability and equity in groundwater use in India (Kumar 2005). Similarly, in the context of Andhra Pradesh, which is the front runner in the provision of free power along with supply restrictions, it is argued that pricing of electricity for irrigation is the only option for addressing agrarian distress (Kumar et al. 2011). However, impact of pricing on groundwater management could vary depending on the water productivity (Malik n.d.). In the case of diesel pricing it was found that price rise may not necessarily result in the reduction in groundwater use (Shah 2007). On the contrary, farmers may apt for high water intensive and high remunerative crops.

The impact of ***water markets*** on groundwater demand is not necessarily negative. Though, markets encourage groundwater use efficiency, they often expand the area per well due to the incentive to sell water. However, the extent of the impact again may depend on the water productivity. Groundwater market in Gujarat, for instance, does not consider the limit of the resources and thus is not sustainable over the long run (Kemper 2007). Topography and distance between the source and the field also influences sustainability. In hard rock, deep alluvial or scanty rainfall areas, development of market sharing results in over-pumping and over-exploitation. On the other hand, Shah (2009) mentions that tradable property ownership creates incentives for improving productivity and conservation.

Participatory groundwater Management or Social regulation[1] appears to be more effective in influencing water demand though evidence is limited at this stage. Available empirical studies show that in the years when water availability was low due to either low rainfall or high groundwater abstraction during the preceding crop season are now able to achieve a combination of crop diversification and water-saving irrigation methods through participatory management (World Bank 2010). A similar experience in Gujarat shows that even though power supply has decreased from 18–20 to 8 h, community participation in groundwater management raised aquifer recharge where farmers are able to cultivate four good seasons in a row (Shah et al. 2002).

Participatory groundwater management is evolving gradually in India. It essentially involves communities observing groundwater variables and attempting local-level, groundwater planning and management. This effort is aimed at augmentation, conservation and improving patterns of groundwater use (Table 9.2). All these initiatives are *diverse* in terms of their scale (village, aquifer, watershed) and approach (farmers collecting data, well drillers providing information, hydrogeologists carrying out surveys, local youth being trained to map the geology). They have a common purpose i.e., to drive a knowledge-based, localized management of groundwater resources that emerges as a consequence of decisions taken at the scale of a village or micro watershed and decisions based on some degree of scientific understanding of groundwater resources. Of course, it goes without saying that the involvement of Government institutions in such initiatives would greatly help in the scaling up of

[1] This section draws from an earlier publication Reddy, V. R., Reddy, M. S., & Rout, S. K. (2014). Groundwater governance: A tale of three participatory models in Andhra Pradesh, India. *Water Alternatives, 7*(2), 275–297.

Table 9.2 Community based groundwater management initiatives in India

Locations	Organisation(s)	Scale	Resource person(s)	Method	Tools used	Parameters measured
Andhra Pradesh	APFAMGS	Villages, spread over districts	Farmers	Farmers record hydrologic variables	Simple budgeting tools in Excel	Water levels, rainfall, well yield, crops, water use for crops
Andhra Pradesh	WASSAN	Village	Farmers	Social regulation; Farmers record hydrologic variables	Hydrologic information for formulating equitable distribution	Well Water level, rainfall,
Rajasthan	Barefoot College	Village	Farmers	Farmers map all water bodies and record hydrologic variables	A simple tool called 'Jal Chitra'	Well water levels, crops, water use for crops
Rajasthan, Madhya Pradesh, Andhra Pradesh	FES	Watershed	Organization and University Research Unit	Organization carrying out monitoring program	Simple water modelling tools	Well Water levels, rainfall, crop water usage
Madhya Pradesh and Maharashtra	ACWADAM in partnership with SPS and GGP (Pani Panchayats)	Watershed/ Aquifer	Hydro-geologists, Watershed Teams and Farmers	NGO and scientists carrying out monitoring program	Hydro-geologic mapping of watershed	Aquifer mapping, flow dynamics, modelling
Kutch, Gujarat	ACT	Village/ Aquifer	Barefoot Geologists (called par workers)	A program for training local youth as geologists	Geologic mapping of saline and freshwater lenses	Aquifer mapping and delineating water quality
Bihar and Saurashtra, Gujarat	INREM	Village	Well drillers and farmers	Documenting local knowledge of people on hydrogeology	Aquifer mapping tool and fence diagrams	Lithology and mapping major geological features
Maharashtra	Hivre Bazar GP	Village/ Watershed	Sarpanch (Mr. Popat Pawar)	Rainfall based water budgeting and GP rules	Measurement & participatory tools	Rainfall, water levels, crops

Source: Government of India (2011)

such efforts. They would also help develop legal instruments that compliment such efforts rather than remain isolated in the form of *command-and-control* rules that most legislative instruments are prone to include. A good legal instrument should provide the protective cover to such initiatives rather than stress on 'symbolic' actions like licensing, policing and punishment, all of which fall under the purview of "command and control" type interventions.

Most of these initiatives are relatively new and need to be assessed for their effectiveness in terms of resource sustainability and equity. A recent study in AP has assessed three models of community based groundwater management. These three models are: (i) The Andhra Pradesh Farmer Managed Irrigation Systems (APFAMGS) which has its origins in APWELL programme of the groundwater department, (ii) Social regulation of groundwater by the Centre for World Solidarity (NGO) and its partners, and (iii) collectivization of bore wells under the Andhra Pradesh Drought Adaptation Initiatives (APDAI) programme being promoted by WASSAN with its partner NGOs. These initiatives have different origins and approaches to participatory groundwater management (Table 9.3). All the three initiatives have been located in the arid and semi-arid districts of Andhra Pradesh, where the extent of groundwater development is quite high. Two of the models focus on social regulation, while one model (APFAMGS) does not have any regulations in-built in to it.

The three models assessed here have the common goal and objective of sustainable groundwater management. All the three institutions are lead by NGOs with support from different agencies including the state government. However, the approaches followed and implementation modalities are different and can be grouped under (i) knowledge intensive; and (ii) social regulation. These approaches have their advantages and disadvantages in terms of achieving their objectives and sustainability of the initiatives (Table 9.4).

9.3.1 Knowledge Based Approach

APFAMGS initiative is based on the principle of demystifying science through enhancing the capacities of the communities in terms of improving their skills and scientific knowledge. The focus is on facilitating or making communities assess the groundwater potential at the village level and estimate the available water before each crop season. These estimates are integrated at the hydrological unit level providing the much needed scientific scale for assessing the groundwater. At the same time, the scale at which observation wells are monitored (village level) is more appropriate to the communities. For, official groundwater assessment is made based on the observation wells located at the mandal (more than 30 villages) level and does not reflect the situation at the village level. Crop water budgets are prepared by the communities at the village level and suggested cropping pattern for the season is provided (based on the groundwater availability) to the community. These details are shared across the villages within the hydrological unit.

Table 9.3 Participatory groundwater management models in Andhra Pradesh

Model	Description
AP FAMGS (AP WELL)	(a) Dug new bore wells for a group of HHs not having access to water with clear sharing, groundwater monitoring and water use efficiency measures (b) Limited to 'new- un-exploited' areas APWELL has been transformed in to the largest groundwater awareness programme in the state premised on: (i) communities monitoring the groundwater status regularly with knowledge and scientific principles, (ii) sharing the knowledge of various alternate crop systems and evolve norms for groundwater management (with facilitation) and this process will lead to less groundwater depletion and better management
SRWM (CWS Partners Program on Groundwater Sharing)	This programme was initiated on a limited scale and based on regulations: (i) Community adopts a norm of 'no new bore wells', (ii) increasing system efficiency through the provision of collective sprinkler irrigation sets; and (iii) bore well owners will share their water with neighbouring farmers leading to substantially reducing water-less families in the village
APDAI (of CRD, facilitated by WASSAN) Collectivisation of bore wells:	This initiative followed an 'area approach' for groundwater management where the bore well owners pool their individual bore wells to provide supplemental/critical irrigation to a larger rain-fed area (entire block) for survival of rain-fed crops. Community has to follow the following rules: (i) no new bore wells for at least 10 years, (ii) all the land within the specified area (including water-less) will have a right for supplemental irrigation for kharif rain-fed crops and (iii) pipe-line network is provide by the project so that water can be taken to any part in the block/area

Source: Reddy et al. (2012)

The approach of 'do-it-yourself' with relatively better scientific or technical inputs has clearly improved the awareness of the well owners. The initiative is highly successful in demystifying science and needs to be considered at the policy level to promote institutional linkages for generating such information at the village level. While such an awareness has helped in checking further expansion of groundwater development i.e., new wells, it failed to encourage other conservation practices like increased investments in recharge structures or equity by sharing the water with un-irrigated farmers. Though our sample village does not provide any evidence on the reduction in water intensive crops (paddy), it is achieved in other places (Reddy 2012). The limited impact is mainly due to the reason that neither social regulations are imposed nor economic incentives are provided to adopt such measures. In fact, farmers feel that APFAMGS merely plays an advisory role without any incentives or disincentives to follow the advisories. The result is lot of useful information is

Table 9.4 Features of the three institutional models

Features	APFAMGS	SRWM	APDAI
Initiative (funding)	External (FAO)	External (AEI, Luxembourge)	State government (DRD)
Implementation	NGOs (BIRDS)	NGOs (CWS + Partners)	Govt. + NGO (WASSAN + Partners) (Mahila Samkhyas)
Years of existence	8	7	2
Groundwater situation	Scarce	Scarce	Scarce
Project scale	Big (650 villages)	Small (19 villages)	Small (8 villages)
Key features	Information	Informal regulation	Formal regulation
Scale of operation	Hydrological unit	Vicinity of wells (within a village)	Area based on the wells (within a village)
Institutional approach	Influencing community through generation of intensive scientific information by the community	Regulating community through awareness and incentives	Regulating community through semi-scientific information based awareness and incentives
Operational modalities	All well owners with focus on information. Followed an extensive approach	Small groups of well owners and dry land farmers. Followed an intensive approach	Larger group of well owners and dry land farmers covering specific location Focus on incentives
Farmers contribution	NIL	20 % towards micro irrigation	75 %
Awareness on groundwater situation	High	High	High
Participation in management	Limited to well owners	High	High
Practicing of recommendations	Moderate	High	Low
Key to success	Professional approach	Leadership and incentives	Incentives
Impacts on access to water	Moderate	High	Moderate
Nature of key impact	Reduction in over exploitation of groundwater	Conservation of water and sharing of water	Conservation and sharing of water
Impact on equity	No	Yes	Yes
Scalability	Good	Poor	Moderate
Sustainability	?	?	?

Source: Reddy et al. (2012)

generated at the appropriate scale helping only the well owning farmers. While the farmers hither to not having wells are dissuaded from digging new wells (through information based awareness), there is no incentive for them to support the initiative. In fact, they are not even members of the committee.

Our qualitative research indicated that farmers are very much interested in having institutional arrangements in the lines of APFAMGS for managing groundwater. But sustainability of APFAMGS initiative is a big question mark in the absence of linkages with formal institutions with policy or legislative backing at the movement.[2] Moreover, the exit protocol is not clearly defined. In number of villages the activities of APFAMGS came to stand still during the two years gap (2009–2011) due to the delay in the extension of the project. One suggestion made by farmers in this regard is to bring the initiative under the groundwater department's purview so that the process would continue in the long run (Reddy et al. 2011).

9.3.2 Social Regulation Approach

The other two models viz., SRWM and APDAI have adopted social regulation to manage groundwater. Though awareness building and data generation by the village communities are important components, the process is not so systematic. The most important aspect of these two models is to bring consensus among the communities to share water between well owners and others. Incentives like reduced risk of well failure as no new wells are allowed, subsidies for micro irrigation, provision for protective irrigation to the dry plots of the well owners, and the irrigation backup they get in the event of well failure, are put in place. Besides, there is financial provision for water harvesting structures to increase recharge, laying pipe lines for water supply to reduce distribution losses and promotion of micro irrigation (subsidies) in order to enhance water use efficiency.

Social regulation appears to be effective in terms of stopping new bore wells as well as larger number of households, especially marginal and small, are benefiting from sharing water with well owners. This not only helped in increasing the cropped area, but also provided protective irrigation to number of plots during critical periods thus saving the crops. This also resulted in equity in the distribution of water and overall improvement in welfare. However, there are differences between the two models of social regulation in terms of their effectiveness. The SRWM appears to be more effective when compared to APDAI. One reason could be that SRWM is older, followed an intensive approach and worked with smaller groups of farmers than APDAI initiative. Though APDAI mostly follows the SRWM approach, it has adopted a broader (area based) and formal approach involving the department (Table 9.4). Besides, groundwater management is one of the pilots under APDAI and hence there are chances of dilution as far as the departmental involvement is concerned.

[2] Though HUNs are registered bodies and can take up activities like input procurement, output marketing, etc, they are yet to be functional in these activities.

Despite the formal approach, participation and rule following is limited in the APDAI case. People indicated that there are no tangible benefits from the initiative and 50 % of the farmers felt that the institutional arrangements are not feasible (Reddy et al. 2012). This view is more conspicuous among those sharing wells. This sceptical nature could be due to the larger contribution (75 %) from the farmers, which is substantial (total costs are 8–10 thousand per acre). On the other hand, the approach of peoples' contribution could provide the much needed ownership and sustainability.[3] It is observed that the formal process of entering an agreement with the witness of *Tahsildar* has also discouraged some villages from joining the initiative.

The formal approach of APDAI appears good on paper, as it follows an integrated approach of drought adaptation. The integration also involves various departments like rural development, groundwater, agriculture, etc., but the feasibility of such integration is doubtful. The approach involves the existing institutions like Mahila Samakhyas, which provide the assurance of sustenance in the medium run at least. At the same time there is a danger of acquiring the stamp of a government programme where people look for freebies rather than regulation and contribution.

On the whole, the social regulation approach seems to work better for sustainable groundwater management when compared to the knowledge intensive approach. Water use and sharing through regulation has increased the area under protective irrigation in an equitable manner. The knowledge intensive approach is not designed to address equity. In the absence of any regulations, formal or informal, farmers do not have any incentive to follow good practices in the given policy environment. Encouraging sharing of water between well owners and others would result in achieving double objectives of conservation and improved access with equity. How to attain this on scale needs serious consideration at the policy level.

Sustainability of these initiatives is a major concern in all the approaches. None of the approaches have a well defined exit protocol. While the APDAI appears to be well placed in this regard as its process involves number of departments and formal institutions. At the same time it requires strong leadership at the village level to implement and take the initiative forward, especially in the context of peoples' contribution. In the case of SRWM, its present success is mainly due to the commitment of NGO partners in the absence of any contribution from the farmers. In the absence of contribution, financial sustainability of the initiatives would be a big concern, especially once the external funding stops. The week sustainability of APFAMGS initiative was already evident during the no fund phase. Fund flows appear to be critical for the success of the initiatives. The initiatives may continue in some of the villages due to strong leadership and commitment of local NGOs even beyond the present funding, as they are at a smaller scale. Scaling up of these initiatives require much more planning and designing.

[3] Of late people's contribution in the government programmes has lost its importance, as people are increasing considering government programmes as welfare measures rather than developmental. And hence contribution is treated as negative rather than ownership.

9.4 Lessons for Future

The review of the role of regulatory instruments in managing demand for water across the countries indicate that there is evidence to say that the commonly used instruments like pricing, supply regulation, direct and indirect policy regulation, etc., have not been effective. This is more so in India due to complex socioeconomic and resource systems and environment. Often policies are neither comprehensive nor they work in tandem. On the contrary they work towards opposite objectives, viz., water conservation policies like promoting low water intensive crops are made ineffective through support price policies that encourage water intensive crops like paddy and free power policies. Unless policy, economic and institutional regulations complement each other, the scope for achieving sustainable and efficient water management is a far cry. Moreover, none of the regulatory instruments have equity in-built in to them. Whatever equity impacts evident seems to be rather incidental. For instance, regulated power supply has checked degradation of groundwater to some extent, which in turn reduced well failure among small farmers. Similarly, regulation of water distribution by WUAs has also improved the access to tail end farmers, who are often small and marginal. At the same time increased inequity is observed in the context of WUAs in Orissa.

The assessment of three community based models has also clearly indicated that achieving sustainability and equity objectives is neither simple nor easily forthcoming. It calls for lot of efforts working through complex rural dynamics at various levels. The reason is that appropriate policies to support or encourage such initiatives are not in place. Often existing policies work towards achieving opposite objectives rather than going in tandem with the participatory initiatives. The three approaches have proved that communities are capable of managing groundwater in a sustainable manner. Communities are capable of understanding and using the technical aspects of hydro-geology. Since groundwater is widely considered as a private property there are no incentives for managing it at the community level. And there are no economic incentives or disincentives to manage groundwater in a sustainable manner.

The review clearly brought out that though some of the instruments like regulated power supply work better than others and social regulation seems to be much more effective. At the same time, unless wide ranging policy changes are brought in these instruments may not be effective. Social regulation initiatives also remain as models rather than being adapted at a wider scale in the absence of complementary policy support. Creating demand for these initiatives is as important as demand management of groundwater. The regulatory instruments for demand management would not be effective as long as policy environment is supply sided. Some of the important policy interventions for making the instruments effective and help scaling up social regulation initiatives on a wider scale include:

- Need for dispelling the notion of water, especially groundwater, as a private property and making it a common property in the real sense. This calls for wide ranging legislations and legal support.

- The present policy distortions of input and output pricing, free power, etc., need to be rationalised to match conservation and equity objectives.
- Regulation through pricing is an effective instrument but hardly adopted at the policy level. In the absence of realistic pricing water use efficiency remains a dream.
- Technology promotion through regulation at the industry level, rather than at the user level, would be easier to enforce. Exploring such options is a worthwhile exercise.
- As long as property rights in water are not clearly defined, community based water management or water sharing is the best option to achieve equity. Encouraging and strengthening existing informal or formal institutional arrangements like WUAs or group wells through policy incentives in terms of water tariffs, electricity tariffs, subsidies for micro irrigation, etc., would enhance community potentials.
- Policies should integrate equity issues in to the process so that they would enhance welfare as well as sustainability of water resources.
- Moving towards aquifer planning at the hydrological unit level to start with and then move to watershed or river basin scale is a desired policy option for sustainable water management in the long run.
- Creating hydrological information at a much smaller scale would be more appropriate for short term farming decisions. This could be attained through creating low cost infrastructure at the village level and provide training at the local level to take up the responsibilities on a regular basis with necessary economic incentives.
- Water sharing at the village level needs to be promoted as a first step in this direction. Existing wells could be linked and termed as common property.
- Government may encourage only new wells on group sharing basis in villages/micro-basins that are identified as critical and semi-critical with respect to groundwater development. Strengthening and enforcing the existing regulations like APWALTA in AP could be a starting point in this direction.
- Delinking land and water rights need to be treated as an important policy goal, at least in the long run.

Thus, the experience of regulatory instruments in water management reveals that wide ranging policy changes are required to make them effective at scale. Replication of the social regulation models could be possible with high transaction costs but sustainability of these initiatives remains uncertain in the present policy environment.

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Chapter 10
Water Rights and Entitlements in India

Rathinasamy Maria Saleth

Abstract With increasing water scarcity in India, the need for establishing institutional mechanisms such as the water rights and entitlements (WR&E) system is widely recognized. But, there are many questions continue to persist as to the form and feasibility as well as the challenges and opportunities involved in establishing such a system in Indian context. This chapter tries to answer some of these questions by (a) discussing the legal, policy, and organizational aspects of WR&E system relevant for India; (b) tracing the evolution of informal and formal WR&E systems at various scales; (c) assessing the opportunity costs of missing or unclear WR&E system in terms of foregone benefits; (d) indicating the technical and institutional potentials as well as the political economy constraints for promoting the WR&E framework; (e) exploring how the WR&E framework can be introduced in areas with rudimentary water rights; and (f) Concluding with the identification of short and medium term options as well as paths and implementation strategies for promoting the WR&E framework for India.

Keywords Incentive gap in water use, India • Opportunity costs of missing water rights system • Rudimentary water rights • Water markets • Water rights system • Water sector reforms

10.1 Introduction

With increasing water scarcity and frequent occurrences of water-related conflicts at macro and micro levels, the institutional arrangements needed for orderly water allocation and efficient resource management are becoming more and more important. Allocation-oriented institutional arrangements require a formal system of water rights and entitlements (WR&E) applicable both at the macro level of regions

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and sectors as well as at the micro level of users and uses.[1] These rights and entitlements need not be ownership rights as they can be equally effective just as usufructuary (or, use) rights. Such institutional arrangements are obviously urgent for countries such as India where an overall supply gap is expected in the very near future. Already, the symptoms of supply–demand gap are already evident in many pockets in the country with serious livelihood threats and fierce political conflicts. The water demand of the country is growing fast due to population growth and economic expansion. As currently developed resources of 644 billion cubic meters or thousand million cubic meters (TMC) represent only 57 % of the utilizable potential (1122 TMC), certainly, there is a technical scope for supply augmentation. But, supply additions are getting increasingly constrained by investment bottlenecks, environmental concerns, and political and legal snags. Even if this potential is realized by overcoming the fiscal, environmental, and political challenges, the supply would still be inadequate as the total water needs of the country is projected to be in the range of 694–710 TMC by 2010, 784–850 TMC by 2025, and 973–1180 TMC by 2050 [Government of India (GOI) 2000]. Such a demand–supply gap can have devastating social, economic, and political consequences for a monsoon-dependent and rural-based economy such as India, unless remedial measures both on the demand and supply side are undertaken urgently.

The scenario facing Indian water economy is rather grave. As the diagnosis identifies institutional bottlenecks as the epicenter of most problems facing water sector, the policy prescription obviously calls for a radical change in development paradigm and urgent reforms in water institutions. Physical approaches based on 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 economic and institutional approaches such as those based on a system of WR&E applicable both at the micro and macro levels. While there is consensus on the need developing the WR&E system, there is also a somewhat a distorted perception as to the technical and political feasibility of establishing such a system in the Indian context. Certainly, the introduction of the WR&E system will not be easy as it entails heavy financial, technical, and political costs. At that same time, it is also not that difficult or costly as it is often made out to be. WR&E are very much a reality as they exist in implicit and informal form both at the macro and micro levels.

The WR&E systems are implicitly recognized in a number of official documents, directly or indirectly formalized in various water allocation procedures such as *Shejpali* and *Warabandi*, and informally followed in many grassroots practices such as *Pani Panchayats* and groundwater markets. The real issue is essentially to formalize these implicit and informal WR&E and make them explicit and transpar-

[1] The terms 'water rights' and 'water entitlements' are used here interchangeably. Water entitlement, like water rights, is a legal right to access water. A water entitlement can be specified as a share of water from a consumptive pool of water as per a water plan or a fixed annual volume. But, there are subtle differences between the two as the water right can be legally obtained but water entitlement has both ethical and legal connotation.

ent. The prospects for making such changes are relatively high in many states in India given their legal and institutional scope, socio-economic and political benefits, and experimental possibilities. In many ways, the costs of establishing the WR&E system are, more or less, the same as those needed for undertaking any other reforms in the water sector. But, it is also true that the social benefits associated with WR&E system are not only far higher than these costs at present but also the net benefits from the system will be growing with the increasing scarcity of water in the future. This paper aims to precisely to establish this point based on a careful review of the legal, economic, and institutional issues and practices in the particular context of India.

10.2 Objectives and Scope

The overall objective of this paper is to demonstrate the rationale, feasibility, and options for establishing the WR&E system including how international funding organizations did or can support the efforts to promote such a system as a durable institutional solution for the water challenges of India. The specific objectives of this paper are to:

(a) Discuss the legal, policy, political, economic and organizational issues pertaining to the establishment of WR&E in India;
(b) Review the evolution of informal and formal WR&E in India at the national, inter-state, state, sectoral, and local levels and also indicate best practice cases at relevant levels;
(c) Assess the opportunity costs of missing or unclear WR&E at different levels in terms of foregone economic, social, and political benefits;
(d) Identify the technical and institutional potentials as well as the political economy constraints for promoting WR&E framework both at the local, sectoral, state, and inter-state levels;
(e) Examine how WR&E framework can be introduced in areas with rudimentary water rights and demonstrate how the framework can be applied to other contexts;
(f) Conclude by identifying short and medium term options as well as paths and implementation strategies for supporting the promoting of WR&E framework for India.

As to the scope, this paper is more eclectic rather than exhaustive in terms of its coverage of the legal, policy, and administrative or organizational aspects governing the water sector. The emphasis will be on the most important aspects of water institutions that are receiving considerable attention in the current debate on water sector reforms both in India and elsewhere. While informal institutions operating at the micro level will receive attention, the major focus will be on the formal institutional arrangements that are operating at the national and regional levels because they are more amenable for purposive reforms than their informal and local counterparts, which are functioning sub-optimally due to the absence of macro level legal and organizational supports.

10.3 Water Rights and Entitlements: An Overview of Issues

For a monsoon-dependent country like India, water remains the dividing line between poverty and prosperity for millions of people. Efficient, equitable, and sustainable use of water requires the widespread adoption of desirable practices such as conjunctive use, supplemental irrigation, water-saving technologies, water transfers, and water recycling. But, this cannot happen in an economic and institutional vacuum. The WR&E system can fill this vacuum to alter the incentives and behaviors by setting the quantitative and qualitative limits for water availability for regions, sectors, and users as well as the economic and legal conditions for water sharing and allocation among these entities. If properly designed and implemented, the WR&E system can also be a policy instrument that can simultaneously address the goals of economic efficiency, social equity, and environmental security. Unfortunately, with narrow approaches, the WR&E system is often misconstrued as a prelude to water privatization and commercialization. Contrary to such a perception, it will be argued here that the WR&E system will be the cornerstone of a new governance structure that can permit social control and public decisions at the stage of allocating initial water rights and entitlements while allowing decentralized private decisions at the of stage of reallocation and actual use of water. The WR&E system is also essential for providing water security as well as generating food and livelihoods for the poor through an efficient and equitable allocation, use, and management of water resources. As a backdrop to the ensuing discussion, it is useful start here with a brief discussion on some of the legal, policy, economic, political, and organizational issues related to the kind of WR&E system to be developed for the specific conditions and requirements of India.

10.3.1 Incentive Issues

The rapidly approaching physical scarcity of water, which is already a reality in a growing number of basins in India, calls for far reaching changes in water resource allocation and radical improvements in water use efficiency. This applies particularly to the irrigation sub-sector with a dominant share in total water use. The persistence of the ‘incentive gap’ or the ‘efficiency gap’, i.e., the gap between the real economic value of water and the low value of water being perceived or assumed by users is a major threat to efficient water use in irrigated agriculture (see Box 10.1). The extensive damages of this incentive problem are already visible in the forms of aquifer depletion, water logging, and soil salinity. The incentive problem has legal roots in the colonial policy of separating resource ownership from resource usage and such policy has continued till today. The dichotomization of ownership and usage eliminates the incentives for resource use efficiency and conservation, as the users cannot claim the benefits from their efficient use. Unless this legal condition

Box 10.1 What Is Incentive Gap?
The ‘incentive gap’ or the ‘efficiency gap’ may be difficult to define in the absence of information on the real value or the opportunity cost of water. In simple terms and as lower bound values, it can, however, be approximated by the gap among water productivity, supply cost, and water rates.

In the context of canal regions, for instance, water productivity is reckoned in the range of Rs. 714–5812/hectare (ha) and supply cost is estimated to be in the range of Rs. 90–603/ha. But, water rates are in the range of Rs. 6–1000/ha) (GOI 1992b). While groundwater use is more efficient, it is not free the incentive problem as the groundwater rates of Rs. 3–48/h (Shah 1991) is far lower than both the supply costs and created benefits.

The incentive gap indicates not just an economic pricing but also the absence of the institutional conditions needed for volumetric allocation such as water rights and the organizations basis for their enforcement and cost recovery.

and its behavioral consequences are corrected, it will not be possible to influence resource use efficiency and conservation.

The failure of regulatory policies ranging from water pricing and user participation to well-spacing and power tariff demonstrates not only their poor design but also the institutional vacuum within which they are implemented. Unless some form of physical limits and use rules are set at the level of individual users, regions, and sectors to make the level and nature of access to water transparent and accountable, many of these regulations cannot be effective in achieving their goals. In the absence of such limits, emergent institutions such as groundwater markets with significant efficiency and equity benefits (Shah 1991; Saleth 1991) can degenerate into instruments for rent-seeking, water monopolies, and aquifer depletion (Janakarajan 1993; Saleth 1993). When individual users see their water constraint, they have the incentive to use water efficiently and such incentive will increase when they have the option for an economic exchange of the saved water. In view of this incentive effect and the equity and ecological safeguards possible when determining the overall allocation of rights and entitlements, the WR&E system will have inherent self-regulating properties. These properties have the potential to obviate the administrative pressures and regulatory failures associated with a plethora of ineffective regulations. The WR&E system can also fill the current legal and institutional vacuum surrounding groundwater markets, water user associations, and basin organizations.

10.3.2 Technical, Legal, and Organizational Issues

Complete physical control over an object is not at all necessary as it is rights never objects that are owned (see Coase 1937: 44; Dales 1968: 792). Although rights can imply physical aspects, they are a physical entity but a legal entity implying a bundle of user rights with correlated duties. Similarly, as the experience in countries such Chile shows that these rights and entitlements need not be ownership rights and it is enough for them to be just as usufructuary (or, use) rights. However, the issues of defining and enforcing such rights in the context of water with its fluid and fugitive characteristics require additional technical, organizational, and infrastructural requirements. The most immediate technical requirement for a water rights system is to establish water balance for each appropriately defined hydro-geological unit under use and source-wise disaggregated conditions as well as alternative scenarios. Meeting this requirement is not difficult for most areas in India given the information availability and technical expertise (Pathak 1988; GOI 1988). While the establishment of the WR&E is also likely to generate new demand for additional and more refined information (World Bank 2004: 16), the existence of the necessary technical capacities and organizational preconditions can enable most states in India to meet such information needs.

The real challenges are in the definition, allocation, and enforcement of water rights. In this respect, the three issues need answers: unit of measurement, criterion for rights distribution, and enforcement and monitoring mechanisms. It is ideal to define WR&E in volumetric terms so that the same amount of water is implied across time and space. But, even this ideal measure faces problems due to return flows and changes in withdrawal point. Thus, volumetric measure, though useful is not an absolute necessity. What is needed is only a shared notion of quantity to an acceptable degree of approximation. In many cases, locally developed institutions are used as substitutes for sophisticated but economically infeasible measurement technologies.[2] But, precise quantification can be possible through water meters as in the case of groundwater and urban areas or advanced measurement structures as in the case of the Majalgaon Canal Project in Maharashtra (see Box 10.2). However, as the experience of other countries having a matured water rights system such as Australia, Chile, and the western parts of the US, once the WR&E system is established, with the development of strong legal and organizational structures for the operation of WR&E system, strong economic incentives would emerge for the development of more robust but less costly water measurement and application technologies.

The criteria for water rights allocation remain neutral for efficiency but are critical for equity.[3] While an open bidding procedure can be considered for rights allocation, other need-based criteria are better to avoid monopolization of rights and address special social concerns (see Box 10.3). It is very important from the equity perspective to ensure water entitlements also to landless groups and socially vulner-

[2] Instances for such substitutions include the use of watermen in many canals systems in Tamil Nadu, Andhra Pradesh, and Karnataka, and the reliance on timing procedures involving local priest and community elders in the irrigations of Canary Islands, Spain (Mass and Anderson 1978: 22–24).

[3] This is immediate from the familiar result of Coase (1937). That is when the rights are private and transferable (or, rentable), their reallocation will correct the inefficiencies associated with the initial distribution of rights. But, from an equity or income distribution viewpoint, the criterion matters as the allocation of rights amounts to asset transfers.

Box 10.2 Technical Scope for WR&E System: An Example from Maharashtra

Apart from its social and political acceptability, the WR&E also requires certain basic technical and design conditions needed for volumetric delivery of water. Such technical preconditions are present in Majalgaon Right Bank Canal where a remote controlled and computer-based dynamic regulation system has been installed under a World Bank assisted projects.

Briefly, dynamic regulation involves (i) 10 cross-regulators fitted with wireless remote transmission units; (ii) volume control structures at each of about 18 distributaries; and (iii) the control centre with a computer system that monitor and record water diversions via wireless networks. The volumetric distribution possible with the computer-based dynamic regulation system enhances the technical prospects of introducing an effective WR&E system in the Majalgaon canal regions.

Source: World Bank (1998a: 123).

able sections. A hybrid criterion is also possible where certain amount of water is allocated among landless persons using the *Pani Panchayat* criterion and the rest is allocated among land owners using the National Commission on Agriculture (NCA) criterion. The amount to be available for allocation to landless can be varied by using the following procedure. First, the total available water is theoretically distributed across the land owners via the NCA criterion. Then, as a form of progressive tax, the distributed water rights in the first stage are proportionately reduced to form a pool for its subsequent distribution among the landless. In this way, larger farms contribute more to the pool than small farms (Saleth 1996). Notably, the provision

Box 10.3 Criteria for Allocating Water Rights: Official Proposal and Local Practice

As per the NCA proposal (GOI 1976: 23), the available groundwater in a basin, after allowing for non-agricultural needs, will pertain to land and each land holding weighted in terms of its soil quality and access to surface water will have a legitimate right to a proportionate share of the groundwater. Apart from equity, this criterion also promotes an integrated use of land and water. But, it has the negative effect of reinforcing inequity in land ownership with the same on water.

This negative effect is avoided by the criterion actually used under the *Pani Panchayat* system being practiced in parts of Maharashtra where rain harvested water is allocated not in terms of land size but in terms of family size (Singh 1991: 35; Vani 1992: 9–10). Usually, about half an acre (0.20 ha) worth of irrigation water is allocated for each person in the family (Thakur and Pattnaik 2002).

of water rights to landless groups presumes transferability or rental possibility. Otherwise, there are no benefits from such rights for irrigation water. This shows that apart from the economic requirements, there are also social needs for the legal provision of transferable rights and entitlements.

Equity concerns and ecological needs remain the major concern also in countries both with a relatively a mature water rights systems such as Australia, Chile, and the western parts of the US as well as those with an evolving rights and entitlement system such as Mexico and South Africa. In all cases, since the rights over most of the resources are already claimed, meeting the rights of new entrants, including the environmental water needs are met with reallocation of existing rights mostly through markets or through state-managed compensation procedures. The latter is actually the practice both in South Africa where most of those requiring water rights are resource poor farmers as well as in Australia where the state support is needed to reallocate water to ecosystems. For countries such as India where there are implicit rights exists in terms of actual control and use (as in groundwater regions) and semi-formal rights exists due to water allocation procedures (as in canal regions), it is necessary to start with a gradual licensing of such implicit and semi-formal rights while working also to ensure new rights, especially to landless groups, urban and rural poor, and environment needs. Transitional licensing is one important means to ensure that the introduction of water rights does not disturb existing claims and informal rights (see Box 10.4). Such licenses can be converted into formal rights with desirable features such as transferability over time. In fact, the water rights system observed in all countries has actually evolved in this way through an interaction of hydrological, economic, and legal systems.

The enforcement and monitoring arrangements for WR&E system needs an enduring state-community-user partnership. The regulatory rights of the state, enforcement and monitoring responsibilities of local organizations, and the use

Box 10.4 Transitional Licenses for Protecting: Existing Rights: Country Experiences

In instituting a new water rights system, it is essential not to disturb established water usages and use patterns. In England and Wales, for instance, when the new legislation came into force, it protected existing users through the instrument of a "license of right", once the users apply, within a year, with proof of their water use over the previous 5 years. Similar provision can also be found in the water laws on countries as different as Italy, Jamaica, and Spain.

Another important feature of the licensing systems in effect in these and similar countries is that licensing is generally waived in respect of water abstractions for meeting immediate domestic and para-domestic uses. Such exemption is also made in the 1994 Water Law of South Africa. Similarly, shallow and low-yielding wells are exempted from licensing requirements.

Source: World Bank (1998b: 56).

rights of the users are to be hierarchically structured within a public trust framework (Singh 1991; Saleth 1996). The public trust framework is closely linked with the Gandhian notion of trusteeship. It provides a basis for linking social control of the state and community organizations with the decentralized decisions of private individuals and groups. In this new governance structure, the overall water allocation, regulation, and management are with the state and community organizations under as public trust whereas field level water allocation and use are under private hands and market influence. The government at the appropriate level has the responsibility to establish the overall legal framework for the water rights system including formal mechanisms for conflict resolution at the regional level. How WR&E are hierarchically structured in an operational context can be visualized in simple terms as follows. First, the total quantity of water and its priority for different sectors are established for a given area. Second, given the sectoral allocation, the amount and its priority are established for different sub-regions within the area. And, given the sectoral and regional allocations, the shares of individuals for different used are established using criteria discussed above. But, enforcement, monitoring, and conflict resolution at the basin and local levels require decentralized arrangements such as basin organizations, local governments, community organizations, and user-based arrangements. Given the existence of a fair amount of institutional potential at the grassroots level and farmers' familiarity with the turn-based water allocation, the task of developing flexible mechanisms for the enforcement of the WR&E system should not be that difficult in many areas in India. In fact, there are institutional and operational synergies between WR&E systems and user-based organizations as has been illustrated by the experience of Chile (see Box 10.5).

Box 10.5 Tradable Water Rights in Chile

The 1980 Water Code dissociated water use rights from the originally intended purpose, and redefined them as a real right (a property right), which could be sold, bought, rented, leased, mortgaged or inherited. A National Registry for Water Use Rights was established, kept alongside the National Real Estate Registry.

Given the water rights system, localized water markets evolved within watercourses or, occasionally, within the same hydraulic system. There is a market-clearing price, and transactions are effected through personal contacts, local newspapers, and water "realtors"--usually, real estate realtors or produce wholesalers. The most common transactions are: sale of the right or part thereof (water rights are fully divisible; its rent or lease for a cropping season or a fixed time span; and spot sale of a volume of water (in volumetric systems only).

The introduction of saleable water rights was facilitated by the dual facts that water use rights had already been granted on most waters and most watercourses were managed by water users associations.

Source: World Bank (1998c: 124).

10.3.3 Economic and Political Issues

From the perspective of efficient, equitable, and sustainable use and management of water resources, the private roles at the stage of water use is as important, if not more, as the public and community roles at the stage initial of water allocation and subsequent regulation and management. In order to enhance efficiency and conservation at the stage of water use, the WR&E regime should ensure private and transferable or, at least, rentable rights, where water entitlements can be temporarily transferred either in part or in full. These conditions are vital for WR&E system to perform its critical economic functions. Since these conditions provide incentives for efficiency and link use decisions with market conditions, they promote optimum use of the resource. Private nature and the scope for transfer or rental of rights are linked with resource values and pricing.[4] Transferability and exchangeability of water rights are crucial to capture and reflect the scarcity or use value of water through price signal and guide water allocation accordingly. Apart from their efficiency effects, transferable private rights also have a distribution function as they can apportion the joint benefits of water exchange among concerned parties. Although the ontological status and fugitive nature of water makes the rights as a legal fiction and allows only a *de facto* user rights (Singh 1992: 27), it is this *de facto* rights (or, actual use and control of water) that are economically more relevant as transferability becomes more important at the level of use than at the level of its ownership. The requirements of private and transferable rights need not contradict the rights of the state or community essential to ensure the ecological security and social equity. As noted already, when these rights are defined within the public trust framework, private and transferable rights are consistent with social control needed to ensure equity and sustainability.

Private and individual rights are also essential to ensure the two-way accountability, i.e., the accountability of individual users to each other and that between the individuals and the community (Singh 1992: 8).[5] Inter-personal accountability is economically very important as it provides a means to address the 'externality' problem that is pervasive in water use. This is because individual water rights do not just define the legal boundary but also demarcate the physical and economic boundaries of individual's actions and their effects. Thus, by relating rights with duties, such effects can be quantified and compensated. As a result, the potential for interpersonal conflicts are minimized. From a strict legal perspective, the transferability of water rights faces problems as they are considered as natural and fundamental rights (Singh 1992: 27). While water for drinking and domestic use can qualify to be a fundamental human right, the same for other economic uses need not have such an ethical qualification. In these cases, therefore, the legal conception of water rights should be such as to allow ownership rights and hence, transferability among

[4] For, what is not owned cannot be priced because prices are just the payments for property rights or, more specifically, for the rights to use an asset (Dales 1968: 792).

[5] Sometimes, communal and groups rights are also advocated (Devi 1991: 624). But, such rights can ensure only the accountability of the community/groups to the state but not that among individual members of the community/group.

legal persons. Otherwise, water rights will remain just a legal notion bereft of any economic and equity significance.

The WR&E system has clear economic and equity justifications. The technical, legal, and organizational feasibility of establishing this system is also bright given the information availability, planning capability, and institutional potential present at different levels. Legal experts have noted that water rights-based legal reform is part of the charter in the Indian Constitution (Singh 1991: 12–13). In fact, there are policy commitments for developing a WR&E as arrangement similar to that have been advocated by various government commissions, committees, and documents (see GOI 1970, 1976, 1992a, b) (see Box 10.6). There are also legal and organizational initiatives both at the national and state levels. Many states have amended past or created new water-related legislations for controlling groundwater over draft (World Bank 1998d). At the national level, the central Groundwater Authority was created for regulating groundwater withdrawals through an administratively managed licensing and permits system in areas with severe aquifer depletion.[6] Similar arrangements are also being created at the state level. More recently, the water resource management sector review undertaken jointly by the Ministry of Water Resources (MOWR) and the World Bank has agreed, in principle, to establish a WR&E framework (MOWR 1996;

Box 10.6 Water Rights in Official Documents and Initiatives

The NCA in its 1976 report postulated a correlative rights system—a land-based proportional allocation of groundwater (GOI 1976: 23). The Model Groundwater (Control and Regulation) Bill of 1992, which was originally formulated in 1970 and also got revised slightly in 1997, has postulated a kind of licensing and permit system, especially in areas experiencing severe aquifer depletion (GOI 1992b). The Bill provides for the mandatory installation of water meters, but has not specified any withdrawal limits. Although the Bill failed to evoke much interest among the states except for some marginal legal initiatives in Gujarat, Karnataka, Maharashtra, and Tamil Nadu, it led to the creation of the central Groundwater Authority in 1997. Similar arrangements at the state level are also being created.

Despite its bureaucratic nature and regulatory orientation, this arrangement provides a formal mechanism both for creating permit-based private groundwater rights as well as establishing public rights in their regulation. As this arrangement becomes more and more decentralized and participatory and when the private use rights are quantified and metered, the allocative role of this new arrangement can be enhanced to complement its regulatory functions (World Bank 1998d: 19–20).

[6] This authority was created in 1997 in response to a 1985 Supreme Court judgment (Supreme Court of India, Civil Original Jurisdiction, I.A. no. 32 IN W.P. (C) no. 4677 of 1985) in 1995 asking to control groundwater depletion. It was notified in gazette (Gazette of India: Extraordinary, part 11, sec. 3, subsec. ii, no. 30, New Delhi, Tuesday, January 14, 1997).

World Bank 1998b: 49–50). Paralleling the policy commitments, there is also a consensus within the research community on the need for such a system (e.g., Dhawan 1990; Jain 1976; Singh 1991, 1992; Shah 1993; Saleth 1996).

Despite the policy commitments and economic necessities, there is a political aversion towards the WR&E system. Many consider it to be an administrative nightmare and a political impossibility while others argue that it will lead to the commercialization of a life-supporting resource. But, these views are not based on full information as the WR&E system being proposed will have social and environmental safeguards and is subject to public regulation and control. It is not intended to reduce the water availability to any individuals or groups, but rather to ensure the tenure and certainty of already available water. As this system creates a basis for reallocating water through compensating current claimants, it does have scope for equity-oriented reallocation needed to empower poor users (Rosegrant and Binswanger 1994). As we will see later, the WR&E system is also not new for India as various forms of implicit, informal, and rudimentary system resembling water rights exists in different parts of the country. Thus, what this proposed system does is only to formalize such arrangements in the interest of all concerned. Such institutional potential reduces the costs of creating the WR&E system whereas growing scarcity and conflicts exacerbate the social costs of the institutional vacuum. The costs are also likely to decline further with the two important institutional initiatives: administrative decentralization through *panchayat* system and management decentralization through water user associations (World Bank 1998b: 29–30). As will be argued, in view of this transaction cost calculus, the political factors, though can delay the process, cannot block the creation of the WR&E system in India.

10.4 Evolution of Water Rights at Different Levels

India does not have any explicit legal framework specifying water rights, even though various acts have a basis for defining some form of such rights. However, additional changes are needed to move from the present conditions of informal, implicit, partial, and unclear arrangement to an improved legal and institutional framework for promoting the kind of WR&E system needed for meeting current and future requirements of the water management in the country. Both the nature and magnitude of these changes vary considerably across contexts, regions, and sectors. For understanding the existing potential and needed changes, it is necessary to see the evolution and status of water rights at the local, sectoral, state, regional, and national levels.

When revenue needs and technical possibilities allowed the colonial administration to develop and control water resources on a large scale, fundamental changes have occurred in the economic and legal basis of water allocation among users. A series of legislations were enacted to establish the state's right over water resources and to specify conditions for users to have access to them. Early British legislations did recognize the customary water rights of individual and groups. However, with the Easement Act of 1882 and the Madhya Pradesh Irrigation Act of 1931, the state's absolute rights over all rivers and lakes were firmly established.[7] While state's absolute rights can affect the development and managerial aspects of water, from the perspective of water use, it is the *de facto* control over water by actual users at the micro level that is more important. For canal irrigation water, rights can be obtained only by express grant and on payment. Time and outlet-based turns (e.g., *Warabandi, Osarabandi, and Varvaram* systems) were developed to physically allocate the water rights. But, as these rights may have a legal sanction under the irrigation acts of concerned states, the neither involve any legal document nor specify the entitled quantity. As a result, users lack recourse to protection. Private rights to groundwater were recognized, but only through land rights.[8] As a result, from a strict legal sense, they cannot be transferred apart from land. While there is a legal security for groundwater rights, the entitled quantities implied by them are not specified, except for the stipulation of an obtuse concept of 'beneficial use'. This system of water rights developed and consolidated during the colonial has continued after independence. It is this system that exists today with some adjustments reflecting changing market and technology.

With the expansion of rural electrification programs, emergence of improved pumping technologies, and changing economic and resource realities, some notable changes have occurred in water rights and allocation both at the micro and macro levels. Although groundwater rights lack transferability in a legal sense, *de facto* water transfers have become extensive through groundwater markets in many regions in the country (Shah 1993). In view of this possibility, farmers are also able to establish *de facto* rights that are much larger than those implied by their farm size. The quantities of water implied by such rights are indirectly defined by the interactive effects of farm size, well depth, pumping capacity, and water selling possibilities (Saleth 1998). Notably, such rights have social recognition as they are often implicitly recognized by other farmers either willingly or otherwise and the governments are unable to regulate them for political reasons. In Gujarat, even farmer groups have also established such rights through more formal arrangements such as water companies and elaborate underground water conveyance networks (Singh and Bhallab 1996). In some cases, these *de facto* water rights are linked with land and labor contracts (Shah 1993; Janakarajan 1993; Saleth 1998). Box 10.7 provides few instances for these forms of group-based and linked water rights in groundwater regions.

In canal regions, the water rights, by law, are fixed-tenure in nature as they are restricted to groups having access to land in canal regions (Saleth 1996: 248). They are only 'access rights' and offer no guarantee for any quantity or its certainty. Due to the physical features distribution networks and spatial considerations in distribution rules, these rights are also biased against tail-end farmers. Moreover, these

[7] Notably, this position was also reflected even in the irrigation and water supply acts enacted after independence. But, the Madras High Court in 1936 and the Bombay High Court in 1979 have declared that the government's sovereign rights do not amount to absolute rights (Singh 1991: 30–34).

[8] As per the 'dominant heritage' principle implied in the Transfer of Property Act IV of 1882 and the Land Acquisition Act of 1894, a land owner can have a right to groundwater as it is considered an easement connected to the dominant heritage, i.e., land.

Box 10.7 Water Rights in Water Companies and in Other Rural Contracts: Few Instances

New forms of water rights have also emerged with changing organizational and contractual arrangements, especially in groundwater regions with severe water scarcity. For instance, in the case of water companies observed in Gujarat, there is an implicit form of group rights. These companies, which are formed both by a voluntary cooperation among farmers as well as by the turn-over of the state-owned public tubewells, also sell water to non-members besides meeting members' water needs. In many cases, elaborate pipeline networks are also constructed to link many contiguous farmers.

In parts of Andhra Pradesh, Gujarat, and Tamil Nadu, the inter-linked nature of groundwater markets with other markets for land, labor, and farm inputs and outputs suggest that the *de facto* water rights of landowners has a leverage with other contractual arrangements involving land leasing, labor contracts, and agreements on input supply and output sales. There are also a water-based tenancy contracts based on different rules for sharing labor, other inputs, and outputs. In these cases, since water rights form an integral part of the whole arrangement, they have an effect far beyond the water resources.

Source: Shah (1993); Janakarajan (1993); Saleth (1998).

rights also lack transferability apart from land as canal water cannot be transferred to non-canal regions. But, there are some notable adjustments in canal water rights in recent years. Not only do farmers transfer their water and turns to others within the commands but also they move canal water to non-canal regions indirectly through groundwater withdrawals in canal regions. Originally, groundwater extraction in canal areas has emerged to supplement canal supply and meet irrigation needs during canal closure periods. But, in recent years, it is being increasingly used to transfer water through pipelines to non-canal regions.

Notably, some of these transfer projects are also funded by formal credit from rural commercial banks as observed in parts of Tamil Nadu (Dinar and Saleth 1997; Dinar et al. 1997). These transfers also redefine and create new sets of water rights (see Box 10.8). In Madhya Pradesh, an Asian Development Bank mission has observed the widespread practice of pumping water directly from canals for irrigating non-canal farms (Breckner and Saleth 2001). Although laws and administrative rules restrict canal water rights only to those paying water charges, such restrictions are not strictly enforced as indicated by the magnitude of water charge arrears in many states (see GOI 1992b). Water charges are, in fact, only small portion of the real values of canal water rights that are captured immediately by productivity and ultimately by capitalized land values. But, with irrigation management transfers, water allocation, cost recovery, and system maintenance have all improved (Vermillion 1997; Oblitas and Peter 1999; Joshi and Hooja 2000). With their greater involvement of water allocation and management, farmers have also begun to realize the value of having water rights. This, in fact, suggests the synergy effects between user organization and water rights.

Box 10.8 Private Water Transfer Networks and Informal Groundwater Rights in Canal Regions

In Periyar-Vaigai Basin, Tamil Nadu, farmers have constructed elaborate pipeline networks for transferring groundwater both from the canal commands as well as from the downstream of newly constructed small dams constructed across the Shanmuga River. The investment costs of pipelines with average length of 3–4 km range between Rs. 50,000 and 200,000.

What is notable of these privately initiated water transfer networks is the involvement of bank loans in the construction of some of them and the emergence of water markets and informal water rights system. With supply of water in a previously rainfed region, land productivity and farm income have increased up to 20 times creating economic and technical conditions for water markets. As the groundwater is moved from aquifers away from actual water use, an informal intra-regional water reallocation has occurred also with the creation of water rights disconnected with land.

Source: World Bank (1998c: 61–62).

At the macro level, there are also both implicit and explicit water rights. In this respect, the broadest form of rights is implied in the constitutional division of power between the central and state governments over water resources itself.[9] These are essentially legal rights to develop, regulate, and manage water resources. Although such rights heavily favor the states, the states' rights are under an increasing pressure in recent years. This is partly due to the emerging need to devolve water rights to the basin and local organizations and partly due to increasing rights and responsibilities of the central government in environmental protection, conflict resolution, and national coordination. As the country is approaching the physical barriers for freshwater expansion, these roles of the central government are bound to grow. It is these larger responsibilities of the central government that justify the need to move water resources from the state list to the concurrent list (Singh 1991; World Bank 1991, 1998c). At the same time, the devolution of rights and entitlements to basin and local levels are also essential to strengthen the regulatory rights of the states, but minimize their involvements in day-to-day water allocation and management functions. The initiatives of many states in creating basin organizations and water user association states are likely to redefine further the existing pattern of macro man-

[9] As per Entry 17 in the State List under the Seventh Schedule of the Constitution, it is the states that have jurisdiction over water resources within their borders. But, the powers of states are subject to Entry 56 in the Union List that allows the central government to regulate and develop interstate rivers and river valleys when this is declared by parliament as a matter of public interest. The central government also has regulatory roles in the water sector vide Article 252 related to interstate water projects as well as in terms of the Forest Conservation Act of 1980, which requires the states to get central clearance for executing ecologically sensitive water projects. The central government also has an important role in resolving inter-state water disputes as per the provisions under Article 262.

agement and regulatory rights over water. Thus, the new institutional paradigm or governance arrangement involves three key elements, i.e., water rights system, user organizations, and state and community regulations, all of which are indispensable both individually and collectively.

There are also some important developments in the evolution of water rights at the macro level. Explicit and implicit forms of water rights also exist at the macro level of sectors and regions. For instance, use prioritization specified in the National Water Policy of 2002 and the same implied in the Constitution[10] provide a basis for establishing the priority of sectoral rights and entitlements. But, these priority rights are not absolute in view of their correlated condition of respecting the individual and group rights over which they are defined. Similarly, they are also not to be misunderstood either as a basis for confiscating individual rights or as a basis for developing rights through state fiat within a command and control framework. Thus, the priority rights can only be a form of general guidelines for instilling social control over macro level water allocation but not a firm rule to obviate the role of economic conditions and market requirements.

On the other hand, the current sectoral pattern of water allocation at the national, state, and local levels can directly be interpreted as *de facto* rights as they represent the economically and socially accepted pattern of actually observed water use. In this sense, these allocations can be a basis for establishing more formal and flexible sectoral rights and entitlements at appropriate regional and resource contexts. In this respect, the most preferred arrangement requires both the physical context of river basins and the organizational framework involving the networks of stakeholders of those basins. For inter-state (or inter-regional) water rights, negotiated agreements on water sharing form a natural basis for developing regional and state water rights.[11] But, in other cases where negotiated settlements have been difficult, the awards given by concerned tribunals established by the central government under the provisions of the Inter-state Water Disputes Act of 1956 can be used as a starting point for developing water rights at the state level (see Box 10.9).[12] Although the tribunal awards settle the dispute by quantifying the water claims, they involve a lengthy process to reach a final settlement.[13] Besides, since the implementation of tribunal awards can be

[10] For instance, the constitutional provisions relating to the fundamental rights to life are used as a basis for assigning top priority for drinking and domestic uses as well as irrigation and ecological water needs.

[11] There are 58 independent water-related agreements among states concluded in the past—39 related to joint projects and 19 related to sharing of river waters—and all of these are under heavy pressure for renegotiation due to the increasing water requirements of concerned parties (World Bank 1998b). See Iyer (1999) for a review of some of these agreements.

[12] Under this Act, the central government has so far set up five tribunals and three of them have come out with amicable decisions (Krishna in 1976, Godavari in 1979, and Narmada in 1979). These include also the tribunal dealing with the politically most sensitive Cauvery River dispute where only an interim award was given and even that is strongly contested by one of the concerned states.

[13] Since the Act has failed to specify the authority to implement the decision as well as the time limit for tribunal decision, it was amended twice—first in 1980 for authorizing the central government to establish the implementation authority and then, in 2002 to specify a 6-year time limit for

Box 10.9 Basis for Developing Regional Water Rights: Practical Instances

The Upper Yamuna River Board provides an instance for developing regional water rights from negotiated agreements. This board allocates the Yamuna water among Haryana, Uttar Pradesh, Rajasthan, Himachal Pradesh, and the National Capital Territory of Delhi within the overall framework of the Memorandum of Understanding (MOU) singed by the Chief Ministers of the co-basin states.

In contrast, the 1976 award of the Krishna Water Dispute Tribunal provides an instance of settlement-based framework for developing regions water rights. The award, which is based on a 75 % dependable flow Krishna River and its distributaries, set quantified water entitlements of 560 TMC for Karnataka, 700 TMC for Maharashtra, and 800 TMC Andhra Pradesh.

Source: World Bank (1998c: 28–30).

contested in the Supreme Court, it is crucial to provide legal binding to final awards. New and more formal organizational arrangements are also being created to tackle inter-state water sharing issues.[14] While the tribunal awards can be a basis for developing regional water rights, they have a major limitation in view of their duration as set by the time period for the review of the award. In the case of Krishna Award, for instance, it is set as 25 years. This creates the undesirable effects of competition among the states with uncoordinated and disjointed investments for establishing claims before the award comes for review. To avoid this, it is essential that the award, once given, should be treated as final, but the concerned states should be encouraged to negotiate for reallocation based on market conditions. As we extend the regional rights to a still higher level, we can also find the basis for national water rights implied in international water treaties such as the treaty between India and Pakistan over the Indus and the same between India and Bangladesh over the Ganges.

While market or negotiation-based arrangements are not tried much in India, there are some evidences for their actual occurrences as well as indications of their future potential. Arguably, these arrangements can be a basis for developing mutually beneficial water rights systems at relevant contexts. For instance, the case of Krishna water transfer for Chennai (Madras) city can be considered as an implicit

tribunal decision (Salman 2002; Richards and Singh 2002). Many experts argue that even the 6-year time limit specified by the 2002 amendment is too long for resolving such a sensitive issue as water sharing.

[14] For instance, The Cauvery River Water Authority has been created to deal with the allocation conflict among the basin states. This entity—patterned after the Murray-Darling River Basin Organization of Australia—is unique in the Indian context as this is the first time that a basin organization is chaired by the Prime Minister with the chief ministers of all the concerned states as members.

inter-state water market. As Tamil Nadu has paid for the entire project costs that also has some significant benefits to Andhra Pradesh, the transfer implicitly involves a payment for the water. While this is a relevant instance for implicit regional water trade, it also shows how the operation of such markets is constrained by incomplete specification of the rights such as the lack of the time and the amount of water to be delivered and the liabilities and recourse to address the failure of meeting the obligations. The potential for similar forms of implicit and explicit inter-regional water markets is also vast in India as states can be encouraged to purchase and sell water either on a payment basis or on a barter basis (i.e., exchange of water for power or food grains). But, such potential exchanges remain dormant essentially due to the absence of a legalized system of inter-state water rights. There are also evidences for large scale intra-state and inter-sectoral water transfers that are mainly from agriculture to urban areas (e.g., Palanisami 1994; Briscoe 1997). Such transfers are undertaken not only by private water selling groups but even by state governments and municipal water supply agencies.[15] Although such transfers are beneficial to the middlemen, urban consumers, and water supply authority, the farmers of the urban fringe agriculture are the heavy losers as there are no water rights to enable them to claim economic compensation for their water.

Although there have been the rudiments of rights to water quality during the British period, these rights are implied mostly in terms of criminal and penal codes of that time. As these provisions are ineffective to control the quality and health impacts of an increasing magnitude of industrial pollution, urban sewerage, and agricultural chemicals, environmental laws and regulations have emerged since the 1980s to establish clearer rights over water quality. These rights are administered by the central and state pollution control boards through a system of pollution permits, penal actions, and treatment responsibilities. While precise legal specification and transferability are lacking, these rights are often judicially handled in terms of the fundamental rights to life and environment enshrined in the constitution. Such rights are, in fact, used in many public interest litigations filed against polluting industries along the Ganges.

10.5 Opportunity Costs of Missing Rights

The opportunity costs of missing or unclear water rights and entitlements at different levels can be reckoned in terms of the potential economic, social, and political benefits being foregone as well as the social and political costs being borne. The overall significance of a water rights system emerges from the following simple arithmetic of costs that can be saved and benefits that are forgone under the current

[15] For instance, in Chennai, in the mid-1960s, the then government bought water rights from ayacutdars of the Red Hills and Cholavaram tanks. In recent years, the city is also considering the transfer of groundwater from the Araniar-Kusaithaliayar aquifer area that holds an enormous promise for providing Chennai with a low-cost supply of high-quality water (Briscoe 1997).

system of water allocation. There is an increasing recognition of the socio-economic and political costs associated with water sector mismanagement. Such costs are attributable mainly to inappropriate water management institutions, especially the absence or lack of clarity on water rights and water entitlements at various levels. While it is difficult to estimate these costs in precise terms, it is certainly possible to indicate their magnitude indirectly through other economic and fiscal losses from different perspectives.

The opportunity costs of lack of water rights are rather serious given the high proportion of the investment being absorbed by water sector. While water sector used to account for about 6 % of the total plan expenditures, the subsidy for irrigation sector alone was nearly 0.30 % of GDP in 1994–1995 (World Bank 1996). This share should have increases still further. But, cost recovery is an endemic problem in the canal-based irrigation sector leading to a heavy financial loss to the tune of 22 billion rupees as of 1989–1990 (GOI 1992b). The percentage of the recovery of working expenses has improved in some states such as Gujarat (78 %), but continues to be still low in most states (about 5 %) [Central Water Commission (CWC) 2009]. Although there is no Delay in project implementation and resource utilization due to inefficient planning and lack of farmers' cooperation also causes severe erosions in the value and benefit of irrigation investment. For instance, India has spent some 325 billion rupees during the Eighth Plan on irrigation development. Even if as little as 10 % of this expenditure is subjected to the problem noted above, it can mean a loss of 32 billion rupees (World Bank 1997). With the creation of powerful incentive among farmers for an efficient water use through the institution of WR&E system and economic pricing procedure, even if we succeed in effecting just a 10 % improvement in water use efficiency, it is possible to add easily an additional 14 million hectare of irrigation potential. Notably, the additional irrigation potential emerging from water use efficiency is very close to what is achieved in an entire 5 year plan period with so much of investment of money and time.

The financial gap in the water sector can be approximated by the difference between the total investment costs and total revenue in the canal irrigation sector. The total investment in canal irrigation during 1951–2000 is estimated to be Rs. 790 billion at current prices (GOI 2000). As we assume even a simple rate of 8 % to account for both interest and depreciation, the annual financial cost of canal irrigation provision comes to about Rs. 63 billion. Although we do not have published information on the revenue from the canal sector, going by the estimate of the Committee on Pricing Irrigation water (GOI 1992b), we can reckon that the total revenue at present can be in the range of about Rs. 3–5 billion. Such a huge financial gap clearly shows that the institutional aspects such as the water pricing policies and organizational mechanisms involved in water-charge collection are performing rather poorly. From an institutional perspective, poor pricing policies and weak organizations can be directly attributed to the absence of a WR&E system essential to provide both a technical basis for volumetric water pricing and an organizational basis for linking user groups.

Considering some of the fiscal, health, output, and resource impacts under existing institutional arrangements governing water allocation, use, and management of

Table 10.1 Opportunity costs estimates for inappropriate water institutions

Item	Problem	Impact (Year)	Average cost (Billion US$)	% of GDP
1	Urban and rural water pollution	Health impacts (1991–1992)	6.60	3.00
2	Soil degradation	Loss of farm output (1991–1992)	1.90	1.00
3	Fiscal costs	Revenue deficit, poor services, and use inefficiency (1994–1995)	0.70	0.30
4	Fiscal costs	Power subsidy, groundwater depletion, and pollution impact farm output (1994–1995)	4.10	1.50
	Total		**15.9**[a]	**4.8**[b]

Source: Brandon and Hommann (1995); World Bank (1996)
[a]1991–1992 figures for items 1 and 2 were converted to 1994–1995 prices using the India GDP deflator (World Bank 1997), and added to the 1994–1995 figures for items 3 and 4. The relevant exchange rate or these periods has been US$ ≈ Rs. 36
[b]All the figures in the column were added to give a ballpark lower bound, abstracting from likely changes in percentage shares between 1991–1992 and 1994–1995

water resources, there are some rough and ballpark estimates both for the aggregate and problem-specific magnitudes of the opportunity costs of inappropriate water institutions in India. Table 10.1 gives these estimates, which are obviously partial and also pertain to the early-1990s. Although these costs relate to the inappropriateness of entire water management institutions, a major part of them can be attributed—both directly and indirectly—to the lack of WR&E system. On the surface, while this looks a too big of stretch of argument, the fact still remains as the WR&E, with its intricate structural and functional linkages with all key legal, policy, and organization components, is the central part of the structure of the whole water institutional arrangements (see Saleth and Dinar 2004). As a result, the costs associated with inefficient resource use and the health impacts of insufficient water provision are directly associated with the absence of WR&E to regulate water withdrawal and ensure water supply. While the creation of WR&E system involves both heavy capital investments and real political costs, the opportunity costs associated with their absence are far higher given its present magnitude and future growth. Although the estimated opportunity costs in Table 10.1 represent about 5 % of GDP in 1994–1995, their present reckoning can be still more alarming. If one considers the interest costs and accounts for the negative effects of urban water scarcity and groundwater depletion happened since 1994–1995, the costs of inaction can be as high as 10 % of current GDP. What is notable is the fact that these costs can be close to, if not higher than, the total water sector investment in India. Apart from their monetary component, the opportunity costs also have an unfathomable social and political component associated with water sharing conflicts that are now becoming an expanding phenomenon both at the local and regional levels. In some cases (e.g., Cauvery and Periyar water disputes), water conflicts have even created major political changes not to mention about the loss of life and property occurring regularly due to frequent local water conflicts and political protests.

10.6 Establishing Water Rights: Potential and Prospects

As shown in Sect. 10.3, implicit, informal, and *de facto* water rights and entitlements exist at all levels. From a strict technical perspective, the creation of the WR&E system is straight forward in many cases as what is required are only the legalization of existing informal rights and *de facto* rights of users, the established conventions on use priorities, and the water allocations implied by tribunal awards and inter-state agreements. From an institutional perspective, there is also a considerable potential exist for developing the WR&E system by building on the water allocation and distribution arrangements such as the *Warabandi*, *Shejpali*, and *Pani Panchayat* systems. The existence of informal rights and institutional mechanisms provides opportunities for creating the WR&E system for sectors, regions, and individual users. Interestingly, despite its informal and imprecise nature, the prevailing water rights system is able to even support the emergence and growth of local water markets, especially in the groundwater areas. There are also many contexts where the WR&E framework can be used to address pressing water problems.

While a user-managed water rights system is ideal for inducing efficient water use, promoting accountability, and resolving conflict, many would agree that its creation is not an easy task in the Indian context. The existence of many small farms, poor conveyance structures, political risks in creating the legal and organizational apparatus, and conceptual/information problems in defining water rights in physical and legal terms remain as major challenges. While the technical and investment needs are truly tremendous, one cannot underestimate the institutional potential for building more formal WR&E systems in many parts of India. Informal water rights--both individual and group—have existed in India since the ancient times (see Siddiqui 1992) and continues even today, albeit in a much weaker form, in many tank irrigation systems of South India (see Box 10.10). The existence of these implicit and informal water rights clearly suggests that the WR&E system is neither

Box 10.10 Instances of Water Rights

In the delta regions of the Gangetic and Mahanadhi in Orissa, West Bengal, Bihar, and Madhya Pradesh, there are officially granted non-transferable long-term water leases with the express purpose of encouraging farmers to use surface water (GOI 1976: 65).

In few South Indian irrigation systems, there are informal but prioritized rights for different distributaries (Vaidyanathan 1985: 63–64). Similar form of priority also exists in the case of water rights in Periyar-Vaigai basin where the water rights from Periyar are treated as senior over the same from Vaigai and separate records are kept for both in departmental office.

In the groundwater regions, it is well known that *de facto* individual water rights exist and also enjoy a large degree of social acceptance. The amount of water implied by them is determined by factors such as farm size, well yield, and pumping capacity. In canal regions, water rights take the form access rights under fixed tenure condition as they are limited to those owning land in canal regions.

Box 10.11 Cases of Rudimentary WR&E System

Two cases observed in Maharashtra have the rudiments for building formal WR&E systems. The *Pani Panchayat* is a user-managed system for sharing harvested water in terms of 'needs' as determined by family size than by farm size.

The *Shejpali* (water distribution roaster) system is a state-managed water allocation system where canal authorities issue "water passes" to farmers. These passes with duration varying from an irrigation season to 6 years have priority that varies directly with their duration. But, they lack quantification and transferability (Gandhi 1981; Rath and Mitra 1989).

There are also a variety of other forms of user and community-managed systems ranging from lift irrigation and water harvesting schemes (Datye and Patil 1987; Sengupta 1993; Singh and Bhallab 1996) having the social and organizational basis for developing decentralized and locally managed WR&E system.

new nor incompatible with Indian ethos. More importantly, there are also a variety of more formal and semi-formal water rights exist as part of formal institutional arrangements having the rudiments for developing formal and full-fledged WR&E systems (see Box 10.11). The *Pani Panchayat* is notable for its equity properties and land-water separation (Vani 1992: 9–10; Ahmed 1992: 271–276). Since water rights are provided to landless, there is an implicit recognition of transferability as the landless cannot benefit from such rights otherwise. This feature of water rights allocation in the *Pani Panchayat* system (also observed in the Sukhomajri system in Haryana), is very important for both equity and efficiency. On the other hand, the *Shejpali* system is designed to encourage efficient water use through an agreement with the farmers for secure water allocation for sanctioned area and crops.

Besides the institutional scope provided by the *Shejpali* and *Pani Panchayat* systems as well as myriad forms of local level arrangements, the currently practiced formal water allocation procedures in canal regions such as the *Warabandi*, *Osarabandi*, and *Varvaram* also offer additional possibilities for building the WR&E systems on a wider scale (see Box 10.12). Although *Warabandi* and its variants offer technical scope for creating a full fledged WR&E system, there is a need for major investments on the modernization of distribution networks, installation of water measuring devices, and creation of enforcement and management organizations. From a technical and organizational perspective, the need for developing new legal systems, additional organizations, and technical capacities is also extensive. New investments for the modernization of water delivery networks, installation and upgradations of water measuring and accounting systems, and the creation of organizations at various water allocation levels are all essential. However, the investment costs of upgrading the technical and organizational basis of the systems are likely to decline due to scale economies emerging from large area coverage.

Box 10.12 ***Warabandi*** **as a Basis for WR&E**

Warabandi, Osarabandi, and *Varvaram are all time-based* rotational water distribution procedures practiced in different parts of the country. They provide a basis for developing formal WR&E as the time or flow-based water entitlements allow the definition of water quantity. Besides their scope for quantifying water entitlements, these systems also assume significance in view of the long tradition, experience, and organizational capacity that the farmers have gained from the turn-based water allocation. These aspects assure the social and organizational conditions essential for the development of formal WR&E systems. However, the legal and technical conditions such as the volume-based rights, measurement systems, and the modernization of water delivery networks are yet to be satisfied in all contexts.

The informal but growing practice of groundwater trade among farmers widely observed across the country provides another more direct instance not only for the existence of *de facto* rights in groundwater but also for the emergence of markets for such rights. Although groundwater cannot be legally transferred apart from land, groundwater transfers do occur through the groundwater markets observed, at least, since 1920s. Despite their localized nature and uneven pattern across regions, groundwater markets are growing in magnitude. Their characteristic features are that they occur without any formal water rights system and involve no sacrifice of self-irrigation. While there is no systematic national-level study on the magnitude of water selling, based on his studies in Gujarat and Uttar Pradesh, Shah (1993) has projected the area irrigated through groundwater markets to be up to 50 % of the total gross irrigated area under private lift irrigation. This projection neither has any systematic basis nor allows disaggregation either by region, well type, or energy use. While there is no current data for this purpose, using the data from the national level sample surveys conducted by the National Sample Survey Organization (NSSO) during 1976–1977 and 1997–1998, Saleth (2012) has estimated that the extent of irrigated area benefiting from 'hired irrigation services' can be about 42 mha.[16]

Although groundwater markets have significant efficiency and equity benefits, they still remain sub-optimal essentially due to the legal and institutional vacuum, i.e., absence of legal status and quantity limits, within which they operate at present. A formal WR&E system that can legalize the existing *de facto* rights and set water quota for these rights could avoid the serious problems associated with the water markets such as water monopoly and aquifer depletion. Thus, a legally specified and organizationally enforced quota-based WR&E system can minimize the negative

[16] This may be an overestimate of the magnitude of water marketing since all these areas may not be using hired services on a regular basis and the hired services may not involve water selling in all cases due to pure pump set rentals.

effects such as aquifer depletion while magnifying the positive benefits of water markets such as allocation equity and use efficiency.

Maharashtra has taken some bold and innovative actions in 2002 and 2003 that have facilitated conditions for the introduction of a system of transferable water rights on state scale. Under the currently ongoing Maharashtra Irrigation Improvement Project supported by the World Bank, the state has displayed its commitment for sectoral restructuring and policy reforms with a series of far reaching legal, policy, and organizational changes. These include (a) adoption of a State Water Policy, (b) introduction of the Maharashtra Water Resources Regulatory Authority Act of 2003 that enabled the establishment of the Maharashtra Water Resources Regulatory Authority (MWRRA),[17] (c) introduction of the Farmer Management in Irrigation System (FMIS) Act that promoted the formation of Water User Associations (WUAs) and Upper Level Associations (ULAs) in all canal regions, (d) introduction of an Amendment Act to transform the Irrigation Development Corporations into River Basin Agencies. Notably, the FMIS Act mandates the transfer of operation and maintenance of minor canals and facilities to WUAs and the upper level canals and reservoirs to the ULAs that will administer the bulk water entitlements of WUAs.

The most fundamental element underlying the reform initiatives of Maharashtra is the creations of the basic legal and organizational preconditions for promoting a state-wide system of WR&E. The MWRRA Act provides for the creation of the WR&E system for all sectors and users, the arrangements for the administration and regulation of this system including dispute resolution, and the conditions for the development of market-based transfers of WR&E both on temporary and permanent basis. A noteworthy aspect of the new Authority is its comprehensive nature as it will have regulatory jurisdiction over water from both surface and subsurface sources and also be responsible for setting water tariffs and water quality standards as well as managing wastewater discharge permits. As per the draft that is being considered, the five irrigation development corporations will be transformed into River Basin Management Agencies with direct responsibilities for the issuance of water entitlements, enforcement of water charges, and the operation of river basin infrastructures. Although the legal, policy, and organizational initiatives undertaken in Maharashtra for creating the WR&E system are in a formative stage, they are truly remarkable and farsighted as they set example for other Indian states to emulate. Conditions that prompted these initiatives include the fiscal and economic implications of brewing water crisis, existence of considerable institutional potential (e.g., *Shejpali* and *Pani Panchayats* systems), and commitments of state leadership, and technical and funding support from the World Bank.

[17] It is important to note that this bill behind this act has been widely discussed and also approved by the state cabinet, but it still remains as a bill before the state assembly and has not yet been passed.

10.7 Concluding Remarks

As water resource development possibilities are becoming thinner and costlier, many countries including India are requiring strong institutional arrangements for the allocation and management of their limited water resources. At the same time, these countries also require to develop additional water resources, wherever it is possible. In line with this changing requirement, public investments have to be directed more towards institutional development projects with slower changes and gradual returns as well as water development works with more risk and high returns. As a result, the emphasis on political economy aspects and context-specific, prioritized, sequencing, and ‘patient’ approaches becomes indispensable. It is in this changing operational and strategic context that the options and strategies available for donor and development aid agencies to support national efforts in developing institutions such as the WR&E system are to be assessed.

The options available to support the development of WR&E in India are generic in the sense that the same options can be applied in a variety of other countries displaying similar economic, political, and resource realities. The past, ongoing, and future investments are the major tools for supporting state governments in creating WR&E systems at various levels. Investments can be an effective tool only when the political environment is propitious and technical support is available for developing the necessary legal and organizational arrangements for underpinning the new allocation mechanisms. Although the building of the political consensus is the task of the state undertaking the reforms, the donor and development agencies can play a catalytic role in mainstreaming the issues and promoting reform dialogues.

This Maharashtra case also illustrates the way the political economy aspects are strategically used to advance the reforms. Besides the use of the political context for reform provided by the fiscal crisis in the state, the creation of the WR&E system was also packaged as part of an investment program for improving and upgrading water storage and delivery networks in the state. Still broadly, it is also important to package water sector reforms itself within a still larger economic and infrastructural investment program. Packaging reforms with investment can provide political incentives and build political coalitions, both of which are critical from the political economy perspective of reforms. In this sense, the efforts to integrate water sector strategies within the larger ambit of the Country Assistance Strategy and Poverty Reduction Strategy are very appropriate both operationally and strategically. This kind of reform packaging advocated in the new water sector strategy of the country indicates further evolution of its strategy of moving from project to sector and, now to economy as a whole.

The case of WR&E reforms in Maharashtra shows only one of the options. It is applicable essentially to conditions that are ripe with felt demand for change. But, there are other options applicable to other states. The options involve a multi-track strategy with medium and long-term approaches. Thus, in states such as Tamil Nadu, Andhra Pradesh, Orissa, and Uttar Pradesh, the medium term option of creating the basic conditions needed for the WR&E system can be created gradually within a phased and sequential manner within a well-planned medium terms framework. In fact, these states have undertaken significant organizational reforms, including the creation of outlet and basin level organizations. It is now time to consider the possibility of piloting the WR&E systems at the basin and local levels. Such pilot schemes can be a part of a larger water sector projects and can include not only irrigated areas but also urban areas.

While the multi-track options suggest different paths for different states, it is necessary to pursue them within the framework of area prioritization as determined by relative institutional potentials and political willingness for reforms. Although the strategy of working with 'focus states' is often criticized by the India media and academics as sidestepping the needs of other states [Operation and Evaluation Department (OED) 2001: 47], there are powerful arguments for concentrating the resources for attaining consistent progress in key areas (Pitman 2002: 30–32). The focused strategy is particularly relevant for promoting critical institutions such as the WR&E system that needs 5–10 year period for its creation and consolidation. This is particularly so as this institutional reform has to be sequenced with and packaged within a larger investment package for sectoral and state level development. It is necessary to reward the institutional reforms and consolidate the social gains rather than fritter away the limited resource and energy on a larger canvas.

From an overall perspective, the general approach is to follow a sequential strategy both in covering the states as well as in promoting institutional components necessary for the WR&E system within the state. Obviously, the states and areas with felt demand and expressed commitment for reform are to receive priority over others. Similarly, the reform components receiving top priority are the creation of the legal and organizational arrangements both at the macro and micro levels, the development of technical information, and system upgradation for volumetric water delivery. The establishment of bulk water rights for sectors and sub-regions has to precede that of the local and individual rights. In promoting the WR&E system in particular and water institutional reform in general, it is necessary to recognize some key rules (Briscoe 2002). The practice of picking the 'low-hanging fruits' is less costly and it provides more incentives for reforms, as 'nothing succeeds like success'. Similarly, the contextualization of reforms is important as there is no unique recipe for universal application. The new water sector strategy of the Bank, in fact, underlines these principles in terms of its emphasis on reform prioritization, sequencing, and principled pragmatism. A recent analysis of water institutional reforms across countries also provides empirical evidences for the way these reform design and implementation principles are actually used by countries to promote reforms (Saleth and Dinar 2004).

Finally, mainstreaming the issue of WR&E system involves more effective use of the policy, academic, and media community. There is also need for a change in the strategy to sell the idea to policy-makers and user community. There is a strategic error in overemphasizing use efficiency and market allocation to the point of eclipsing the very crucial equity and poverty alleviation effects of the WR&E system. In fact, the market allocation is easily distorted to project the system as a precursor to water privatization and commercialization. The media has to be involved in discussing the issue and in presenting why and how this is indispensable for the water future of the country.

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Chapter 11
Water Saving Technology in India: Adoption and Impacts

A. Narayanamoorthy

Abstract Water use efficiency under conventional flood method of irrigation, which is predominantly followed in Indian agriculture, is very low due to substantial conveyance and distribution losses. A number of demand management strategies and programmes have been introduced to increase the existing water use efficiency in Indian agriculture. One such method introduced relatively recently in Indian agriculture is drip method of irrigation. Drip method of irrigation is proved to be an efficient method in saving water and increasing water use efficiency as compared to the conventional surface method of irrigation, where water use efficiency is only about 35–40 %. Though drip irrigation method is in use over the last two decades or so, not many comprehensive studies have been carried out focusing on its adoption and impacts in India. In this study, therefore, an attempt is made to (a) study the nature and extent of adoption of drip method of irrigation, (b) find out the impact of drip method of irrigation on water saving, productivity and farm income, (c) estimate the economic viability of drip investment with and without subsidy, and (d) suggest policy interventions to increase the adoption of drip method of irrigation.

Keywords Drip irrigation • Water saving • Economic viability • Productivity of drip irrigation • Indian agriculture

11.1 Introduction

With the fast decline of irrigation water potential and continued expansion of population and economic activity in most of the countries located in arid and semi-arid regions, the problems of water scarcity is expected to aggravate in the future (see,

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Biswas 2001). Macro estimates carried out by the International Water Management Institute (IWMI) indicate that one-third of the world population would face absolute water scarcity by the year 2025 (Seckler et al. 1998, 1999). The worst affected areas would be the semi-arid regions of Asia, the Middle-East and Sub-Saharan Africa, all of which are already having heavy concentration of population living below poverty line. Though India has the largest irrigated area in the world, many regions are already reeling under sever water scarcity problems, partly because of inefficient use of water. Owing to various reasons the demand for water for different purposes has been continuously increasing in India, but the potential water available for future use has been declining at a faster rate (Saleth 1996; CWC 2004). The agricultural sector (irrigation), which currently consumes over 80 % of the available water in India, continues to be the major water-consuming sector due to the intensification of agriculture (see, Saleth 1996; MOWR 1999; Iyer 2003). In spite of having the largest irrigated area in the world, the coverage of irrigation is only about 40 % of the gross cropped area as of today in India. One of the main reasons for the low coverage of irrigation is poor water use efficiency under the flood (conventional) method of irrigation, which is predominantly practised in Indian agriculture. Considering the water availability for future use and the increasing demand for water from different sectors, a number of demand and supply management strategies have been introduced in India to augment the supply as well as to control the demand for water. One of the demand management strategies introduced recently to control water consumption in Indian agriculture is drip method of irrigation (DMI). Unlike flood method of irrigation, drip method supplies water directly to the root zone of the crop through a network of pipes with the help of emitters. Since it supplies water directly to the crop (instead of land) as followed in the flood method of irrigation, the water losses occurring through evaporation and distribution are completely absent (INCID 1994; Narayanamoorthy 1996, 1997, 2001; Dhawan 2002). The on-farm irrigation efficiency of properly designed and managed drip irrigation system is estimated to be about 90 %, while the same is only about 35 % to 40 % for surface method of irrigation (INCID 1994).

A few studies have been carried out focusing on the impact of drip method of irrigation on various parameters in different crops over the last 10 years or so. While some have studied the impact of DMI on productivity, electricity and water saving, others have studied its economic viability in different crops, using both experimental and field survey data. Results of experimental data reported in INCID (1994) show that water saving in DMI over the method of FMI varies from 12 % to 84 % in different vegetable crops. In the case of fruit crops, the lowest water saving was found to be 45 % (pomegranate), whereas the highest water saving is estimated to be 81 % in the case of lemon. Water saving was also found to be 65 % in sugarcane and about 60 % in the case of coconut. Studies carried out using field level data in Maharashtra also show that the water saving due to DMI is about 29 % in banana, 37 % in grapes and about 44 % in sugarcane (Narayanamoorthy 1996, 1997, 2001, 2003).

Some of the studies have attempted to find out whether the investment in drip irrigation is economically viable or not in different crops. While some have estimated benefit-cost ratio including water saving as well as excluding water saving (INCID 1994), others have estimated benefit-cost ratio and net present worth under with and without subsidy condition (Narayanamoorthy 1997, 2001, 2004a). The benefit-cost ratios provided for different crops in INCID (1994) indicate that investment in drip irrigation is economically viable, even after excluding water saving from the calculation. The estimated benefit-cost ratio comes to 13.35 in crops like grapes and 1.41 in the case of coconut. However, it is not clear whether the B-C ratios presented in INCID (1994) are estimated using discounted cash flow technique or not.

In spite of various benefits, the coverage of area under drip method of irrigation is not appreciable in India except for a few states as of today. The area under DMI has increased from a mere 1500 ha in 1985 to 70,859 ha in 1991–1992 and further to about 1.897 million ha at the end of 2010–2011. INCID (1994) report, which presents an overview about the development of drip irrigation in India, indicates that about 80 crops, both narrow and widely spaced crops, can be grown under DMI. Although DMI is considered to be highly suitable for wide spaced and high value commercial crops, it is also being used for cultivating oilseeds, pulses, cotton and even for wheat crop (INCID 1994; Narayanamoorthy 2004b).

Among the various reasons for the slow progress of adoption of this new technology, its capital-intensive nature seems to be one of the main deterrent factors. Drip irrigation technology requires fixed investment that varies from Rs. 20,000 to 55,000/ha depending upon the nature of crops (wide or narrow spaced) and the material to be used for the system. Since the Indian farmers have been getting water for low cost from the public irrigation system and also from well irrigation, there is less incentive to adopt this capital-intensive technology unless it is necessary. Moreover, since it involves fixed investment farmers, often ask questions like what will be the water saving and productivity gains? Is investment on drip irrigation economically viable? What will be the pay back period of the drip investment? These issues are raised because of absence of many credible field based studies on DMI covering different regions of the country. Some of the studies have shown that the results derived from research station data are substantially different from that of survey data (see, Narayanamoorthy 2001). Keeping in view the various issues of drip method of irrigation, an attempt is made in this paper to review the adoption and impacts of water saving technology namely drip method of irrigation in India using secondary data and available case studies. Specifically, the study discusses (a) the government policies and programs being pursued to promote this technology; (b) the nature and extent of their actual adoption in different regions and cropping systems; (c) its impacts in terms of water saving, crop productivity; (d) economic viability of drip investment; (e) the major issues and questions that require attention for future research and policy.

11.2 Promotional Activities on Drip Irrigation in India

Since drip method of irrigation is a new technology in India introduced relatively recently, government supported promotional programmes have been in operation since the sixth plan. In fact, the promotional programmes have made significant impact on the adoption of drip irrigation in India in states like Maharashtra and Andhra Pradesh. Drip method of irrigation was introduced in India during the early seventies at the Agricultural Universities and other Research Institutions. The scientists at the Tamil Nadu Agricultural University (TNAU), Coimbatore, who are considered to be the pioneers in drip irrigation research in India, have conducted large-scale demonstration in the farmers' field for various crops, which received encouraging response from the farmers (INCID 1994). However, the adoption of drip method of irrigation was very slow till mid-eighties mainly because of lack of promotional activities from the governments.

The formation of the National Committee on the Use of Plastics in Agriculture (NCPA) during 1981 under the Chairmanship of Dr. G. V. K. Rao is termed as the first milestone for the development of micro-irrigation in India (GOI 2004). With the establishment of 17 different Plasticulture Development Centres (PDCs) across different agro-climatic regions in the country, the NCPA has played a crucial role in the technological development of micro-irrigation in India. Besides recommending policy measures to the government, the NCPA also played an important role in promoting drip method of irrigation through conducting seminar focusing on micro-irrigation and its beneficial impact (GOI 2004).

Apart from the government efforts, some research institutes and private drip set manufactures have also been playing an important role in promoting drip method of irrigation in India. For instance, The Report of Task Force on Micro Irrigation mentions "Jain Irrigation Systems Ltd., Jalgaon has been playing a pioneering role since its inception in 1989 for promoting micro irrigation" (GOI 2004, p. 124). The establishment of the Jain Irrigation Systems Limited in 1988–1989 marked a watershed in the spread of this technology. Their approach was unique, committed, scientific and persistent. A "Systems approach" from concept to commissioning was adopted by them. Learning from the mistakes and the short comings of the past, this new company undertook extensive surveys in the market, interacted with scores of customers who had installed drip irrigation systems in their field, critically evaluated its ills and took systematic and determined steps to remove these ills. The concept in fact was pioneered in the country by the Jain Irrigation, Jalgaon.

Since drip is a new technology and a capital-intensive venture, government operates schemes for drip irrigation with subsidy. In states like Maharashtra, both the Central and State governments are operating schemes for promoting drip method of irrigation. Central scheme was started during 1982–1983 (during the Sixth Plan) by the Ministry of Water Resources (Minor irrigation Division), Government of India. Through this scheme, the Government of India provided a subsidy of 50 % to the farmers with the matching contribution from the State governments for installation of micro-irrigation devices. Government of Maharashtra has made pioneering efforts for the successful adoption of drip irrigation system and to make cost effective by providing subsidies to small and marginal farmers to the extent of Rs. 2282.35 lakh during the period from 1986 to 1993 (INCID 1994). As per the latest information available from the *Economic Survey of Maharashtra: 2006–07*, an amount of Rs. 629.18 crore (Rs. 485.35 crore for drip irrigation and Rs. 143.83 crore for sprinkler irrigation) have been distributed to the cultivators in the form of subsidy by the government to promote micro-irrigation up to March 2006 (GOM 2007).

The Central scheme of drip irrigation introduced during the Seventh Plan did not get good response since the subsidy was limited to only small and marginal farmers and due to capital paucity this group could not afford the drip systems even at the subsided rate. After knowing the ground realities, many new measures were incorporated under the new scheme introduced during the eighth plan. Under the new schemes, the subsidy amount is limited to either 50 % of the cost or Rs. 15,000/ha whichever is lower. The subsidy scheme has undergone lot of changes over the years. As of 1999–2000, the Government of India provides assistance of drip installation for horticultural crops at 90 % of the cost of the system or Rs. 25,000/ha, whichever is less for small and marginal, SC/ST and women farmers and 70 % of the total cost or Rs. 25,000/ha, whichever is less for other category of farmers. Assistance was also provided for drip demonstration at Rs. 22,500 or 75 % of the system cost per hectare whichever is less (GOI 2004). It is to be noted that the rate of subsidy tends to vary with the schemes implemented by the state. While most of the horticulture crops are included under subsidy scheme, water-intensive crops such as sugarcane are excluded from the subsidy scheme supported by the Central government.

11.3 Nature and Extent of Adoption of WST[1]

Drip method of irrigation was initially introduced in the early seventies in India but its development was very slow in the initial years and significant development has been achieved especially since 1990s. Due to various promotional schemes introduced by the Government of India and states like Maharashtra, Andhra Pradesh, Gujarat, etc, the area under drip method of irrigation has increased from 1500 ha in 1985 to 70,589 ha in 1991–1992 and further to 1.89 million ha in 2010–2011 (INCID 1994; AFC 1998; ICID personal communication during 2012). This estimate is based on the information available from GOI departments, which have been

[1] Data availability on micro-irrigation is one of the serious constraints in India. In spite of the fact that most of the area currently cultivated under micro-irrigation is established through various governments sponsored schemes, coverage of area under MI by states, crops and farmers' category are seldom published by any single agency. This does not allow the researchers to study the trends and determinants of micro-irrigation across states in detail. It is pertinent to collect and publish the data on micro-irrigation periodically so as to strengthen the research on micro-irrigation.

operating subsidy schemes for promoting drip method of irrigation. However, as mentioned in the *Report of the Task Force on Microirrigation*, a large number of institutions, commercial organisations, universities, large public/private sector companies, NGOs, etc., have taken up drip irrigation in the country for their farms/crops, which do not get reflected in the data available with GOI departments. Therefore, approximately, another 100,000 ha are covered under drip system by these organisations, whereby the total area under drip irrigation system in the country would go up further (GOI 2004, pp. 130–131).

In spite of having many advantages over FMI, the development of drip irrigation does not match the expectations in most of the states. Table 11.1 presents state-wise area under drip method of irrigation for three time points namely 1991–1992, 1997–1998 and 2009–2010. It is evident from the table that drip irrigated area has increased substantially over the years in all the states of India. In all three-time points, Maharashtra state alone accounted for nearly 50 % of India's total drip irrigated area followed by Karnataka, Tamil Nadu and Andhra Pradesh. Over the last 10 years, significant growth has been achieved in area under drip method of irrigation in absolute term in many states. However, drip irrigated area constitutes a very meagre percentage in relation to gross irrigated area and also in relation to its total potential area, which is estimated to be 27 mha by the Task Force on Micro-Irrigation (GOI 2004). For instance, during 2009–2010, the share of drip-irrigated area to gross irrigated area was just 2.12 % and about 3.43 % in relation to total groundwater irrigated area of the country.

Table 11.1 State-wise area under drip method of irrigation

State	Area ('000 ha)			Percent to total area		
	1991–1992	1997–1998	2009–2010	1991–1992	1997–1998	2009–2010
Maharashtra	32.92	122.995[a]	604.44	44.64	50.00	31.86
Karnataka	11.41	40.800[b]	209.47	16.17	16.58	11.04
Tamil Nadu	5.36	34.100	153.44	7.59	13.86	8.09
Andhra Pradesh	11.59	26.300	505.21	16.41	10.70	26.63
Gujarat	3.56	7.000	226.77	5.05	2.85	11.95
Kerala	3.04	4.865	15.89	4.30	1.98	0.84
Orissa	0.04	2.696	11.05	0.06	1.10	0.58
Haryana	0.012	1.900	11.31	0.17	0.77	0.60
Rajasthan	0.30	1.600	30.05	0.43	0.65	1.58
Uttar Pradesh	10.11	1.500	12.64	0.16	0.61	0.67
Punjab	0.02	1.100	17.93	0.03	0.45	0.95
Other States	2.127	1.150	99.08	3.00	0.47	5.22
Total	70.59	246.006	1897.28	100.00	100.00	100.00

Source: AFC (1998); GOI (2004)

[a]Includes state subsidy scheme area of 58,498 ha

[b]Includes area under central and state schemes for development of oil palm and sugarcane

Although over 80 crops are suitable for drip method of irrigation, only a few crops have been dominating in the total area under drip irrigation so far. As of 1997–1998, crops like coconut, grapes, banana, citrus, mango and pomegranate together have accounted for nearly 67 % of total drip irrigated area. States like Maharashtra, Andhra Pradesh, Tamil Nadu and Karnataka account for a major share of the area in all these crops. More importantly, out of 26,460 ha of banana's total area, Maharashtra state alone accounted for as much as 93 % at the end of 1997–1998. It shows that the adoption of drip method of irrigation is very much concentrated only in a few states despite having severe water scarcity in different regions in the country.

Who is using DMI in India? Do farmers use DMI without subsidy given by state agencies? Unfortunately, clear answers are not available for these questions from the existing reports and studies, despite the fact that drip method of irrigation has been promoted by government over the last 20 years or so. However, a nationwide study carried out by AFC (1998) reveals that drip method of irrigation is still essentially considered to be the scheme of the government. As of 1997–1998, area under DMI other than government schemes (without subsidy) accounted for only about 18 % of India's total drip irrigated area, indicating that farmers are reluctant to adopt drip irrigation without subsidy. Studies need to be carried out as to why the individual farmers without subsidy are not willing to adopt drip method of irrigation despite substantial benefits from it.

11.4 Impact of WST on Water Saving, Crop Productivity and Farm Income

It has been proved by some studies that drip method of irrigation helps to save water and improves water use efficiency, reduces cost of cultivation and increases productivity of crops and farm income (INCID 1994). While reducing water consumption, it also reduces substantial amount of electricity required for irrigation purpose, by reducing working hours of irrigation pumpsets (Narayanamoorthy 1996). Normally, the impact realised using experimental data may not match with the field data because of varying agro-economic conditions between the two-settings. Therefore, we have discussed the impact of DMI on different parameters using both the experimental and field data.

11.4.1 Water Saving

One of the prime advantages of drip irrigation is that it saves substantial amount of water as compared to conventional method of irrigation. Though studies using field level data are rarely available focusing water use efficiency and water saving of

DMI, many research stations situated in different parts of the country have evaluated the water saving capacity of DMI for different crops. We have presented the water requirements, saving of water and water use efficiency under DMI and FMI for different crops in Table 11.2 based on the data from experimental stations. The water saving capacity of DMI is expected to be different for different crops as the consumption and the requirement of water varies from crop to crop. As expected, the water saving for vegetable crops varies from 12 % to 84 % per hectare over the conventional method of irrigation. Water saving varies from 45 % to 81 % per

Table 11.2 Water saving and productivity gain by drip method of irrigation -experimental results

Crop's name	Water consumption (mm/ha)		Yield (tonne/ha)		Water saving over FMI (%)	Yield gain over FMI (%)	Water use efficiency[a]	
	FMI	DMI	FMI	DMI			FMI	DMI
Vegetables								
Ash gourd	840	740	10.84	12.03	12	12	77.49	61.51
Bottle gourd	840	740	38.01	55.79	12	47	22.09	13.26
Brinjal	900	420	28.00	32.00	53	14	32.14	13.13
Beet root	857	177	4.57	4.89	79	7	187.53	36.20
Sweet potato	631	252	4.24	5.89	61	40	148.82	42.78
Potato	200	200	23.57	34.42	Nil	46	8.49	5.81
Lady's finger	535	86	10.00	11.31	84	13	53.50	7.60
Onion	602	451	9.30	12.20	25	31	64.73	36.97
Radish	464	108	1.05	1.19	77	13	441.90	90.76
Tomato	498	107	6.18	8.87	79	43	80.58	12.06
Chillies	1097	417	4.23	6.09	62	44	259.34	68.47
Ridge gourd	420	172	17.13	20.00	59	17	24.52	8.60
Cabbage	660	267	19.58	20.00	60	2	33.71	13.35
Cauliflower	389	255	8.33	11.59	34	39	46.67	22.00
Fruit crops								
Papaya	2285	734	13.00	23.00	68	77	175.77	31.91
Banana	1760	970	57.50	87.50	45	52	30.61	11.09
Grapes	532	278	26.40	32.50	48	23	20.15	8.55
Lemon	42	8	1.88	2.52	81	35	22.34	3.17
Watermelon	800	800	29.47	88.23	Nil	179	27.15	9.07
Mosambi	1660	640	100.00	150.00	61	50	16.60	4.27
Pomegranate	1440	785	55.00	109.00	45	98	26.18	7.20
Other crops								
Sugarcane	2150	940	128.00	170.00	65	33	16.79	5.53
Cotton	856	302	2.60	3.26	60	25	329.23	92.64
Coconut	–	–	–	–	60	12	–	–
Groundnut	500	300	1.71	2.84	40	66	292.40	105.63

Source: INCID (1994) and NCPA (1990)

[a]Water consumption (mm) per quintal of yield

hectare in fruit crops. In crops like cotton, coconut and groundnut, water saving varies from 40 % to 60 % per hectare. Importantly, water saving in sugarcane is over 65 % per hectare when compared to conventional method of irrigation.

Water saving under drip method of irrigation occurs mainly because of three reasons. First, since water is supplied through a network of pipes, the evaporation and distribution losses of water are very minimum or completely absent under DMI. Second, unlike FMI, water is supplied under DMI at a required time and required level and thus, over-irrigation is totally avoided. Third, under the conventional method of irrigation, water is supplied for the whole of cropland, whereas DMI irrigates only the plants. Though the results of the experimental data discussed above clearly suggest that water saving due to DMI is substantial, one cannot completely rely on these results because the environmental conditions that are prevailing under experimental stations are totally different from the farmers' field. Therefore, we discuss below the water saving including its efficiency under DMI using farm level data in the context of three crops namely sugarcane, banana and grapes.

Water consumption per hectare for any crop is determined by factors like horse power of the pumpset, water level of the well, capacity of the pump, size of delivery pipes, condition of the water extraction machineries (WEMs), distance between place of water source and field to be irrigated, quality of soil, terrain condition, etc. These factors vary considerably across farmers. Pumpsets with higher horse power lift more water per unit of land compared to the pumpset which has lower horse power. Most of the studies based on research station data have measured water consumption in terms of centimeter (CM) in drip irrigation. But, in practice, measuring water in terms of CM is not an easy task at field level as HP of the pumpsets and water level of the well changes considerably across the farmers. In order to avoid these difficulties, water consumption is measured in terms of horse power (HP) hours of irrigation.[2] Table 11.3 presents per hectare consumption of water in terms of HP hours for drip and non-drip adopters for all three crops: sugarcane, grapes and banana. It is clear from the table that the consumption of water by crops under drip method of irrigation is significantly less than flood method irrigation (FMI). While water saving in sugarcane comes to about 44 %, the same is estimated to be about 37 % in the case of grapes and about 29 % in the case of banana. Among three crops,

Table 11.3 Water use efficiency in drip and non-drip irrigated crops

Particulars	Method	Sugarcane	Grapes	Banana
Water consumption (HP hours/ha)	DMI	1767.00	3310.38	7884.70
	FMI	3179.98	5278.38	11,130.34
Yield (quintal/ha)	DMI	1383.60	243.25	679.54
	FMI	1124.40	204.29	526.35
Water use efficiency (HP hours/quintal)	DMI	1.28	13.61	11.60
	FMI	2.83	25.84	21.41

Source: Calculated from Narayanamoorthy (1996, 1997, 2001)

[2] HP hours of water is computed by multiplying HP of the pump-set with hours of water used.

water saving in terms of HP hours is much higher for banana crop as compared to other two crops. Drip method saves about 3245 HP hours of water per hectare for banana, while it is about 1412 HP hours for sugarcane and about 1968 HP hours for grapes. The requirement of water varies for each crop depending upon the soil quality and other factors and therefore, the saving of water due to DMI is varied among the three crops discussed. As mentioned earlier, unlike flood method of irrigation, since water is supplied only at the root zone of the crops and that too at a required quantity, water losses occurring in the form of evaporation and distribution are completely absent under DMI. This helps DMI adopters to save water considerably as compared to the non-adopters of DMI.

As reported by experimental data based studies, the results of field data also show that water use efficiency (WUE) is substantially higher for drip-irrigated crops as compared to the same cultivated under flood method of irrigation. Our analysis shows that sugarcane cultivated under drip method of irrigation consumes only 1.28 HP hours of water to produce one quintal of output when compared to 2.83 HP hours of water for producing the same quantity of output under non-drip irrigated condition, i.e., to produce one quintal of sugarcane under non-drip irrigated condition about 1.55 HP hours of additional water is consumed. Similar to sugarcane crop, water required to produce one quintal of output in banana and grapes is also found to be substantially lower under DMI as compared to their counterpart. Under DMI, banana consumes only 11.60 HP hours of water to produce one quintal of banana output as against the use of 21.14 HP hours of water for the same quantity of yield under non-drip irrigated condition. In the case of grapes, each quintal of output involves the use of just 13.60 HP hours of water under DMI as compared to the use of 25.84 HP hours under non-drip irrigated condition. The fact comes out clearly from the analysis is that DMI also reduces the water required to produce one unit of crop output substantially when compared to flood method of irrigation.

11.4.2 Electricity Saving

Electricity (energy) used for lifting water from wells is also saved considerably due to drip method of irrigation. Water saving and electricity saving are highly interrelated under DMI and therefore, an analysis on electricity use under drip method is presented in this section. It is observed in the foregoing section that HP hours of water used per hectare of crop under DMI are significantly less than FMI. Therefore, it follows simply that the consumption of electricity also reduces significantly under DMI. We have estimated electricity consumption based on the hours of pumpset operation for both the drip adopters and the non-drip adopters groups. For estimating the quantum of electricity saved, it is assumed that for every hour of operation of pump-set, 0.750 kWh of power is used per HP.[3] Since all the farmers in both the

[3] Details of consumption of electricity by pumpset and relevant estimates can be seen from Shah (1993).

groups have used only electrical pumpsets, we have simply multiplied HP hours of water with assumed power consumption of 0.75/kWh/HP to arrive at the per hectare electricity consumption. The estimated consumption of electricity (in kWh) presented in Table 11.4 clearly depicts that farmers using DMI utilised very less amount of electricity as compared to FMI farmers in all three crops. Farmers who cultivated sugarcane under DMI could save about 1059 kWh of electricity per hectare as compared to those farmers cultivated sugarcane under FMI. Similarly, while the farmers cultivating grapes could save electricity about 1476 kWh/ha due to DMI, the saving of electricity is estimated to be about 2434 kWh/ha in banana over the farmers who cultivated the same crop under FMI with similar environment.

Farmers with drip irrigation operate less number of hours of pumpsets and therefore, consumption of electricity is quite low. Since the saving of electricity through drip method of irrigation is very high, it would help to reduce the total electricity bill to be paid by the farmers. We have estimated the money saved in the total electricity bill per hectare through energy saving. Since Maharashtra State Electricity Board supplies electricity on flat-rate (FR) basis for agriculture, it was not possible to get per kWh price of electricity. Therefore, we have assumed Rs. 3.26/kWh, which is the current average cost of electricity supply in Maharashtra, as a nominal rate to estimate the saving of electricity in monetary terms. In accordance with this, on an average, about Rs. 3454/ha can be saved on electricity bill alone by cultivating sugarcane under drip method of irrigation. Similarly, farmers cultivating grapes and banana under DMI can save about Rs. 4811 and 7934/ha respectively. It suggests that the drip irrigation technology helps to reduce the cost of cultivation enormously by reducing the cost of electricity besides helping to save the precious inputs like electricity and water.

As in water consumption, the energy used to produce one quintal of crop output is computed by dividing per hectare energy (electricity) consumption by yield of each crop per hectare. Electricity consumed to produce one quintal of sugarcane is quite low for drip adopters in Maharashtra. For instance, on an average, sugarcane cultivators under DMI used about 0.968 kWh to produce one quintal of sugarcane, whereas the same is estimated to be about 2.121 kWh for those who cultivated sugarcane under FMI. This means that for every quintal of sugarcane production about 1.163 kWh of electricity can be saved through drip method of irrigation. Electrical

Table 11.4 Electricity consumption by drip and non-drip irrigated crops

	Electricity consumption (kWh/ha)		Electricity saving over FMI		
District	DMI	FMI	In percent	In quantity (kWh)	In money value (Rs)[a]
Sugarcane	1325.25	2384.99	44.43	1059.74	3454.75
Grapes	2482.77	3958.78	59.45	1476.01	4811.80
Banana	5913.53	8347.75	41.16	2434.00	7934.80

Source: Estimated using Narayanamoorthy (1996, 1997, 2001)

[a]Rs. 3.26/kWh, which is the current (2003–2004) average cost of electricity supply in Maharashtra State, is assumed to estimate electricity saving in terms of money value

energy consumed to produce one quintal of crop output is also found to be low for drip adopters in banana and grapes as well. While grapes cultivators under DMI used about 10.21 kWh to produce one quintal of grapes, the non-drip adopters have used about 19.37 kWh. Similar trend is observed in the case of banana crop as well. Obviously, higher productivity and relatively low amount of water consumption have reduced per quintal requirement of electricity significantly in drip irrigated crops.

11.4.3 Productivity Gains

One of the important advantages of drip method of irrigation is productivity gain. Most of the time yield is affected because of moisture stress faced by crops. It is difficult to maintain water supply constantly for crops by surface method of irrigation due to various reasons. Studies related to drip method irrigation have confirmed that problem of moisture stress is completely reduced by providing irrigation through drip as it supplies water at the root zone of the crops at a required frequency and quantity. As a result, the yield of crops cultivated under drip method of irrigation is much higher than the crops which are cultivated under the surface method of irrigation.

Productivity of crops presented in Table 11.5 shows that it is significantly higher for the farmers who have adopted drip method of irrigation as compared to the non-drip adopters in all the three crops. The yield difference in absolute term between the adopters and the non-adopters of drip method of irrigation comes to nearly 259 quintals per hectare for sugarcane, a gain of 23 % over non-drip irrigated crop. In the case of grapes, the productivity difference between DMI and FMI adopter comes to about 19 % and the same comes to 29 % in the case of banana crop. The important point to be underlined here is that despite incurring more cost on yield increasing inputs, productivity of crops cultivated under FMI is significantly lower than that of DMI. There are three main reasons for higher yield in drip irrigated crops. First, because of less moisture stress, the growth of crops cultivated under DMI was good which ultimately helped to increase the productivity. Second, unlike surface method of irrigation, drip does not encourage any growth of weed, especially in the

Table 11.5 Productivity of crops under drip and flood irrigated condition

	Productivity (quintal/ha)		Productivity increase over FMI	
Crop	DMI	FMI	Percent	Quantity
Sugarcane	1383.60	1124.40	23.05	259.20
Grapes	243.25	204.29	19.07	38.96
Banana	679.54	526.35	29.10	153.19

Source: Computed from Narayanamoorthy (1996, 1997, 2001)

Table 11.6 Expenditure to produce unit of output under drip and non-drip condition

Particulars	Sugarcane		Grapes		Banana	
	DMI	FMI	DMI	FMI	DMI	FMI
Yield (quintal/ha)	1383.60	1124.40	243.25	204.29	679.54	526.35
Cost of cultivation (Rs/ha)	41,993.20	48,539.88	134,506.19	147,914.96	51,436.66	52,738.56
Cost of production (Rs/quintal)	30.35	43.17	552.95	724.04	70.69	100.19

Source: Computed from Narayanamoorthy (1996, 1997, 2001)

non-crop zone. Weeds consume considerable amount of yield increasing inputs and reduce the yield of crops in surface method of irrigation. Third, unlike surface method of irrigation, fertiliser losses occurring through evaporation and leaching through water are less under drip method of irrigation as it supplies water only for crop and not for the land. Though the expenditures incurred by the non-adopters on different yield increasing inputs are more than the adopters in all three crops, this does not coincide with increased yield of crops. Therefore, one can conclude that this productivity enhancement in all three crops is because of drip method of irrigation.

DMI also increases the cost efficiency, i.e., it reduces the cost required to produce an unit of crop output. The estimated per quintal cost (calculated by dividing the total cost of cultivation with per hectare yield of three crops) shows that the non-adopters spend nearly Rs. 13 over the adopters to produce every quintal of sugarcane in Maharashtra. Likewise, in grapes, the non-adopters have incurred over Rs. 171 per quintal over the adopters and in banana, the non-adopters have incurred nearly Rs. 30 to produce one quintal of output over the counterpart (see, Table 11.6). It suggests that apart from increasing the productivity of crops, drip method of irrigation also increases cost efficiency substantially than the flood method of irrigation. On the whole, the analysis carried out using both the experimental and field level data clearly suggests that drip method of irrigation increases productivity of crops that too with reduced cost of cultivation.

11.5 Economic Viability of Drip Investment

One of the important questions often asked about the drip method of irrigation is whether or not drip investment is economically viable to farmers cultivating crops using this new water saving technology. This question arises mainly because drip method of irrigation requires relatively large amount of fixed investment to install it in the field and therefore, everyone (from policy makers to farmers) wants to know its economic viability in different crops. Though quite a few studies have analysed the impact of drip method of irrigation on different parameters, not many studies have attempted to look into the economic viability of drip investment even by using experimental data. Some estimates on benefit-cost ratios are available from three secondary sources namely INCID (1994); Sivanappan (1995) and AFC (1998). It is not clear whether the estimates available in these three studies are carried out using discounted cash flow technique.

The capital cost required for installing drip system for different crops has been increasing over the years due to increase in the cost of materials used for manufacturing the drip system (GOI 2004). The capital cost of drip system largely depends upon the type of crop (whether narrow or wide spaced crops), spacing followed for cultivating crops, proximity to water source (distance between the field and source of water) and the materials used for the system. Wide spaced crops generally require less capital when compared to the crops having narrow space, as the latter would require more laterals and drippers per hectare. INCID (1994) results indicate that the requirement of capital cost is much higher for banana (Rs. 33,765/ha) as compared to the same required for mango (Rs. 11,053/ha), which is a wide spaced crop.

As regards B-C ratio, the results available from INCID (1994) show that investment in drip method of irrigation is economically viable, even if it is estimated without taking into account subsidy given to farmers. The B-C ratio estimated excluding water saving varies from 1.31 in sugarcane to as high as 13.35 in grapes. Obviously, the B-C ratio increases significantly further, when it is estimated after including water saving. Various case studies reported in INCID (1994) also indicate that investment in drip irrigation is economically viable for different crops. Similar to INCID (1994), Sivanappan (1995) also estimated B-C ratio for different crops cultivated under DMI using data pertaining to the year 1993. It also suggests that the investment in drip irrigation is economically viable for different crops since the B-C ratio estimated was more than one. While the B-C ratio for pomegranate was estimated to be 5.16, the same is estimated to be 1.83 for cotton, which is a less-water intensive as well as a narrow spaced crop. Unlike the results reported in INCID (1994) and Sivanappan (1995), AFC (1998) which estimated B-C ratio using field survey data collected from 3850 sample farmers, showed different picture on the viability of drip investment.

Though B-C ratio available from different sources suggests that the investment in drip irrigation is economically viable for farmers, one cannot completely rely on these results because of the following reasons. First, the studies discussed above are not clearly mentioned how the income stream is estimated during the entire life period of drip set in drip irrigated crops. Secondly, studies especially by Sivanappan (1995) and INCID (1994) have not mentioned the methodology that is followed for estimating the B-C ratio for different crops. These estimates also appear to be output–input ratio, but not B-C ratio estimated using discounted cash flow technique. Third, the past studies on this aspect have either carried out B-C analysis without proper methodology or relied on the experience of one or few farmers adopting DMI. Fourth, none of the above studies mentioned the assumptions that are followed for estimating B-C ratio. In view of the limitations of the available studies, there is a need to empirically evaluate the economic viability of DMI within a relatively more systematic methodological framework.

In order to evaluate the economic viability of drip investment in the context of three crops, we have computed both the Net Present Worth (NPW) and the Benefit-Cost Ratio (BCR) by utilising the discounted cash flow technique. Since the NPW is the difference between the sum of the present value of benefits and that of costs for a given life period of the drip set, it collates the total benefits with the total costs covering items like capital and depreciation costs of the drip set. In terms of the NPW criterion, the investment on drip set can be treated as economically viable if the present value of benefits is greater than the present value of costs. The BCR is also related to NPW as it is obtained just by dividing the present worth of the benefit stream with that of the cost stream. Generally, if the BCR is more than one, then, the investment on that project can be considered as economically viable. A BCR greater than one obviously implies that the NPW of the benefit stream is higher than that of the cost stream (Gittinger 1984). The NPW and BCR can be defined as follows:

$$\text{NPW} = \sum_{t=n}^{t=1} \frac{B_t - C_t}{(1+i)^t}$$

$$\text{BCR} = \frac{\sum_{t=n}^{t=1} \frac{B_t}{(1+i)^t}}{\sum_{t=n}^{t=1} \frac{C_t}{(1+i)^t}}$$

Where, B_t = benefit in year t; C_t = cost in year t; t = 1,2,3,.......n; n = project life in years; i = rate of interest (or the assumed opportunity cost of the investment)

Since drip irrigation involves fixed capital, it is necessary to take into account the income stream for the whole life span of drip investment. However, since it is difficult to generate the cash flows for the entire life span of drip investment in the absence of observed temporal information on benefits and costs, we need to make few realistic assumptions so as to estimate both the cash inflows and cash outflows for drip investment. These assumptions are:

1. The life period of the drip set is considered as 5 years for sugarcane and banana, but 10 years for grapes as followed by the INCID study (1994) as well as the experience gathered from the field.
2. The cost of cultivation and income generated using drip method of irrigation is assumed constant during the entire life period of drip set in all three crops.
3. Differential rates of discount (interest rates) are considered to undertake the sensitivity of investment to the change in capital cost. These are assumed at 10 %, 12 % and 15 % as alternatives representing various opportunity costs of capital.
4. The crop cultivation technology is assumed constant for all three crops during the entire life period of drip set.

As a backdrop to our benefit-cost analysis of DMI, we first briefly discuss about the gross cost of production, profit without discount, capital cost (without and with subsidy) and the amount of subsidy received by the farmers. Table 11.7 presents the details of production, gross income and other details for three crops namely sugarcane, grapes and banana. To complete the analysis of the relative economics of DMI and FMI, we have calculated the relative profit levels of three crops for the adopters and non-adopters of DMI. Profit of a crop is not only determined by its total quantity of output but also its quality. Prevailing market conditions also plays a crucial role in determining the price of agricultural commodities. It has come out from the earlier studies that drip method of irrigation not only helps in increasing the yield of the crops but also improves quality of the product and fetches higher price in the market (INCID 1994; Sivanappan 1994; Narayanamoorthy 1997).

Let us study how profit (undiscounted) varies between drip and non-drip irrigated crops in our study. While calculating profit (gross income minus cost A2), the

Table 11.7 Capital cost, production cost, gross income, subsidy among drip and non-drip irrigated crops

	Sugarcane		Grapes		Banana	
Particulars	DMI	FMI	DMI	FMI	DMI	FMI
Cost of cultivation (Rs/ha)[a]	41,993.20	48,539.88	134,506.19	147,914.96	51,436.66	52,738.56
Gross income (Rs/ha)	106,366.00	85,488.20	247,817.02	211,037.97	134,043.75	102,934.73
Profit (Rs/ha)[b] (Farm business income)	64,372.80	36,948.32	113,310.83	63,122.97	82,607.09	50,196.17
Capital cost of drip set (Rs/ha) (without subsidy)[c]	52,811.00	–	32,721.00	–	33,595.00	–
Capital cost of drip set (Rs/ha) (with subsidy)[c]	33,547.56	–	20,101.00	–	22,236.00	–
Subsidy (Rs/ha)	19,263.44	–	11,359.00	–	12,620.00	–

Source: Calculated from Narayanamoorthy (1996, 1997, 2001)

[a]Production cost (A2) includes the operation and maintenance cost of drip set and pump-set

[b]This is the difference between gross value of production and production cost (A2)

[c]It does not include pump-set cost

total cost was calculated by considering only the variable costs but not the fixed cost components like interest rate and depreciation.[4] To calculate per hectare profit, we subtract the total cost of cultivation from the total income for the group of adopters and the non-adopters. The gross income (in rupees) is calculated by multiplying total yield with price received by the farmers for their crop output. It can be seen from Table 11.7 that per hectare profit of the adopters in sugarcane is Rs. 27,424 higher than that of the non-adopters. In terms of percentage, profit of the drip adopters is higher by about 74 % over the profit of the non-drip farmers. This is not surprising because on the one hand drip irrigation reduces the cost of cultivation of sugarcane and on the other hand it increases the yield of sugarcane.

The average profit among the drip adopters is significantly higher than that among the non-drip adopters in case of both grapes and banana as well. The profit level among drip adopters in grapes is Rs. 50,187/ha higher than that among non-adopters, whereas the same is about Rs. 32,400/ha for banana. While the profit differential is substantial for drip irrigated crops, it cannot be taken as a conclusive indicator of the comparative advantages of the new irrigation technique as our profit calculation is based only the variable cost but ignores fixed cost components like depreciation and interest accrued on the fixed capital while calculating the net profit. The life period of drip-set is one of the important variables which determine the per hectare profit. Moreover, since it is a capital-intensive technique, the huge initial investment needed for installing drip systems remains the main deterrent for the widespread adoption of DMI. To what extent this discouragement effect is real and to what extent such effect can be counterbalanced by government subsidy are some of the important policy issues requiring empirical answers.

Since DMI is a capital-intensive technology, government provides nearly 50 % of the capital cost as subsidy to encourage the adoption of drip irrigation in crop cultivation. The average capital subsidy comes to Rs. 19,263/ha for sugarcane, Rs. 11,359/ha for grapes and Rs. 12,620/ha for banana. As a proportion of the total capital cost of drip set, subsidy amount accounts for about 35 % to 37 % among three crops, which is within a limit of provision made by the government. With this background, let us analyse benefit-cost pattern of drip investment using discounted cash flow technique.

In order to assess the potential role that subsidy plays in the adoption of DMI, we have computed both the NPW and the BCR separately by including and excluding subsidy in the total fixed capital cost of drip set. Financial viability analysis under different rates of discount will indicate the stability of investment at various levels of the opportunity cost of investment. Although the BCR is sensitive to discount rate and the degree of such sensitivity depends on the pattern of cash flows, it is interesting to observe the sensitivity of the BCR when there is simultaneous change in both subsidy and discount factor. Table 11.8 presents the results of sensitivity analysis for sugarcane, grapes and banana crop computed under the assumption that there

[4] The cost of cultivation used in our analysis refers to cost A2, which includes all actual expenses in cash and kind incurred in production by owner plus rent paid for leased-in land.

Table 11.8 Net present worth and benefit cost ratio for drip irrigated, sugarcane, grapes and banana under with and without subsidy condition

Particulars	Sugarcane		Grapes		Banana	
	Without subsidy	With subsidy	Without subsidy	With subsidy	Without subsidy	With subsidy
Net present worth (Rs/ha)						
At 15 % discount rate	169,896	186,656	551,220	540,241	247,753	257,635
At 12 % discount rate	214,357	231,558	622,257	610,987	267,797	277,941
At 10 % discount rate	226,952	244,481	677,911	666,440	282,542	292,867
Benefit cost ratio						
At 15 % discount rate	1.909	2.098	1.795	1.767	2.288	2.343
At 12 % discount rate	2.079	2.277	1.799	1.774	2.243	2.353
At 10 % discount rate	2.095	2.289	1.802	1.778	2.253	2.361

Source: Computed from Narayanamoorthy (1996, 1997, 2001)

will not be any change in the cost of production and gross income during the entire life period of drip set.

As regards sugarcane crop, the NPW of the investment with subsidy is marginally higher than that under 'no subsidy' option. At 15 % discount rate, the NPW of drip investment is about 169,896/ha without subsidy but Rs. 186,655/ha with subsidy. This means that the subsidy enables the farmers to get an additional benefit of Rs. 16,759/ha. It can also be observed that the difference between the NPW under 'with subsidy' and 'no subsidy' scenarios is decreasing along with each increase in discount rate. For instance, the NPW under without subsidy condition increased from Rs. 169,896/ha at 15 % discount rate to Rs. 226,951/ha at 10 % discount rate. Similarly, under subsidy condition, the NPW increased from Rs. 186,655/ha at 15 % discount rate to Rs. 244,481/ha at 10 % discount rate. Similar to this, under without subsidy condition, the BCR also increased marginally from 1.909 at 15 % discount rate to 2.095 at 10 % discount rate. The higher BCR under subsidy condition suggests the positive role that subsidy plays in improving the economic viability of drip method of irrigation in sugarcane.

The NPW and BCR are estimated separately for banana and a grape also shows that the NPW of the investment with subsidy is marginally higher than that under 'no subsidy' option for both banana and grapes. For instance, at 15 % discount rate, the NPW of drip investment for banana is about Rs. 247,753/ha without subsidy but Rs. 257,635/ha with subsidy. This means that the subsidy enables farmers to get an additional benefit of Rs. 9882/ha. It can also be noted that the difference between the NPW under the two scenarios is decreasing along with each increase in discount rate. The difference in NPW for the two scenarios which is Rs. 10,325 for banana and Rs. 11,471 for grapes at 10 % discount rate declines to Rs. 9882 and Rs. 10,979 for Banana and Grapes respectively at 15 % discount rate. This differential behaviour of NPW across discount rates for the two crops is attributable to the observed differences in cash flows and cultivation practices and the assumed difference in drip set life span for the two crops. The BCR without subsidy for banana is about 2.253 at 10 % discount rate slides down to 2.228 at 15 % discount rate. For grapes, in contrast, the BCR declines only marginally as the rate of discount increases. Although the same pattern of decline in BCR is observed across discount rates even under the alternative scenario of cash flows with subsidy, the BCR is higher with subsidy than otherwise. This suggests the positive role that subsidy plays in improving the economic viability of DMI for our sample crops irrespective of the time preference of the farmers.

An important policy issue in the context of DMI adoption is the number of years needed to recover fully the capital costs involved in drip installation. The year-wise computation of NPW for sugarcane, banana and grapes clearly shows that farmers can recover the entire capital cost of the drip set from their net profit in the very first year itself. This finding contradicts with the general belief that the capital cost recovery for drip investment takes more time. More importantly, when farmers can recover the capital costs within a year, the role of discount rate as a device to capture the time preference of farmer seems to be of considerably lesser importance than one might think. However, in order to have more definite answers to the economic and social viability of DMI, we need a social rather than the private cost-benefit evaluation being attempted here. A comprehensive evaluation can be done by incorporating both the social benefits in the form of water saving, additional irrigation, lower soil degradation and retention of soil fertility as well as the social costs in terms of the negative food and fodder in the crop pattern shift and labour displacement. On the whole, the BCR under different discount rates indicates that drip investment in three crops considered for detailed analysis remains economically viable even without subsidy.

11.6 Pointers for Future Research and Policy

The study clearly demonstrates that micro irrigation has many advantages over the method of flood irrigation followed predominantly in India. Drip method of irrigation reduces cost of cultivation, weed problems, soil erosion and increases water use efficiency as well as electricity use efficiency, besides performing as a useful devise in reducing the over-exploitation of groundwater. However, despite providing substantial amount of subsidy, the spread and coverage of drip irrigation in India is not very encouraging as of today due to various reasons. There is a feeling among some quarter of policy makers and researchers that the adoption of drip method of irrigation cannot be increased without providing subsidy because of its capital-intensive nature. It is true that drip irrigation is a capital-intensive technology, but it does not mean that its adoption of cannot be increased without subsidy. Subsidy can be a necessary condition for encouraging the adoption of drip method of irrigation but cannot be a sufficient condition for sustaining the growth of it, as many other factors determine the adoption of the same. Studies carried out using field level data covering three important crops clearly show that the investment in drip irrigation is economically viable even without government subsidy. The estimated benefit-cost (BC) ratio varies from 1.73 to 2.23 among the three crops under without subsidy condition. Even though subsidy is not needed to enhance the economic viability of the drip system, it is still needed to enhance the incentive for the widespread adoption of DMI particularly among the resource poor farmers (marginal and small categories). Subsidy can be phased out eventually once the new irrigation technology covered an adequate enough to expand subsequently through the demonstration effect.

The most important task standing before the policy makers is to find out the ways and means to convince the farmers about the economic and social feasibility of drip method of irrigation. Since it involves relatively higher amount of investment, farmers often ask the questions such as what will be the payback period? Whether investment will be viable? How much will be the water saving? and What will be the productivity gains? It appears that these questions arise mainly because of poor exposure about the social and economic advantages of drip technology. Therefore, efforts are needed to convince the farmers through quality extension network.

A lot of policy initiatives needed so as to expand the adoption of DMI in India. Specifically, government should make all efforts to reduce the capital cost of the drip system to encourage the farmers. By recognising drip industry as an infrastructure industry as well as announcing tax holiday for specific time periods to all those drip set industries which produce genuine drip materials, the competition can be increased that will ultimately bring down the cost of the system. The economic and environment viability of the low cost drip irrigation system being introduced by some companies should also be evaluated using farm level data. Second, the present subsidy scheme, which provides uniform rate of subsidy for all crops, needs to be restructured taking into account the water consumption of the crops and level of groundwater exploitation of the region. Higher amount of subsidy for water-intensive crops, including sugarcane should be given. Areas with over-exploitation of groundwater (dark areas) and water scarcity should also be given higher amount of subsidy than those water-abundant areas. Third, for a speedy growth of drip irrigation, an interlinked special package scheme can be introduced where priority must be given in providing bank loan for digging wells and electricity connection (pump-set) for those farmers who are ready to adopt drip method of irrigation for cultivating any crop. Four, sugar industries should play proactive role in increasing the adoption of drip irrigation in sugarcane, using their close contract system with the cultivators. In spite of the fact that sugarcane consumes bulk of the irrigation water in different states,[5] serious efforts are not taken to bring the sugarcane under

[5] It is reported that in states like Maharashtra, sugarcane crop, which accounts for barely 2.50 % of the cropped area, consumes nearly two-third of irrigation water. In spite of increasing the water rate for irrigation purposes periodically since 2000–2001, the area under sugarcane in the state has

drip method of irrigation. Some target must be fixed for each sugar industry to bring cultivation of sugarcane under drip method of irrigation within a specific period. Five, inadequate information about the operation, maintenance as well as usefulness of drip irrigation is one of the main reasons for its uneven spread across regions in India. Even the adopters do not know fully how much of subsidy is available per hectare for different crops. Owing to poor exposure, farmers are reluctant to invest such relatively large money on drip irrigation. In fact, many farmers do not know the fact that drip irrigation can also be used efficiently and economically for crops like sugarcane, cotton, vegetables, etc. The extension network currently operated mainly by government agencies does not seem to be making significant impact on the adoption of this technology. Therefore, there is a need to revamp the whole extension network by involving the drip set manufactures (public and private partnership) in order to improve the quality of extension service. Six, groundwater is the only source of water being used for drip method of irrigation in India. Since water use efficiency under surface sources (canal, etc.) is very low owing to heavy losses through conveyance and distribution, farmers should be encouraged to use water from surface sources for drip method of irrigation. This can be done by allocating certain proportion of water from each irrigation projects exclusively for the use of micro irrigation. Seven, one of the important reasons for the low spread of this technology even in the water-scarce area is the availability of highly subsidized canal water as well as electricity for irrigation pumpsets. Appropriate pricing policies on these two inputs may encourage the farmers to adopt this technology. Eight, though drip irrigation has been in use in different States since mid-eighties, no agency has clear idea about the potential of micro-irrigation of each state. Therefore, it is essential to prepare State-wise and crop-wise potential area for DMI. A detailed estimate on State-wise potential would be useful to fix the target to be achieved and also formulate schemes for promoting drip method of irrigation. Nine, State sponsored schemes are not formulated in most of states except in Maharashtra and Andhra Pradesh. All other states have been operating schemes mainly with the support of Central government (known as centrally sponsored schemes), which started in 1990–1991. Considering the water scarcity, it is essential to have separate State sponsored schemes in each state to promote micro-irrigation by following the experience of Maharashtra State.

On future research, more and more research studies need to be carried out pertaining to its economics and adoption using field survey data to strengthen the policy decision and provide feed-back about the issues pertaining to drip method of irrigation to policy makers. The research findings available presently on drip irrigation are not adequately enough to provide answers to the questions such as: Who are the adopters of drip method of irrigation? What are the characteristics of the adopters? Can small and marginal farmers adopt drip irrigation without subsidy? What are the problems of the present subsidy scheme and how to revamp the same? Why do farmers not adopt drip irrigation for cultivating crops like pulses, oilseeds and other simi-

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been increasing continuously at a faster pace, which poses different challenges to the policy makers.

lar crops? What is economic and environmental impact of DMI? Can DMI be used to solve the problem of over-exploitation of groundwater? What is the economic viability of different crops cultivated presently under DMI? Unless adequate answers are available to these questions, we may not be able to make judicious policy decision to expand the adoption of water saving technology at a fast rate.

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