WORKING PAPER 187

GROUNDWATER FOR AGRICULTURAL USE IN INDIA: AN INSTITUTIONAL PERSPECTIVE

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2007

GROUNDWATER FOR AGRICULTURAL USE IN INDIA: AN INSTITUTIONAL PERSPECTIVE

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Abstract

Depletion of groundwater resources has emerged as a major concern in many parts of India today. This has a tendency to disproportionately affect the poor farmers by limiting their access to the resource. Appropriate institutional structures are, therefore, required to manage groundwater, ensure equitable distribution of irrigation water and increase agricultural productivity. The paper examines the alternative regulatory mechanisms that exist in India to prevent overexploitation of groundwater resources. This brief interpretive appraisal of some of the existing institutional arrangements also seeks to provide an overall perspective within which the different regulatory mechanisms can be assessed.

Background

Over the years, groundwater has emerged as an indispensable resource for agricultural use in India, especially in areas where there is scarcity of surface water. With the advent of Green Revolution technology in farming followed by the adoption of modern water extraction mechanisms, there has been a spurt in the extraction rate of groundwater to meet agricultural needs. Rural electrification program and availability of credit at lower rates have further helped farmers to increase area under groundwater irrigation. Development of groundwater irrigation has not only helped the well owning farmers but also the non-well owners through emergence of 'water markets' (Saleth, 1994; Shah, 1993). However, such rapid deployment of the resource along with lack of well-defined property rights has made it vulnerable to over-exploitation, especially in hard rock water

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scarce areas[2]. Several micro-studies undertaken in the hard rock regions document evidences of groundwater depletion and indicate that the resource is becoming increasingly scarce[3]. 'Overdrafting'[4] and 'overcrowding'[5] of wells are the two main features of groundwater scarcity. Importantly, groundwater over-extraction has led to several undesirable consequences in many parts of the country for example; well failure, reduced well yield, complete abandonment of wells, saline water intrusion in coastal areas etc. This calls for a need to put in place innovative institutional arrangements to manage groundwater – a common property resource – especially in water scarce areas. Essentially, appropriate institutional structures are also required to increase agricultural productivity and ensure equity in distribution of irrigation water.

[2] More than 90 percent of the hard rock areas in India are estimated to be concentrated in the Deccan plateau covering roughly the states of Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu. A few other states, e.g., Gujarat, Madhya Pradesh and Bihar, also contain large chunks of rocky formations.

[3] See for example, Chandrakanth et al. (2004); Janakrajan (1993).

[4] 'Overdrafting' means that groundwater withdrawals tend to exceed the annual replenishment via groundwater recharge, the excess being accounted for by a permanent reduction in the volume of groundwater stock underneath – it is in this sense that over-exploitation of groundwater is described as 'groundwater mining'. The manifestation of groundwater overdraft is lowering of water table. In economics of groundwater irrigation, permanent recession in groundwater table raises both the capital and operating costs of well irrigation. Overexploitation of groundwater may also lead to serious consequences in certain situations. If decline in water table in a tract continues unabated, the rising cost of groundwater irrigation may prove inadequate to arrest the process of decline in water table. In coastal areas groundwater quality may also be damaged due to intrusion of saline water from the neighbourhood.

[5] 'Overcrowding' of wells implies mutual interference of wells. In technical terms, the 'radii of influence' of wells overlap, that is, a well is located within the 'radius of influence' of another well (s). Due to such 'overcrowding' of wells the operational cost of water lifting rises as the discharge of water lifting mechanism diminishes and duration for completing an irrigation operation rises. Consequently, the well owner with a smaller water lifting capacity is disadvantaged. In the extreme case he may not be able to lift any water till the well owner with the larger capacity stops the operation of his pump.

Scheme of the Paper

Against this backdrop, the paper to begin with highlights the growing dependence on groundwater resources for agriculture in India and thereby discusses the extent and consequences of groundwater over-extraction. The paper then methodically examines the basic features of the regulatory management interventions existing in India to prevent overexploitation of the resource and hints at the major advantages and shortcomings of the respective approaches. As a prologue to this exercise, the paper presents an overview of the existing groundwater laws and regulations under the realm of the Groundwater Model Bill to regulate and control development and management of the resource. This brief appraisal essentially underlines the salient features of the Model Bill in the light of its regulatory structure, enforcement viability and scope for user's participation. Thereby the status of certain state-specific groundwater regulations have also been discussed.

Groundwater Development for Agriculture in India

Dependence on Groundwater for Agriculture

In India, groundwater irrigation has played a crucial role in expanding agricultural production to meet the food needs of the rapidly growing population. As Robert Repetto comments, "The Green Revolution has often been called a wheat revolution; it might also be called a tubewell revolution" (Repetto 1994; p. 35). Approximately, groundwater can irrigate 35 million hectares (Mha), which exceeds the 33 Mha of irrigation potential created through all major and medium irrigation works (Saksena, 1989; Dhawan, 1990). The use of groundwater for irrigation has considerably increased from a meagre 6.5 cubic km in 1951 to over 50 cubic km in 1997 (Singhal, 2003). Table: 1 also shows that the net irrigated area by wells in India has increased considerably over the years as compared to the other sources.

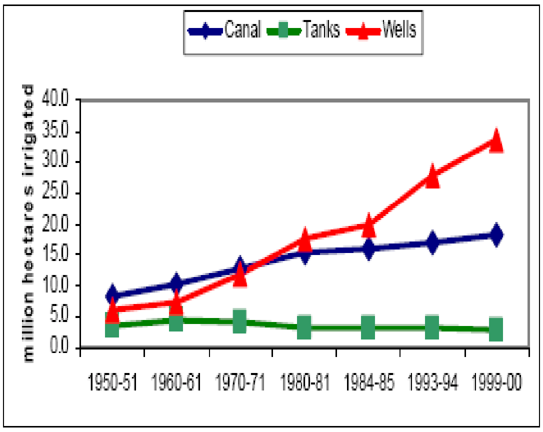
Table: 1 Trends in Net Irrigated Area (NIA) by sources in India, 1950-51 to 2002-03 (Area in Million hectares)

Sources	1950-51 to 59-60		1960-61 to 69-70		1980-81 to 89-90		1996-97		2002-03	
	Area	Percent of NIA	Area	Percent of NIA	Area	Percent of NIA	Area	Percent of NIA	Area	Percent of NIA
Canals	9.2	41.2	11.2	41.9	16.3	38.3	17.4	31.5	15.0	28.2
Tanks	4.2	18.6	4.5	16.6	3.0	7.0	3.3	6.1	1.9	3.6
Wells	6.6	29.8	8.7	32.6	20.8	48.7	30.8	55.9	33.6	63.3
Others	2.3	10.4	2.4	8.9	2.5	6.0	3.6	6.6	2.6	4.9
Total NIA	22.3	100.0	26.8	100.0	42.6	100.0	55.1	100.0	53.1	100.0

Source: Janakarajan and Moench (2006)

Currently, groundwater irrigates nearly 60 percent of the total irrigated area, which recorded an annual growth rate of 13.7 percent from 1960 to 1999 (Department of Agriculture and Cooperation, 2004). Beginning around 1960, owing to the adoption of Green Revolution Technology, groundwater irrigation developed at an explosive rate (see Figure: 1), while tank irrigation declined fast and surface water irrigation grew much more slowly. Precisely, groundwater irrigated area in India has increased considerably and is projected to continue growing at an exponential rate until the 'ultimate' irrigational potential is reached in 2007 (Moench, 1992; World Bank, 1998). Table: 2 below shows the development of groundwater irrigation structure over time in India.

Fig: 1 The evolution of forms of irrigation in India (1950-2000)



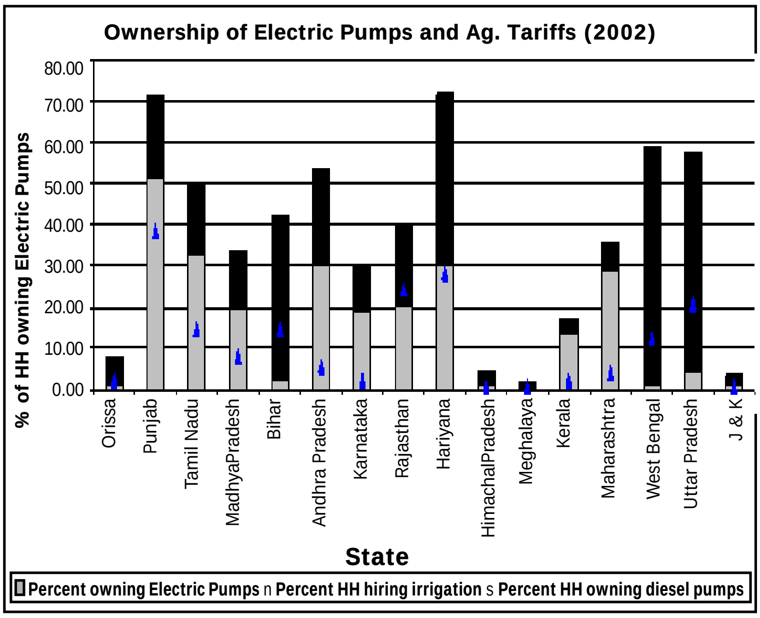
Source: World Bank, 2005

Table: 2 Development of groundwater withdrawal structures (in thousands) in India

Year	Dug wells	Shallow tube wells	Public tube wells
1950-51	3860	3	2.4
1960-61	4540	22	8.9
1968-69	6100	260	14.7
1973-74	6700	1138	22.0
1977-78	7435	1749	30.0
1979-80	7786	2132	33.3
1984-85	8742	3359	48.2
1989-90	9407	4754	63.6
1993-94	10225	5040	69.4
1996-97	10501	6743	90.0
Source: Singh and Singh (2002)			

Efficiency of groundwater use is, in general, higher than that of surface water due to the fact that groundwater is available on demand at the point of use and requires little conveyance. Dhawan (1995) has shown that yields in groundwater irrigated areas are higher by one-third to one-half than those in areas irrigated from surface sources. The reliability of groundwater sources also reduces variability of production (World Bank, 1998). The benefits of groundwater irrigation are numerous and they have been summed up by various authors (Shah, 1993; Moench, 1995). These include higher productivity and it's more equitable distribution among various classes of farmers, insurance against drought and stabilisation of agricultural production and enhanced employment generation. Furthermore, the development of groundwater irrigation has not only helped the well owning farmers but also the non-well owning farmers through 'water market' (Saleth, 1994; Shah, 1993). Fig:2 compiled from NSSO 54th Round data shows that a high percentage of households hire irrigation service in many states, which in turn reflects the extent of development of groundwater market in these states.

Fig: 2 Ownership of irrigation pumps (2002)



Source: Compiled from NSSO 54th Round

Extent and consequences of groundwater depletion in India

The total annual replenishable groundwater resources of the country have been assessed as 433 Billion Cubic Meters (bcm) and the net annual groundwater availability is estimated as 399 bcm (Ministry of Water Resources, 2007). The stage of groundwater development is 58 per cent. However, the development of groundwater in different areas of the country has not been uniform. Approximately 200 billion cubic meters of groundwater is extracted annually in India, which is the highest volume of annual groundwater extraction in the world (Shah, 2005). As reported by Scott and Shah (2004), India is the world's largest groundwater user in terms of both absolute volumes pumped and the total number of users. Currently, there are approximately 20 million wells, a number that has been increasing at approximately at one million per year; the majority of which are equipped with electrical pumps (Mukherjee and Shah, 2005).

Highly intensive development of groundwater in certain areas of the country has led to decline in groundwater levels and sea water intrusion in coastal areas. There is a continuous growth in 'dark'[6]and 'overexploited'[7] areas in the country. Based on the norms of the Central Groundwater Board, about 3.53 percent and 2.53 percent of the total number blocks of the country have been classified as 'overexploited' and 'dark' blocks, respectively (Singh and Singh, 2002). Out of 5723 assessment units (Blocks/ Mandals/Talukas) in the country, 839 units in various States have been categorized as 'over exploited'. In addition 226 units are 'critical' or 'dark'. There are 550 semi-critical units, where the stage of ground water development is between 70 per cent and 100 per cent (MoWR, GOI website www.wrmin.nic.in). The Central Ground Water Authority (CGWA) has notified 20 severely critical/over exploited areas in the country for

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[6] The stage of groundwater development is above 85 per cent and within 100 per cent of annual replenishable resource.

[7] 'Overexploited' implies more than 100 percent exploitation. The annual groundwater extraction exceeds the annual replenishable resource

regulation of groundwater development and management. 'Dark' or critical blocks increased at continuous rate of 5.5 percent over the period 1984-85 to 1992-93. At this rate, it is estimated that roughly 36 percent of the blocks in the country would be either dark or critical by 2017-18 (Moench, 2000), which in turn would imply non-accessibility of water to the poor farmers due to the increase in cost of further drilling of tube wells and lifting, particularly in groundwater irrigated areas.

Table: 3 Categorisation of blocks as overexploited and 'dark' on all-India basis (2002)

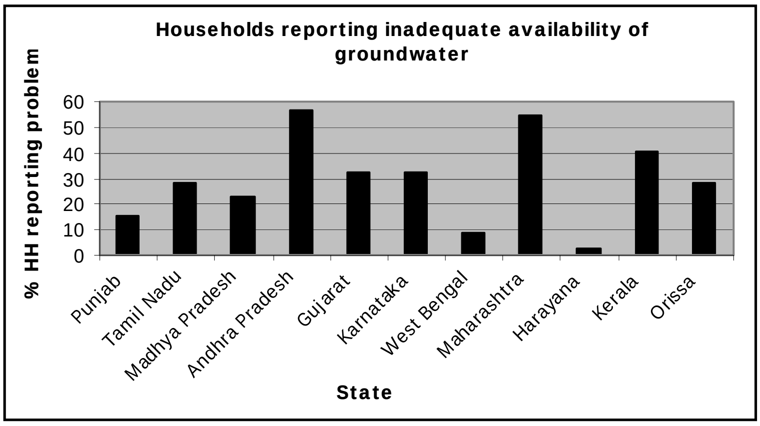
State	No. of districts	No. of blocks*	Number of blocks			
			Overexploited		Dark	
			Number	Percent	Number	Percent
Andhra Pradesh	23	1104	6	0.54	24	2.17
Gujarat	19	184	12	6.52	14	7.61
Haryana	16	108	45	41.67	6	5.56
Karnataka	19	175	6	3.43	12	6.86
Madhya Pradesh	45	459	-	-	3	0.65
Maharashtra	30	503	-	-	34	2.26
Punjab	12	118	62	52.54	8	6.78
Rajasthan	30	236	45	18.07	11	4.66
Tamil Nadu	21	384	54	14.06	43	11.20
Uttar Pradesh	63	895	19	2.12	22	2.46

Source: Singh and Singh (2002)

* Number of blocks for all other states except Andhra Pradesh (*mandals*), Gujarat (*talukas*) and Maharashtra (*watershed*)

The NSSO 54th round data on cultivation practices in India reveals farmers' perception on increasing groundwater scarcity. A large proportion of farmers in many states, especially in Andhra Pradesh (56.8 percent) and Maharashtra (54.8 percent), have reported inadequate availability of groundwater in their wells (Fig:3).

Fig: 3 Inadequate groundwater availability



Source: Compiled from NSSO 54th round

Interestingly, relatively fewer numbers of households in Haryana (2.9 percent) and Punjab (15.3 percent) have reported such inadequacy inspite of the declining water level trends in these states, perhaps because of the fact that they are better endowed to drill deeper in the event of water shortage in their wells.

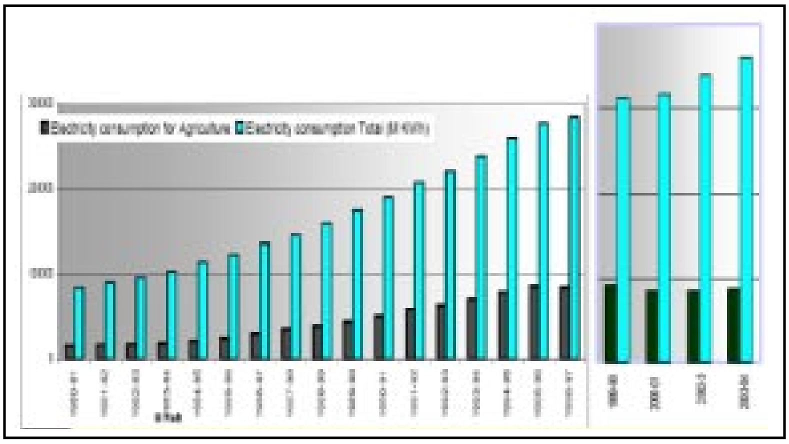
In several parts of India (north Gujarat, southern Rajasthan, Saurashtra, Coimbatore and Madurai districts of Tamil Nadu, Kolar district of Karnataka, parts of Andhra Pradesh, Punjab, Haryana and Uttar Pradesh) declining water levels are in the order of 1-2 m per year (Singh and Singh, 2002). Groundwater use has expanded in many areas beyond sustainable limits, especially in western and peninsular India. Scott and Shah (2004) report that in Karnataka some 20 percent of the state's total 1.2 million wells go dry every year. As remarked by Seckler *et al* (1998), declining water levels could reduce India's harvest by 25 percent or more. Janakarajan and Moench (2006) have also shown how degradation of the groundwater resource base through over-extraction and pollution has increased rural poverty, social inequity and conflict in many parts of India, particularly in Tamil Nadu. The authors assert that although per capita availability of foodgrains has gone up steadily over a period of time from 141 kg per year in 1951 to 200 kg in the year 2000, it has not ensured food availability for all sections of society. They have further argued that the impact of emerging groundwater problems on yields and rural livelihoods is embedded in issues of differential access to groundwater resources that are exacerbated by unsustainable development and power relations at village level. While there is a strong association between levels of groundwater development and reduction in poverty, inequity remains and progress is threatened by an emerging overdraft and other groundwater problems. Table: 4 below summarises the extent of groundwater depletion as pointed out by different studies.

Table: 4 Studies presenting the extent of groundwater depletion in India

Study	Period	Measure of groundwater depletion
Scott and Shah	2004	20% of Karnataka's total 1.2 million wells go dry every year; world's largest groundwater user in terms of both absolute volumes pumped and total number of users.
Shah	2002	highest annual groundwater abstraction volume
Singh and Singh	2002	3.53% and 2.53% of the total number blocks of the country classified as overexploited and dark blocks respectively; declining water levels are in the order of 1-2 m per year.
Moench (2000)	1984-85 to 1992-93	'Dark' blocks increased at continuous rate of 5.5% over the period 1984-85 to 1992-93
Seckler, et.al.	1998	declining water levels could reduce (1998) India's harvest by 25% or more
Janakarajan and Moench	2006	over-extraction increasing rural poverty, social inequity and conflict in many parts of India, particularly Tamil Nadu

In this context, it is important to note that over time, availability of free or nearly free subsidized electricity for irrigators has also motivated farmers to turn to groundwater. India has also witnessed a steady increase in energy subsidies to groundwater irrigation pumpsets (amount of electricity used in agriculture grew, as shown in Figure: 4).

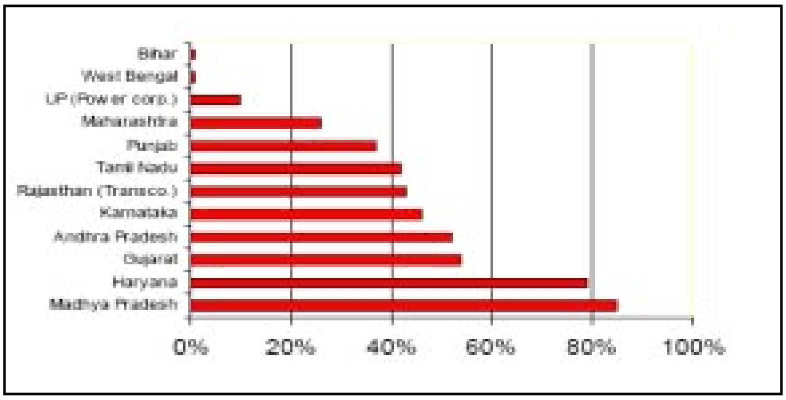
Figure: 4 Increase in electricity consumption for agriculture.



Source: World Bank, 2005

According to the Planning Commission, while the agriculture sector accounts for nearly one-third of the sales of the State Electricity Boards, the revenues from farmers account for only 3 percent of total revenue. The World Bank (2005) estimates that subsidies to farmers account for about 10 percent of the total cost of supply, or about Rs 240 billion a year, which is equivalent to about 25 percent of India's fiscal deficit and two and a half times the annual expenditure on canal irrigation, with large impacts on fiscal deficits at the state level (as shown in Figure 5).

Figure: 5 Electricity subsidies to agriculture as percent of Gross Fiscal Deficit 2000-01



Source: World Bank, 2005

To sum up, although groundwater development has brought considerable economic growth and diversification in rural areas (Shah and Mukherjee, 2001), degradation of the resource base in the recent years is threatening rural livelihoods and long run availability of groundwater. Many of the most highly productive localities are already under severe groundwater stress. For example, in Punjab groundwater in about 60 percent of blocks is already being overdrawn, while for Haryana and Tamil Nadu the figure is around 40 percent. In Rajasthan the proportion of over-exploited blocks has risen from 17 percent to 60 percent over the last seven years. For the country as a whole about 14 percent of all blocks are either over-exploited or critical, a number which is expected to reach 60 percent in just twenty-five years time (World Bank, 2005). This is undoubtedly a crucial water challenge facing India in the coming decades. Therefore, policy makers face a unique dilemma: how to ensure and preserve the benefits to farmers and the wider economy of rapid groundwater expansion; while attempting to control its excesses (Scott and Shah, 2004).

Groundwater Laws and Regulations in India

Groundwater rights prevailing in India could be characterized as a version of the English doctrine of absolute right, under which landowners have an absolute right to water under their land. When land is sold, groundwater access rights pass with the land and cannot legally be separated from it. More so, the volume of water extracted does not legally depend on the area of land owned and any landowner can abstract any volume of water (Narain, 1998; Singh, 1990; 1991). Precisely, *de jure* property rights in groundwater are not clearly defined but *de facto* it is accessible to all those who own the overlying land. Such legal framework often leads to indiscriminate use of groundwater resources and also implies that only the land owners own groundwater. Consequently, the landless – who constitute more than 30 percent of the rural farm population – do not enjoy private ownership of groundwater or other water rights.

Hence, with the goal of regulating groundwater development and also to ensure sustainable availability and equitable distribution of the resource to various sectors and sections of society, a 'Model Bill to Regulate and Control the Development of Groundwater' was circulated as early as 1970. In India, water is a state subject and therefore the Model Bill could not be adopted directly by the Central Government. Instead, it was circulated to the states with the recommendation that it - or a suitable modified version of it - be adopted as legislation. No state, however, adopted the Model Bill. Since the initial Model Bill was never adopted, the Ministry of Water Resources constituted a Working Group to re-examine the provisions of the 1970 draft and suggest revisions. The updated revised versions were redistributed in 1992 and 1996, which extended to cover all uses including drinking/domestic uses and also exempted small/marginal farmers from obtaining prior permission of the Groundwater Authority for the construction of groundwater abstraction structures provided these are for their exclusive use only. In 2005, the Model Bill was reviewed again to include provisions relating to regulation, development and augmentation of groundwater resources. Importantly, draft bills have been presented in the legislatures of several states including Tamil Nadu and Karnataka but have never been enacted effectively. So far only Gujarat and Maharashtra have actually passed a legislation bearing on groundwater. Also, the National Water Policy, 2002 contains certain provisions which propose regulating groundwater over-exploitation through implementation of artificial recharge projects, conjunctive use of surface water and groundwater, periodical reassessment of groundwater potential on a scientific basis, etc.

Groundwater Model Bill: Salient features

The main provisions of the 'Model Bill to regulate and control the development and management of groundwater' are as follows:

1. Constitution of a Groundwater Authority by each state to discharge the various functions under the legislation, comprising of a Chairman, a representative of the Central Groundwater Board, representatives of the concerned state government

departments and knowledgeable persons in matters relating to groundwater. The authority should also be supported by technical persons and other staffs considered necessary for enforcing the legislation.

2. The State governments acquire power to restrict construction of groundwater abstraction structures by individuals or communities for all purposes including drinking and domestic use.

3. The Authority can declare any area to be a 'notified area' if it is of the opinion that controlling and regulating groundwater extraction and use of groundwater in that area is necessary.

4. Anyone (except small and marginal farmers) wishing to sink a well for any purpose within the notified area must obtain a permit from the authority. Such applications for permit are to be considered by the Authority keeping in view, the purpose for which water is to be used, availability of groundwater, existence of other competitive users, long-term groundwater level behaviour, and other relevant factors.

5. Every existing user of groundwater in the State should apply to the Authority for grant of a Certificate of Registration recognising its existing use and authorising the continued use of groundwater. The Authority is vested with the power to cancel any permits, registrations or licences if necessary.

6. The Authority could take up steps to ensure that exploitation of groundwater resources does not exceed the natural replenishment to the aquifers. Wherever, there is a mismatch, steps could be taken to ensure augmentation of groundwater resources in addition to regulatory measures.

7. The Authority should upkeep the data-base on groundwater related information.

8. To improve groundwater situation, the Authority may identify the recharge worthy areas in the State and issue necessary guidelines for adoption of rain water harvesting for groundwater recharge in these areas.

9. The Authority should take steps for promotion of mass awareness and training programs on artificial recharging of groundwater through different government, non-governmental or educational institutions.

10. The Authority should be provided with complete legal support to enforce the various provisions of the legislations and the Civil Courts are barred from granting injunction on any decision taken by the Authority

An appraisal of the Model Bill reflects that it represents one of those situations where the State essentially controls and regulates the use and extraction of groundwater; while private owners own and manage the wells. The State monitors and regulates the level of groundwater extraction through constitution of the Groundwater Authority, which in turn exercises power to restrict construction of groundwater abstraction structures in any area, if considered necessary. In other words, state neither owns groundwater[8] nor wells but uses regulations to restrict the right to use and extract groundwater. Registration of existing wells, issuing permits for digging new wells and declaring an over-exploited area to be a 'notified area' are some of the provisions of groundwater legislations, which often entail transaction costs on the part of the State.

Evidently, the Model Bill sets up regulations that imply concentration of power at the State level or in that matter the Groundwater Authority, with no local involvement. Ever since the inception of the Model Bill, there has been practically very little headway as far as implementation of groundwater legislations in different states is concerned. The reason could be lack of either effective implementation mechanisms due to lack of local involvement or the sensitivity of the State attempting to regulate what for landowners, is essentially an open access resource. As mentioned earlier, the English Common Law Doctrine prevailing in India

[8] State does not own groundwater either through possession of overlying land or through a law that assigns property right of water resources to the State (i.e., groundwater is not a State property).

endows every landowner to extract groundwater underneath his or her land with no limit on quantity. Therefore, proposals for government regulation of wells and their use could be sensitive as many well owners would view it as an attempt by the state to take control over their personal resources. Besides, often "system managers...have no effective power to enforce the rules or the penalties for violating those rules" (Vaidyanathan, 1991, p. 19).

It is also important to note that the Model Bill largely limits participation of water users in management of groundwater resources. The Groundwater Authorities are dominated by officers from technical departments appointed by the State and there is no user representation in the Authorities. Notification of areas is also controlled by the State and the Groundwater Authorities and there is no provision for user involvement in defining the areas to be notified. The Authority is also vested with the power to take decisions over creation of new wells and usage of water from existing wells. Precisely, the Bill sets up a regulatory system, insulated from local involvement, where power is concentrated at the state-level and formally wielded by the technical bureaucracy. In other words, it does not envision user participation in management decision-making and seeks to limit the scope for user interference. Importantly, this lack of scope for user involvement often limits the ability of the State to take advantage of local concerns and initiatives. Legislative structures, therefore, need to provide avenues for greater users' participation in order to tap local initiatives effectively that could in turn generate management solutions to many emerging groundwater problems.

Finally, the Model Bill is rather limited in its approach of regulating groundwater extraction through direct administrative control mechanisms and thereby overlooks the potential of management opportunities represented by indirect economic levers such as water markets. Resource poor farmers who lack financial viability to construct wells of their own can access groundwater through such water markets. Water markets facilitate redistributing water to highest value uses, particularly during times of scarcity. Importantly, no specific features of the Bill appear to be fundamentally incompatible with the development of water markets. However, the institutional impetus of centralised regulation promulgated by the Model Bill could actually generate a tendency to respond to groundwater problems by attempting to place further direct controls on use. On the contrary, indirect market based approaches could encourage a flexible administrative structure to facilitate private transactions and shifting water to the higher value-lower volume uses. Markets have in fact emerged but the centralised regulatory approach through State control does not address this issue. Nevertheless, the regulations often tend to indirectly influence the functioning of such markets.

Status of state-specific groundwater regulations

As a matter of fact, ever since the circulation of the Model Bill, no State has actually adopted it, except Gujarat and Maharashtra. The states of Andhra Pradesh, Goa, Tamil Nadu, Kerala have also enacted and implemented some groundwater legislation. However, the legislation framed by these States excludes many of the key provisions contained in the Bill and has never actually been enforced in any area. Recently, Andhra Pradesh has made some headway by passing the Water, Land and Trees Act that has been enacted with effect since April, 2002. The following paragraphs discuss a few such state-specific initiatives undertaken to tackle the problem of groundwater over-exploitation (see table: 5).

Andhra Pradesh

In recent years, Andhra Pradesh has seen a sharp rise in the number of energised wells drilled to irrigate cash crops in water-scarce regions, facilitated by the provision of subsidised electricity. Uncontrolled use of borewell technology led to groundwater being extracted at a rate much faster than the rate of recharge. Besides, the existing system of 'water rights' in Andhra Pradesh considers groundwater not as a common resource but as belonging to the landowner. In May 2000, the Water Conservation Mission, or the 'Neeru-Meeru' programme was first launched to tackle the problem of drastically falling groundwater levels and thereby increase total rechargeable water. This programme harped on decentralisation of management and regulation of water resources to local communities by referring to people's participation. More recently (in 2002), the Andhra Pradesh Water, Land and Trees Act has been enacted, which brings into effect a distinct Authority to not only promote water conservation and enhance tree cover but also vested with other wide-ranging and extensive powers which it may, with the prior approval of the State government, delegate to District and Mandal (block) level authorities. As per this Act, wells have to be registered with this new authority which can prohibit groundwater pumping in certain areas and even order closure of wells. The provisions of the AP WALT Act are essentially similar to those of the Model Bill, where the State regulates and controls the level of groundwater extraction and use. In order to regulate the currently irrational use of groundwater, the Final Report of 'the Commission on Farmers' Welfare' which was set up at the end of September 2004 by the Government of Andhra Pradesh, recommended that the State government should aim for the public takeover of groundwater resources. All the existing borewells would have to be taken over, after paying appropriate compensation to the current owners and all new borewells would be dug by and be owned by the state government. Thereafter, water could be provided from the borewells on payment of water cess on volumetric basis.

Gujarat

Gujarat enacted groundwater legislation by partially amending the 'Bombay Irrigation Act' as applicable to the State. The legislation is applicable to nine identified over-exploited districts in the State. Furthermore, unlike the Model Bill, construction of all groundwater extraction structures has not been brought under the purview of legislation. Instead only construction or deepening of wells having depth of more than 45 m has been barred. In 2001, the Government of Gujarat constituted the Gujarat Groundwater Authority to monitor and regulate groundwater extraction and use in the State. However, a model bill to regulate and control the development of groundwater is under still preparation.

Maharashtra

The State through a notification has promulgated an Act titled the "Maharashtra Groundwater (Regulation for Drinking Water Purposes) Act, 1993", which applies to the whole State and seeks to regulate the exploitation of groundwater for protection of public drinking water sources. The Act prohibits sinking of a well by any person or community for any purpose without prior permission within 500 meters of a public water source. The Groundwater Authority constituted by the State has the authority to prohibit, regulate or restrict extraction of water from wells and it can declare any area as ‘water scarce area’ for a period not exceeding one year when it is of the view that public drinking water sources in the area are likely to face scarcity. On declaration of an area as water scarce, construction of wells except for drinking water purposes is prohibited. Essentially, the Act is modelled on the Model Bill of 1970 discussed earlier.

Punjab

The government of Punjab is of the view that enactment of legislation should be deferred because it would have an impact on a very large number of small and marginal farmers. The State government advocates steps such as cropping pattern diversification, restrictions on new electric connections in over-exploited and ‘dark’ areas, introduction of sprinkler or drip irrigation and artificial recharge etc., in order to check over-exploitation of groundwater. In this context, it is important to note that the Model Bill in fact protects the rights of resource poor small and marginal by limiting the ability of affluent larger farmers to make investments in well deepening and construction. In 1998 the Punjab Groundwater (Control and Regulation) Act was framed, but it has remained in draft since then.

Madhya Pradesh

Madhya Pradesh circulated the “Peya Jal Parirakshan Adhiniyam’ as early as 1986 for preservation of water in water sources and for regulation of tubewell construction in order to maintain water supplies to the public for domestic purposes. Under the Act, the Collector has been assigned power to declare any area as a ‘water scarcity area’ for any period in order to maintain or increase the supply of water to the public or to ensure its equitable distribution. Digging of tubewells without permission for any purpose in water scarcity areas is prohibited under the Act. In addition, digging of tubewells in the zone of interference of any tubewell constructed or maintained by the State government or other local authority for the purpose of domestic water supply to the public is prohibited.

Karnataka

In order to regulate the exploitation of groundwater for protection of public sources of drinking water and matters connected therewith, an act tilted 'The Karnataka Groundwater (Regulation for Protection of Sources of Drinking Water) Act' was passed in 1999. However, the Karnataka Groundwater (Regulation and Control) Bill 2002, which has been drafted on the basis of the provisions suggested in the Model Bill, is still under consideration of the State Government.

Tamil Nadu

The State Government of Tamil Nadu has passed an Act namely "Tamil Nadu Ground Water (Development and Management) Act, 2003" which includes provision of Tamil Nadu Groundwater Authority to regulate and control water development in the State. This Act seeks to protect groundwater resources to provide safeguards against hazards of its over-exploitation and to ensure its planned development and proper management in the State. However, the legislation is yet to be adopted.

The above discussion about the status of groundwater legislation in different states of India reveals that despite the promulgation of well-framed regulations to control groundwater over-exploitation, there has been little headway in their actual implementation and enforcement. The State-specific legislations are essentially based on the provisions suggested in the Model bill with suitable modifications as per requirement. Like the Model Bill, they too do not provide much scope for participation and involvement of water users in the decision-making and management process. As mentioned earlier, there could be two possible reasons for failure to enforce groundwater legislations in different states; 1) sensitivity of the State attempting to regulate what, for landowners, is essentially an open access resource and 2) lack of effective mechanisms for implementation due to lack of scope for utilising user initiatives and concerns through their involvement.

Table: 5 below summarises the state-specific adaptation of Groundwater Bill to control groundwater development for a selected few states in India.

Table: 5 Enactment of Groundwater Bill to regulate groundwater development in some States (groundwater-scarce)

State	Legal Status	Comments
Andhra Pradesh	Andhra Pradesh Water, Land and Tress Act (WALT), 2002	AP WALT, 2002 covering whole State has been enacted with effect from 19th April, 2002
Gujarat	Gujarat Ground Water Authority (GGWA) has been constituted by Government of Gujarat in 2001. Model Bill to regulate and control the development of ground water is under preparation.	To be enacted. However, groundwater legislation has been enacted by partially amending the 'Bombay irrigation Act' (applicable to 9 identifies districts only)
Haryana	Draft Bill is under preparation by the State Government.	To be enacted
Karnataka	The Karnataka Ground Water (Regulation and Control) Bill, 2002 is under consideration of the State Government.	To be enacted
Madhya Pradesh	Madhya Pradesh Peyjal Parirakshan Adhiniyam, 1986 for protection of drinking water sources exists. Model Bill to regulate and control development of groundwater is under consideration.	To be enacted
Maharashtra	Maharashtra Ground Water (Regulation for Drinking Water Source) Act, 1993 was enacted to regulate the exploitation of groundwater for the protection of public drinking water sources. Maharashtra Ground Water Regulation Act has also been drafted and being laid on the Table of House	It applies to the whole of the State and has come into force with effect from 10th September, 1993
Punjab	The Punjab Ground Water (Control and Regulation) Act, 1998 has been framed	To be enacted. The Govt. of Punjab however advocates steps such as; crop diversification, restrictions on new electricity connections in 'dark' areas, introduction of sprinkler/drip irrigation, artificial recharge to check over-exploitation, etc. rather than enactment of legislation/bills as it could impact small / marginal farmers adversely.
Rajasthan	Rajasthan Ground Water (Regulation) Bill, 1997 is under consideration of the State Government.	To be enacted
Tamil Nadu	The Chennai Metropolitan Area Ground Water (Regulation) Amendment Act, 1987 has been enacted to regulate groundwater development in Chennai and some of the nearby revenue villages. The State Government of Tamil Nadu has passed an Act namely "Tamil Nadu Ground Water (Development and Management) Act, 2003" which includes provision of Tamil Nadu Ground Water Authority to regulate and control water development in the State of Tamil Nadu.	To be enacted

Preventing Overexploitation:

Means of intervention

In India, broadly four types of regulatory interventions exist to prevent groundwater overexploitation[9]. The first type consists of *state regulation* whereby government introduces rules or incentives that influence the extraction behaviour of individual well owners. The second type of intervention is through *active involvement of government* in the utilization and distribution of water resources. For example, implementation of watershed programs, rehabilitation of tanks to recharge groundwater, channelling of groundwater resources through public tube wells, etc. The third approach invokes *community management* to conserve groundwater. This aims to make use of local level information of the village community to prevent excessive extraction of the resource. The fourth type of regulation is most complex and deals with redefining the structure of *property rights* within which the private sector, the state and the community operate. Finally, it is also important to note that informal *'groundwater markets'* could be quite effective in addressing the twin objectives of equity and efficiency with regard to groundwater management thereby improving accessibility to the resource for meeting agricultural needs.

The following presents a detailed discussion of each of these approaches and their respective advantages and shortcomings.

State regulation

Within this category distinction can be made between 'direct' (imposition of direct control on the use groundwater) and 'indirect' (controlling groundwater use indirectly through other variables such as electricity rates, crop prices and credit policies) regulations.

Indirect regulation:

Theoretically, introduction of 'water rates' irrespective of the way in which water is extracted is the best form of indirect state regulation because it

[9] See for more details; Dhawan (1991), Sengupta (1985), Shah (1989).

would induce farmers to economise water use. Therefore, lowering or increasing the water rate could control the overall extraction rate of groundwater. This system is feasible when water extraction mechanisms are publicly owned, as it prevailed in China prior to the economic liberalisation of the 1980s (Kramer, 1989). However, when most water extraction mechanisms are privately owned, as in India, collection of water rates is practically impossible because of the obvious problems of monitoring and the associated corruption. Hence, concerns regarding the unregulated groundwater resource use (especially in the hard rock regions) have prompted certain state governments to intervene in groundwater management through certain indirect mechanisms. Some of the important indirect interventions to regulate groundwater use in India are:

(i) Credit policies: Credit-related measures for the preservation of groundwater resources mostly take the form of restrictions imposed on the granting of loans for water extraction mechanisms in areas of groundwater scarcity. For instance, in Gujarat, for wells of more than 150 ft depth, a 'No Objection Certificate' is required to obtain loan from the government. However, ever since the introduction of this regulation in 1967, the rules have tended to become less and less stringent over the years. In sum, credit restrictions for the preservation of groundwater resources have made little headway since most of the cases are dealt mostly on political grounds and to this extent a 'No Objection Certificate' remains to be a mere formality. On the contrary, large amount of subsidized credit have supported the expansion of water extraction mechanisms, which has contributed not only to the overexploitation of the resource, but also to its inequitable distribution (due to distributive biases of credit allocation)[10] .

[10] If licenses are introduced to control the construction of water extraction mechanisms, the possession of a license could be made a condition of eligibility for institutional loans.

(ii) Cropping patterns: Cropping patterns depend on a wide range of factors, some of which can be influenced to discourage the more water-intensive crops. However, in India it is rather difficult to raise the support prices of water-intensive crops to conserve water because of political pressures. For, example sugarcane cultivation can cause enormous damage to groundwater resources in areas of scarcity. Since, a tax on sugar would not be feasible, a more realistic measure could be to ban the installation of sugar factories in water-scarce areas, which in turn would curb sugarcane cultivation. Nevertheless, how pragmatic this policy could be needs a careful examination. If sugarcane factories are banned, farmers could divert sugarcane to jaggery production as groundwater use is influenced by input-output price ratio and relative profitability. Based on this argument, rice cultivation under groundwater could be claimed to be a criminal waste of water.

(iii) Electricity pricing: It is commonly argued to be a powerful measure of regulating groundwater use. The marginal cost of extraction is near to zero under flat rate pricing and hence it creates strong incentives against conservation of groundwater. Pro rata pricing, by contrast, imposes a cost on every unit of water extracted and therefore induces farmers to economize water[11]. However, flat rate pricing is associated with certain distributional effects (Shah, 1993) by enabling resource poor small and marginal farmers to access the resource at a reduced cost.

To sum up, each specific measure of indirect regulation tends to raise its own problems. These may include, for instance, political resistance from the big farmers' lobby (as has happened in Gujarat with electricity pricing), undesirable 'side effects' (as would apply to taxing of water-intensive crops if these are also labour-intensive), or inequitable distribution of costs and benefits (when credit restrictions give a few rich farmers the monopoly of water extraction mechanisms). Precisely, the indirect regulations often tend to be ineffective. For instance, if electricity rates

[11] See for more detailed discussion for the equity and efficiency implication of prorate and flat rate electricity pricing; Moench (1995), Narayanmoorthy (1995), Palmer-Jones (1995), Saleth (1997).

are raised farmers can switch to desel engines. If institutional credit is not available for water extraction mechanisms, farmers (especially rich ones) can turn to alternative sources of credit. And support prices have little influence on open market prices, which are far more important in determining cropping patterns. Therefore, indirect regulations alone cannot resolve the problem of dwindling groundwater resources and other direct forms of interventions are also necessary.

Direct Regulation:

Direct state control on private uses of groundwater is also pursued to conserve the resource. For instance, limiting the number of new wells that can be dug in a particular zone, imposing minimum spacing requirement[12] , licensing well digging, banning extraction of groundwater for irrigation in particular areas when the water table falls below a pre-specified level, etc. However, the problem with such control procedures is that of enforcement. The high 'monitoring cost' and 'inefficient bureaucracy' restrain to institute a system of centralised control on groundwater extraction rate. In addition, these controls often have distributional implications. Spacing regulations create and strengthen the monopoly power of existing owners of water extraction mechanisms protecting them from competition from other suppliers and keeping water prices higher than would otherwise be the case.

In practice, the actual effect of such norms and the manner of their enforcement is often inequitable and regressive. When landholdings are small and fragmented, spacing between wells cannot be ensured without denying permission to latecomers whose proposed well may come within the radius of influence of the existing well in an aquifer. This kind of regulation at times becomes regressive, as farmers with comparatively smaller holdings and lower credit potentials are mostly

[12] In Gujarat, for example, a proposed new tubewell is not allowed within the command area of a state tube well or within the radius of 680m of an existing tube well over 150 ft (50 m) deep. The applicant is required to secure the consent of neighbouring WEM owners before an electricity connection or bank finance is provided (Shah, 1993).

the latecomers to an aquifer. Furthermore, since the spacing norms do not apply to a modern water extraction mechanism being located close to a traditional water extraction mechanism, they seek to protect resource-rich early exploiters from late exploiters; but do not offer any protection to existing owners of traditional water extraction menchanisms who are usually poor. Precisely, spacing regulations, which have come in more recently, often serve to exclude the poor who are late entrants into the game. To add to this, since the norms are enforced through banks and electricity boards, the well-off farmers who can finance their own investment and afford somewhat costlier diesel engines remain completely unaffected by them. Unofficial premium on electricity connections are common and often quite high (Shah and Raju, 1988).

Public sector involvement

Aside from regulating the private sector through direct and indirect means, the government can also actively involve in utilization and distribution of water resources through implementation of watershed programs, rehabilitation/rejuvenation of existing tanks for augmenting groundwater recharge, etc. Since economic instruments are by and large non-functional due to political factors, it is important to explore the incentives that are needed to influence groundwater use in water starved areas. For example, technological aspects with regard to importance of drip or sprinkler irrigation in mitigating water scarcity could be addressed appropriately in groundwater policies. Such improved irrigation techniques (drip, sprinkler, etc) could essentially increase water use efficiency by reducing water demand without reducing the services provided. In this context, surface water also needs to be considered apart from groundwater since promoting the former is one possible way of protecting the latter[13]. Usually current government involvement almost exclusively takes the form of constructing and operating public tube wells.

[13] Dhawan (1987, p. 1154) argues that ‘wisdom lies in paying more attention to the development of surface irrigation works, so that a sizeable fraction of surface water end up in the groundwater table’.

Public Tubewells: an example

A major instrument of public policy – State Tubewell (STW) programs – is devised originally to stimulate groundwater irrigation and to ensure that the access to this communal resource is diffused and is not monopolised by the rural elite. It is argued by several scholars (Dhawan, 1982; Sakthivadivel, 1989) that public tube wells have a definite role to play where landholdings are essentially small and fragmented as in the case of water scarce hard rock areas. The line of argument cited above in favour of public tube wells as an institutional alternative, however, loses much of its relevance in the context of hard rock regions in view of their incompatibility on technical grounds. For hard rock regions, open dug wells are technically found to be ideally suited. Average command area of dug wells being rather low (less than 2 hectare), it would mean, in operational terms, government coping with an innumerable number of open dug wells. The other major problem with public tube well programs is their management, efficiency and quality of irrigation service they are able to provide, which have proved to be quite unsatisfactory. Numerous field studies, have pointed out poor maintenance, lack of accountability of the tube well operator of the community, domination by local elite, frequent power cuts, delays in repair and procurement of spare-parts, local feuds regarding the right of passage, etc., are amongst the several problems that STW programs suffer from. This renders the argument in favour of public tube wells weak.

Nevertheless, there are some efforts in selected pockets of hard rock regions to install public tube wells as an institutional alternative. The study done by Satyasai and Dhawan (1989) in Khammam district of Andhra Pradesh pertains to 80 farmers benefiting from public tube wells (located in the command of 12 selected tube wells) of which the majority are small farmers and belong to scheduled castes and tribes. It was found that small farmers did benefit from public tube wells through improvement in crop pattern, crop yields, and cropping intensity. However, overall experience with public tube wells in various regions of the country is quite disappointing from the point of efficiency. As far as equitable distribution is concerned, the rural elite usually succeed in appropriating most of the benefits of public supply (Ballabh and Shah, 1989)[14]. In the light of this discussion, one becomes sceptical about the policy option in favour of public tube wells, more so in hard rock regions where these are found to be incompatible on technical grounds.

Community management

An important alternative to state intervention is that of community management[15]. Democratic village institutions can play the crucial role of allocating groundwater through community decisions, if properly revitalised. This approach aims to enable the village community to make use of the information and control it possesses on local resources in order to prevent depletion. If farmers feel a genuine sense of 'participation' in community decisions, they may be much more inclined to comply with them than with state-enforced regulations.

Community Wells: an example

The disillusionment experienced with the working and performance of public tube wells with regard to both efficiency and equity concerns has led to the search for alternative institutional arrangements for groundwater management. Based on the theoretical premise that involving beneficiaries in the management of groundwater would help to solve problems which public tube wells suffer, certain forms of institutional arrangements like community wells and cooperatives could be advocated in the country. The functioning and management of these forms usually exhibit a mix of both successes and failures, as documented by several empirical investigations. Crucial factors for 'success' of such arrangements (as identified from literature) are the small size of the groups and homogeneity in the group members in terms of caste and landholding, quality of leadership, external support in both leadership, and management.

[14] Ballabh and Shah (1989, p.23) have gone so far as to assert that 'the experience with public tubewells is uniformly and resoundingly disappointing'.

[15] Agarwal and Narain (1989) argue in favour of environmental protection by rejuvenating village institutions e.g. panchayats or gram sabhas.

Whereas factors that caused failures of community wells ranged from the wrong citing of wells, insufficient water yield and inadequate technical or managerial support from the promoting agency (Patil and Kulkarni, 1989; Sathe, 1989).

Community processes may succeed to instil a sense of responsibility for the conservation of a community resource, such as groundwater. This requires a fundamental change in the perceived ownership rights, which in turn makes the approach problematic to implement. It is also important to note that the success of community management largely depends on the cooperation amongst the stakeholders. Their cooperation might arise in two ways. First, if there is a collective gain from the conservation of the resource that is larger than the individual private gains. This condition is, however, unlikely to be fulfilled in case of large farmers, who therefore, tend not to cooperate. Second, the problem of 'free-riders' can be sought through coercion and sanctions (e.g., imposition of fines on those who violate the agreed rules of water use). This is unlikely to work, if community institutions are dominated by those who also stand to gain from the exploitation of groundwater. Unfortunately, in rural India, it is the case that rich large farmers are precisely in that position. Therefore, the potential of this approach appears to be severely limited by the concentration of power in the hands of those who derive private benefits from allocation mechanism that underlies the overexploitation of groundwater.

Property rights

There is a lack of properly specified property rights on groundwater resources in India. In fact, it is extremely difficult to define property rights to groundwater. Customarily, in India, the rights in groundwater belong to the landowner as groundwater is attached to the land property. There is no limitation on the volume of groundwater extraction by a landowner. Since, landownership is a prerequisite to ownership of groundwater (Singh, 1994), it is difficult to assign 'open access' nature to groundwater resource. Although land owners own groundwater, this right is limited by the huge investment necessary to tap the groundwater by construction / drilling of irrigation well(s) and high well failure probability, which makes a selected few among them to have access to groundwater. Unless groundwater is tapped in a well and water is available in it, there is no accessibility, since there is no guarantee that any land owner who attempts to construct / drill a well is assured of groundwater, even for a short period.

As mentioned earlier, the existing structure of property rights to groundwater is governed by the Indian Easements Act of 1982, which has been adopted from the English Common Law (exclusive right of an individual owner to a private property). In contrast, legislation in countries like France, Germany and the United States includes provisions that permit only reasonable use of one's property without any intent to injure the neighbour's. For example, the groundwater governance structures in India and the United States exhibit certain fundamental differences in their principles and performance. As already mentioned, groundwater rights in India allow landowners to withdraw unlimited volume of groundwater from the underlying aquifer regardless of the impact on other landowners. More so, the basic governance structure has remained unchanged over the years, despite the increasing groundwater overdraft problems. In other words, the governance structure is somewhat rigid and static that has failed to adapt itself to the changing groundwater extraction scenario and modify as per required to address the growing groundwater problems. On the contrary, in the United States, the groundwater regulations vary considerably to incorporate one of the four different regimes; common law doctrine of absolute use, reasonable use doctrine, correlative rights doctrine and doctrine of prior appropriation. These doctrines have evolved with the passage of time to address the varying problems of groundwater overdraft in different states. Thus, the regulatory regimes in the United States exhibit some sort of flexibility and dynamism to account for the diversified nature of groundwater overdraft problems. This flexibility in the management system essentially renders more effectiveness to the performance of the regulatory mechanisms as there is a wider scope to deal with the varying nature of groundwater related problems in different states.

Therefore, there is need for a legislative change in India by limiting groundwater extraction over a particular period to the amount of water that percolates through the land over the same time period or by defining some kind of collective property rights over groundwater. However, it is rather difficult though not completely dismissible, to define and legally enforce such property rights. Also, some fundamental changes with regard to redefining property rights structure are required which should exhibit certain extent of flexibility and dynamism so as to appropriately address the varied nature of groundwater related issues in the country.

Social ownership of wells – a 'mixed' intervention

Socialising wells even if motors continue to be privately owned is another form of intervention to control groundwater overexploitation. Such socialization of wells have major advantages like, 1) prevention of overexploitation since public control could be exercised on the number and depth of wells in a particular area; 2) reducing problem of well interference by facilitating rational location of wells through coordinated planning; 3) equitable distribution of groundwater as large farmers would not have virtual monopoly of access to this resource; 4) transferring the risks in drilling wells from private individuals to community or government; 5) facilitate emergence of community management. Nevertheless, it has been largely overlooked in the literature on the management of groundwater resources.

Groundwater markets

Groundwater markets, in which farmers buy and sell irrigation water, provide one of the most promising institutional mechanisms for increasing access to and use of groundwater for irrigation (Moench 1994). Well-developed groundwater markets hold possibilities of achieving the twin objectives of efficiency and equity in groundwater use (Shah, 1989; 1993). In much literature, the term 'water market' has been used to describe a localised, village-level informal arrangement through which owners of WEMs sell irrigation services to other members of the community. Empirical research indicates a variety of contract forms and a wide range of prices in groundwater markets. Buyers may pay for water by providing labour, or a share of the crop, though the tendency is to move towards a cash charge per hour of water supplied as groundwater markets develop (Chaudhry 1990; Shah, 1991).

Groundwater markets make it possible for those without wells to use groundwater for irrigation. This improves equity of resources because it is generally the smaller farmers who do not own tube wells. The opportunity to sell groundwater can make it profitable for farmers to invest in wells even if their own holdings are too small to use the full pumping capacity (Shankar 1992)[16] . The expansion of irrigation through groundwater markets has also led to increases in cropping intensity and the demand for agricultural labour, which ultimately benefit the landless and those who rely on wage labour for household income. For example, increased employment opportunity is one of the biggest advantages for landless members of pump groups in Bangladesh (Wood and Palmer-Jones, 1990). Some researches of groundwater markets have, however voiced concern about who appropriates the gains from irrigation (Pant 1991, Janakrajan 1994). The prospect of exploitative 'water lords' may arise, especially where control over water through well ownership reinforces inequality based on land and other assets (Barah, 1992). In South Asia, de facto ownership of the resource is accorded to the owners of the wells that lift the water. This in turn requires a considerable investment in wells and pumps, as well as ownership of at least some land above an aquifer. Janakrajan (1994), based on studies in Tamil Nadu, argues that as a result of this unequal access to resources and the poor bargaining capacity and dependent status of water purchasers vis à vis

[16] The thrust of empirical research on groundwater markets in India has underscored the superiority of the institution of groundwater markets over public tube well system in catering to the irrigation needs of small and marginal farmers (Dhawan, 1991).

water sellers, a few farmers emerge with power to exercise control over the groundwater resources and extract surplus. However, the well owners' extraction of monopoly rents from water sale is most likely to be problematic where the water markets are not competitive. Since topography and the distance between the source and field restrict water transactions, market competition is more difficult to achieve. Importantly, the availability of groundwater resources and alternative irrigation supplies can reduce the seller' monopoly power and hence the price of water (Shah 1991). Groundwater markets are contestable, especially where water tables are high[17] .

Availability of water resources, scale and quality of adoption of irrigated farming technologies, progress of rural electrification, quality of power supply, and extent of land fragmentation are among the factors that seem to influence the pace of development of water markets. In many hard rock areas (e.g., parts of Karnataka), where water yields are low, a variety of inhibitions and taboos prevent WEM owners from sharing water with others. In contrast to this, in some hard rock areas of Tamil Nadu (Madurai district) water markets are fairly well established, the facilitating factor being the attractive economic gains derived from modern crop production technologies (Copestake, 1986). These contrasting responses within the hard rock regions underline the need for studying salient conditions that would stimulate water markets where they do not exist.

The social effects of water markets depend on: a) the extent to which water markets have developed, b) the efficiency of market transactions, and c) the fit between the groundwater endowment of a region and the system of appropriation implied by water markets. Where water sellers enjoy a high degree of monopoly power, they can skim the

[17] Shah (1989) has reviewed the water market research in India. He has noted that most of the Indian work on water markets has been heavily concentrated in Gujarat. Also, in many water scarce areas, especially in the southern peninsula, water markets are either non-existent or in primitive forms.

bulk of marginal value product generated by irrigation service on the buyers' field. In contrast, a seller operating in an efficient water market will be under pressure to sell more water to more buyers and, in the process, to cut the price to the level close to his average economic cost of pumping. This will generate a larger irrigation surplus and better livelihoods for the resource poor and landless, and still sellers as a class may not necessarily earn less total profit than in the former situation.

Summary

The depletion of groundwater resources is an alarming and urgent problem in some water scarce parts of India. In addition, there are profound connections between the overexploitation of groundwater resources on the one hand, and the inequitable distribution of economic gains and political power on the other. This is perhaps of the fact that rights to groundwater in India are entirely derivative on ownership rights to land. Therefore, as long as land itself is privately and unequally owned, the scope for achieving an equitable and sustainable use of groundwater is limited. Precisely, the equity and efficiency concerns regarding the use and management of a common property resource like groundwater form the basis of alternative institutional arrangements that have evolved in the water-scarce regions of India. In view of the varying field situations, there is also a need for evolving location-specific solutions to the problems of the use and management of groundwater. However, there is no quick and simple solution to the problem. It is clear from the above discussion that, in practice only a combination of different forms of interventions can make significant dent on the problem. Therefore, state regulation, community management, market forces, etc. should not be seen as mutually exclusive measures.

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