WATER PRAXIS DOCUMENT Nr. 14

Local groundwater regulation

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FOREWORD

The challenges in water management are enormous; the efforts required to avert the water crisis from deepening will have to be commensurate.

At ARCADIS Euroconsult, 'water' has always been at the core of our activities. We try to make things that work and try making things work - from water resource development to institutional improvement. As a result, we have substantial experience from praxis, from 'the waterfront': the small concepts that are required to translate big ideas into practice. In the *Water Praxis Documents,* we are attempting to document and share that experience.

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Failed groundwater governance: irrigation by water tankers

Acknowledgements

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Groundwater governance being developed: participatory hydrological monitoring

ABSTRACT

This document reviews the scope for local regulation in intensively used groundwater systems. It brings together a number of examples of local management of groundwater from various socio-political backgrounds: Pakistan, India, Egypt and Mexico. The examples are few and far between and show a mix of failure and success in demand and supply management of groundwater. Yet in the cases where local regulation has worked, it has often been the only thing that did so. The examples also show that - in contrast to conventional policy recommendations - effective groundwater management can occur without quantified groundwater rights and without central regulatory power. To support local regulation, either as a complement or alternative to central regulation, the document makes the case for bridging the knowledge gap - making hydrology less esoteric - and casting the net wide in awareness building, increasing the chance of finding local champions and movers and shakers. The document also recommends enabling rather than regulatory legal frameworks to underpin local management; the promotion of demand and supply management measures (for which there is still often considerable scope) and more emphasis on the local protection of groundwater quality.

1 COMMUNITY MANAGEMENT IN GROUNDWATER

1.1 Rights and registration

With groundwater centre stage in agricultural development in Central America, South Asia, China and North Africa and important pockets outside these regions, the need for managing rather than just developing groundwater is increasingly clear. Groundwater is the main stay of large agricultural economies and a major source of drinking water in many rural areas, towns and even mega cities. However, declining water tables, saline water intrusion, increased levels of arsenic and fluoride in drinking water, land subsidence are all pointers to resource management that needs to be set right.

The concerns over groundwater utilization have the ring of the infamous 'tragedy of the commons' - unlimited access to a common pool, leading to its decline. Solutions advocated remind one of the old 'tragedy' discussions: defining access - registration of abstraction points, issuing permits, defining groundwater rights (even tradable groundwater rights). But the real drama appears to be that not many of these rights based solutions are around in practice.

Take this quote from a recent World Bank technical paper, for instance. While advocating the importance of regulating groundwater through defining rights, it also makes the point that: 'The technical, administrative and social aspects of rights definition pose a major difficulty.

First, groundwater systems are often poorly evaluated and monitored and the quantitative basis for defining rights tends to be weak.

Secondly, in some countries the number of wells that would need to be monitored is extremely large, many being located remotely on private land.
Thirdly, water rights systems are socially complex and often based on deeply-embedded cultural values' (Foster et al, 2000, 68). Add to this the weak enforcement that prevails in many parts of the world, exemplified by the fact that many wells have for years been illegally connected to the electricity grid or have very large dues and the case for external regulation and defining groundwater entitlements becomes weak.

1.2 Local regulation

Local regulation - decentralized collective management of groundwater resources by water users - is often mentioned as the alternative option. It is either advocated as a self-standing solution, or proposed as a complement to external regulation. The same technical paper, quoted above, for instance states that: 'Where feasible, active self-governance is (in the long run) preferable to the imposition of government rules' (op. cit., 63). There are indeed examples from high-income countries, in particular the

American West and Spain, described by Blomquist (1992), Smith (2002), Hernández-Mora et al. (2002) among others, where groundwater users have, with various degrees of success, federated to safeguard the sustainable supply of water.

This document concentrates on countries with poorer economies. With the poorer economy usually comes a greater dependency on agriculture, a larger number of groundwater users and in general weaker external enforcement mechanisms. What is the scope of local regulation in groundwater in these circumstances?

To explore this question the document examines a number of examples of local groundwater management from Pakistan, India, Egypt and Mexico. These examples of local groundwater management are still few and far between - dots in a sea of no management. Furthermore, there appear to be no examples of groundwater users regulating groundwater quality, nor are there cases of local regulation in areas with large, unconfined aquifers.

Yet, particularly in areas with shallow, semi-confined aquifers, collective management systems have come about, home-grown usually, sometimes quite rudimentary, but what is more important in some cases on a scale that matches the extent of groundwater overuse. Particularly where the impact of recharge or pumping is immediate and dramatic, local regulation has developed. Often, the local rules concern the shallow water-bearing strata or the groundwater travelling down to the aquifer proper. For this reason, it makes sense to distinguish between groundwater management and aquifer management.[1]

The focus is on groundwater management here. The next section documents a number of cases of local groundwater management and looks into the mechanisms that caused the local regulatory institutions to come about, become effective or disappear. The two cases from India describe groundwater recharge movements, augmenting supply. In Pakistan, Egypt and Mexico, the focus is on regulating demand. In the Mexico and Egypt example, organizations developed, whereas in the Pakistan and India example, management was by norms that developed in response to intensive groundwater use. The different political systems may explain the difference with the sometimes rowdy democracy in South Asia giving space to popular movements, whereas the more sanitized one-party rule in Mexico and Egypt are more likely to translate into organized organizations.

On the basis of the cases, an attempt is made to find the common denominators in the geographically and politically diverse examples and analyse what makes local regulation work and where it is constrained. The document ends by summing up a number of ideas on promoting local regulated groundwater management.

[1] The concept of aquifers is often deceptive – a massive water system, recharged over a considerable period of time, in danger of irreversible decline. Such systems require nothing less than organizations covering large regions and working on long time horizons to reverse the tide. In reality, groundwater systems are often patchworks of small semi-independent systems, covering several layers, some with a short, some with a long response time.

Case	Country	Size	Type of management	Measures
Mastung	Pakistan	2-3,000 ha	Informal, committee	Spacing rules, zoning
Panjgur	Pakistan	2-3,000 ha	Informal norms	Ban on dugwells
Alwar	India	Scattered	Community organization	Recharge, regulation of wells
Saurastra	India	Scattered	Informal norms, leadership	Recharge, regulation of wells
Salheia	Egypt	1,000 ha	Water user association	Common network, ban
Costa de H.	Mexico		Groundwater association	Water saving measures
Querétaro	Mexico		Groundwater association	Water saving measures

2 CASES

2.1 Balochistan, Pakistan

Groundwater development in Balochistan, Pakistan's great south-western desert, has a long history. The area is arid in the extreme (50-400 mm rainfall annually) and has little surface water. For a long time, scattered springs, minor rivers, animal-driven Persian wheels and particularly *karezes* sustained small residential agriculture. These *karezes* (called qanats in neighbouring Iran) are engineering marvels. They consist of a string of shafts connected through a tunnel. The tunnel picks up water from a motherwell - either an underground spring in the piedmont zone or a subsurface flow on the bank of a temporary river. It then conveys water over a length of 500 to 3,000 m before it emerges close to the agricultural command area. The cost of establishing karezes is high and in most cases prohibitive for individuals. The systems were typically constructed on a collective basis - either by the future owners or by a team of specialist kareze developers working on behalf of farmers-investors. A typical kareze in Balochistan will yield anything up to 200 litres per second and will serve a maximum of 200 shareholding families. Not only establishment costs are high: kareze maintenance is equally expensive. The cooperative strength of the kareze shareholders is thus constantly put to the test.

In the second half of the 1960s, dugwells became a popular alternative to karezes. A range of government programmes that provided subsidized equipment to farmers stimulated this development. Groundwater supplies were considered to be limitless. The vision in these days was to turn the arid land into a green oasis with the aid of pumped groundwater. In addition to the installation of subsidized dugwells, groundwater usage was further promoted through the provision of cheap electricity, as elsewhere in South Asia.[2]

For ease of collection of dues, moreover, a system of flat rates was used for most electrified tubewells, which further encouraged intense pumping. To that, the low (minus 50%) recovery of electricity charges can be added, with farmers assuming an almost 'riparian' right to the electricity grid crossing their land. By the 1980s, dugwell and tubewell development had gathered an enormous momentum.

In many valleys of Balochistan, karezes started to collapse. Groundwater reached below the level to which the tunnel section of the karezes could be deepened. This left no choice but to develop dugwells to chase the falling groundwater table. Where these fell

[2] Energy subsidies to tubewell owners persist in most South Asian countries in spite of an increase in areas with overdraft and water quality problems. In India an estimated USD 6.5 bil-lion is spent annually on subsidized agricultural power supply (which includes 'leakages' on account of flat rates). On surface irrigation development and flood protection, an estimated USD 4 billion is spent annually and on watershed improvement USD 0.5 billion.

dry, the quest for water was continued with tubewells with submersible pumps. In some places, however, such as Kuchlak in Quetta Valley, even tubewells have hit rock bottom. The demise of karezes and the proliferation of private wells have often been construed as the victory of the individual over the collective. In this theory, the first to release their share in the communal systems were the larger farmers, who had the resources to develop a private well. The heavy burden of maintaining the drying kareze then fell increasingly upon the smaller farmers. This was true in many cases, but another part of the story is that it was often the have-nots, the farmers who did not have a share in the kareze who were the first to use the opportunities offered by the new technology. At the end of the groundwater rush, however, in several valleys there was a concentration of access to groundwater in the hands of rich farmers. This happened in particular in those areas; where with groundwater tables falling drastically, only deep tubewells can now produce water. Cost of a deep tubewell is in excess of USD 10,000. This is a price, which only few can afford.

Neither under customary law nor under government jurisdiction, did rules exist to control the decline in groundwater tables and the resulting concentration of access to groundwater. Nor did any government organization have a mandate to handle groundwater management. In response to the crisis, the Government of Balochistan issued a Groundwater Rights Administration Ordinance in 1978. The Ordinance - as several others of its kind - established a procedure for licensing wells. These were to be sanctioned by District Water Committees with the possibility of appeal to a Provincial Water Board. A special and unique feature of the Ordinance was that licensing had to be based on area-specific guidelines. Unfortunately no such area-specific guidelines were ever formulated, if only because it could have provided a welcome opportunity to discuss groundwater management strategies. Instead, everything was left to coincidence and the Ordinance was hardly ever used, in spite of a dramatic decrease in groundwater tables in many parts of the Province.

There were two valleys that have been an exception to the seemingly unstoppable course of events. First was Mastung valley, separated from Quetta, the capital of the Province by the Lak Pass. Karezes had sustained perennial irrigation in Mastung for several centuries. This was changed as elsewhere in the Province when diesel-operated centrifugal pumps were gradually introduced in the late 1950s and early 1960s. Their impact was not immediately felt, but in the mid-1960s after a spell of dry years, the flow of several karezes started to decline. Conflicts between kareze shareholders and dugwell developers became frequent. A number of local leaders imposed a ban on well development in the area, which was considered the recharge zone of the karezes. Disputes, however, continued, inducing the local administration to formally ask the tribal elders of the area to formulate rules on groundwater use. In 1969, a meeting was convened. At this time, the interests of the kareze owners prevailed, if only because they outnumbered the new dugwell developers. The dugwell-free zone was confirmed, yet at the same time it was decided not to allow any new karezes either in this zone. Outside the zone, minimum distances were specified and a permit procedure was agreed. The latter was not put into practice. Apart from the rules, a panel of three important elders was nominated to oversee the rules and the permits. They, however, found little time to devote to their duties and, after a few years, the responsibility shifted to the civil administration.

Though the rules were by and large enforced, the tragedy was that they were not strict enough and could not prevent overdraft. From the mid-1970s, the annual decline in groundwater tables was 0.7 m. With several large karezes beyond salvation, this type of irrigation became more and more derelict. Slowly also the political clout of the kareze owners eroded. A number of attempts were made to exploit loopholes in the Groundwater Rights Administration Ordinance and get a formal permit to develop wells in the dugwell free zone. This finally happened in the 1990s. It also signalled the end of the karezes in Mastung and the local groundwater use rules. Ironically, the Ordinance issued to facilitate groundwater management signalled its undoing in Mastung.

The second valley where local regulating groundwater management came into existence - but more successfully - is Panjgur, part of Makran Division. In the past, most of the land was irrigated by trenches (*kaurjo*) that were dug in the bed of the Rakshan River, the main stream in Panjgur. In recent decades, however, these flood-prone systems were replaced with karezes, feeding on the subsurface flow of the Rakshan or the infiltrated run-off from the surrounding low hills. The rapid expansion of karezes in Panjgur is almost an anachronism. It is rooted in a number of socio-economic changes - the disappearance of the local feudal overlords, the inflow of cash from remittances by manual labourers working in the Gulf States, leading to a sudden emancipation of former have-nots with the capital to invest in water resource development.

Concomitant with the expansion of kareze irrigation, a rule came into being that put an all-out ban on the development of dugwells and tubewells. The restriction did not extend to new collectively owned karezes. These could still be built, effectively giving everyone an equal opportunity to access groundwater. The rule came into force after kareze owners in Panjgur had witnessed the rapid decline in the groundwater table in other parts of Makran and the disastrous effect this had had on the karezes.

The limitations on the development of dugwells were widely understood, but not precisely formulated. They differ between villages, but a minimum distance of 5 km from an existing kareze is used in various places. After some upheaval, drinking water supply wells were exempted from the ban. The implementation of the ban is highly informal. Basically each kareze owner has the moral right to intimidate each potential investor in a dugwell. If this has no effect, the local administration is approached, that invariably sides with the majority group of kareze owners, if only out of law and order considerations. The groundwater rules in Panjgur have the character of a social norm.

They are not supported by a special organization and no attempt has been made to define them individually. The rule rights simply consist of an embargo on certain groundwater abstraction technology; it does not discriminate between prior and later users. This has undoubtedly helped to have the norm enforced by social pressure.

2.2 Rajasthan, India

Very similar in aridity to Balochistan is the Indian state of Rajasthan. Western Rajasthan, constituting large part of the Thar Desert is mostly arid. With annual rainfall of 300-500 mm, Eastern and Southern Rajasthan are semi-arid with pockets of extensive groundwater overdraft. In Eastern Rajasthan, many NGOs have been able to catalyze community action in rainwater harvesting and groundwater recharge. Some of the most notable work of this kind is by such NGOs as Tarun Bharat Sangh and PRADAN, which offer important lessons about alternative modes of organizing community-based groundwater resource management.

PRADAN, a multi-state NGO, began working in Alwar District in the 1980s with the local administration in Kishangadh Bas to improve the implementation of anti-poverty programmes. Following this beginning PRADAN, Alwar developed a water conservation project in the Mewat region that aimed at the revival of the traditional *Pal* system of rainwater harvesting. A Pal is a bund built along a contour and in many ways is a miniature version of a tank but without sluice gates and canals. A typical *Pal* is made of earth, around 8-12 ft high and around 12-15 ft wide at the base; but some of the larger *Pals* are 80-100 m long. Grass or vegetation is grown along the sides so that the soil erosion is minimized; and the top of the bund is used as a cart road. PRADAN helped build over 110 pals in Alwar in a watershed planning framework with some watersheds having several *pals*. The development of the recharge structures was preceded by an intense effort at developing democratic and representative community organizations.

The *Pals* serve a number of functions:

a) they prevent the massive soil erosion that floods otherwise cause, making the plains as bare and rocky as the surrounding hills;
b) by reducing the velocity and force of rainwater run-off, they greatly reduce the pressure that the floods would place on the dams constructed downstream;
c) they make the flood waters spread over a larger area than was previously the case; and
d) each *pal* forms a mini-tank of shallow depth; water stays for 50-60 days during which over 60% percolates to the shallow aquifer while the rest evaporates. The last two ensure large-scale recharge of groundwater-bearing strata and facilitate well irrigation.

PRADAN has been able to build on a modest scale without losing out on quality. Tarun Bharat Sangh (TBS), operating in the same district, has used a different approach to community participation in local water management. In its Johad building programme, TBS has achieved what most NGOs want but fail to - scale. They work in roughly 550 villages spread over 5 subdivisions of Alwar district. In comparison, its efforts at developing community organizations have been less intense and comprehensive. The water harvesting work of TBS covers approximately 6500 km² area; and therefore its impact is visible to outsiders as well as to people living in these villages. It has been working with a variety of water harvesting structures including bund (bunds), *johads* (small ponds or reservoirs), *medbundi* (farm bunds), etc. However, the centrepiece of their work has been the johad. They have built around 2,000 of these already. They began slowly at a rate of 20/year but have gathered momentum and since the mid-1990s, have done around 350-400 every year.

A *Johad* basically is no different from the *Pals* that PRADAN works with. Its purpose is to check rainwater in gullies and riverbeds, impound the water so checked for 50-60 days while the land in the submergence area 'drinks water, quenches its thirst and fills up its stomach like camels do' (as the local farmers would say). Spill-ways called uparahs are provided to allow excess water to overflow. After the water dries up, crops are grown in the '*peta*' lands; and wells get recharged so that additional irrigation becomes possible. *Pals* are designed similarly. However, *Johads* are invariably designed as semi-circular structures; whereas *Pals* are normally straight bunds. Essentially, there is no difference. Both are low-cost, but priceless devices for capturing, storing and optimally using limited rainfall in an undulating topography.

An important lesson TBS's work offers in development is that scale begets scale. Once the benefits of development work become visible and talked about amongst villages, demand for similar work emerges on its own; and once a demand system gets created, half the job of eliciting farmer participation is done. TBS has built large concentrations of *johads* in areas where they began working in 1985 or thereabouts. These concentrations have produced what many believe are demonstrable impacts on farm economies as well as the ecology of these areas. Wells which a few years ago were completely dry or could hardly be pumped for an hour a day now abound in water and can be pumped for as long as farmers need them. Several small rivers and numerous natural streambeds that had dried up for decades have suddenly sprung into life and many flow perennially. Farms which had not been cultivated and given up as wasteland have begun growing crops like *arson*, wheat, *make*, etc. To TBS's endless worry, some sugarcane cultivation has also begun. Many abandoned wells have been recommissioned. And an area, which had become a lost cause, has become green and is poised on a reverse road to prosperity. Even up-lying lands, which did not yet benefit from TBS's interventions seem to command a better market price. Some of the prime land in areas with *johad* concentration has shot up to USD 10-1,2000 per ha.

A major impact of *johad* concentrations has been in checking both floods as well as droughts. In the parts of Alwar district which have a dense concentration of TBS supported *johad* and other water harvesting structures, the effect of the 1996 flood was minimal or absent all together; elsewhere, floods devastated villages, destroyed *pucca* bunds and in general created great havoc. So their earlier surmise that *johads* are effective drought-proofers was surpassed by this experience. A dense system of *johads* cuts the pace and fury of sheet flows that race down the hills at a fearsome speed and force, and thus pre-empts what might otherwise become a flood.

TBS's works are cheap compared with government structures. A couple of mid-sized *pucca bunds* cost only around USD 700 each besides farmers' contributions. The same *bunds* would have cost USD 9-14,000 at least had they been built by the Irrigation

Department. In the areas where *johads* are built in clusters, surrounding areas have become lush green and rapeseed yellow; wells had water at 3-4 m; the number of diesel pumps had begun soaring, and small streams and rivulets had begun flowing. The traditional institutions of managing water harvesting structures were beginning to be revived pretty much on their own; and there was an enhancing of water retention. In Hammirpur, for instance, the land under the *bund* belonged to a private farmer; the village Gram Sabha persuaded him to give his land for building the *bund* and compensated him by creating a new holding by cutting up small pieces from the lands belonging to farmers in the submergence area.

Several lessons emerge from the comparative experience of PRADAN and TBS. First, PRADAN's emphasis on building sustainable local institutions improved the quality of their work but checked the speed and scale of their work; in contrast, TBS's functional approach to building ad hoc local organizations helped them quicken and upscale their work. Secondly, building water-harvesting structures in clusters enhanced the impact of each in impounding water, checking flash floods and recharging the aquifer. Finally, as communities got involved in 'producing' water, new norms on water management, appropriation and use began to emerge which were absent when water was seen as gift from God.

2.3 Saurashtra Gujarat, India

By far the most energetic and inspired response to the intensification of groundwater scarcity globally has come in the form of a mass movement for well recharge and water conservation in Saurashtra in Gujarat (India). As with Rajasthan and Balochistan, Gujarat is a low rainfall area. Even more than the other areas, it has seen a widespread decline in groundwater tables, bringing with it added problems such as fluorosis.

The Saurashtra recharge movement was catalyzed first by the Hindu religious teacher Swadhyaya Pariwar and subsequently joined by other sects of Hinduism as well as by scores of NGOs and grassroots organizations in the aftermath of the three-year drought in 1985-1987. Way back in 1978, speaking at the inauguration of a common property forest (*Vriksha Mandir*), another charismatic leader, Pandurang Shastri Athawale, or *Dada* as he is popularly known amongst his devotees, had told his followers: 'If you quench the thirst of Mother Earth, she will quench yours …'. This teaching was found prophetic, but 10 years later the warning seemingly became true. The three successive drought years that Gujarat - in particular, Saurashtra and Kutch - faced in 1985-1987 brought water issues to their cyclical peak in the public mind. Taking a cue from Israel, Pandurang Athavale began asking his followers why can farmers in North Gujarat and Saurashtra not adapt and improvise on the techniques used the world over for harvesting and conserving rainwater in situ. 'The rain on your roof, stays in your home; the rain on your field, stays in your field; rain on your village, stays in your village', was the talisman he gave to the people of Saurashtra. Many Swadhyayee farmers began trying out alternative methods of capturing rainwater and using it for recharging wells.

In the 1989 monsoon, there were isolated experiments throughout Saurashtra; but in some *Swadhyayee* villages, the entire community tried out such recharge experiments on all or a majority of the fields; and here, they found the results stupendously beneficial. The beneficial results of early well recharge experiments by *Swadhyayee* communities began to be communicated and shared widely in 1990. Come 1991: the well recharge experiments began multiplying in scale. 1991 was a good monsoon, which helped these experiments to succeed. It was in the 1992 monsoon that these recharge experiments began taking the shape of a movement. Farmers of all hue — *Swadhyayees* and others — began collecting as much rainfall as they could on their fields and in the village and channelling it to a recharge source. This was exactly opposite of what they had done for ages so far; during the monsoon, the standard operating procedure was to divert rain-channels to a neighbour's field or a common land or a pathway; not now; now everyone wanted to link all natural water-carrying channels — on private, public or no-man's land — to his well or farm pond for recharge. Stories began doing the round inside and outside the *Swadhyaya Pariwar* about groups of Swadhyayees building check dams or deepening tanks or building anicuts or working together to recharge all private wells in the village. By now, many small and large NGOs joined the movement, each trying to help in its own way. A resource centre (Saurashtra Lok Manch) compiled information on technologies used by different groups of farmers for well recharge, printed it along with illustrative pictures and made these leaflets available in every nook and cranny of Saurashtra. The well-recharge movement had caught on like wildfire; and now, it was not just *Swadhyayees*; farmers of all persuasions joined in.

After 1995, many local NGOs took to groundwater recharge activities in a big way. Another major influence was that of diamond merchants in the city of Surat. Over 700,000 households in Saurashtra depend on the diamond industry for all or part of their livelihoods. While most Saurashtrians work as workers in diamond cutting and polishing units in Surat, some hit it big as diamond merchants and acquired great riches. All these have strong roots in Saurashtra; and recently, diamond merchants have been at the forefront of Saurashtra's recharge movement not only as resource providers but also as catalysts and organizers. More recently, the Government of Gujarat's 'check dam' scheme - under which government contributes 60% of the resources required to build a check dam if the village comes up with the other 40% - has provided a further stimulus to the popular water harvesting and recharge movement. Some 12,000 check dams of various sizes have been constructed under this scheme.

There are no formal studies of the actual scale of the well recharge work; however, many different sources suggest that between 1992 and 1996, between 92,000 and 98,000 wells were recharged in Saurashtra; and some 300 *Nirmal Neer* (farm ponds for recharge) were constructed. *Swadhyaya Parivar* workers were so enthused that they set themselves a target of over 125,000 wells and over 1,000 farm ponds during 1997. It is widely believed that if 500,000 wells in Saurashta are recharged, the region can solve its irrigation as well as its drinking water problem.

Two aspects of the well-recharge movement are significant: first, the dynamic of the movement, especially with respect to appropriate technological innovation in water harvesting, conservation and recharge; and secondly, why did it succeed in attracting as broad a people's participation as it seems to have. According to some observers, since 1992, several dozen new methods have been designed for capturing rainwater, conserving it and using it for recharge. In terms of complexity, these are no big deal; most of them are improvisations on old methods; but they have been devised by farmers experimenting, learning, improving, perfecting and then propagating. The *Swadhyaya Pariwar* has an ingenious communication machine that propagates information on new techniques widely and rapidly; Shamjibhai Antala of Saurashtra Jalsewa Trust, acted as a one-man communication machine, taking the message of well recharge from village to village. The basic technique of well recharge is simple and involves drawing channels to direct all the rainwater in a sump or sink-pit (typically 1.2*1'*1 m) made beside the well; a channel is made from the sump to the well 15 cm above the bottom of the sump so that dirt and soil in the water settles at the bottom and the water that flows into the well is free of them. Over time, the well-recharge movement has brought in its wake a veritable revolution in experimentation and improvisation in recharge techniques. Starting with wells, the movement began encompassing other recharge sources such as rooftops, water logged land, soak pits, rivers, tanks. Also, starting with *Swadhyayees*, later Swaminarayan Sampradaya and other religions sects played a crucial role in capturing this continuous learning in print and propagating it across the countryside. What makes this a movement is that none of the participating organizations play a domineering role in supporting or spreading the activity; thus in most senses, the movement is self-orchestrating, self-coordinating and self-propagating.

Why did the well recharge experiment catalysed by the *Swadhyaya Pariwvar* and crusaders such as Shamjibhai Antala grow into a movement? Several reasons can be advanced; but the correct response is probably a combination of several of these.

- First, the strong allegiance of core *Swadhyayees* to Athavale, and their readiness to give his ideas a serious try catalyzed the first generation of well-recharge experiments in Saurashtra.

- Secondly, Athavale 'marketed' the message of well recharge in the package of instrumental devotion; at no stage in the early years did the *Swadhyayees* ask farmers to recharge their wells because it was economically profitable; they untiringly cited Athavale's teachings that, 'if you quench Mother Earth's thirst, she will quench yours'; this helped to underplay the economics of well recharge in making up the individual mind; early pioneers undertook recharge experiments as an act of devotion to God and to follow the path shown to them by *Dada*.

- Thirdly, the fact that Athavale's ideas about well-recharge had to do with one of the most pressing, urgent and critical problems facing the people of Saurashtra explains why the movement took off in Saurashtra rather than in districts like Kheda or Baroda which are also *Swadhyaya* strongholds.

- Fourthly, and critically, the spread of the *Swadhyaya* movement is in the form of communities. In numerous cases, there are entire villages that have turned to *Swadhyaya*; even otherwise, in the countryside, it is more common to find a group allegiance to the *Swadhyaya* movement than by scattered individuals. This meant that in early recharge experiments, either the entire village or a substantial proportion of a village's farmers agreed to participate. As in the Alwar case described above, this helped the community to internalize the positive externality produced by each recharged well. If, instead, only isolated farmers had recharged their wells individually, it is doubtful if the early results would have been as strikingly beneficial as they were found. That the internalization of the positive externality of well recharge has produced a powerful 'snowball effect' on people's participation is evident from the experience of many villages.

- Fifthly, post-1994, however, the large-scale adoption of well-recharge through promotional and extension effort of NGOs and other religious movements was facilitated greatly by widely shared reports about highly beneficial productivity and income effects of well-recharge programmes on farming. It was at this stage that the driving force of the movement began to change gradually; well recharge as an act of instrumental devotion began to get replaced by well recharge as a technically rational economic act as the movement began spilling out of the *Swadhyaya Movement* and *Swaminarayan Sampradaya*. Probably, even amongst the followers of these, there was an added economic impetus to do the devotional act.

- Sixthly, and finally, post-1995, the scale of participation - and the resulting momentum - that the movement has achieved spontaneously itself have been a powerful engine for the movement's growth. In terms of the theory of externality, the reluctance of the individual farmer to invest in well recharge is explained by his inability to internalize the positive externality produced by his investment. However, if a substantial proportion of farmers take to well recharge, it progressively makes more and more sense for the farmer on the margin to recharge his own well.

Following the investment in recharge structures, basic ground rules on how to use groundwater developed in a number of - though not many - places in Gujarat. One of the ground rules in water harvesting and groundwater recharge work by diamond merchants in Saurashtra, for instance, establishes that nobody pumps water directly from water harvesting structures. Utthan, a local NGO has also met with successful experience in Rajula where people in several villages have accepted the norm of not allowing tubewells deeper than 65 m. In Panch-tobra village of Gariadhar taluka, the community agreed that no new wells would come up within 30 to 100 m of the water harvesting and recharge structures constructed. In Dudhala, the local drinking water and recharge committee issued a ban on drilling wells within a 60 m radius of a recharge structure and no wells beyond 20 m depth were allowed (Kumar 2001).

Similarly, Shamjibhai Antala has asserted that 15 villages in Amreli and Bhavnagar have adopted a new social contract for more responsible water use after water harvesting and recharge structures have been constructed.

2.4 East Delta, Egypt

The vast majority of farmland in Egypt depends on surface supplies from the Nile. Faced with a finite water stock, but a burgeoning population growth, the Government of Egypt is trying to increase the land under irrigation, among others by the reuse of drainage water and increased use of groundwater. In the development of new area, the Government of Egypt has followed a policy of giving out land concessions to private investors - both small- and large-scale.

One such area is Salheia in the East Delta. Landowners, many based in Cairo, purchased smallholdings, in anticipation of the extension of the surface irrigation network to this area. As the development of surface irrigation was considerably delayed, many found an alternative source of water in developing shallow wells, tapping the shallow groundwater (20 m) at the fringe of the irrigated area. As the recharge of groundwater of the area was limited, the different well owners, however, soon found pumping operations interfering with one another and neighbours turned into competitors. Well yields and well reliability went down. Even worse, saline seawater started to intrude in the Salheia area.

In 1993, one of the landowners-investors took the lead in preventing the situation from becoming chaotic. He organized a get-together of the 400-odd landowners in the area of 1000 ha. Given the relatively small number of players, this was a manageable effort. The meeting decided on a hydro-geological survey of the area, to determine safe yields and establish a common management system. The background of the initiator-investor is interesting: a water professional - with ample background in local organizations.

Following the hydro-geological survey, the landowners-investors decided to continue pumping from a limited number of wells only and to develop a common network of pipelines. The investment of the network was some USD 300 per ha, which was to be recouped from the water charges. The individual system was thus transformed in a collective asset. The agreement between the farmers led to the establishment of the Omar Enb al Khattab Water Users Association. The Association also decided on a ban on new wells in the area. Apart from regulating groundwater, the Association lobbied for the extension of surface irrigation.

When this finally came - after several years - several of the farmers remained reliant on groundwater as many of the fields were far away from the canal. The network and the wells continued to be operated as a common utility. One problem was that some landowners discontinued using the land, speculating that the value would increase. This left the burden of paying the capital costs of the common network on a smaller number of farmers.

The Salheia case then moved beyond coordinated individual responses to groundwater problems and even 'communalized' groundwater by linking all lands to a common pipeline network. A local groundwater association opens up a large range of management options that do not exist in a social norm-based mode of groundwater management (as in Balochistan for instance), as the next cases illustrate.

2.5 Guanajuato, Mexico

Guanajuato State is part of Mexico's arid and semi-arid centre and north-west of the country. It exemplifies the rapid agricultural and industrial development of this part of Mexico. Guanajuato is the centre of high value horticultural production for the North American export market. Sanitary requirements demand that the export vegetables are irrigated by 'clean' groundwater. At present, the State accounts for 21% of all registered wells (3,300) in the country . The over-commitment of groundwater in the area has resulted in a serious decline in groundwater with almost all of the 20 aquifers in the region in overdraft. For a long time, the magnitude of the problem was unknown. Countrywide inventories of groundwater were only made at the end of the 1960s.

There have been a number of attempts to self-regulate groundwater use. The first attempt occurred in the 1960s in the Costa de Hermosillo (Wester et al, 1999). An employee of the Water Resource Secretariat convinced groundwater users - mainly farmers - to bring back extractions from 1,100 M m³ to 800 M m³ over a four-year period between 1963 and 1967. This was largely achieved by installing water meters, canal lining and a shift to less water-consumptive crops. New investigations in 1967 unfortunately showed that the reduction in water consumption in the previous period was inadequate and that abstraction would need to be brought down to 350 M m³. This finding was the undoing of the restriction programme. Farmers judged the 350 M m³ target unachievable. Since then, a second programme of restrictions on groundwater use was launched but abstraction continues to cruise at 650 M m³. There is a clear parallel with the experience in Mastung (Pakistan), described in section 2.1, where restrictions were effective, but turned out to be insufficient resulting in the termination of the local water management regime.

A second effort in local groundwater management concerned the COTAS. COTAS stand for Comités Técnicos de Aguas Subterráneas - technical groundwater committees. The National Water Law, which was accepted by the Mexican Congress in 1992 created the possibility of establishing these local committees. The National Water Law, however, is vague. It contains articles that simultaneously suggest that anything goes as well as the opposite. An example is "water users must organize themselves to be financially self-supporting bodies and improve water use efficiency. All these organizations will be monitored by the National Water Commission". The vagueness leaves big questions on the autonomy of the COTAS and the role of external regulation by the government.

One example of a COTAS is the Querétaro aquifer. This aquifer is primarily used by urban and industrial consumers with agriculture taking care of 20% of extractions. An intense effort to organize groundwater users in Querétaro was undertaken in 1998 on the directions of Vincente Fox , the then Governor of Guanajuato. A team of sociologists worked for eight months organizing meetings at national, state and local level. The core groundwater management issues were identified with local experts and then presented to an assembly of authorities and groundwater users. The users formed a COTAS and identified a series of water saving activities - in irrigation improvement and waste water reuse. The COTAS also formulated a number of groundwater use regulations. The promising model and process were then adopted as a model for other aquifer systems in Mexico. Unfortunately, the scaling up was done without consideration for the intensive process that went on before . As a result of the more hurried process, COTAS tended to drift towards becoming a consulting platform only attended by people, who do not necessarily have the inclination to self-organize or self-manage the shared groundwater resource.

3 COMMON DENOMINATORS

3.1 Local regulation at work

The cases present a spectrum of local regulation by groundwater users, from the development of local norms to recharge and regulate groundwater - to user organizations with a programme of water saving and mobilizing 'new' water resources. Some examples have been successful, others have failed. Most cases are spontaneous responses to a severe local groundwater crisis. Without wanting to suggest that all can be taken care of by local management, the case studies confirm the idea that local regulation in groundwater management is possible - at least in a number of situations. In fact, in the areas studied collective groundwater management was the only thing that worked. Groundwater legislation existed in law documents, but not in courts; well registration, let alone top-down regulation, never started and rights were all but possible to formulate.

There are a number of common themes in the cases:

- the importance of universality - of not excluding any potential user in the regulations. None of the cases barred a new entrant from having access to groundwater or defined the quantitative right of one well owner over another
- The fact that groundwater management is possible without a formal local organization - loosely enforced norms in several situations is a powerful alternative, but there are limitations to what management by norms can achieve
- The importance of information and getting it right. Mastung and Costa de Hermosilla are both examples of promising initiatives gone wrong because of inadequate understanding of the water balance, whereas in Egypt the geo-hydrological survey was a main joint activity of the ground water users
- The possibility of supply side management - as in the Gujarat - most regulations have not put anyone out of business. Instead either supply and recharge of groundwater have been improved (Gujarat, Rajasthan, Querétaro), efficiency measures have been undertaken and areas where groundwater can still be safely developed have been identified (Panjgur, Mastung).

3.2 Norms or rules rather than rights

Informal rules and norms even without formal or informal organizations can effectively control groundwater exploitation. The examples from Panjgur and Saurashtra show this. This is nothing new. A very early groundwater rule, the harim (border), is mentioned in Islamic law and is still loosely in force in several parts of the Middle East. The harim defines a no-go area for new wells - usually 250 m in soft soil and 500 m in hard rock from an existing well or kareze.

The norms that developed in Panjgur, Mastung and Gujarat were all surprisingly simple: a ban on certain types of wells; zones where no well development is allowed; no drilling beyond a certain depth; water for drinking water only; or a strong discouragement of water-intensive crops. In the watershed movement in Maharastra, similar simple rules came into force: no irrigation well to be deeper than a drinking water well and no second well for a family (Anna Saheb Hazare, pers. com.). In Hiware Bazar, a model village in the same state, bore wells were forbidden and the cultivation of high water demand crops is only allowed with drip systems. All these norms are easy to monitor by anybody. Compliance or non-compliance is visible and does not need a special organization to enforce it. Any person can through open contempt or intimidation withhold another person from breaking the moral code. This is in fact what happened in Panjgur.

A second characteristic is that none of the norms exclude anybody from using groundwater. They are non-discriminatory do's and don'ts, based on universal access. They are different from rights, which would entitle some more than others. It is difficult to see how such rights would be enforced by social pressure. This was in fact the reason why in many parts of Balochistan karezes could not be sustained. In fact, groundwater rights would almost 'need' an organization to protect those whose interest is defined by the rights against those who are excluded.

This has a number of implications. First is that the scale of groundwater overuse in many areas is such that it can only be addressed by a 'movement', able to achieve a wide coverage fast, as in the case of the Saurashtra recharge movement. A 'rights and organization' approach on the other hand would take time and resources, that in many areas do not exist. This is also where in Rajasthan the intense organizational approach of PRADAN was less effective than the informal movement of the TBS. To further illustrate the argument, one may look at the efforts of introducing participatory irrigation management and promoting water users associations. Despite considerable effort, the coverage of such organizations is still limited . Similarly, the efforts in determining rights and establishing local organizations on the scale of South Asia with an estimated 24 M groundwater users are too daunting. In describing groundwater management in the High Plains (US), Burke and Moench (2000) also provide an important footnote to the preoccupation with participatory organizations. The groundwater districts in the High Plains are not 'fully participatory', as only a few users are actively involved in the management of the districts. The groundwater districts, however, are able to reflect popular preferences and have public recognition, which goes a long way to effective local management.

This leaves the development of local norms and more loosely structured organizations as a viable option. Blench (1998) has questioned the preoccupation with the 'community' as the focus of development and local management and has argued that local structure should be analysed before going for the standard option. There is evidence from the different cases that an equalitarian group helped the development of norm-based resource management, but it does not seem a prerequisite. In terms of transaction costs - when the costs of enforcement are low, the community organization that supports it does not need to be very forceful. As experience in Saurashtra shows, the community is not necessary the organizing mechanism, but it provides the network where adoption of recharge techniques and groundwater use norms reaches the required density to sustain it.

There is, however, a limit to what norms can achieve. First there are do's and don'ts - but to come with a more comprehensive groundwater management strategy that includes supply side measures in many cases a local organization is required - this can, however, grow 'from below' rather than being introduced part and parcel. This route is particularly open when the groundwater system allows access to all - as in the example from Salheia, Egypt.

Secondly, norms and social pressure may not develop everywhere. Where groundwater availability simply cannot sustain universal access, as in the case of many deep aquifers, it is difficult to see how social pressure would come about. In Balochistan in many valleys, a few farmers are left pumping from deep tubewells: no management regime develops here and they will probably continue pumping till the water runs out.

Thirdly, loose self-regulatory systems are vulnerable, particularly where they affect groundwater demand. When the local rules and claims to groundwater use are not recognized, they may be easily subverted by other developments. An example comes from the basalt plains south of Asmara in Eritrea. A local norm prescribed that when the water table fell below a certain depth, water would only be pumped for domestic purposes. This local management regime came unstuck, however, when the surface water that recharged the groundwater system was diverted by a new dam (Burke pers. com.).

3.3 Supply versus demand side management

In none of the cases of successful local management, was any groundwater user forced to give up pumping or reduce his farm business Instead in all cases, the options either for augmenting supply (through improved recharge) or higher water efficiency were exploited.

There are still unutilized options - ultra low cost drip irrigation.

In many parts of South Asia, the only long-term solution to sustaining groundwater irrigation without hitting farm production and rural livelihoods is through technologies that produce more by pumping less. Drip and sprinkler technologies have been aggressively promoted in India since the mid-1980s; yet, today, the area under them is only 60,000 ha. A big part of the problem is subsidies that, instead of stimulating the adoption of these technologies have actually stifled their market. Subsidies have been directed at branded, quality-assured systems, but in the process have not allowed viable, market-dependent solutions to mature. There is growing evidence that suggests, however, that once farmers realize the benefits of drip irrigation, its use can spread amongst large as well as small farmers. A good example that illustrates this is that of small growers in Maikaal (Madhya Pradesh) and Kolar (Karnataka), where IDE, an NGO committed to promoting market-based rural technology, introduced low-cost drip irrigation systems.

In both areas, the programme was in direct competition with irrigation equipment companies like Jain and Pineer, the mainstream players in this business. Their equipment typically costs USD 1,750/ha, which puts it out of reach of most farmers - apart from the few that manage to access the subsidy programmes. IDE promoted a low-cost drip system that cost 40% of this (USD 700/ha). The adoption was initially confined largely to middle peasantry, but then began to spread to small and marginal farmers. A common aspect of both regions is a vibrant farm economy under siege from groundwater depletion. Maikaal's organic cotton growers and Kolar's mulberry farmers find that protecting the core of their livelihood systems is their biggest challenge. After two failed monsoons, in Maikaal as well as Kolar, a typical well can be pumped for 30-45 minutes at a go after allowing it 'to rest' often for 2-3 days. When the affordable drip irrigation was introduced, farmers in Maikaal and Kolar received it like a godsend. Not only did they adopt the technology in a hurry, but they also began to experiment with it and improvise with it. The grey market of unbranded products offers limitless opportunities for economizing on capital investment. Most farmers laid drip systems at USD 350/ha by assembling them with grey market material. Their grey market dealers also offer them written guarantee of 5 years, which most farmers trust would be honoured if invoked. Some farmers who have been using grey products since 1996 are quite happy.

As the drip technology gets internalized here, the name of the game is cutting its cost down to the minimum. Grey sector entrepreneurs recognized that many-first time users would try out drip technology only in a drought to save their crops with little water. They also recognized that demand is highly price elastic. To encourage such small farmers to try out drip irrigation, one innovative manufacturer introduced a new product labelled 'Pepsi'- basically a disposable drip irrigation system consisting of a lateral with holes. At USD 90/ha, Pepsi costs a fraction of all other systems, but for small farmers who are trying out the technology for the first time, the disposable system offers an important alternative. As one Patina farmer said, 'if I can buy a system at the cost of the interest amount, why should I invest capital? Why spend USD 30 on a filter when a piece of cloth can serve the same purpose as effectively?'

As a result no one was put out of business by the local regulating institutions. In Saurashtra and Alwar the route to restoring the balance ran through farmer investment in a variety of recharge structures. In several cases, norms on not overusing the water recharged by one's neighbour's efforts were corollary to individual investment in the common resource. Similarly, in Mastung, Panjgur, Salheia and the various Mexican examples, no-one was forced to give up irrigated agriculture. There were still areas earmarked for expansion, whereas changes in using water more judiciously enabled groundwater users to continue farming. The transaction costs of establishing these local regulating mechanisms were low, as there were no losers with whom to negotiate.

The question this poses, however, is what to do when the options for increasing recharge or increasing water productivity are exhausted. It seems that in those cases, only external regulation (of which in large parts of the world, there are few convincing examples) or the physical collapse of wells will restore balance.

The remarkable point, however, is that in many areas which are going through a crisis of rapidly falling groundwater tables, options for recharge or increasing water use efficiency are not activated. Once can speculate why. It may be because recharge options or water efficiency options are not known or not available at the right price. The spread of low cost drip irrigation in Western Maharastra and Karnataka after a number of failed attempts illustrates the point (see box). Worldwide, farmers primarily adopt water-saving technologies, not to save water, but to sustain farm yields and household incomes. Water-saving technologies, moreover, often have other benefits, which encourage their adoption - lower energy costs, convenience, better crop management.

Where local regulating mechanisms are in place and where there is a heightened understanding of the limits to groundwater consumption, they facilitate the acceptance and adaptation of the different options to reverse groundwater overuse. This can be done through individual choices or through agreement between water users, as in the Mexican examples.

3.4 Accelerating local regulation: the role of information

An adequate local groundwater management regime is well served by an understanding of local hydrogeology. The ultimate failure of groundwater management in Mastung is an example of the importance of knowing the constraints to the common resource. Unfortunately, the work of professional geohydrologists hardly travels to groundwater users who would stand to benefit most from it. Since pumps in most places have been around for a few decades, a groundwater crisis is usually the first of its kind and there is usually little knowledge on the magnitude, quality and dynamics of the invisible resource. The Participatory Hydrological Monitoring (PHM) programme developed in Andhra Pradesh, India under the APWELL project (Govardhan Das, 2001) is a unique experiment in trying to overcome this obstacle. Under the PHM, farmers are being trained in measuring groundwater parameters themselves. They are provided with:

- A drum and a stop watch to measure the discharge of a number of their wells
- A water table recorder to measure the depth of the water table
- A rain gauge, installed in a sheltered place
- Ready reckoner tables and training in how to make crude water balances.

The farmer group reports it’s findings to a field hydrologist who helps to analyse the results and provides routine to the measurement efforts. The PHM has had a marked impact in the areas where it has been used. It has been combined with agricultural extension focused on crops and cropping techniques with high ‘water productivity’. Floriculture, castor seed, cotton, maize have been promoted as alternatives to highly water-demanding rice cultivation. At present, rice accounts for less than 5% of the area under crop, a marked departure from other groundwater dependent areas. Another breakthrough was the promotion of vermiculture. With the aid of worms, waste is transformed into compost, which significantly improves soil water retention capacity and brings down ground water consumption. Further farmers have been taking a number of steps to improve recharge close to their wells - sink pits and small check dams. PHM and agricultural extension have been effective in introducing local demand and supply side alternatives. In Andhra Pradesh, the next step is to turn the current awareness and understanding into local resource planning as well as to scale up the effort. In this respect, the State offers a number of promising ‘leads’ - there is a plan to have an observation well of the Groundwater Department in each village and have this monitored by the local community or watershed group. Also in the last annual government ‘mass contact’ campaign, senior government staff were sent out with simplified water balances to discuss in village meetings. Although the implementation was not perfect or comprehensive, the initiative was probably ‘a first of its kind’ - a massive effort to bring groundwater knowledge to groundwater users.

There are a number of clues from these beginnings - training groundwater user groups and local experts in the operation of observation wells, integrating local observation in state monitoring, both components reinforcing one another and promoting effective improvements - higher water productivity and local recharge systems, as in Saurashtra. All these are a great improvement on the now often esoteric nature of hydrological science

4 CONCLUSIONS - CHANGING THE AGENDA

The magnitude of intensive groundwater use in many parts of the world is so big that the main management challenge is scale, providing some order among very large numbers of groundwater users (see Burke, in 2002). Against the examples in this document where the tide was reversed, there is a multitude of cases that have gone from bad to worse. Much of the rapid urbanization in groundwater-dependent areas is attributed to groundwater resources being overstretched. In several parts of coastal Gujarat, groundwater depletion in dry season is so serious that for part of the year people move out of the areas due to lack of drinking water. In many other parts of South Asia, drinking water tankers have become a regular feature even in rural areas.

Whether ‘external regulation only’ will work is questionable - groundwater bills have been around now for many years in several countries with serious overdraft problems, but they have not translated in anything that approaches real life. Extensive studies have documented the magnitude of the groundwater problems, and in the meantime valuable time is lost.

It is clear that a new agenda is required - strengthening local water resource management and taking lessons from the few success stories of self-regulated and self-orchestrated groundwater movements. The Dublin Principle of subsidiarity in water management needs to be taken far more seriously among groundwater professionals. Elements of a new agenda should be:

a. Focus on wide coverage, density and scale of improvements - ‘rights’-based approaches, if they could be made to work at all, will in many areas consume time and social energy, that is better utilized in setting up functional organizations and promoting new rules and norms
b. Create wide awareness on the limits to groundwater utilization and on effective action to reverse overuse (recharge; efficient use) - casting the net widely and hoping to find champions, even among the unlikely - such as the religious leaders and diamond merchants in Gujarat
c. In support of the above - reverse the orientation of hydro geological science - the outputs of which are now often shrouded in secrecy or vagueness: models, studies, formulas impervious for the non-expert mind; a large effort is required to bring hydrogeology to the field and create capacity to study and analyse groundwater behaviour locally; linking central and local monitoring programmes may help
d. Actively develop and promote alternatives to intense groundwater use - the examples show there is a wide range of effective options - vermiculture, ultra-low-cost drip, sink pits, recharge bunds, etc. each suited to certain local conditions. At present, however, these techniques still need to be adjusted and promoted so as to become part of the standard repertoire of groundwater users

e. Build local groundwater management into watershed improvement programmes - avoiding watershed management programmes dealing exclusively with increased recharge of groundwater, while ignoring the way in which water is used. Moreover , creating enough density to show the impact of watershed improvement and encourage active management of water supply and demand. Similarly, build local groundwater management into community water supply and sanitation programmes
f. Develop enabling rather than regulatory legislation and facilitate the development of local management organizations and local rules; the COTAS in Mexico are a promising opening, provided they are not relegated to a marginal consultative role. Further energy needs to be devoted to making local management organizations work - either by local champions or external facilitators. This is brought out by the experience of the Groundwater Rights Administration Ordinance in Balochistan, by the COTAS in Mexico and also by groundwater associations in Spain (Hernández-Mora et al., 2002)
g. Make much more of local management and monitoring of groundwater quality (often linked to over-extraction) - there are few examples at most where groundwater users are involved in managing the quality of the groundwater resources - but given the extent of groundwater pollution and quality deterioration, much more has to be done in this field. In controlling surface water pollution by industries in countries with relatively weak formal enforcement mechanisms, good results have been obtained through public disclosure (World Bank, 2000). In groundwater quality management, there are large opportunities for improvement along these lines too.

REFERENCES

Blench, R. 1998. Fragments and sentiments: why is 'the com-munity' the focus of development: a Zimbabwean case. Ag-ricultural Research and Extension Network Paper 81. Lon-don: ODI.

Blomquist, W. 1992. Dividing the water: governing groundwa-ter in Southern California. San Fransisco: ICS Press.

Burke, J.J and Moench, M. 2000. Groundwater and society: resources, tensions and opportunities, themes in groundwa-ter management for the twenty-first century. New York: United Nations Department of Economic and Social Af-fairs.

Das, B. 2001. Miles to go; drought of 1999-2000 Andra Pradesh. In A. Agarwal, S. Narain and I. Khurana (eds), Making water everybody's business: practice and policy of water harvesting: 382-396. New Delhi: Centre for Science and Environment.

Davila-Poblete, S. 2000. The organization of small irrigation units. Draft technical report for the National Water Com-mission, Mexico.

Foster, S., Chilton, J., Moench, M., Cardy, F., & Schiffler, M. 2000. Groundwater in rural development: facing the chal-lenges of supply and resource sustainability. World Bank Technical Paper 463. Washington: World Bank.

Govardhan Das, S.V. 2000. Participatory hydrological moni-toring (PHM) - an effective tool for community managed groundwater system. Paper at International Conference on Land Resource Management for Food, Employment and Environmental Security. Delhi, 9-13 November 2000.

Kumar, D.K. 2001. Drinking water: a scarce resource. The Hindu Survey of the Environment 2001: 93-104.

Nandi, S., Roy, S.B., van Steenbergen, F. 2001. From PIM to local IWRM in West Bengal. INPIM Newsletter, 11.

Rathore, M.S. and Mathur, R.M. 1999. Local strategies for wa-ter management and conservation: a study of the Shekha-wati Basin, Rajasthan. In: M. Moench, E. Caspari and A. Dixit (eds), Rethinking the mosaic: investigations into local water management. Kathmandu: Nepal Water Conservation Foundation.

Shah, T. 2000. Mobilising social energy against environmental challenge: understanding the groundwater recharge move-ment in western India. Natural Resources Forum 24: 197-209.

Swaminathan, M.S, Saxena, N.C., Chaturvedi, M.C., Mohan Gopal, G., & Om Thanvi. 2001. Jal swaraj: a report on the technical, legal and administrative issues concerning the *johad* in Lava Ka Baas. New Delhi: Centre for Science and Development.

Van Steenbergen, F. 1995. The frontier problem in incipient groundwater management regimes: the case of Balochistan. Human Ecology 235(1): 53-74.

Wester, F., Pimentel, B.P. & Scott, C. 1999. Institutional re-sponses to groundwater depletion: the aquifer management councils in the State of Guanajuato, Mexico. Paper pre-sented at international symposium on Integrated Water Management in Agriculture, Gomez Palacia, Mexico, 16-18 June 1999.

World Bank. 1999. Groundwater regulation and management. New Delhi: Allied Publishers.

World Bank - Development Research Group. 2000. Greening industry; new roles for communities, markets, and govern-ments. New York: Oxford University Press.