CHAPTER 12

Rules rather than rights: self-regulation in intensively used groundwater systems

F. van Steenbergen
Arcadis Euroconsult / MetaMeta, the Netherlands
fvansteenbergen@compuserve.com

T. Shah
International Water Management Institute (IWMI), India Program Office, India
t.shah@cgiar.org

ABSTRACT: This chapter reviews the scope for self-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 self-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 self-regulation, either as a complement or alternative to central regulation, the chapter 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 chapter also recommends enabling rather than regulatory legal frameworks to underpin local management; the promotion of demand and supply management measures (for which there often is still 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.

Concerns over groundwater utilisation have the ring of the infamous *tragedy of the commons* –unlimited access to a common pool, leading to its decline. Solutions advocated are remindful of the old *tragedy* discussion: 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. Second, in some countries the number of wells that would need to be monitored is extremely large, many being located remotely on private land. Third, water rights systems are socially complex and often based on deeply-embedded cultural values…" (Foster *et al*. 2000). Add to this the weak enforcement that prevails in many parts of the world, exemplified by the fact that many wells for years are 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 *Self-regulation*

Self-regulation –decentralised 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" (Foster *et al.* 2000). There are indeed examples from high-income countries, in particular the American West and Spain, described by Blomquist (1992), Smith (this volume), Hernández-Mora *et al.* (this volume) among others, where groundwater users have with various degrees of success federated to safeguard the sustainable supply of water.

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

To explore this question the chapter 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 (Rathore & Mathur 1999, Shah 2000). Furthermore, there appear to be no examples of groundwater users regulating groundwater quality nor are there cases of self-regulation in areas with large unconfined aquifers.

However, 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 at a scale that matches the extent of groundwater overuse. Particularly where the impact of recharge or pumping is immediate and dramatic, self-regulation has developed. Often local rules concern the shallow water bearing strata or the groundwater travelling down to the aquifer proper. For this reason it makes sense to make a distinction 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 self-regulatory institutions to come about, become effective or disappear. The two cases from India describe groundwater recharge movements, augmenting supply. In the Pakistan, Egypt and Mexico cases the focus is on regulating demand. In the Mexico and Egypt example organisations developed, whereas in the Pakistan and India example management was by norms, which 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 sanitised one-party rule in Mexico and Egypt more likely to translate into organised organisations.

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

2 CASES

2.1 *Balochistan, Pakistan*

Groundwater development in Balochistan, Pakistan's great south-western desert, has a long history. The area is arid to the extreme (50–400 mm/yr rainfall) 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

[1] The concept of aquifer is often deceptive –a massive water system, recharged over a considerable period of time, in danger of irreversible decline. Such systems would 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.

Table 1. Examples of self management in groundwater.

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 organisation	Recharge, regulation of wells
Saurashtra	India	scattered	Community organisation	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

of a string of shafts connected through a tunnel. The tunnel picks up water from a mother well –either an underground spring in the piedmont zone or a subsurface flow on the bank of temporary river. It then conveys water over a length of 500 to 3,000 m before it daylights 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 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 L/s and will serve a maximum of 200 shareholding families. Not only establishment costs are high: *kareze* maintenance is equally expensive. The co-operative strength of the *kareze* shareholders is thus constantly tested (van Steenbergen 1995).

In the second half of the 1960s, dugwells became a popular alternative to *karezes*. A range of government programmes that provided subsidised equipment to farmers stimulated this development. Groundwater supplies were considered to be limitless. The vision in those days was to turn the arid land into a Green Oasis with the aid of pumped groundwater. In addition to the installation of subsidised dugwells, groundwater usage was further promoted through the provision of cheap electricity, as elsewhere in South Asia[2]. For ease of the 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 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 constructed 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 for 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 that did not have a share in the *kareze*, that were the first to use the opportunities offered by the new technology. At the end of the groundwater rush, however, there has been a concentration of access to groundwater in the hands of rich farmers in several valleys. This happened in particular in the areas where groundwater tables have fallen drastically and only costly deep tubewells can produce water nowadays. The cost of a deep tubewell is in excess of US$ 10,000. This is a price, which only few can afford.

[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 US$ 6,500 million is spent annually on subsidised agricultural power supply (which includes *leakages* on account of flat rates). An estimated US$ 4,000 million is spent annually on surface irrigation development and flood protection and US$ 500 million on watershed improvement.

Neither under customary law nor under government jurisdiction were there rules to control the decline in groundwater tables and the resulting concentration of access to groundwater. Neither did any government organisation 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 the 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. The 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 continued, however, 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* in this zone either. Outside the zone minimum distances were specified and a permit procedure was agreed. The latter was not put in 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 the political clout of the *kareze* owners also 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 self-regulating groundwater management came into existence –but more successful– is Panjgur, part of the Makran Division. In the past, most of the land was irrigated from 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 local feudal overlords, the inflow of cash from remittances from 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 eye-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 the 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, which invariably sides with the majority group of *kareze* owners, if only out of law and order considerations. Groundwater rules in Panjgur have the character of a social norm. They are not supported by a special organisation and no attempt has been made to define individual ones. The rule rights simply consist of an embargo on certain groundwater abstraction technology and do 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 a 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 catalyse community action in rainwater harvesting and groundwater recharge. Some of the most notable work of this kind is by NGOs such as Tarun Bharat Sangh and PRADAN, which offer important lessons about alternative modes of organising for community-based groundwater resource management.

PRADAN, a multi-state NGO, began working in the Alwar District in the 1980s with the local administration in Kishangadh Bas to improve the implementation of anti-poverty programmes. Following this beginning, PRADAN, in 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 it is a miniature version of a tank but without sluice gates and canals. A typical *pal* is made of earth, around 2.5–3.5 m high and around 3.5–4.5 m 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 minimised; 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 with an intense effort in developing democratic and representative community organisations.

Pals serve a number of functions: 1) they prevent the massive soil erosion that floods otherwise cause, making the plains as bare and rocky as the surrounding hills; 2) by reducing the velocity and force of rainwater runoff, they greatly reduce the pressure that the floods would place on the dams constructed downstream; 3) they make the flood waters spread over a large area than happened earlier; and 4) 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 gets evaporated. 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 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 sub-divisions of the Alwar district. In comparison, its effort in developing community organisations has been less intense and comprehensive. The water harvesting work of TBS covers an area of approximately 6,500 km^2; 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 per year but have gathered momentum and since the mid 1990s, they have done around 350–400 every year.

A *johad* is basically 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 as 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 becomes visible and talked about amongst villages, demand for similar work comes forth on its own; and once a demand system gets created, half the job of eliciting farmer participation gets done. TBS has built large concentrations of *johads* in the areas where they began work 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 be hardly pumped 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 to 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 begun, too. Many abandoned wells have been recommissioned, and an area, which had become a basket case, has become green and is poised on a reverse road to prosperity. Even up-lying lands, which have not yet benefited 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 US$ 10,000–12,000 per ha.

A major impact of *johad* concentrations has been in checking both floods as well as droughts. In the parts of the Alwar district that have dense concentrations 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 *johad*s cuts the pace and fury of sheet flows that race down the hills with fearsome pace and force, and thus pre-empt what might otherwise become a flood.

TBS's works are cheap compared to government structures. A couple of middle-sized *pucca bunds* cost only around US$ 700 each besides farmers' contributions. The same *bunds* would have cost US$ 9,000–14,000 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 get 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 organisations helped them quicken and upscale their work. Second, 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 about water management, appropriation and use began to emerge which were absent when water was seen as gift of 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 mass movement for well-recharge and water conservation in Saurashtra in Gujarat (India). As Rajashtan 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 catalysed first by the Hindu religious teacher Swadhyaya Pariwar and subsequently joined by other sects of Hinduism as also by scores of NGOs and grassroots organisations in the aftermath of the three-year drought during 1985–87. 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", who found this teaching prophetic. But 10 years later the warning seemingly became true. The three successive drought years that Gujarat –in particular, Saurashtra and Kutch– faced during 1985–87 brought water issues to their cyclical peak in the public mind. Taking a clue from Israel, Pandurang Athavale began asking his followers why farmers in North Gujarat and Saurashtra cannot adapt and improvise on 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 getting communicated and shared widely during 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 channel 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 –in private, public or no-man's land– to his well or farm pond for recharge. Stories began going round within and outside the Swadhyaya Pariwar about groups of *Swadhyayees* building check dams or deepening tanks or building *anicuts* or working together to recharge all the village's private wells. By now, many small and big NGOs joined the movement, each trying to help in its own ways. A resource centre (Saurashtra Lok Manch) compiled information about 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 corner 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 in recent years, diamond merchants have been at the forefront of Saurashtra's recharge movement, not only as resource providers, but also as catalysts and organisers. More recently, the Government of Gujarat's *check dam* scheme –under which the government contributes 60% of the resources required to build a check dam if the village comes forth with the 40% balance– has provided 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 1992–96, between 92,000–98,000 wells were recharged in Saurashtra; and some 300 *Nirmal Neer* (farm ponds for recharge) were constructed. Swadhyaya Pariwar's 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 Saurashtra are recharged, the region can solve its irrigation as well as drinking water problem.

Two aspects about the well-recharge movement are significant: first, the dynamics of the movement, especially with respect to appropriate technological innovation in water harvesting, conservation and recharge; and second, why it succeeded in attracting people's participation as broad as it seems to have done. According to some observers, since 1992, several dozens of 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 these are improvisations of 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 about new techniques widely and rapidly; Shamjibhai Antala, from the 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 m × 1 m × 1 m) made besides 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 from 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 lands, soak pits, rivers, tanks. In addition, first the *Swadhyayees* and later the Swaminarayan Sampradaya and other religious 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 organisations plays 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 Pariwar and crusaders like 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 a serious try to his ideas catalysed the first generation of well-recharge experiments in Saurashtra. Second, 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 the making up of 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.* Third, 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 strong-holds. Fourth, 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 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 internalise 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 internalisation of the positive externality of well-recharge has produced a powerful *snowballing effect* on people's participation is evident from the experience of many villages. Fifth, post-1994, however, the large-scale adoption of well-recharge through the 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 the Swaminarayan Sampradaya. Probably, even amongst the followers of these, there was an added economic impetus to do the devotional act. Sixth, and finally, post-1995, the scale of participation –and the resulting momentum– that the movement has achieved spontaneously itself has been a powerful engine for the movement to grow. In terms of the theory of externality, the reluctance of the individual farmer to invest in well-recharge is explained by his inability to internalise 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 –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 had a successful experience in Rajula, where people in several villages have accepted the norm of not allowing tubewells deeper than 65 m. In the 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 from a recharge structure and no wells beyond 20 m depth were allowed (Kumar 2001).

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 land under irrigation, among others by the reuse of drainage water and increased use of groundwater. In the development of new areas, 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 soon found, however, that their pumping operations were 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 land owners-investors took the lead in preventing the situation from becoming chaotic. He organised a get-together of the 400-odd landowners in the area of 1,000 ha. Given the relatively small number of players this was a manageable effort. The meeting decided on a hydrogeological survey for 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 organisations.

Following the hydrogeological survey, the land owners-investors decided to continue pumping from a limited number of wells only and develop a common network of pipelines. The investment of the network was some US$ 300 per ha, which was to be recouped from the water charges. The individual system was thus transformed into 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 to rely 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. A 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 as well.

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[3]. 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 undertaken 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 Mm^3 to 800 Mm^3 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 Mm^3. This finding was the undoing of the restriction programme. Farmers judged the 350 Mm^3 target unachievable. Since then, a second program of restrictions on groundwater use has been launched, but abstraction continues to cruise at 650 Mm^3. 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 stands 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 to establish these local committees. However, the National Water Law is vague. It contains articles that simultaneously suggest that anything goes as well as the opposite. An example is "water users must organise themselves to be financially self-supporting bodies and improve water use efficiency. All these organisations 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 organise groundwater users in Querétaro was undertaken in 1998 on the directions of Vicente Fox, the then Governor of Guanajuato. A team of sociologists worked for eight months in organising meetings at a 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 wastewater 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 to 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 persons, who do not necessarily have the inclination to self-organise or self-manage the shared groundwater resource.

3 COMMON DENOMINATORS

3.1 *Self-regulation at work*

The cases present a spectrum of self-regulation by groundwater users, from the development of local norms to recharge and regulate groundwater –to user organisations with a programme of water saving and mobilising *new* water resources. Some examples have been successful,

[3] A guesstimate is that approximately half of the wells in Mexico are registered.

others failed. Most cases are spontaneous responses to a severe local groundwater crisis. Without wanting to suggest that all can be taken care off by local management, the case studies confirm the idea that self-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 organisation –loosely enforced norms in several situations are 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 Hermosillo are both examples of promising initiatives gone wrong because of inadequate understanding of the water balance, whereas in Egypt, the geohydrological survey was a main joint activity of the groundwater users.
- The possibility of supply side management –as in the Gujarat– most regulations have not put any one out of business. Instead either supply and recharge of groundwater have been improved (Gujarat, Rajashtan, 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 organisations, 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), mentioned in Islamic law, 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. comm.). 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[4] and does not need a special organisation 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 any body 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 that in many parts of Balochistan *karezes* could not hold. In fact groundwater rights would almost *need* an organisation to protect those whose interested 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 organisation* approach, on the other hand, would take time and resources, which are not there in many areas. This is also where the intense organisational approach of PRADAN was less effective than the informal movement of the TBS in Rajashtan. To further

[4] As such these norms are more practical than caps on pumping hours or discharges.

illustrate the argument, one may look at the efforts of introducing participatory irrigation management and promoting water user associations. In spite of considerable effort, the coverage of such organisations is still limited[5]. Similarly, efforts in determining rights and establishing local organisations at the scale of South Asia with an estimated 24 million groundwater users are too daunting. In describing groundwater management in the High Plains (USA) Burke & Moench (2000) also provide an important footnote to preoccupation with participatory organisations. Groundwater districts in the High Plains are not *fully participatory*, as only a few users are actively involved in the management of the districts. 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 organisations 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 different cases that an egalitarian 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 organisation that supports it does not need to be very forceful. As the experience in Saurashtra shows, the community is not necessarily the organising 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 they are do's and don'ts –but a local organisation is required in many cases to come with a more comprehensive groundwater management strategy that includes supply side measures– however this can grow *from below* rather 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 a few farmers are left pumping from deep tubewells in many valleys: no management regime develops here and most likely they will continue pumping till the water runs out.

Thirdly, loose self-regulatory systems are vulnerable, particularly where the rules try to regulate groundwater demand. When the local rules and claims to groundwater use are not recognised, 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. comm.).

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 for either augmenting supply (through improved recharge) or higher water efficiency were exploited.

As a result no one was put out of business by the self-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 to overuse the water recharged by one's neighbours 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 self-regulating mechanisms were low, as there were no losers to negotiate with.

The question this poses, however, is what to do when the options for increasing recharge or

[5] Participatory processes are often used to create broad support for new organizational structures. As a side effect, the new structures sometimes become more democratic than their management objectives strictly require (see also Nandi *et al.* 2001)

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 that are going through a crisis of rapidly falling groundwater tables, options for recharge or increasing water use efficiency are not activated. One 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 1). Worldwide, farmers primarily adopt water saving technologies not to save water but to sustain farm yields and household incomes. Moreover, water saving technologies often have other benefits, which encourages their adoption –lower energy costs, convenience, better crop management.

Box 1. Unutilised demand management options –the example of ultra low cost drip systems.

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 these is only 60,000 ha. A big part of the problem is subsidies which, 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 realise 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 program was in direct competition with irrigation equipment companies like Jain and Pineer, the mainstream players in this business. Their equipment typically costs US$ 1,750 per 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 (US$ 700 per 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 over it. The grey market of unbranded products offers limitless opportunities for economising on capital investment. Most farmers laid drip systems at US$ 350 per ha by assembling them with grey market material. Their grey market dealers also offer them a written 5-year guarantee, 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 internalised here, the name of the game is cutting its cost down to the minimum. Grey sector entrepreneurs recognised that many first time users would try out drip technology only in a drought to save their crops with little water. They also recognise that their 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 US$ 90 per ha, *Pepsi* costs a small 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 mentioned, "if I can buy a system at the cost of the interest amount, why should one invest capital? Why spend US$ 30 on a filter when a piece of cloth can serve the same purpose as effectively?".

Where self-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 agreements between water users, as in the Mexican examples.

3.4 *Accelerating self-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 reaches 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 of 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 2000) 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 the of water table.
- A rain gauge, installed in a sheltered place.
- Ready reckoner tables and training to make crude water balances.

The farmer group reports its finding 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 groundwater consumption. Further farmers have been taken 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. In addition, in the last annual government *mass contact* campaign, senior government staff were sent out with simplified water balances to discuss in village meetings. Though 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 wise monitoring, both components reinforcing one another and promoting effective improvements–higher water productivity and local recharge systems, as in Saurashtra. All these are great improvements 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, this volume). Against the examples in this chapter where the tide was reversed, there is a multitude of cases that have gone from bad to worse. Much of the rapid urbanisation in groundwater dependent areas is attributed to the groundwater resources being overstretched. In several parts of coastal Gujarat, groundwater depletion in the dry season is so serious that for part of the year people move out of the areas for 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 into anything that approaches real life. Extensive studies have documented the magnitude of 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:

1) Focusing on wide coverage, density and scale of improvements –*Rights* based approaches, if they could be made to work at all, will in many areas consummate time and social energy, which is better used in setting up functional organisations and promoting new rules and norms.
2) Creating wide awareness on the limits to groundwater utilisation and on effective action to reverse overuse (such as recharging, 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.
3) In support of the above –reversing the orientation of hydrogeological 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.
4) Actively developing and promoting alternatives to intense groundwater use –the examples show there is 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.
5) Building local groundwater management into watershed improvement programmes –avoiding that watershed management programmes deal exclusively with increased recharge of groundwater, while ignoring the way that water is used. Moreover creating enough density to show the impact of watershed improvement and encouraging active management of water supply and demand. Similarly, building local groundwater management into community water supply and sanitation programmes (Das 2001).
6) Developing enabling rather than regulatory legislation and facilitating the development of local management organisations 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 make local management organisations 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 (Dávila-Poblete 2000), and also by the groundwater associations in Spain (Hernández-Mora *et al.*, this volume).
7) Making much more of local management and monitoring 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 (Govardhan Das 2000).

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