Promoting local management in groundwater

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Abstract There is a strong case for making greater effort to promote local groundwater management—in addition to other measures that regulate groundwater use. Though scattered, there are several examples—from India, Pakistan, Yemen and Egypt—where groundwater users effectively self-imposed restrictions on the use of groundwater. There are a number of recurrent themes in such spontaneously-developed examples of local regulation: the importance of not excluding potential users; the importance of simple, low transaction cost rules; the power of correct and accessible hydrogeological information; the possibility of making more use of demand and supply management strategies; and the important supportive role of local governments. The case is made, using examples, for actively promoting local groundwater management as an important element in balancing groundwater uses. Two programmes for promoting local groundwater management in South India are described—one focussing on participatory hydrological monitoring, and one focussing on micro-resource planning and training. In both cases the response was very positive and the conclusion is that promoting local groundwater regulation is not difficult, costly or sensitive and can reach the necessary scale quickly.

Résumé Beaucoup d'arguments plaident en faveur de l'accroissement de l'effort de promotion d'une gestion locale de l'eau souterraine. Il existe de nombreux exemples (en Inde, au Pakistan, au Yémen et en Egypte), quoique dispersés, où des consommateurs d'eau souterraine se sont imposé des restrictions d'usage. De tels exemples de réglementation locale, dont les développements sont spontanés, répondent à certains thèmes récurrents: l'importance de la prise en compte de consommateurs potentiels, l'importance de règles simples et de faibles coûts de transaction, le pouvoir d'informations hydrogéologiques fiables et accessibles, le développement potentiel de l'utilisation de stratégies de gestion de l'offre et de la demande et l'important rôle de soutien des autorités locales. L'argumentaire est centré, à l'aide d'exemples, sur la promotion active d'une gestion locale de l'eau souterraine, en tant qu'élément pondérateur essentiel des usages de l'eau souterraine. Deux programmes de promotion d'une gestion locale des ressources en eau souterraine, tous deux en Inde méridionale, sont exposés. L'un est centré sur un suivi hydrologique participatif, et l'autre sur la formation et une gestion à petite échelle. Les retours se sont avérés positifs dans les deux cas. En conclusion, la promotion d'une réglementation de l'eau souterraine à l'échelle locale n'est ni difficile, ni coûteuse, ni délicate, et pourra s'avérer nécessaire dans un futur proche.

Resumen Hay una motivación fuerte para incrementar los esfuerzos que promuevan la gestión local del agua subterránea—además de otras medidas que regulan el uso de dicha agua subterránea-. Hay varios ejemplos aunque dispersos de India, Pakistán, Yemen y Egipto, donde los usuarios del agua subterránea de manera efectiva se auto impusieron restricciones en el uso de ella. Hay varios temas recurrentes en esos ejemplos de regulación local espontáneamente desarrollados: la importancia de no excluir a los usuarios potenciales; la importancia de las reglas simples y con bajo costo en los trámites; el poder de la información hidrogeológica correcta y accesible; la posibilidad de hacer mayor uso de estrategias de gestión tipo demanda—suministro; y el papel importante del respaldo de los gobiernos locales. La motivación se hizo, usando ejemplos, que promovieron activamente la gestión local del agua subterránea como un elemento importante para obtener equilibrio en los usos de aquella. Se describen dos programas que promueven la gestión local del agua subterránea en el sur de la India—uno enfocado en el monitoreo hidrológico participativo, y uno enfocado en la

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planeación y entrenamiento acerca del micro-recurso. En ambos casos la respuesta fue muy positiva y la conclusión es que promover la regulación local del agua subterránea no es difícil, ni costoso, ni causa ofensa y puede alcanzar el balance necesario rápidamente.

Keywords Groundwater management · South Asia · Yemen · Egypt · Water budget · Community management · Participatory monitoring · Micro-planning

Introduction

In many areas of Asia and the Middle East intensive aquifer use has been the single major factor that transformed the rural economy in the last 25 years. It has boosted crop production and improved access to relatively clean drinking water. Some lesser-known positive effects are that lowered water tables reduced non-beneficial evapotranspiration and increased the capacity to buffer storm water. Yet in many areas the miracle created by intensive aquifer use is under strain. Overuse of groundwater is by now documented in several rural economies in Asia and the Middle East. The consequences differ between places, but are often alarming: declining, sometimes vanishing water tables, saline water intrusion, increased levels of arsenic and fluoride in drinking water, land subsidence. There is a search for solutions. Literature makes several suggestions, such as groundwater pricing, defining rights and concessions, participatory groundwater management. These are prima facie reasonable but often not grounded in evidence. Some of the suggested solutions, on closer look, may even prove to be impractical.

One example is groundwater pricing. It is a major anomaly indeed that in many areas the use of groundwater is cheap and subsidized. Several Indian states, such as Andhra Pradesh and Punjab have introduced a free power supply policy, even though their groundwater resources are heavily stressed. Another form of subsidy is low flat rates, which put no premium on heavy pumping. These policies are irresponsible, because they drain public budget, create intransparancy[1] and give wrong signals to water users. But it is debatable whether they cause overuse or even accelerate it—because even when not subsidized, groundwater pumping is a relatively minor item in the farm budget.

Another solution is defining access—registration of abstraction points, issuing permits, defining groundwater rights and giving out concessions. The problem with this solution is that groundwater systems are often poorly evaluated and monitored. As a result the quantitative basis for defining rights is usually weak. Second, in some countries the number of wells that would need to be registered and next monitored is extremely large, making the enforcement of such concessions problematic. This is exemplified by the fact that in many countries a substantial number of wells is illegally connected to the electricity grid for years or have very large dues on payments, without corrective action being taken. The case for externally defined groundwater entitlements as a result is weakened.

This article explores a third solution stream, that of local groundwater management. For the purpose of this paper, 'local management' is defined as the regulation of groundwater use by local stakeholders, i.e. local governments and groundwater users. Such decentralized collective management of groundwater resources is often mentioned as the alternative option or supplementary option (Chebaane et al. 2004). It follows in the footsteps of other local resource management strategies that have been promoted in areas of forestry and fishery. Foster et al. (2000) state that: 'Where feasible, active self-governance is (in the long run) preferable to the imposition of government rules'. There are examples from high-income and middle-income countries, in particular the American West and South, Spain and Mexico, described by Blomquist (1992), Wester et al. (1999), Smith (2003), Hernández-Mora et al. (2003), and Sandoval (2004) among others, where groundwater users have with various degrees of success federated to safeguard the sustainable supply of water. Local groundwater management is either advocated as a self-standing solution, or proposed as a complement to external state-initiated regulation and appears to circumvent the enforcement problems of defining rights and entitlements.

This article explores the scope for local participatory groundwater management and the contribution it can make alongside other interventions. It first explores a number of examples of local groundwater management from Pakistan, India, Egypt and Yemen and tries to draw generic lessons. The point to make is that these examples of local groundwater management are few and far between and came about unprompted by external support. The article subsequently discusses two programs that systematically tried to promote local groundwater management and assesses the scope and efficacy of such programs.

Cases

This section examines a number of examples of local groundwater management characterized by different degrees of community regulation. The examples concern mainly areas with shallow, semi-confined aquifers. The collective management systems in the examples are homegrown, mostly quite rudimentary. Though few and far between, in the places, where they came about, they were the only mechanism that worked. The cases from Pakistan and Egypt concern the regulation of demand. In the examples from India demand and supply management in the form of promotion of recharge was combined. In the Egypt example a new organization developed and in Yemen and Nellore, existing organizations took groundwater regulation on board. In the Pakistan and Gujarat, India examples management was solely by norms, that developed

[1] Free power supply and flat rates are often 'used' by power providers to mask substantial leakage to other uses (van Steenbergen and Oliemans 2002).

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Table 1 Summary of cases of local groundwater management

Case	Country	Size	Type of management	Measures
Panjgur	Pakistan	2,000–3,000 ha	Informal norms	Ban on dugwells
Mastung	Pakistan	2,000–3,000 ha	Informal norms, committee	Spacing rules, zoning
Nellore	India	1500 ha	Informal norms, local government	Ban on boreholes, recharge, water saving
Saurashtra	India	Scattered	Informal norms, religious leaders	Recharge, regulation of wells
Salheia	Egypt	1,000 ha	Water user association	Common network, ban on new wells
Al Mawasit	Yemen	2,000–3,000 ha	Drinking water committee	Zoning, ban on agricultural wells

in response to intensive groundwater use. This section first describes the cases and then tries to identify some common denominators. Table 1 is a summary of the cases.

Balochistan (Mastung and Panjgur Districts), Pakistan

Groundwater development in Balochistan, Pakistan's great south-western desert, has a long history. The area is very arid (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* (vertical wells) sustained small residential agriculture. These *karezes* pick up water from a motherwell—either an underground spring in the piedmont zone or a subsurface flow on the bank of temporary river and conveys water over a length of 500–3000 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. Not only establishment costs are high: kareze maintenance is equally expensive.

In the second half of the 1960s dugwells became a popular alternative to karezes, followed by tubewells in the 1980s. With this development 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 water table. Where these fell dry the quest for water was continued with tubewells with submersible pumps. 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 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 in several valleys been a concentration of access to groundwater in the hands of rich farmers. This happened in particular in the areas where, with water tables fallen drastically, only deep tubewells nowadays can produce water. The cost of a deep tubewell is in excess of US$10,000. This is a price, which only few can afford.

No rules existed under customary law or government jurisdiction to control the decline in groundwater levels and the resulting concentration of access to groundwater (van Steenbergen 1995). In response to the crisis, the Government of Balochistan issued a Groundwater Rights Administration Ordinance in 1978. The Ordinance 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. The licensing had to be based on area-specific guidelines. Unfortunately no such area-specific guidelines were ever formulated. Instead much was left to coincidence and the Ordinance was hardly ever used, in spite of a dramatic decline in water 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, close to Quetta, the capital of the Province. 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 several 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, causing 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. 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 levels was 0.7 m. With several large karezes beyond rescue 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

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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 successfully—is Panjgur, part of 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. 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 water table in other parts of Makran Division 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, that invariably supports the majority group of kareze owners. 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 individual rights. The rule simply consists of an embargo on certain groundwater abstraction technology and does not discriminate between prior and later users. This has undoubtedly helped to have the norm enforced by social pressure.

Maramreddypalli, Nellore, Andhra Pradesh, India

As in Balochistan, Nellore District, like many other parts of Andhra Pradesh State in India, has seen a dramatic change in water use in the last decades. Whereas tanks and shallow dugwells were the prime source of water up to the mid-1980s–1990s, there was a nearly complete transformation in most of the district with borewells becoming the main source of water. In a large part of the district this trend was accelerated by the development of inland shrimp ponds, often with urban capital.

Maramreddyapalli village, located in Sitarampuram block in Nellore District, is one of a few exceptions to this scenario. Maramreddyapalli is a village of nearly 200 families—depending largely on agriculture, either as owner-cultivators or landless labourers. There is also a substantial livestock population—of 2,500 heads cows, buffaloes, sheep and goats—that is equally dependent on safe water supply. Within the village boundaries there are slightly over 40 irrigation dugwells. These dugwells are limited in depth, a typical well being between 10 and 15 m deep. During the monsoon period water tables rise to 2 m and in the course of the year they drop to 15 m. This is adequate to satisfy all agricultural and domestic requirements. What is very remarkable is that in Maramreddypalli there are no deep tubewells. As in Panjgur in the previous case, this is ruled by a local norm that no farmer should invest in a tubewell. The rule was introduced in 1995 at the behest of the village council (*gram panchayat)* after consultation with the different village elders. The ban was prompted by the drought in the preceeding 3 years and the stress it brought with it and by observing the even more drastic changes in the 'scampi' (shrimp) growing areas.

Ever since it was put in place the local rule is kept alive by regular reference to it by the village council. This endorsement is in a way a minimal effort but it is sufficient and effective. There have been very few incidents in which the rule was violated. When in 2001 one farmer started to drill a tubewell at night, a large number of people rallied around—led by the women committee—and forced the drilling operation to discontinue. This successful collective action subsequently reinforced the rule.

In support of this norm, restrictions on crop choices are in place within the village. These are more voluntary imposed limitations—having to make do with limited quantities of water—than collectively agreed and enforced rules. The preference is for so-called dryland crops, such as as jowar (sorghum), ragi, aarikelu (millet), groundnut, green *gram* and yellow *gram* (pulses) and sunflower. Particularly sorghum and millet were staple crops in the area in the past, and whereas elsewhere food habits have changed, they persisted in Maramreddyapalli. Paddy and shrimp pond cultivation, that requires considerable amounts of water, common in neighbouring villages, are almost absent from Maramreddypalli. In addition, several measures are used to augment water supply. With support from the government watershed programme, five check dams were constructed across the small ephemeral streams in the area to promote recharge. A village forest protection committee was formed to co-manage the local forest with the Forest Department. Some irrigation channels were lined to avoid conveyance losses, whereas along others shade-trees are planted for the same reason.

Saurashtra, Gujarat, India

Whereas Maramreddyapalli is an exception in its area, a more widespread spontaneous response to groundwater scarcity has come in the form of mass movement for well recharge and water conservation in Saurashtra region in Gujarat (India). Saurashtra is a low rainfall area. The decline in groundwater levels was compounded by an increased incidence of fluorosis (manifest in dental stains, joint problems and kidney failure). This is caused by drinking water

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derived from groundwater that has declining levels and is subsequently abstracted from deeper layers.

The Saurashtra well-recharge movement was catalysed by the Hindu religious teacher Swadhyaya Pariwar and subsequently joined by other sects of Hinduism and also by scores of non-government organisations (NGOs) and grassroots organizations in the aftermath of the 3-year drought during 1985–1987 (Shah 2000). 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. . .". At the time most 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 1985–1987 brought water issues to a peak in the public mind. Pandurang Athavale began asking his followers why farmers in North Gujarat and Saurashtra could not adapt and improvise on the techniques used elsewhere for harvesting and conserving rainwater *in situ*. Several *Swadhyayee* (followers of Swadhyay Pariwar) in the farming community 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. They often found the results stupendously beneficial. The positive impact of the 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 backgrounds—*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. This changed as 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 to circulate about groups of *Swadhyayees* building check dams or deepening tanks or building anicuts or working together to recharge all private wells of the village. At this time also many small and big NGOs joined the movement, each trying to help in its own way. A resource centre 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 spread 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 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 organizers. More recently, the Government of Gujarat's 'check dam' program—under which government contributes 60% of the resources required to build a check dam if the village comes forth with the balance (40%)—has provided further stimulus to the water harvesting and recharge movement. Some 12,000 check dams of various sizes have been constructed under this scheme. The most likely estimate suggests that between 1992 and 1996, between 92,000 and 98,000 wells were recharged in Saurashtra; and some 300 recharge ponds were constructed.

Two aspects about the well-recharge movement are significant. First is the dynamics of the movement, especially with respect to appropriate innovation in water harvesting, conservation and recharge. The basic technique of well recharge is simple and involves drawing channels to direct all the rainwater in a sump or sink-pit made besides the well. A channel is made from the sump to the well 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 clean. Over time, the well-recharge movement has brought more experimentation and improvisation in recharge techniques. Most of the techniques did not require much engineering and as a result the movement could become self-propelled.

A second significant aspect is how the recharge movement succeeded in attracting broadly people's participation, as it seems to have. The explanation is a combination of reasons. First, the strong allegiance of core *Swadhyayees* to their leader, and their readiness to give a serious try to his ideas, catalysed the first generation of well-recharge experiments in Saurashtra. Added to this was the religious connotation—farmers did not recharge their wells because it was economically profitable, but because it was seen as an act of devotion. Second, and very critically, the spread of movement was in the form of communities. In numerous cases, entire villages turned to *Swadhyay Pariwar.* This meant that in these recharge experiments, either the entire village or a substantial proportion of a village's farmers agreed to participate. This helped the community to internalise the positive externality produced by each recharged well. The visible impact of the large number of recharge wells produced powerful 'snow-balling effect'. The large-scale adoption of well recharge was subsequently 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 to counter groundwater level decline.

Following the investment in recharge structures basic ground rules on how to use groundwater developed in a number of places in Gujarat—though not uniformly. One

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of the ground rules in water harvesting and groundwater recharge work by diamond merchants in Saurashtra, for instance, established that nobody pumps water directly from water harvesting structures. *Utthan*, a local NGO, too has met with successful experience in Rajula where people in several villages have accepted the norm of not allowing tubewells deeper than 65 m. In Panchtobra village of Gariadhar sub-district, the community agreed that no new wells would come within 30–100 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).

Salheia, East Delta, Egypt

The vast majority of farmland in Egypt depends on surface supplies from the River 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 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 however soon found their pumping operations interfering with one another and neighbours turned into competitors. Well yields and well reliability went down. Worse even, saline seawater started to intrude in the Salheia area.

In 1993 one of the land owners-investors took the lead in preventing the situation becoming chaotic. He organized 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 organizations.

Following the hydrogeological survey, the land owners-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 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 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. 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 ‘communalised’ 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.

Al Mawasit, Yemen

In Wadi Al Zabaira in Qadas, Al Mawasit District, Taiz Governorate of Yemen, local committees already existed but they increased their agenda so as to include groundwater management and address the issue of water security, in Yemen often described as the country’s largest challenge after national security. Drinking water management committees were established in Al Dhuniab and Kareefah, in 1992 and 1994. This was done as part of a large rural drinking water program. In both settlements village networks were constructed, supplied from 30 m deep dugwells. The committees in both Al Dhuniab and Kareefah developed an impressive track record in the management of their rural water supply system. Their boards were systematically re-elected and business rules regularly updated. Revenues are kept and maintained in secured special accounts with interest rates. This enabled the water committee to reduce the water tariff for the local poor. In addition, public centers such as schools, mosques, and health centers are connected free of charge. Official bills are issued for all other connections. Since the completion of the schemes, water has been available 24 h a day and occasional breakdowns have been solved in a timely manner.

These committees are a source of pride and have tremendous goodwill. Though they were set to manage the drinking water systems, the committees in both Al Dhuniab and Kareefah extended their scope of activities to include the sustainable protection of the groundwater resource. In Al Dhunaib, the project water committee issued a rule that no well could be drilled within 1 km from the drinking water source.

As in the Nellore case however, one farmer in Al Dhuniab made an attempt to drill a 2 m diameter hand dug well with reinforced concrete rings with a depth of 25 m in a location 200 m away from the water source of the drinking water scheme. Well development took place within the confines of the courtyard. It was done at night, when villagers were away to nearby towns. The covert operation was discovered

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in the end, however. A joint meeting was organized with all leading villagers. The meeting concluded that a large representation should visit the site and meet the farmer to ask him to backfill the newly developed well. This social pressure and the argument that no precedents should be allowed was effective and the newly developed well was closed.

The enforcement of a local ban on additional wells in Kareefah was even more intriguing. In Kareefah one local farmer was about to get an official permit to develop a well from the National Water Resource Authority (NWRA) under the provisions of the national water law. This greatly alarmed the Kareefah drinking water management committee, that suspected that any additional well in this area would jeopardize the drinking water system on which all livelihoods depended. The chairman of the Kareefah committee cajoled the local branch of the National Water Resource Committee by phone and through visits. He argued with the Authority not to even give a well permit to himself, if he ever requested, even though he was one of the largest land owners. This anecdote had the important effect in Kareefah of a social leader 'leading by example' and clearly putting public interest above individual interest. The fear in Kareefah moreover was that—whatever the criteria for awarding official well permits—once one farmer succeeded in drilling an irrigation well, many farmers would follow and the source of drinking water would be threatened sooner or later.

The two committees of Al Dhuniab and Kareefah also teamed up when the General Authority for Rural Water Supply Projects (GARWSP) planned a borewell for a neighbouring village within a kilometre distance of the existing surface water source of one of the water schemes. The committee recommended GARWSP to develop a shallow dug well instead. Unfortunately, the rural water authority went ahead and drilled a borehole of more than 200 m deep, yet without finding groundwater.

The examples show that based on local understanding the local committees effectively regulate groundwater in their own setting—and are more strict than the government agencies such as NWRA and GARWSP who tried to drill boreholes or give permission to drill wells in the neighbourhood of the projects' water sources for agriculture proposes. Both government agencies are limited in their capacity to implement the water law, if only because they lack the necessary resources and local knowledge. There is a strong case to match the enforcement of the water law with participatory local water management and make maximum use of complementarities.

Lessons Learned

The cases present several examples of self-regulation by groundwater users, triggered by local initiative. The cases vary 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 failed. The case studies support the argument that local regulation in groundwater management is possible in at least a number of situations. *In fact, in several of the areas studied—Panjgur, Nellore, Saurastra, Al Mawasit—collective groundwater management so far has been the only thing on the ground that has worked.* Other efforts in the same area had, so far, limited impact. Groundwater legislation existed in law documents but not in courts; well registration did either not start or was not effective in balancing groundwater demand and availability (as in Al Mawasit and Mastung). Pricing had limited effect on groundwater use.

There are a number of common themes in these examples of local regulation:

- The importance of universal access—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 rules however described *how* everyone could access groundwater—the type of wells, their locations or the cropping patterns allowed. In the Yemen case everyone had access to drinking water, but no one was allowed to make wells for agricultural purposes.
- The fact that local groundwater management was possible without a formal local organization. As the cases from Panjgur and Nellore show, loosely enforced norms in several situations can be powerful arrangements that can come about quickly and do not require high transaction costs. They are reinforced by local leadership leading by example and by joint local action against those that deviate from the norm. The existence of such norms is nothing new. A very early groundwater rule, the *harim* (border), mentioned in Islamic law and is still loosely in force in several parts of the Middle East. The *harim* defines an area in which new wells are not permitted—usually 250 m in soft soil and 500 m in hard rock from an existing well or *kareze*. There is an upper limit though to what management by norms can achieve. They are "do's" and "don'ts"—but need to come with a more comprehensive groundwater management strategy that includes supply side measures, or to work at higher geographical scale a local organization is required. Also, 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.
- The simplicity of the rules. The norms that developed in Panjgur, Mastung, Nellore, Gujarat and Al Mahawit were all very straightforward and easy to monitor by everyone: 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 in India similar simple rules came in force: no irrigation well to be deeper than a drinking water well and no second well for a family. In Hiware Bazar, a model village in Maharashtra state in

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India, bores and wells were forbidden and the cultivation of high water demand crops is only allowed with drip irrigation systems. All these norms are easy to monitor by anybody. Compliance or non-compliance is visible[2] 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.

– The importance of correct information on the groundwater resource. Mastung is an example of a promising initiative gone wrong because of inadequate understanding of the water balance, whereas in Egypt the hydrogeological survey was a main joint activity of the groundwater users. Unfortunately the work of professional hydrogeologists hardly travels to groundwater users who would stand to benefit most of 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 possibility of demand and supply side management—as in the Gujarat—ensures that most regulations have not put any one out of business. Instead either supply or recharge of groundwater have been improved (Gujarat), water use efficiency enhancing measures have been undertaken and areas where groundwater can still be safely developed have been identified (Panjgur, Mastung). The remarkable point is that in many areas that are going through a crisis of rapidly falling water levels, options for recharge or increasing water use efficiency are not used. The development of local regulation, however, often triggers the introduction of these measures, such as micro-irrigation, recharge, changing cropping patterns, improved soil moisture management. In none of the cases of successful local management have any groundwater users been forced to give up pumping or reduce their farm business. Instead new options for either augmenting supply (through improved recharge) or higher water efficiency were exploited. A similar finding comes from a series of case studies undertaken by the British Geological Survey (BGS in press).
– The important supportive role of local governments—as in Mastung and Nellore. Moving one step further is the scope for combining groundwater management with other functions, as demonstrated by the local drinking water committees in Al Mawasit who expanded their agenda beyond the operation and maintenance of the drinking water infrastructure.
– The limitations of the cases—they all concerned relatively small areas—3,000 ha and below (except the Saurashtra case) . This is probably the scale where local management can come about on the strength of local leadership and community initiative. However, in many cases groundwater management needs to take place at higher geographical scales as well. This necessitates external support, providing frameworks for user-driven management at such intermediate scales. Similarly, in none of the cases was groundwater quality managed or measured, though in many areas this is an important issue too.

Promoting Local Regulation

The examples discussed above all came about by ‘chance’ and developed more or less spontaneously. The question, however, is whether and how local regulation can be initiated on a larger scale. The scale of groundwater overuse in many areas is such that only a ‘movement’ is able to achieve wide coverage fast to address it. Some of the other approaches suggested in literature—such as giving out groundwater rights or concessions or setting up management organizations may be useful, but would also take time and resources, that in many areas are not there. To illustrate this point one may look at the efforts of introducing participatory irrigation management and promoting water users’ associations in irrigation canal systems. In spite of considerable effort the coverage of such organizations is still limited.[3] Similarly, the efforts in determining rights and establishing local organizations at the scale of South Asia with an estimated 24 million groundwater users are daunting.

In this section two examples of promoting local groundwater management are described, both from Andrha Pradesh in India. The argument is not to advocate community groundwater management as the ‘only way’, but to argue that local groundwater management—by users, local governments and others—is an important cornerstone in promoting groundwater management, alongside legislation, registration, the development of aquifer associations and the rationalization of related energy pricing. In describing groundwater management in the High Plains (USA) Burke and Moench (2000) provide an important footnote to a pre-occupation 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 the 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 valuable intervention. As the experience in Saurashtra shows the community is not necessarily the organizing mechanism, but it provides the network where adoption of recharge techniques and groundwater use norms reaches the required density to sustain it.

The two examples of externally promoting local groundwater management both come from Andhra Pradesh State in India. As in other parts of India, groundwater overuse is high profile in Andhra Pradesh—with newspaper features

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

[3] Participatory processes have often been 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).

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of farmers committing suicide after their wells failed. The official number of bores or wells—connected to the power grid—is 2,350,000 in a state with a population of 78 million people. In the past irrigation depended largely on tanks and on dugwells, but many tanks have witnessed a period of institutional and physical decline and many dugwells have fallen dry. Over time the cropping pattern in Andhra Pradesh changed, with dry season rice and sugarcane on the increase at the cost of traditional staples such as pulses and sorghum. The drought of 2000–2003 exacerbated the groundwater decline. It forced many rural settlements into dependency on water supply through government-provided water tankers. A particularly dramatic development over the last 15 years in several areas is the increased reliance on deeper groundwater for drinking water with higher levels of fluoride causing fluorosis. According to one report slightly over 4,000 village units have been classified as ‘dark’ (meaning groundwater uses exceeds availability), covering 465 *mandals* (subdistricts) or more than 40% of the State.

The State Government has responded in several ways. First is the launch of a large-scale watershed management program, promoting the construction of small water harvesting structures. These consisted of recharge wells, contour trenches, check-dams and the conversion of tanks into percolation tanks among others. These recharge structures have often been effective in restoring water tables, but the local response in many cases was to build more bores and wells immediately after—causing imbalance to persist. In an evaluation of the five watersheds—with water harvesting investments ranging between US$40–100/ha—Bakka Reddy and Ravindra (2004) established that the public investments have had significant positive effect on recharge and soil moisture. They were in most cases matched in equal amounts by a spurt in the development of new boreholes, which caused overuse to persist in the ‘improved’ watersheds.

The State Government also announced the Andhra Pradesh Water Land and Trees Act. Important elements of the Act are the registration of wells, the licensing of drilling rig operators and a permit procedure for new wells. The Act was put under enforcement in 2004. By January 2005, 65% of the official wells were registered—a remarkable achievement—although it also raised the issues of non-official (illegally connected) wells. A third government response was to promote micro-irrigation in a major way through the Andhra Pradesh Micro-Irrigation Project. Eligible farmers were provided with subsidized drip systems from recognized manufacturers. The cost of the systems is of the order of US$1500/ha—with 50% of this cost subsidized by the government.[4] The price for this package included after sales services and extension by the manufacturers, though they have been hard-pressed to deliver on this, one reason being the shortage of trained manpower in this field.[5] The demand for the drip irrigation systems was particularly large among medium-sized and large farmers as they had land to expand. The drip systems are particularly appreciated as they allow water to be conveyed over large distances (which is important because it is difficult to develop wells) and because they save labour costs in weed control and field channel maintenance. A rough estimate is that these savings through installation of drip irrigation amount to US$250/ha. Parallel to the official delivery channel, lower costs drip irrigation systems are now on the market, using recycled plastic. The cost of these systems is US$300/ha, but they have a shorter life. The main point, however, is that the promotion of the drip systems did not reduce agricultural water consumption. In the absence of local water planning the provision of drip systems then introduces more efficient agriculture in an expanded area (with less recharge) and not less water use.

In spite of these important initiatives, the government signals with regards groundwater management have been mixed. The 2004 election was won by the opposition Congress party very much on a free electricity ticket. The free electricity was provided starting in 2004 to 2,100,000 wells—with only 10% of the official wells belonging to larger farmers being excluded from the arrangement. There are a large number of unofficial wells. In addition outstanding electricity bills for agricultural wells were waived.

Two initiatives were undertaken to introduce local participatory groundwater management on a larger scale in Andhra Pradesh. The first was the Participatory Hydrological Monitoring (PHM) programme developed under the Andrha Pradesh Well Irrigation Project (APWELL) and continued under the Andhra Pradesh Farmer Managed Groundwater Systems project (APFAMGS) and the second one, the Capacity Building component of the Water Conservation Mission Support Unit.

The PHM programme systematically tried to overcome the lack of knowledge of groundwater users about the groundwater resource, on which paradoxically their livelihoods depended. A key theme in the program was ‘demystifying science’, making basic hydrogeological information available to groundwater users, who are faced with the possible consequences of overuse and are the main force to address the problem (Govardan Das 2000; Arcadis 2003).

Under the PHM farmers were trained in measuring hydrological parameters such as water levels and rainfall themselves. They were supported in the preparation of water balance charts and to base crop plans on the basis of available water resources. Prior to initiating the monitoring program, awareness raising meetings (using local folk theatre) were organized. These were combined with local meetings to jointly identify and assess the main groundwater-related issues. Following this introduction water users were trained in the use of a drum and a stop watch to measure the discharge of a number of their wells; a water table recorder to measure the depth to the water table as well as a rain gauge. Ready reckoner tables were subsequently used to make water balances. The monitoring results and an inventory of local water resources were the input for the preparation of farmer crop plans. A groundwater balance estimation was prepared for the end of the wet season and

[4] In bio-diesel plantation subsidies were higher: 90%.

[5] Particularly as the target for Andhra Pradesh State is 2.5 million ha and for India as a whole 12 million ha.

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for the dry season and dovetailed with the farmer crop plans. This was discussed in a 'crop water budgeting workshop', where farm plans were matched with available resources. Follow up was then provided by extension visits, meant to familiarize farmers with lower water demand crops, and by visits of a field hydrologist, who among other things, surveyed the rate of crop adoption. This survey was then used to reassess the groundwater balance.

The PHM—combined with the agricultural extension—had a marked impact in the areas. It led to a shift to crops and cropping techniques with high 'water productivity'—such as floriculture, castor seed, cotton and maize. After the PHM program, rice accounted for less than 5% of the area under crop, a marked departure from other groundwater-dependent areas. Another breakthrough was the promotion of vermiculture. The compost thus produced significantly improved soil water retention capacity and brought down groundwater consumption. Further, farmers in several areas improved recharge close to their wells, by constructing sink pits and small check dams. In the first stage PHM was introduced at village level, but it was subsequently upscaled to sub basin groundwater management.

A second, even larger-scale attempt to promote local groundwater management was the capacity building component under the Water Conservation Mission. The Water Conservation Mission was set up as a coordinating mechanism by the Government of Andhra Pradesh to manage the various large-scale watershed programs in the State. As part of the program it was realized that promoting water harvesting without simultaneously introducing local demand management would not resolve the problem of groundwater stock running out before the end of the irrigation season (Bakka Reddy and Ravindra 2004). The capacity building program was set to address this. It differed from the PHM program in that it tried to create awareness and get a process of micro-resource planning going in a short time in a large area. The program consisted of a series of three local workshops. The first was a one-day training session, which aimed to raise awareness on local water management and the possible provisions to address problems. The trainings invited 25–35 persons each—mostly members of the Natural Resources Committees of the local governments (*gram panachyat*) from a cluster of six to eight villages. The training first differentiated between good and bad practices in groundwater management and then a groundwater problem and solution tree was prepared. This ensured that groundwater management was put firmly on the agenda. This first training also introduced the formal institutional instruments to address groundwater management, in particular the facilities under the Andhra Pradesh Water Land and Trees Act and the responsibilities of the Natural Resource Management Committees of the local village governments (*gram panchayat*). The experience from the training was that these regulatory provisions were never communicated before and it was unlikely that they would ever be used, as long as this situation existed. The second training session was given 6 months later. Whereas the nature of the first training session was awareness raising, the second tried to initiate a process of micro water resource planning. The training was a 2-day event, engaging again 30–35 people, to a large extent coinciding with the earlier training. As in the meantime elections had taken place, there were, however, some changes in the Natural Resource Management Committees. A special effort was made to include the village heads (*sarpanch*) in this second training, besides a large group of representatives from the hosting village. The first day of the second training recapitulated the first training, whereas the second day was devoted to micro water resource management planning. On this second day a micro water management plan was prepared for the *gram panchayat* that hosted the training. The preparation of the micro-plan used a set of straightforward but effective participatory rural appraisal techniques, in particular a transect walk on local water resources—noting down the conditions of wells, tanks and feeder canals; a transect walk on domestic water—noting down the condition of drinking water facilities; resource mapping—drawing with coloured powder an overview of the village with special emphasis of the different water facilities; a trend analysis—noting down population growth, change in cropping patterns and change in water use and other relevant factors over a 40-year period; and the preparation of a simple water balance and water audit—using a crude estimate of available recharge in the *gram panchayat* and the water consumption under different uses. Following this, the different activities were triangulated and a water management micro-plan was prepared by the representatives of the hosting village. These micro-plans were subsequently finalized and endorsed by the *gram panchayat*.

Over a period of 6 months 970 such trainings were given, involving 27,800 trainees. The training covered all the 270 subdistricts (*mandal*) that were officially classified as water-stressed or close to 25% of the state. The trainings were given by local district-based non-government organizations that were already involved in the implementation of the watershed program. As part of the training 970 micro water resource management plans were prepared. In general, these consisted of a package of local regulatory measures and usually quite modest investments. A break-down of the contents of the 970 micro plans indicated that specific activities were identified for action in four realms:

– Local regulation of groundwater use (98%)
– Desiltation and clearance of tanks and feeder canals (90%)
– Small water harvesting and groundwater recharge measures (88%)
– Repairs of local drinking water facilities (75%).

A break-down of the local regulations, formulated in the 52 training sessions in one of the districts (Warangal) showed that in 92% of the *gram panchayat* plans were made to change to less water consuming crop patterns. In 88% of the trainings decisions were made on restricting the area under rice cultivation in the dry season. In 82% plans were made to restrict the development of new wells—either in absolute terms or in terms of well depth or zoning. In a small number of *gram panchayats*—located

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near small rivers—restrictions were proposed on local sand mining: indiscriminate sand mining by outsiders affected the capacity of these local streams to buffer monsoon flows and recharge local aquifers.

Conclusions

There are a number of lessons from these efforts in promoting local groundwater management. First is the feasibility of it, at least in the water stressed area in Andhra Pradesh—with local regulatory measures identified in almost each *gram panchayat*. A second lesson is the importance of different initiatives converging: the promotion of local management, the introduction of new legislation, sharing of groundwater data, the support to local water harvesting measures and the presence of extension services that can promote high value low water consumption crops or water use efficiency measures, as under the PHM program. Most of these initiatives are far less effective if not supported by others (see also CRIDA, no date; BGS, in press). A third lesson is that promoting local groundwater regulation is not difficult, costly or sensitive. The capacity building program under the Water Conservation Mission reached to scale quickly and was organized through an already existing network of committed local non-government organizations working together closely with district-level project directors of the government watershed programs. The program had several other benefits—it mobilized support for the issue of groundwater management not only from the members of the Natural Resource Management Committees but from many others too, including members of Parliament and non-government staff. In promoting groundwater management there is a large value in wide coverage and density, as it can create a self-propelled movement with visible impacts on the groundwater situation. This point is also a reflection on the 'rights' based approaches that are proposed to counter groundwater overuse. The point with defining groundwater rights and concessions is that they, if they could be made to work at all, will in many areas take up inordinate time and social energy that is better utilized on setting up functional organizations and promoting new rules and norms. Reaching scale is important and could also be promoted by systematically incorporating the promotion of local groundwater management into watershed improvement or rural drinking water supply programs.

A final point is the importance of extending efforts in local groundwater management to other fields—in particular, groundwater quality management and groundwater management under conjunctive use in large unconfined aquifers in irrigation canal commands. This may be more difficult but not impossible. Again, here local monitoring, as in PHM, can be the trigger to action. 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. Similarly, there is scope for improved groundwater management in irrigation canal commands. In some of the commands in Punjab, Pakistan groundwater use is now so intense (accounting for more than 50% of farm supplies) that overuse has become a reality, manifest for instance in the intrusion of saline groundwater from saline groundwater zones into fresh water zones. An effort to prepare micro plans was made on the Kamalia Distributory that takes off from Burala Branch Canal of the Lower Chenab Canal in Pakistan (PPSGDP 2002). The initial response of farmers and local agencies was lukewarm, but after a first awareness building stage, the ice was broken. During the course of the activity participatory piezometers were installed at farmers' land and local water management was discussed in plenary. The results were a shift from paddy cultivation to other crops and water releases to the tail ends of the distributory for the first time in 3 years. Promoting local groundwater management in these conjunctive environments requires a simultaneous reconsideration of surface water deliveries. There is large scope here in making large improvement in water management—that at present is hardly explored.

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