Informing and Enabling
Local Ground Water Governance for Yemen

Taha Taher, Bryan Bruns, Omar Bamaga, Adel Al-Weshali, and Frank van Steenbergen[i]

Prepared for The National Conference on Management and Development of Water Resources in Yemen, January 15-17, 2011

ABSTRACT

This paper discusses local groundwater management in Yemen and how stakeholders can work together to improve water governance. In the last few decades the discourse on groundwater management in Yemen has increasingly been cast in terms of crisis – triggered by rapidly declining groundwater tables around cities and in main agricultural areas. However, in many areas in the country farmers have responded to these threats to local water security by implementing at least some local rules and restrictions on the use of groundwater. This paper describes this trend towards development of local groundwater governance, which could make a major contribution in realizing the goals of national water sector policies and strategies. Seven cases from different parts of the country are presented. The paper discusses how the process of local management could be nurtured and how it could contribute to restoring balance in water use in Yemen.

INTRODUCTION

Yemen's rich heritage of managing water includes not only the famous Marib dam, mountains wrapped with terraces, and a multitude of surface irrigation systems based on diversion dams and springs, but also the social capital of institutional arrangements for leadership, water allocation, resource mobilization, and conflict resolution. Water governance is currently challenged by rising water demand, aquifer depletion, expansion of irrigated agriculture, urbanization, loss of natural recharge, and other changes. Many communities have taken initial steps to prevent harmful development of water resources, avoid wasteful use, harvest rainwater, replenish groundwater, and ensure access to water for drinking and domestic use. Many communities have required spacing between wells, and some have closed or restricted usage of wells that interfere with domestic water sources. Individual farmers have done things such as switch to more efficient irrigation technologies, adjust cropping patterns, and share in investing in and using wells and pipe networks. However, as depletion of fossil aquifers grows more severe, much more may need to be done. A change to better management of shared common pool resources of surface and groundwater cannot be accomplished by individual users acting on their own, and neither can the government acting alone overcome the problems. Instead, cooperation among stakeholders is essential for improving water governance.

This paper discusses how to support this trend and how to scale this up. Such local action could play an essential role in adapting to growing water scarcity and realizing the goals of Yemen's National Water Sector Strategy and Investment Program (NWSSIP) and the National Water Sector Support Program. Effective and equitable water governance at the

level, with stakeholders cooperating in various ways including through water user groups, associations, local councils and other institutional arrangements, could be crucial for achieving the objectives underlying the Water Law and NWSSIP, as it develops institutions that can work as effective partners with national and basin scale activities to improve water management.

In South India, development of local groundwater governance institutions has reduced water consumption but at the same time brought economic growth. Perhaps surprisingly, many of the most important impacts have come not from strict law enforcement or punitive sanctions, but instead emerged through improvements in communication, local groundwater monitoring, and sharing of information. While geographic conditions are very different in Yemen, this paper suggests that there is similarly much potential to gain from improving understanding, facilitating deliberation and consensus-building, and supporting local initiatives to manage groundwater and other water resources more carefully and more wisely.

While much discussion of participation concentrates on how farmers and other stakeholders might take part in government projects and programs, this paper switches the emphasis to what communities can do themselves, and how government can participate in community-driven water governance, particularly by providing support to inform and enable local problem-solving. The paper points out a number of practical opportunities to promote and extend community groundwater management – including the creation of a movement of good examples, improvements in extension services, the training of support groups (drillers, local councils, security forces) and the engagement of the recently created water management institutions. The paper then discusses ways of strengthening water governance and building institutions for community-driven water management, and outlines a sequence of practical steps to help communities assess their situation, consider principles, goals, and options, reach agreement, and carry out practical actions to adapt to water scarcity and improve water management.

BACKGROUND

Yemen's communities possess rich traditions of experience managing land and water resources, demonstrated not only by physical works such as terraces, diversion dams and canals but also by an array of customary institutions for organizing collective action; regulating access to land for cultivation, grazing, and water harvesting; and resolving conflicts by discussion, mediation and arbitration through networks of social relationships.[ii] Traditional spate irrigation institutions established leadership roles, norms for shared contributions; allocated rights to water (primarily through upstream-first-served rules suited to uncertain and highly variable flows); and provided processes for dealing with conflicts.[iii] Many of these arrangements date back centuries, and some are recorded in historic documents.

The local governance not only concerned surface water, but also related to the use of groundwater. In the past in Shabwa and Hadramout for instance local laws ensured that any new qanat (canal) that was to be developed could not interfere with existing ones. If a

newly constructed qanat was found to interfere with an existing one, work on it would have to be stopped immediately.[iv] Another age-old groundwater management rule is the 'harim' (border) that has its origins in the Sunnah (statements approved by the Prophet PBUH considered as legally binding precedents). The harim defines a protected area[v] around a spring, qanat, or well – where no other source could be developed and contaminating activities were forbidden.

Over the last several decades, tube wells and motorized pumps have been used to supply growing populations and extend irrigation. The development of new wells has expanded rapidly and water tables have continued to decline. The economic boost in the seventies and the eighties, and the remittances from workers in gulf countries which accounted for billions of US dollars, opened intensive investments in groundwater irrigation. The area under groundwater irrigation in Yemen has increased from 37,000 ha to 500,000 hectares in a matter of 40 years. The annual decline is typically 2.5 to 4.5 meter - with Sana'a Basin exceeding this and the decline being closer to 7 meters a year.

A major legal instrument promulgated to manage groundwater is the 2002 Water Law. The Water Law spells out licensing requirements for new wells and describes new institutional water management arrangements - such as the Basin Councils and WUAs. At present Basin Councils have been set up in four basins. Under many projects – in drinking water supply and in irrigation – water users associations (WUAs) and smaller water user groups (WUGs) are being promoted.

A simple and very practical example is the Community Water Management Project (CBWMP) which helped form WUGs and WUAs to enable local communities to work collectively to manage their groundwater resources including local women. Many lessons were learned from this experience. Local communities are willing to look after their water resources when they are given the chance and their skills are being upgraded. Communities are becoming more aware of the intensity of water scarcity and the possible future impact on them and the coming generations. Support from authorities in terms of capacity building, technical issues and suitable incentives should be designed to enable the new WUGs/WUAs to continue and stand on their own. Follow up and guidance to the newly established WUAs are needed, especially from the related authorities dealing with groundwater management.

Much of the discussion of groundwater regulation has concerned enforcement of the Water Law: in particular the high number of unlicensed wells being drilled. Recently two new trends have emerged. First, where local conflicts on groundwater development were exceptional, they are more common now - for instance in Amran and Sana' a Basins. Whereas Lichtenthäler observed that in spite of falling groundwater tables there were no conflicts over water in Amran in 2000, in 2010 he says protests and blockages have become common.[vi] Second, in many areas farmers have created local rules and regulations.[vii] Increased extraction from the common pool resources of aquifers has dried up springs and wells. Many communities have sought to prevent harm to existing users, most notably by norms restricting well spacing and banning export of water from their area by tankers. In other cases farmers have closed disputed wells, invested in

groundwater recharge, or have connected separate wells by a shared network of pipelines, allowing water to travel from one area to the other. The agricultural wells also double in several cases as sources of domestic water supply and private village pipe networks supplying domestic water supply services.

Under the Water Law well licensing procedures have been introduced. Even so, as mentioned, many wells continue to be unlicensed. Some communities seeking to stop potentially harmful wells have sought support through local councils, security authorities, courts, and the branches of the National Water Resource Authority. Regrettably, such efforts have often been difficult, time-consuming, and fruitless. Even so, the fact that well development is in principle no longer a 'free for all' and needs to be licensed under the Water Law has offered a source of legitimacy to local initiatives in introducing restrictions and rules.

EXAMPLES FROM YEMEN

Below a number of cases are described of local groundwater management in Yemen. An overview of a number of cases is given in table 1. Though such cases are not systematically recorded, the impression of the table is that community regulation of groundwater is not exceptional and occurs in several places throughout the country. Other examples of local initiatives are included in various articles and reports, such as those mentioned in the bibliographic note at the end of this paper.

Table 1: Cases of local groundwater management

	Place	Type of local rule
1	Hejraht al-Asham, Jabal al-Sharq-Dhamar	Restrict well drilling
2	Wadi Khalaka, Sana'a	Restrict well drilling, ban on tankers, well depth
3	Khrabat Muhyab, Bani Matar, Sana'a	Restrict well drilling, well spacing
4	Qarwa Beshar, Jahanah, Khawlan, Sana'a	Restrict well drilling
5	Hijrat al-Muntasir, Amran	Ban on new drilling
6	Wadi al Qarada, Bani Hushaish, Sana'a	Restrict well drilling, recharge weirs in wadi bed, well sharing
7	Wadi Akarem, Dhamar	Restrict deep drilling in the main wadi
8	Bani Garban, al-Kafr District, Ibb	Restrict drilling of new wells
9	Al-Gawaref, Ibb	Ban on qat irrigation
10	Wa'alah, Amran	Ban on water transport by tankers
11	Bait Sarhan and Alhamrmaly, Amran	Ban on water transport by tankers
12	Al Ma'akhad, Amran	Ban on water transport by tankers
13	Qa'a Al-Shams, Amran	Ban on water transport by tankers
14	Bani Maymoun, Amran	Tankers only within village
15	Wadi Dhelaa, Hamdan, Sana'a	Well spacing, well sharing, dam development
16	Wadi Al Zabaira in Qadas, Al Mawasit District, Taiz	Restrict/ban well drilling, closing disputed wells

17	Al Aroosi, Mehan, Sana'a	Closure of disputed wells, agreement on reservoir operation
18	Al Mashra, Damar	Ban on drilling

Qarada

One example of local management of groundwater concerns Qarada in Sana'a Basin. Qarada is a distributary of the Wadi El Sir. The short term floods in the wadi are diverted to spate irrigate the land, but more importantly they recharge the shallow aquifers. Grapes – in different varieties - are the almost exclusive crop in the area. Because the area is open, it is prone to frost and growing qat is not an option.

There are over 100 wells in the area – typically these are 300 meters apart. Up to 2002/2003 well drilling continued unabated – with a fifteen meter decline a year until the water table reached 320 meters in 2008. The problem of sulphur and fluoride levels increased with depth. In anticipation of the new Water Law, additional wells were developed that were subsequently covered and are not yet used.

The production of the wells over the years also dropped to less than 50%. For a long time the answer to water scarcity was to invest in new and deepened shared wells, rather than in shared conveyance networks. The cost of developing a well is considerable however – and can go up to YR 40 million. Part of the resistance to investing in modernized irrigation systems was the skepticism – partly well founded – on the usefulness of drip systems, as these would not work with the widely spread root system of the old grape plants.

In 2003 two WUAs were established for the area – Al Qarada and Al Ashraf. This was triggered by the Sana'a Basin Water Management Project, which also worked on creating awareness and increasing the interest for improved irrigation systems. Membership grew over the years: Al Qarada started with 70 members but now has 130 members. The WUAs regulate and monitor the drilling of wells. The way it works is that if in the area of the Al Qarada WUA unlicensed drilling is about to start, a complaint will be lodged to the government by the Al Asharaf WUA. This is done to preserve harmony in the area of Al Qarada. The reverse process is initiated by al Qarada if unlicensed drilling is planned in Al Asharaf.

Recharge in the area greatly improved after the construction of 47 stone check dams in the riverbed under the Sana'a Basin Water Management Project. These structures slow the speed of the floods – and increase the infiltration rate. The speed of the water is still sufficient to ensure that sediment is removed. The investment in the structures including the stone bank protection amounted to USD 1 M. A comparison of this type of structure with recharge dams found that they are significantly more effective in recharging local aquifers – particularly in comparison with large dams.[viii]

There are several plans to improve water use in the area. One plan is to promote drip irrigation but use a storage tank to create enough pressure. The development of drip systems suitable for the wide-rooted crops is a special challenge. There are also request

for better support in marketing and extension: grapes suffer from pest attacks but there is no effective extension. Also there is concern that the grapes may suffer from import of raisin from other countries.

Khrabat Muhyab, Bani Matar, Sana'a

The main water source of the Khrabat Muhyab area is the run-off from Jebel Mountains. This feeds the aquifers and springs. Over the years farmers have moved to groundwater irrigation, typically pumping water from wells 150 to 180 meter deep. The wells – if only because of their cost – are shared by many families. A typical well may have seventeen shares and ownership is between 25-30 families.

Following a violent conflict in a nearby area over the sharing of water from a dam that was to be built by the government, farmers decided to regulate the use of water in their area. The establishment of the WUA – called 'Bled Agustan' was triggered by seeing the conflict and hardship arising from overuse of groundwater in nearby areas – it was not set up by any project but created at the initiative of concerned farmers.

The WUA initially regulated the seven wells in Khrabat Muhyab village. Minimum rules were set on the distance between wells that irrigate 53 ha[ix] under fruits and staple crops (not qat). Wells were to be at least five hundred meters apart – but depending on the location the distance can be even larger. The minimum distance to a spring for instance is 2000 meters.

Whereas the WUA initially covered seven wells in two villages, its usefulness has been recognized and it now covers the area of 58 wells in eight villages. The membership went up from 80 to several hundred. The development of new wells in the area is not allowed unless a clear need for a new well (rather than getting water from an existing well) is proven and the minimum distance is observed. Improved irrigation techniques are relatively exceptional in the area and there appears to be a good scope for improving water management on this front too.

Dhelaa, Hamdan, Sana'a

Dhelaa is located at relatively close proximity to Sana'a and has a long history of irrigated agriculture. The area receives surface water from the four kilometer Matba tributary of the Wadi Dhelaa and in the past was supplied both by surface flows from the river bed and by ancient qanats or horizontal wells. Sabean inscriptions inside the tunnel of the qanats suggest that they were developed at least two thousand years ago. Over the years the tunnel was gradually deepened to keep up with fluctuating water tables. Land levels also increased over time – due to sediment from the adjacent hills. Fifty years ago dug wells were developed – initially operated by animals but as water tables became deeper the wells were deepened and farmers increasingly resorted to diesel pumps. At this time grapes, apricots and maize were the main crop – mixed with qat and fuel wood.

As the qanat ran dry from 1982 onwards, and as shallow wells started to fail around 1990, farmers shifted over to deep wells – boring up to 300 meters deep – with water tables

between 150 to 200 meters. The shift to deep wells coincided with a transition to growing mainly qat and fuel wood trees – as the deep wells required a higher value crop. In Dhelaa five wells have been developed – all under shared ownership. Ownership in the wells is divided in shares – corresponding to half a day's water supplies (contingent on availability of high voltage electricity). The shares – for instance sixteen per well – may be owned by more than family. This can bring well ownership up to thirty families per well. All wells are shared and families have shares in more than one well. Moreover, the five wells in Dhelaa are connected through a shared pipeline system. This makes it possible to irrigate the entire area from different wells and to compensate for the temporary breakdown of one deep well by sourcing water from another well. In Dhelaa a minimum distance on new wells has also been imposed. This used to be 500 meters from an existing well - but has now increased to 700 meters.

Within these distances it is not allowed to develop a new well – but one can always buy water from one of the existing wells. Because all landowners are interconnected and because everybody has a share in at least one well, enforcement of this rule has had to overcome problems. Farmers in Dhelaa came to the regulated and shared system after seeing the severe decline in groundwater in nearby Shamlan where many wells were developed in a very short timeframe. The rule was introduced gradually – under the leadership in this case of the local sheikh family. There is no water users association in Dhelaa. If there were a conflict on the local regulations, then the local council, security forces or members of parliament could be called upon. In fact, if there are conflicts, it is on the joint running of the shared wells: who is first, how to compensate for power outages, and how to pay for the cost of maintenance and repairs.

The wells in Dhelaa are not only used for agriculture: they are used for drinking water supply as well. The community has in fact built up their own water supply system from the same wells. Special pipes connect to different sections of the small town. This developed over the years. The wells were initially for irrigation – but were next connected to the mosques and then to individual households and public water points. YR 2000/month (nearly USD 10) is paid per month for a house connection.

The water table has more or less stabilized, More or less – because some wells still need to be deepened – but very modestly. The main drinking water well for instance has to be deepened with six meters over the last three years but other wells are stable. The seeming balance is also attributed to the construction of a recharge dam at Al Merbaha – one of the two sources of Wadi Madla. The work was initiated by the sheikh family – who invested YR 6 M in the construction of dam at the end of the 1990's. The dam was subsequently upgraded in 2002 to a 25 meter high structure with a sand core and rip rap covering at a cost of YR 150 M. The dam is overdimensioned – even in the recent wet year it has not filled more than a third of its capacity. The dam however is reportedly successfully contributing to recharge in the area. In fact the reservoir is also positioned on top of the mother well of the qanat, although the tunnel system has been disconnected in this area.

Wadi Ghulaka, Nahem, Sana'a

The area of Wadi Ghulaka still has sufficient groundwater and carefully guards it. The construction of the Arisha Dam was initiated to improve recharge to the mainly shallow wells in the area. There is in fact a ban on drilling wells too deep – with the limit set at 200 meters. The fear is the quality of the deeper groundwater – which is expected to be saline. Another local rule is a strict ban on selling water outside the area. Tankers are not allowed into the area – neither to collect water from the shallow wells nor from the dam reservoir. The local rules were initiated by the chairman of the WUA established for the Arisha Dam.

Wadi Al Zabaira, Al Mawasit, Taiz

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.[x] 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 hours a day and occasional breakdowns have been solved in a timely manner.

These committees are a source of pride and have substantial goodwill. Though they were set up 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 kilometer from the drinking water source.

One farmer in Al Dhuniab made an attempt to dig a two meter diameter well with reinforced concrete rings with a depth of 25 meters 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 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 landowners. 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 irrigationirrigation 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 bore well for a neighboring village within a kilometer 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, without finding groundwater.

Hijrat al-Muntasir, Amran

Like in many other parts of Amran, in Hijrat al-Muntasir the cultivation of qat has been on a meteoric rise, bringing a fragile wealth in a remote rural area (Lichtenthäler 2010). The cultivation of qat was enabled as elsewhere by deep wells, but these were prone to failure. This was partly compensated by purchasing tanker water from nearby villages – in particular al-Qarin. With water tables falling in al-Qarin itself, however, the village issued an official local decree (marqoum) signed by village elders forbidding the sale and trade from their wells to outsiders. As the ban in al-Qarin came into effect, qat farmers in Hijrat al-Muntasir made one more effort to develop a well.

This met fierce resistance from the other villagers, who were very concerned about the effect of yet another well on the spring that is the main drinking water source of the seven hundred inhabitants. The conflict was brought to the attention of the Deputy Governor of Amran and chairman of the Amran Basin Council. Following the dispute, the drilling was stopped and investment in local sanitation facilities was initiated under a project of the Social Fund for Development. The ban on new wells unfortunately did not prevent the spring from drying up.

Lessons from Local Initiatives

There are several conclusions to be drawn from these cases:

- First there is a high level of local management in several cases – often introduced very recently. The local rules consist of measures such as well spacing, closure of disputed wells, and bans on sales to water tankers. In some cases wells are interconnected. There is often considerable community effort to improve groundwater recharge. The notion that groundwater development is an individual affair is in many cases not correct: deep wells in particular are costly and are

shared between a large number of farmers. In some cases several wells in a local area are connected to one another – so that water can be shared in case of well failure. Some wells are not exclusive for agriculture, but instead feed local self-supply village drinking water systems – as for example in Delaa.

- Second local management is in some cases encouraged by projects – such as the awareness and social mobilization activities under the Sana'a Basin Water Management Project or the Groundwater and Soil Conservation Project. In other cases communities come together after having seen disaster striking nearby areas or after having been faced with conflicts occurring in their own area. In general such conflicts are 'functional': they trigger a response – as in the case of Hijrat-al-Muntasir. They are preferable to the default situation where wells continue to be developed unabatedly and the 'race to the bottom' is unchecked.

- Thirdly, the Water Law and the licensing procedures imbedded in it are important – though not necessarily in a direct way. The fact that wells in principle need to be licensed has conspicuously signaled that groundwater is no longer an open access resource and restrictions should apply. This has given impetus and strength to local groundwater management. Invoking the licensing procedures under the Water Law is one of the instruments in local water management – as the case of Al Qarada shows. From the Sana'a Basin Water Management Project there are examples of villages pressuring local councils and the National Water Resources Authority to more effectively regulate and license. In an essentially tribal society this demand for regulation – local and central - is remarkable.

- Fourth, where local groundwater management is in place, the initiative may be taken by a local sheikh, by another respected leader or by a WUA, as in Wadi Al Zabaira. There may be many sources of local leadership – not necessarily the traditional sheikh. In Khrabat farmers themselves established a WUA and this WUA subsequently attracted more members. Some rules may be explicit and are managed by local organizations, but other rules exist as norms and expected practices and do not require a specific organization to support them.

- Finally the local rules and regulation concerns a broad range of measures – location and depth of wells, recharge measures, management of reservoirs and in some exceptional cases cropping bans. Their impact can be high and they are an important component in managing local water resources. It is in fact hard to see how groundwater use in Yemen can be regulated without it being built on a foundation of local acceptance and initiative.

SCOPE FOR IMPROVED LOCAL GROUNDWATER MANAGEMENT IN YEMEN

Groundwater is invisible, and the ways it flows through aquifers are often slow, complex and hard to understand, making groundwater governance difficult.[xi] The intense use of groundwater is something of the last decades and there is no prior experience on what constitutes sustainable management of groundwater, despite Yemen's long experience

with locally-managed governance of surface water. In both urban and rural areas of Yemen, however, there is growing awareness of the dangers of depletion, that groundwater is not a vast or unlimited sea but instead is a limited and diminishing resource, and that withdrawal by users poses a shared problem that requires combined and integrated action to solve. As discussed above, this has provided the basis of action in some areas and should provide the basis for action in far more areas in the country. The importance and scope for local community groundwater management is acknowledged in professional and academic publications. More effective local institutions for groundwater governance will provide a better foundation for peaceful negotiation and management of the challenging issues of shifting water from agriculture to urban needs, in ways fair and acceptable to all those involved.

A recent synthesis of research on groundwater in the Sana'a Basin provides some useful though limited data on how slowly groundwater flows (hydraulic conductivity), often only a few kilometers per year or less.[xii] the implication is that local communities are the ones who most immediately suffer the impacts of high withdrawals, and correspondingly, local areas would retain most of the short and medium term benefits of reducing extraction, for example by shifting to more efficient irrigation techniques, and increasing groundwater recharge. Rather than being a unified sea, or a single vast common pool, aquifers are instead a mosaic of smaller pools, interrupted by faults and other geological formations, with groundwater only slowing flowing between different areas. Shared interests are local, making this a suitable scale for organizing collective action by stakeholders. Thus the local scale of villages, districts, and small sub-basins is crucial for organizing collective action by stakeholders.

Local groundwater management needs to be more actively encouraged – and could complement other developments in water institutions in the last ten years (such as the Water Law, National Water Resources Authority, Basin Councils and Water Users Associations). Improving local groundwater institutions requires the facilitation of local governance processes and creating a better understanding and awareness of the groundwater potential. Much more could be done to make hydrological information from technical studies and official monitoring available to water users, and to synthesize local knowledge and experience as part of participatory analysis of local conditions and options for improved water management.

Much of the discussion of water management has been framed in terms of technical concepts of integrated water resources management and regulation through formal institutions. Less has been done to understand customary and religious principles applicable to dealing with increasing water scarcity (which can be seen as ways of realizing important principles of IWRM in a locally meaningful way).[xiii] The specific ways these might apply to a particular local problem are something for which local discussion and deliberation are crucial. However, in the context of Yemen, principles such as ensuring access to drinking water ("right of thirst"), avoiding waste, avoiding harm, encouraging productive use of resources, balancing private and public interests, and assuring orderly distribution of water that respects customary norms and rights, offer

powerful ideas for developing more effective, locally meaningful, institutions for water governance.

Experience in Yemen and internationally shows the potential for a community-driven approaches, which could involve stakeholders in a sequence of practical steps, supported by information and responsive enforcement by national and basin institutions. Such efforts will require overcoming many difficulties, may only progress gradually through relatively modest steps, and require a willingness to experiment and learn from success and failures along the way. The challenges are different in different locations – depending on the local community structure, its leadership and economic interests. It differs between the different aquifer systems – the limestone areas, the sandstone aquifer and volcanic aquifers – as well as the coastal alluvial systems. In all these areas the depth of aquifers differs, as does the interplay between surface and ground water, and the interdependence between different water abstraction sites.

Recent research on governance of shared resources such as groundwater has emphasized how monitoring by users is often crucial to the feasibility and success of governing commons.[xiv] A particular challenge in dealing with groundwater is that is invisible, making it hard to understand and hard to monitor. Thus, the feasibility of management will often depend on finding rules that can be monitored, rather that attempting management that depends on extensive technical analysis. Governance of groundwater is more likely to succeed if it is based on simple rules that are easier to understand and monitor, rather than complex, technically based licensing regulations. Considering the feasibility of monitoring helps to understand the measures communities have already undertaken, those that might be most likely to work, and the ways in which technical information might help to enhance understanding and governance of groundwater.

Table 2 outlines current measures and potential options, ranked in terms of their visibility. The table highlights in bold some of the variables that are more visible and more likely to be influenced by intervention, including drilling of new wells and well spacing, which currently receive attention, some such as irrigation efficiency which have been demonstrated to be feasible and could be further encouraged, and others, such as crop type and area and recharge which have received relatively less attention. The table also helps point out the difficulties faced by any approach that would rely on quantitative information about withdrawals, aquifer storage and flows, due to the difficulty of observation and associated costs, technical complexity and uncertainty. At the same time, the table makes clear there are a range of options for intervention, and overreliance on a single measure would be risky and miss important opportunities that could be gained through more diversified approaches, which communities can customize to fit local conditions.

Table 2. Monitoring Groundwater: Visibility and Implications for Local Management[xv]

no	VISIBILITY	VARIABLES	EXAMPLES	IMPLICATIONS FOR INTERVENTION
1	High	**Drilling new wells**	Presence of drilling rig, moratorium on new wells	Potential to empower & support local controls, improve formal enforcement
2		Deepening or replacing existing wells	Presence of drilling rig, existing well, and irrigation	"People have to live." Hard to stop
3		**Spacing of wells**	500 meters apart	Avoiding harm, already practiced
4		**Selling water to tankers**	Forbidding export, requiring formal water rights and approval	Avoiding harm, local priority, some examples of restrictions
5		Abstraction for domestic water	Hauled by people or donkeys, piped use can be metered	Priority for drinking, right of thirst, local regulation to protect sources
6		**Crop type**	Ban bananas, alfalfa, or other crops with high water demand?	(Potentially :) Waste, harm, denying water. Few examples so far.
7		**Crop area**	Limits on expansion	Productive use of resources, equity, agreements not to expand, enforcement
8		**Conveyance**	Canal or pipes	Incentives for saving. Avoiding waste
9		**Delivery**	Flood, furrow, basin, sprinkler, bubbler, drip	Incentives for saving. Avoiding waste
10	Moderate	Duration of irrigation	Hours, seasons	Avoiding waste, community interests
11		Fuel consumption	Liters of diesel	Cost, fuel price subsidies
12		**Excess irrigation**	Runoff, weeds, non-beneficial evapotranspiration	Waste, productivity, hard to measure precisely, can estimate and inform
13		Providing water to neighbors	Pipes, water flows	Hard to restrict
14		**Community approval of well drilling**	Consultation and consensus by community & local council	Increasing community control
15		**Government approval of well drilling**	Licenses. Uncertain quality of procedures and analysis.	Need for participation and transparency
16		Depth to water table	Meters from surface	Can map and graph systematically to inform communities
17		Well recovery rate	Hours to restore level	Can analyze and inform
18		**Aquifer recharge**	Terracing, check dams, basins	Many existing examples. Can analyze technically and inform.
18	Low	Quantity abstracted	m^3	Requires meter, hard to control, vulnerable to manipulation
20		Impact on other wells and springs	Drying up nearby wells or springs, cone of depression	Often hard to prove, complicated to measure, sometimes obvious
21		Aquifer transmissivity	Lateral flow, meters per unit of time	Can assess from local experience, Can analyze technically and inform
22		Aquifer storage capacity	m^3 of water per m^3	Can assess from local experience, Can analyze technically and inform

EXAMPLES FROM DIFFERENT PARTS OF THE WORLD

Examples of community groundwater management come from many parts of the world: Pakistan, Egypt, India – but also Spain and the United States.[xvi] Particularly relevant examples of systematic support for local groundwater management come from Andhra Pradesh in India.[xvii] Several programs have supported community groundwater management – the most substantial project in terms of geographical coverage and methodology being the Andhra Pradesh Farmer Management Groundwater Systems Project (APFAMGS).

In APFAMGS there was no investment in infrastructure. The emphasis was instead on increasing the collective understanding of the groundwater resource by and through farmers. Farmer measurement of basic hydrological parameters was to be the basis for coordinated crop planning by groundwater-dependent farmers. APFAMGS is active in 62 hydrological units (sub-basins); spread over seven districts in Andhra Pradesh. The average population size of a hydrological unit is 9,684. Though there is a range, the average number of groundwater users in a hydrological unit is 406. In each of the hydrological units a number of activities are undertaken:

- Promoting participatory hydrological monitoring – with farmers measuring their own water levels as well as running local rainfall stations
- Crop water budgeting for the entire hydrological unit on the basis of available recharge – with farmers in the end deciding themselves how to adjust their cropping system
- Farmer water schools, again largely run by farmers – to improve understanding of groundwater and introduce water saving techniques and change cropping patterns.

The impact of the APFAMGS activities has been analyzed from the detailed database that the project maintained.[xviii] The main results were:

- In 50% to 71% of the hydrological units with predicted negative water balances, farmers adjusted their crop choice immediately from what they had planned originally for the dry season of that year
- In all these hydrological units, farmers adjusted the proportion of high water demand crops over the years. In all these units water-intensive rice cultivation was reduced – in half of the cases almost making an exit from the cropping patterns, even from high starting points.
- This resulted in rising water tables, suggesting that the intensive awareness program was particularly successful in the overstressed areas.
- To add to the successful adjustment in cropping patterns, there has also been a significant increase in the use of improved field irrigation, moisture conservation and micro-irrigation methods– going up from 15 % of the area in 2005/2006 to 34 % of the area in 2007/2008. The increase concerns methods that involve subsidized investment – in particular drip and sprinkler systems, as well as methods that

concerned management measures adopted by farmers, such as check basins or the use of vermicompost.

- Most importantly better groundwater management did not result in lower returns – but rather the opposite. The net value of agricultural outputs in all the hydrological units in the project was higher than in the pre-project period – with increases ranging from 6 to 111%. In non-project areas on the other hand, the net value per hectare dropped with one exception and ranged from -51% to 34%. There are several factors at play here – one is that there is a large scope to improve water management and at the same time improve production and introduce profitable farming techniques and crop choices.

In Yemen similarly there is scope to further promote community groundwater governance. Various projects, including the Community Water Management Project (CBWMP), Groundwater and Soil Conservation Project (GSCP), and Sana'a Basin Water Management Project (SBWMP) have shown that water user groups and water user associations can play an important role in efforts to improve water management. Considerable scope exists to enhance and expand such efforts, in ways that will also make them more locally sustainable, especially through greater integration with decentralized activities at the scale of local communities, sub-basins and districts. Several immediate options are:

- Document and upscale existing examples of effective local management. Engage farmer leaders from good practice areas in spreading the message, exchanging ideas, and creating a movement of local groundwater management – particularly in the hotspot areas. Consider and develop support for projects similar in nature to the APFAMGS project
- Integrate promotion of community groundwater management in the large ongoing irrigation programs – in particular the National Irrigation Project (NIP), the Ground Water and Soil Conservation Project, and the possible successor programs. In these projects an Irrigation Advisory Service (IAS) is engaged in introducing efficient irrigation systems – in particular conveyance systems and drip irrigation. An IAS Plus is now being formulated which in addition to the promotion of the modern irrigation systems would (1) systematically promote the process of facilitation of community regulation of groundwater usage (2) promote a broad range of water saving measures – not only more efficient techniques for delivering irrigation water – but also better scheduling, land leveling and field moisture conservation methods and (3) provide agricultural advice and services – on alternative crops, better marketing, better crop husbandry. At present the coverage of extension services is low although the demand from farmers is high.
- Systematically engage key support groups in the local management of groundwater Working with local councils, with security forces and with well drillers – giving examples of community water management and the provision of the Water Law. Consider supporting local association within these groups – such as drillers associations with self-regulating rules and code of good practice.

- Work on improving connections between the different new water management organizations (Basin Councils and WUAs) and local management of groundwater. Engage existing WUAs – including the ones created in rural water supply projects – in community groundwater management.

CONCLUSIONS

Balancing water use with inflows and equitably coping with water scarcity will depend on local water users working together, as Yemenis have done historically. Before the advent of deep tubewells and motorized pumps, water use was inherently limited to the amounts available from spate flows, springs, rainfall, and shallow groundwater. At current rates of extraction, the fossil water in deeper aquifers will be depleted within years or decades, as has already occurred in many areas around Taiz and some other parts of Yemen.[xix] The challenges concern whether adjustment can occur in a reasonably equitable, orderly, and efficient way, and the extent to which high quality water in deeper aquifers might be preserved for drinking and other high value use in the future.

Water user associations take multiple forms: informal and formal, small and large, for piped domestic supply and for irrigation, and already play a significant role in water management, particularly in the operation and maintenance of piped water systems. Collective action to improve infrastructure and provide services, in water and other sectors, has repeatedly proved feasible in Yemen, but needs adequate autonomy and a supportive environment to be sustainable. The Social Fund for Development is a recent example that shows again that, despite differences in wealth, power, gender, tribal identity, and other factors, communities in Yemen can deliberate and come to considered decisions about how to invest and manage, in ways that are socially inclusive and emphasize serving the needs of all, including those who are poor and vulnerable. This could be facilitated through support by a well-managed program, with skilled field staff who are ready to listen to and work with the whole range of stakeholders, helping making sure that benefits are not captured by a few but instead are distributed in a just manner among all stakeholders.

A process for supporting community water governance can be organized in a series of steps. This should concentrate at the level of villages and districts, appropriately integrated with activities at the sub-basin, governorate, basin and national scale. This could be done at relatively low cost. While key activities need to be carefully carried out, it would be feasible to scale up for widespread implementation and meaningful results with a time frame of a few years.

A community-driven process should start by working in districts where there is substantial interest from local leaders and citizens in finding better ways of dealing with water scarcity, and where some local initiatives already exist. Initial workshops and training can prepare district councilors and others to go out to communities and help them assess and improve local water management. Box 1 outlines key steps for a process of participatory water assessment.

This paper suggests that there is great potential to support rural communities in improving water management, as an important part of realizing the goals of the NWSSIP, WSSP, NIP, and other policies and programs for water in Yemen. A sequence of activities can help assess local conditions, review values, envision feasible and desirable futures, consider options and reach agreement and carry out practical steps to improve water governance. National agencies, governorates, and basin commissions, and programs such as NWSSP, can support such a process, particularly through:

1. Facilitating participatory assessment processes,
2. Making technical information and analysis available, and
3. Providing effective enforcement that responds to local priorities.

The approach discussed in this paper would be relatively low cost, and could be rapidly rolled out and scaled up. Making it work would require sincere implementation, allowing diversity in activities adapted to local conditions and priorities, experimentation and learning from experience. Local and higher levels institutions would complement each other, working at multiple scales to inform and enable improved water management by stakeholders working together.

Box 1. Participatory Water Assessment (PWA)[xx]

- Initial meetings bring stakeholders together to discuss local water problems, past efforts, and examples of what communities have done elsewhere to improve groundwater management and water conservation
- Sketch maps identify water resources and problems (along with topographic maps, air photos, and remote sensing images if available). Participants can record different impacts and changes such as wells that have gone dry, change in crops and agricultural techniques, and the impact on families. Trends in water use, well numbers and depth, irrigated area and other factors can be plotted on graphs and maps.
- Joint walks to observe water sources and water uses help participants to consider actual conditions and discuss problems.
- Reviewing relevant values helps identify priorities and principles that should guide the search for solutions. In the context of Yemen, important values are likely to include customary and Islamic values of assuring access to drinking water, avoiding waste and harm, orderly access, productive use of resources, and balancing of public and private interests.
- Envisioning a desirable future that could result from better management of shared resources is a crucial stage, synthesizing ideas from earlier steps, reacting to current problems and the scenarios most likely to occur if changes are not made, and coming up with feasible, desirable shared visions for a better future.
- Participants can then consider specific practical steps that they could take to respond to local problems and priorities, moving towards a future they want. This could include assuring access to adequate supplies of water for drinking and domestic use, preventing harmful changes, reducing waste, replenishing groundwater, adapting agriculture to increasing water scarcity and improving livelihoods. Discussion should emphasize what communities, at the level of households, villages, and districts could do using their own capabilities and

resources, but might also identify what more they might be able to accomplish with aid from outside.

- Agreement should be established on some practical steps that communities can do on their own, deciding who will do what, and when to meet again to review progress and discuss problems, solutions and further steps that could build on initial accomplishments.
- Periodic meetings can be held to follow up on what has occurred, work out ways to deal with problems that have arisen, and take further actions to improve water management.

NOTES

[i] The authors with to thank the Scientific and Presentation Committees of the Conference for the opportunity to present the paper, and for helpful suggestions, including comments from Dr. Al-Hamdi. Statements in the paper are the responsibility of the authors and do not represent any organization with which they are or have been affiliated.

Author information:

Dr. Taha Taher has extensive experience as a researcher and development practitioner concerned with water management in Yemen. He was the manager for the pilot Community Water Management Project implemented by the Water and Environmental Centre (WEC) of Sana'a University. He has authored and co-authored many reports and other documents on water management in Yemen. tmtahiri@y.net.ye

Bryan Bruns is a consulting sociologist specializing in improving participation in water resources management. Recently, he was a member of the World Bank Implementation Completion Mission for the Sana'a Basin Water Management Project. He co-edited *Water Rights Reform: Lessons for Institutional Design* as well as *Negotiating Water Rights*, and many other publications (see www.bryanbruns.com). Together with Dr. Taha Taher he conducted and co-authored the 2009 *Yemen Water Users Association Study: Findings and Recommendations for a Problem-solving Approach.* bryanbruns@bryanbruns.com

Dr. Omar Bamaga is a staff member of the WEC. He is a researcher in the NWO CoCoon team 'Groundwater in the Political Domain' and involved in the documentation project on accountability in local groundwater management. oabamaga1@yahoo.com

Dr. Adel Al-Weshali is an associate of the Water and Environmental Centre (WEC) of the Sana'a University and Associate Professor in the Faculty of Agriculture. He is a researcher in the above mentioned documentation project and was the Dean of the Sanhan Community College. drweshali@yahoo.com

Dr. Frank van Steenbergen is a water resources specialist with MetaMeta, a company devoted to social change and sustainable resource management. He has extensive experience in the region, particularly with spate irrigation management and groundwater governance and has authored several books and popular publications – including *Ideas for Groundwater Management* and *Managing the Groundwater Buffer for Development and Climate Change Adaptation*. He is a lead researcher in the NWO CoCoon research program, "Groundwater in the Political Domain' and a member of the World Bank's GW-Mate team.fvansteenbergen@metameta.nl

[ii] **Bibliographic note**:

The paper draws on experience of the authors in Yemen and internationally, including field visits and project implementation. In addition to specific citations later in these endnotes, the following sources provide information on many of the topics discussed in the paper.

- For an insightful assessment of spate and spring irrigation institutions in Yemen, see Varisco 1983.
- Al-Hamdi 2001 provides a thorough and still very relevant analysis of water issues, particularly in the Sana'a region.

- Lichtenthaler 2003 describes local institutions that govern access to land and water, the transformations involved in increasing groundwater use, and principles from customary and Islamic law relevant to improving water governance.
- Hellegers et al. 2008 analyze economic incentives and raise important questions about current assumptions and policies.
- Ward 2009 analyzes water conflicts and the potential for improving local dispute resolution.
- Vermillion and Al-Shabani 2004 analyze local collective action and government intervention in micro-dam development.
- Bruns and Taher 2009 review experience with water user associations in Yemen and recommend approaches for improving sustainable participation in water governance.

[iv] For further information on this and other cases, see Baquhaizel, et al. (forthcoming).

[v] *harim defines a protected area…* The harim is usually defined as 250 meter from the spring or well in soft rock terrain and 500 meters in hard rock areas.

[vi] *conflicts over water in Amran…* Lichtenthäler 2003, 2010.

[vii] *farmers have created local rules —* Van Steenbergen and Shah 2003 explain why simple rules are more effective for governing groundwater than technically-based licensing schemes.

[viii] *[Check dams] more effective in recharging local aquifers…* Alderwish and Alderwish 2009.

[ix] 12000 lebnha (= 44 sqm)

[x] *local committees… increased their agenda so as to include groundwater management* van Steenbergen 2006

[xi] *making groundwater governance difficult…* Research on groundwater governance in South Asia and elsewhere is synthesized by Shah 2009. Van Steenbergen 2006 has an overview of experiences in promoting local groundwater management in different parts of the world.

[xii] *how slowly groundwater flows…* Hydrosult et al. 2010

[xiii] *realizing important principles of IWRM…* Caton 2007 discusses how water problems in Yemen are framed by ideas and discourse, particularly conceptions of integrated water resources management (IWRM).

[xiv] *monitoring by users is often crucial…* Ostrom 2009.

[xv] *Table 1. Monitoring Groundwater* Table prepared by Bryan Bruns. A modified version was included in the AOPP Report (Ward et al. 2010).

[xvi] *Examples of community groundwater management…* van Steenbergen 2006

[xvii] *local groundwater management … from Andhra Pradesh in India…* Van Steenbergen 2010 updates the experience in supporting local community groundwater management based on several large initiatives in India.

[xviii] *impact of the APFAMGS activities…* van Steenbergen 2010

[xix] *deeper aquifers will be depleted…* Handley 2000 described aquifer depletion and conflict around Taiz.

[xx] *Box 1. Participatory Water Assessment…* For further discussion of this process, see Bruns and Taher 2009.

REFERENCES

Alderwish, Ahmed Mohammed and Wael Ishaq Mohamed Alderwish 2009. Integrated Water Management for Small Catchments in Arid Mountain Regions. Mimeo. Sana'a; Sana'a Basin Water Management Project.

Al-Hamdi, M. 2000 Competition for scarce groundwater in the Sana'a Plain, Yemen. A study on the incentive systems for urban and agricultural water use. IHE PhD thesis. *Balkema Publishers. ISBN* 90, no. 5410: 426.

Baquhaizel, Salem Abdullah, Ibrahim Ahmed Saeed and Mohammed Salem bin Ghouth. (forthcoming). Documentary study on models of traditional irrigation systems & methods of water harvesting in Hadramout & Shabwah governorates. Sana'a: EPC, EKN.

Bruns, Bryan, and Taha Taher. 2009 Yemen Water User Association Study: Findings and Recommendations for a Problem-Solving Approach. Sana'a: Groundwater and Soil Conservation Project, December 19.

Caton, S. C. 2007 Yemen, Water and the Politics of Knowledge. In *University of California, Berkeley*. Berkeley, California.

Handley, C. D. 2000 Water stress; some symptoms and causes; a case study of Ta'iz, Yemen.

Hellegers, P., C. Perry, N. Al Aulaqi, A. R Al Eryani, and M. Al Hebshi. 2008. *Incentives to reduce groundwater extraction in Yemen*. Sana'a: WE.

Hydrosult/WEC/TNO 2010 Assessment of Water Resources Potential of The Sana'a Basin Strategic Options for the Sustainable Development and Management of The Basin's Water Resources. Republic of Yemen Ministry of Water and Environment Sana'a Basin Water Management Project. IDA Credit 3774-Yem. Sub-Component 3(D)

Lichtenthaeler, G. 2003 *Political ecology and the role of water: environment, society and economy in northern Yemen*. Ashgate Pub Ltd.

— 2010 Water conflict and cooperation in Yemen. *Middle East* 254. Spring 2010, 30-36.

Naji Abu-Hatim, and Ahmed Shawky Mohamed. 2009 Participatory Irrigation Management and Cost-Sharing in Yemen. In *Water in the Arab World: Management Perspectives and Innovations*, ed. N. Vijay Jagannathan, Ahmed Shawky Mohamed, and Alexander Kremer, 367-382. Washington D.C.: World Bank.

Ostrom, E. 2009 Beyond Markets and States: Polycentric Governance of Complex Economic Systems. Nobel Prize Lecture.

Shah, T. 2009 *Taming the Anarchy: Groundwater Governance in South Asia*. Washington, DC: RFF Press.

Susmita Dasgupta, Craig Meisner, Andrew Makokha, and Richard Pollard. 2009 Community Management of Rural Water Supply: Evaluation of User Satisfaction in Yemen. In *Water in the Arab World: Management Perspectives and Innovations*, ed. N. Vijay Jagannathan, Ahmed Shawky Mohamed, and Alexander Kremer, 383-399. Washington D.C.: World Bank.

Taher, Taha 1996 Water Availability versus Water Rights - A Case study Wadi Siham. *Symposium of Water Resources in Arab Countries*, in Tripoli, Libya

— 2002 Rainwater Harvesting Systems: a Community Based Managed Systems. *Journal of Science and Technology*, no. 1, Vol. 7, 2002, University of Science & Technology, Sana'a, Yemen

van Steenbergen, Frank. 2006 Promoting local ground water management. *Hydrogeology Journal,* 14, 380-391.

— 2010 Community-Based Ground Water Management in Andhra Pradesh: Moving Towards Proven Models. Mimeo, Washington: World Bank GW Mate.

van Steenbergen, F., and Tushaar Shah. 2003 Rules Rather than Rights: Self-Regulation in Intensively Used Groundwater Systems. In *Intensive Use of Groundwater. Challenges and Opportunities*, ed. M. Llamas and E. Custodio. Lisse, The Netherlands: Balkema.

Varisco, D. M. 1983 Sayl and ghayl: The ecology of water allocation in Yemen. *Human Ecology* 11, no. 4: 365–383.

Vermillion, D. L, and S. Al-Shaybani. 2004 Small dams and social capital in Yemen: how assistance strategies affect local investment and institutions. Colombo: International Water Management Institute.

Ward, C. 2009 Water Conflict in Yemen: The Case for Strengthening Local Resolution Mechanisms. In *Water in the Arab World: Management Perspectives and Innovations*, ed. N. Vijay Jagannathan, Ahmed Shawky Mohamed, and Alexander Kremer, 233-267. Washington D.C.: World Bank.

Ward, Christopher, Abdullah Saleh Saif, Mohammad Sultan, Nasser Fadl, Omar Sakkaf, Taha Taher, and Salem Basuhay. 2010 *Action Oriented Policy Paper: Assessment of Phase I and suggestions for Phase II*. June 30th, 2010. Sana'a Basin Integrated Water Resources Management Project. Republic of Yemen