GROUNDWATER SECURITY IN YEMEN

Role and Responsibilities of Local Communities in Conserving Groundwater

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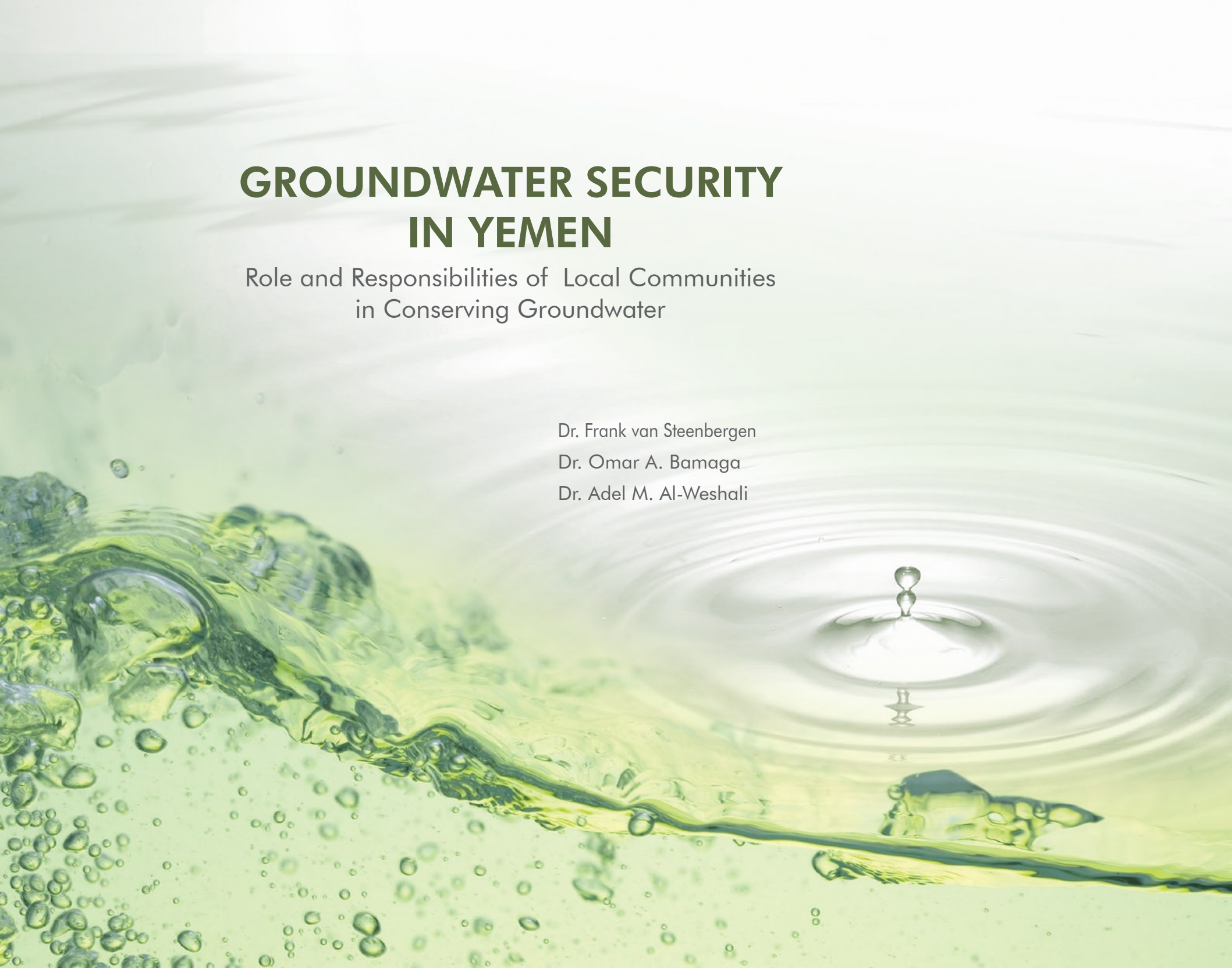

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1. INTRODUCTION

This paper describes current groundwater use in Yemen. It focuses on two aspects: local management of groundwater by farmers themselves and the link between local management and the 2002 Water Law and other legislation. With respect to groundwater security the paper particularly asks the question: who is accountable to whom?

The development of groundwater use in Yemen has been rapid and unprecedented in time and place. According to Al-Eryani et al (2011) groundwater-irrigated agriculture increased from 37,000 ha in 1970 to 400,000 ha in 2005. This is the equivalent of a third of the national cropped area. Most of this is under high value crops: fruit, vegetables and qat, often mixed with timber and firewoodtrees. The groundwater boom has kept the rural economy vibrant. Agricultural employment increased by 25% between 1970 - 1996. whereas agricultural net value of output quadrupled (Al-Eryani et al. 2011).

Farmers in the irrigated areas are the 'haves'. Elsewhere in rural Yemen, food insecurity persists. It is even on the rise. According to the World Food Program/ VAM (2010) 7 million people or 35% of the population are undernourished. A categorization of those most vulnerable is: rural and rain-dependent farmers: growing unirrigated wheat and qat, with limited diversity in income sources, a large number of dependents, and generally far away from main facilities. The extremely poor districts (with more than 70% of the population classified as poor) are rain-dependent mountain districts in Al Baida, Amran and Shabwah Governorates (Social Development Fund 2007).

The groundwater boom in itself is a source of insecurity. There is no unified nation-wide data base on groundwater water levels and abstraction, but where water balances have been estimated, the scales are out of kilter. Most dramatic the water balance for Sana'a Basin estimates abstraction to be five times the amount of recharge – 270 Mm3 against 51 Mm3 (Earth Science Systems 2005). In other parts of the country the disequilibrium is less severe but nevertheless worrying: 34 Mm3 against 18 Mm3 in Wadi Ahwar (Hydrosult 2008) and 235 Mms against 115 Mm3 in Hadramawt (Komex 2002). More telling than these studies is the evidence in the real world. GARWSP reports that it is becoming increasingly difficult to drill a successful wells for the national rural water supply program: the number of failed drillings stands at more than 40%. Falling water tables are reported from each Governerate. Severe disaster spots are found along the coast in Tihama – where reduced supplies of surface water and overuse of groundwater have caused some coastal villages to fall prey sand dune formation. Because of shortages, urban water delivery in several major cities provided at ever larger time intervals. Then Hales (2010) quotes Government of Yemen estimates, that violence accompanying land and water disputes results in the deaths of some 4,000 people each year.

The paper is based on documentation of a number of cases of local management, undertaken in the period

November 2010-February 2011. These cases were identified in a number of ways – but mainly through informal networks. One remarkable point was that it was relatively easy to identify examples, especially in the highland districts – suggesting that local regulation of groundwater is not at all exceptional. The message is that in many areas farmers have responded to the risk of falling groundwater tables and in some cases deteriorating quality that followed the intense exploitation of groundwater. In the coastal areas – where groundwater overuse issues are in places equally severe – there appeared to be less examples of local management, probably to the larger complexity of the water systems (conjunctive use of spate irrigation and groundwater) and larger aquifer systems.

2. CASES OF GROUNDWATER LOCAL MANAGEMENT

The intense use of groundwater in arid environment and the falling groundwater tables triggered several government and donor responses: the enactment of the Water Law; the creation of Water Users Associations (WUAs) in investment projects, particularly since 2000 and the implementation of programs aiming to introduce efficient irrigation techniques. Substantial effort has also gone into creating awareness on groundwater overuse.

The Water Law was accepted by the House of Representatives in July 2002. The Law is a major watershed in that it marked the beginning of the idea that groundwater is no longer for everybody to take. The Law describes a well licensing procedure – applicable for wells extending beyond 60 meters depth. The National Water Resources Authority established in 1995 and its branch offices established later in some (not all) of the Governerates are the regulator in this respect. The Water Law also contains the basis for setting up new organizations in water management: Water Basin Committees, Water Zone Committees (for parts of the basins) and Water Users Associations as well as federations and unions of WUAs. The Water Law does not describe the power and procedures for these new bodies, but it refers to a bylaw that is to be developed later.

This did not prevent the development of irrigation-based WUAs in a large number of programs, such as the Irrigation Improvement Project, the EU Food Security Program, the Land and Soil Conservation Project, the Groundwater and Soil Conservation Project, the Sana'a Basin Water Management Project, the Community Water Management Project, Abyan Water Management Project and under different activities of NGO's such as Care or Triangle. The best estimate is that 700 WUAs were formed – often registered under Law 39/ 1998 or Law 12001/ on Cooperative Societies and Associations. This arrangement was not entirely appropriate, as it defines the WUAs as membership organizations for agricultural improvement – entitled to certain privileges – but not as local management bodies. The status of the 700 WUAs formed in the last decade is unknown and an inventory would be important. Anecdotal evidence suggests that many WUAs have withered after the intensive engagement in the concerned project was over.

The seemingly lackluster performance of the irrigation-based WUAs may be contrasted with the relatively good performance of water committees that were set up in drinking water programs. A total of 108 communities with water supply projects were surveyed in 2007 in Dhamar and Hodeidah Governerate (IOB 2008). The survey found that in 81% of these communities the committees were still functioning, proportionally more in Hodeidah. In most cases though the larger assembly is dormant, the core group of community members meets regularly – involving pump operators, technical persons, meter readers and administrators. In two-third of the committees there had been elections or replacement of leadership. Committee chairmen were paid in 40% of the cases. There were no female committee members, however.

As was to be expected the functionality of the drinking

water systems was strongly related to the functioning of the committee. Intriguingly the relation was not one to one. Among the 108 cases systems were operative in 89% of the communities with a functioning committee and 70% were operative in communities without a functioning committee. The committee members received general support in institution building, but in pump operation and repairs committee members are largely self-trained or acquired skills elsewhere. All in all of the 108 sampled systems 85% was operational – which is good by international standards. There is a large capacity to self organize in rural Yemen and the technical services for operating tubewells are amply available.

The responses to falling water tables have not been limited to formal institutions only, rather the opposite. In a substantial number of communities local informal rules have been developed among water users to regulate the use of groundwater locally. A list of cases of local groundwater management that were identified in the documentation and from other sources is given in Table 1. It appears that since 2000 two new trends have emerged. First is that where earlier local conflicts on groundwater development were exceptional, they became more common– see also above. Whereas Lichtenthaeller (2003) for instance observed that in spite of falling groundwater tables there were no conflicts on water in Amran in 2000, in Lichtenthaeller (2010) he describes that protests and blockages are common in Amran by the late 2010's. Second is either triggered by conflict or heightened awareness in many areas farmers have come to local rules and regulations. Increased extraction from the aquifers dried up springs and shallow wells. Many communities have sought to prevent further harm to existing users, for instance by norms restricting well spacing and banning export of water from their area by tankers. In other cases farmers closed disputed wells, invested in groundwater recharge or connected separate wells by a shared network of pipelines, allowing water to travel from one area to the other. In some cases the agricultural wells were also doubled up as sources of domestic water supply and private village pipe networks were developed.

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 Areesha, Nahem, 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 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	Protection zone
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 disputed wells, agreement on reservoir operation

18	Al Mashra, Damar	Ban on drilling
19	Wadi Al-Har, Anss, Dhamar	New agricultural wells only if they serve drinking water too
20	Mawia, Taiz	Joint WUA to regulate new well development, replacement of qat in some area
21	Al-sinah, Almaafer, Taiz	Well distance, blocking out well development in sensitive areas, permission by NWRA only with consent of the cooperative
22	Wadi Sana'ah, Dhamar	Spring protection – zoning; distance rule
23	Hejrat al-a'asham, Jabal Al-sharq, Dhamar	Protection zone
24	Al-Wahda, Al-Maafir, Taiz	Ban on new wells, non-well owners to share in existing wells
25	Zubera, Wadi Siham, Hodeidah	Preventing new shallow development by referring cases to Local Council and NWRA

Sources: field documentation, van Steenbergen (2006), Ward and Al-Alauqi (2008), Bruns and Taha (2009), Bonzanigo and Borgia (2009) and Lichtenthaeller (2010 - 2011)

In the following pages a number of recently documented cases are described in more detail. In annex 1 other cases are summarized.

Wadi Qarada, Bani Hushaish, Sana'a

One example of local management of groundwater concerns Qarada in Sana'a Basin. Qarada is a tributary of the Wadi El Sir. The short terms 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 no option.

There are over 100 wells in the area – typically these are 300 meter apart. Up to 2002 / 3 well drilling continued unabated – with a fifteen meter decline a year till the water table reached 320 meters in 2008 the threat of sulphur and fluoride levels increasing with increased 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 M. 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 out 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 that 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 if unlicensed drilling is planned in Al Asharaf.

Recharge in the area greatly improved after the construction of 47 stone checkdams in the riverbed under the Sana'a Basin Water Management Project. These structure slow down the speed of the floods – and increase the infiltration rate. The speed of the water moreover ensures that sediment is still removed. The investment in the structures including the stone bank protection amounted to USD 1 M. A comparison of these type of structure with recharge dams – indicate that they are significantly more effective in recharging local aquifers – particularly in comparison with large dams (Alderwish and Alderwish 2009).

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. The run-off feeds springs and the aquifers. Over the years farmers have moved to groundwater irrigation, typically pumping water from 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 2530- families.

Following a violent conflict in a nearby area over the sharing of water from a dam that was to be build by the government farmers decided to regulate the use of water in their area. The establishment of the WUA – called 'Belad Albustan' 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 (12000 lebnah) under fruits and staple crops (not qat). Wells were to be at least five hundred meters apart – but dependent on the location the distance can be even larger. The minimum distance to a spring for instance is 2000 meter.

Whereas the WUA initially covered seven wells in two villages its usefulness was 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.

Wadi Dhelaa, Hamdan, Sana'a

Wadi Dhelaa is located at relatively close proximity to Sana'a and has a long history of irrigated agriculture. The area is supplied surface water from the four kilometer Matba tributary of the Wadi Dhelaa and used to 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– with sediment from the adjacent hills causing land levels to rise. Fifty years ago dugwells were developed – initially operated by animals but as water tables became deeper the wells were deepened diesel pumps were increasingly resorted to. 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 over the years up to 300 meter – with water tables between 150 to 200 meters. The transition to deep wells coincided with a transition to growing qat and fuel wood trees mainly – 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 days water supplies (contingent on availability of high voltage electricity). The shares, which can amount to 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 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 been imposed as well. This used to be 500 meters from an existing well - but has now increased to 700 meter.

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 not been unproblematic. 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. If there would be a conflict in 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 but 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 mainly – 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 meter 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 tributaries of Wadi Dhelaa. The work was initiated by the sheikh family – who invested YR 6 M (USD 30,000) 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 over dimensioned – even in the recent wet year it has not filled for 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 though the tunnel system has been disconnected in this area.

Wadi Areesha, Nahem, Sana'a

Wadi Areesha is located about 70 km east of Sana'a. In this region attempts to discover deep groundwater have been failed. However, the area still has sufficient shallow groundwater and carefully guards it. Sana'a Basin Water Management Project implemented some activities in the area which mainly aimed to improve water use efficiency, groundwater recharge and supporting WUA. Wadi Areesha dam is the most important water structure in the area, which was basically initiated to improve recharge to the mainly shallow wells in the area. Until 25 years ago, shallow groundwater was available at 5070- m below ground level. In 1995, the community, decided to construct Areesha dam hoping that water will re-appear in wells located downstream. The dam was rehabilitated in 2008 with support of SBWM Project. Now all wells are located around the reservoir, from which water is pumped to the fields through pipes- upto 4 km long. The WUA of Areesha dam undertakes operation and maintenance of the dam. There are a number of rules were agreed upon.

Here is in fact a ban on drilling well too deep – with the upper limit set at 200 meters, however, there is no restriction on the distance between wells. Another local rule is a strict ban on direct water withdrawals from the reservoir and 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 investment in wells and pipelines is collective, with groups consisting of 1520- farmers.

Al-sinah, Almaafer, Taiz

Al-sinah area is located in wadi Al-asloom, Almaafer District, Taiz Governorate. This is 30 km west of Taiz. The area consists of 12 groups of villages with a total population of approximately 18000 (2004 census). It is well-known for its cooperative society. The story of cooperative society dates back to the end of 1960s, when the community decided to establish this organization to nurse water and electricity projects but also to facilitate education and health improvements. Al-sinah and its cooperative society stand out as a single example of long-term institionalized local development and resource management.

Al-sinah basin contains 35 agricultural bore wells, owned by farmers either individually or shared. Most of these wells were developed in the 1970s. The average depth of wells is 260 m, but the water table is found at 96 m. However, the water table is declining continuously: a decline of 6 m was observed in the year 2010. Groundwater is used for irrigation of a number of cash crops mainly qat and vegetables. No modern irrigation systems are in use, except for conveyance pipes for delivering water to the plots.

Water and electricity are the cooperative society's main activities. The cooperative society owns three wells. Water is pumped to four elevated tanks, perched on top of the mountain, and then distributed to homes via a network of pipelines. 1900 homes are subscribed to the network. The water is provided for drinking and domestic purposes only: it is prohibited to use water for agriculture. Al-sinah cooperation association has few remarkable features that earmark it as an outstanding example of local water management:

- democratic structure - management is elected every three years with an elaborate structure of twelve election assemblies. There is no traditional local leader. The preference is for people of high integrity. There are no big social and income differences in the community and education is widespread even among women.

- conditional partnership with public agencies. the Al-sinah cooperation association systematically liaises with public agencies and has sought specific support for parts of ita investment program where public agencies had the right thing to offer. However, the association has refrained to be automatically involved in projects (Ward and Al-Alauqi 2008)

The association also plays a role in local groundwater management. Within the area a distance between wells in the range of 500 meter is observed. One striking example of the application of this rule was in the mid 1990s, when well drilling n the neighboring hamlet threatened the sustainability of the Al-Sinah water supply well field. The association bought up some scattered fields in this neighboring hamlet, then drilled wells there – and subsequently capped the wells. Because local people respect the «500 meters between wells» rule, the capped wells prevented any other water development in

the area and the Al-Sinah water supply was protected (Ward and Al-Alauqi 2008).

The Al-sinah association also works together with the Taiz branch of the National Water Resources Authority (NWRA). NWRA is not issuing any well drilling permit without consulting the association and obtaining a written consent from the association. Since two years no more well bore well drilling permits are issued. The association is trying to affirm this rule by declaring the area as a protected zone. A study has been completed and now is considered for approval by NWRA. Neither are farmers are not allowed to dig open shallow wells without obtaining consent from the association.

Al-sinah is hence a case of local and central regulation reinforcing each others. Two years ago NWRA issued a well drilling permit to farmers without consulting the association. The association objected against the drilling. The disputed well was located outside the Al-sinah basin but at a 1000 m distance from a well owned by the Association. However, NWRA gave an undertaking that the new well would not have a negative effects on the Al-sinah well. In case if any interference, the new well would be closed and handed over to the Al-sinah association.

Further to boost groundwater recharge, the al-Sinah association is working with the Social Fund for Development on the construction of a dam. The association has obtained the required land with its own resources. In addition the association is working with local councils to maintain and rehabilitate traditional cisterns and ponds.

Alkadarah, Qadas, Taiz

Alkadarah consists of a number of villages and isolated homes scattered over several mountains and valleys. Agricultural lands are located in the lower section of the valleys or on the mountains as terraces. Due to the geology of the area, no deep groundwater is found in Alkadarah. Shallow groundwater is available in some of the valleys, but yields are low and unreliable. Rain-fed farming of sorghum and vegetables predominates. The shallow groundwater is used for qat irrigation.

The main concern is that drinking water is under threat. Traditionally the community depended on shallow dug wells, springs or cisterns to fetch their domestic and drinking water needs. The communities decided in the 1980s to construct drinking water networks entirely by their own resources. They formed committees for managing water projects and four projects were implemented. The water project at Hanhan, Bani Mansoor is one of these projects. It was constructed in 1982. The project committee drilled the well, constructed the water tank and pipelines. Later, the Hanhan system was merged with another water system, the Wadi Aljannat project. The latter facility was supplied by two wells. However, due to low well production, water is provided to homes once every three days. The depth of the ranges between 5090- meter. A standard rate of 200 YR per cum is collected form subscribers. A third system, Algobua-Aldho'uf project, was also established in 1982, but was abandoned for a long time due to differences between stakeholders.

A few village clusters in Alkadarah still do not have to piped water supply. Some of these approached the Algobua and Aldho'uf project committee to allow the drilling of new well. The response was guarded for fear

that this new well may affect the water resource negatively. Negotiation and mediation between the two parties is in progress. The Algobua and Aldho'uf project committee earlier is prevented the drilling new agricultural wells in their valley, on the basis that the 10 private wells which already exist are enough.

Wadi Sana'ah, Dhamar

Wadi Sana'ah is located 15 km west of Dhamar city. The catchment area of the wadi consists a part of Ga'a Jahran plateau. A number of old dams existed in the area, and remains of some of them are still in place, for example Al-dheeb dam and Al-gash'goosh dam. Wadi Sana'ah is characterized by fertile soil and good availability of groundwater. Variety of crops can be grown in the plateau but not qat: frost formation prevents this. Wells density in the plateau is comparatively low, with only 12 wells at distances varying between 500 to 1000 m. The depth of wells varies between 25 – 220 m, with most of wells having a depth between 70120- m. The farmers respect the 500 m rule, which is also the norm adopted by the NWRA branch in Dhamar for resolving disputes between farmers.

Wadi Sana'ah contains many springs, but several springs disappeared after the earthquake that hit Dhamar area in 1982. Only few springs are still perennial; most only appear in the summer. The location of springs is identified by the light blue color of soil (called sa'a), indicating that it was frequently logged by water. To protect the springs, the farmers do not allow the drilling of tube wells in the wadi. However, shallow dug wells (at a depth of 24-meter) are permitted.

Hejrat al-a'asham, Jabal Al-sharq, Dhamar

Jabal Al-sharq consists of many small valleys and mountains that mark the beginning of the western mountainous slopes. The area is located about 20 km north of Al-sharq town, Dhamar Governorate, and includes historical villages and castles.

Wadi Alwa'ad has relatively flat lands that were covered with coffee plantations in past. Now, qat is the dominant crop in addition to sorghum, corn and some vegetables, but all crops are rainfed. Shallow dug wells are the main source for groundwater. Only few wells have water throughout the year, especially wells that are located in the downstream of the wadi. The water table of shallow wells is at 1015- m. Some of these open well are common "waqaf" and are used for drinking water supply. An open well called "alnazool" is believed to be 500 years old and has water throughout the year. However, the springs are the preferred source for drinking water in the area. The yield of the springs varies in time and locations. Some springs can be found only in the rainy season. At one of the most yielding spring, a 20 l container was filled in about 14 min. Villagers will queue day and night for getting their share. As in many other places, springs are regarded as sacred common property which should be preserved. No well drilling is allowed nearby springs.

New plantation of coffee was noticed in the area, which indicates that coffee plants still can compete with qat. Some of these new plantations replaced old coffee trees - which require more water, as it has been said.

3. LESSONS

There are several conclusions to be drawn from these cases:

First, Investment in groundwater is surprisingly collective. This is different from the perception that groundwater is the behold of individual large farmers. Wells in many cases are shared between a large number of shareholders – not the property of a single person. In some cases wells are connected by a shared pipeline. In several cases – Alkadarah, Al-sinah, Dhelaa there has been collective investment in community drinking water supply.

Second, there is a high level of local management in several cases – often introduced rather recently. The local rules consist of measures such as well spacing, closure of disputed wells, zoning and bans on sales to water tankers. There is often considerable community effort to improve groundwater recharge. Table 2 (page18) is a list of different local regulations. A common denominator of these local regulations is their visibility. Consequently it is easy to observe for everybody whether rules are applied or not and no special organizations is required to enforce.

Third, 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.

Fourth, the Water Law and the licensing procedures imbedded in it are important – though not necessarily in a direct way. The Water Law is generally taken serious: testimony of this is that in several areas in Bani Husheish farmers had new wells developed prior to the enactment of the Water Law, then closed and hid these wells, so they could be utilized some time in the future. The fact that wells in principle need to be licensed 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. In Al-sinah the local cooperative cooperated with NWRA by recommending wells to be licensed. There is mutual reinforcement in several cases of local rule and national law, effectively having rural pluralism in action. A remarkable strategy of enforcing the licensing of drilling is from Qarada – where cases are not raised among close neighbours but where an outside WUA is expected to make the case – so as to avoid conflict between close neighbours. The same point has been made in other interviews where WUA members

preferred a subbasin group to do the sensitive work of regulating goundwater use within member communities. There seemed to be a need for an effective second or third party to avoid direct conflict.

Fifth, where local groundwater management is in place, the initiative may be taken by a local sheikh, or aqil, by another respected leader or by a WUA, as in Wadi Al Zabaira or cooperative as in Al-sinah. 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.

Water Users Associations have also been created under a large number of projects. In some cases this has triggered local initiative towards better groundwater management; in other cases local rules were in place and the WUA did not add value or maybe even be at variance – as in Wadi Dhelaa. The main message is that WUAs are not the only route to promote local groundwater management, but that they can play a long lasting role if properly encouraged. This is for instance part of the mandate of the Union of Water Users Associations – that coordinates with the activities of 120 active WUAs. There is a need to support these long lasting roles. Now engagement between Government and WUA end with project closure and also WUA are often established in anticipation of getting access to government or donor support (see for instance Bonzanigo and Borgia 2009).

Sixth, the local rules and regulations 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.

Seventh, not in all cases has local management been able to reverse the tide. In Qarada and Al-sinah depletion was slowed down but not stopped. Farmers operate on the basis of accepted practices and best guesses in making. Providing information to the water users that matter most.

Table 2. Monitoring groundwater: visibility of rules and implications for local management

no	Visibility of rules	Groundwater management rule	Means of monitoring	Implication 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 neighbours	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

Source: Taher et al (2011)

4. CONCLUSION: WHO IS ACCOUNTABLE TO WHOM?

The central question in this paper was: in groundwater security who is accountable to whom? It appears that at least in several areas that there are mechanisms whereby water users are accountable to one another. There are a substantial number of cases where farmers have established local rules to regulate groundwater use and well development. The arrangements vary. In some cases this was by mutual understanding and commonly accepted norms; in some other cases farmers created their own organization to do so. In a few cases WUA created by projects served to catalyze restriction in groundwater use. Though not directly enforced, the fact that there is a Water Law and a regulating body – NWRA and its branch offices – has strengthened the hand of local initiatives. In some cases the relation goes further: in Al-sinah the cooperative society is consulted before drilling licenses are issued. In other areas water users have made arrangement

Local ground water management is hence an essential building block of groundwater security. It is hard to see – given the local autonomy in Yemeni society and the sheer number of wells - how the groundwater development and use can be regulated – unless it is grounded in local management. This is also acknowledged: it is the first principle in the recent Sana'a Declaration for a Yemeni Partnership, endorsed by the Cabinet in 2011. The new bylaw to the Water Law makes the same point – in its article 6 for instance.

There is a need to go beyond good principles, however, and to strengthen local groundwater management at scale. Several steps and adjustment would go a long way:

First step is to promote local groundwater management on the basis of good practices – preferably from farmer to farmer and from community to community mode. This has been done before and consists of bringing different communities together, exchanging ideas and creating mild competition. Some institutional mechanisms in place to do this – the Union of Water Users Associations for instance. This Union is now national but can also be organized at basin level – would be a suitable launching pad for a farmer movement. The impression is that local regulation is more common in the highland areas than it in coastal zones – though overuse problems are severe there too. Management is more complicated as the environment is conjunctive and aquifer less easily even so defined – it is important to build on few examples in this areas too.

Second step , which is related to the first one, is to make sure the basic information is available for farmers to understand local hydrogeology and groundwater availability. Over the years a large number of studies have been undertaken – some concerning the entire country (such as the WRAY Project), some dealing with a specific basin or sub basin. In spite of the often substantial effort gone into the data collection analysis, the results are never shared with those most immediately concerned. The recommendation is to 'harvest the low hanging fruit' and communicate the information that is there in formats that create a better understanding.

Third step is to strengthen linkages between water users and Local Councils and the Branch Offices of NWRA. This happened in the Sana'a Basin Water Management Project – with good results – and is happening elsewhere

too, but should be systematically out scaled. There is a long history of local councils acting as an arbitrator of last resort in case of water issues – and this can be further strengthened. Similarly NWRA has catalyzed local management in a number of places, though in other cases it has also sometimes bypassed it (see annex 1). In Amran there is a systematic effort to strengthen the role of Local Councils in water management – including training of Local Councils in basic social and management skills. More of such acitivities – linked in with decentralization support programmes – should be taken up.

Fourth step is to combine the promotion of local groundwater management with promoting agricultural productivity. Ward and Naif (2011) quoting figures from NWRA make the point that there is a considerable yield gap still. The actual crop yields for main crops irrigated crops is only 20 to 40% of the optimum. The largest gap is for alfafa (19% of optimum), followed by qat (27%). For grapes, banana, oranges and mango the yield is respectively 40%, 42%, 46% and 51% of the optimum. In addition there is much to gain in the post harvest handling. Even more basic: in many areas faced with declining groundwater tables, even basic field water management practices – such as leveling – are not in place. In other words there is a large slack in the system – making it possible to sustain and increase yields, while reducing water consumption under better local management.

Fifth step is to streamline groundwater management in different water-related programs – the drinking water programs , irrigation efficiency and watershed programs. Under all these investments Water User Groups, Water User Association or Water Committees are formed – creating the basis for discussing local management. The new bylaw tof he Water Law – long awaited but only very recently finalized - provides openings. Clause 13 for instance describes the advisory function of the WUAs to NWRA. Clause 14 provides for WUA – provided they represent two-thirds of the water users – to make mandatory rules. Clauses 74 and 75 makes the 500 meter distance rule (actually based on the harim rule from early Islamic legislation) and spring protection zones compulsory. There is ambiguity however on who is doing what and some clauses appear one-way: clause 13 describes a main function of the WUA as 'to assist NWRA in implementing water rules through dealing with a single community based organization'. This does injustice to self organizing power of local communities and their accountability for their own sustainable future.

It is important not to equate local groundwater management with WUA formation and assume that local groundwater management can only be channelized through formal WUAs. The examples in this paper show otherwise. Another pitfall to be avoided is to see WUAs as extension of higher water authorities only. There is strong fundament for local groundwater management – with users accountable to one another - and the need to more systematically nurture it – so that it complements all other actions groundwater security in Yemen.

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Annex 1

Local groundwater management:cases described in other sources

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 (van Steenbergen 2006). 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 ru- ral 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 substantial 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.

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 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.

Source: van Steenbergen (2006)

Wa'alah, Amran

Several WUGs in Amran basin have been established in the past few years by GSCP with the help of GTZ. The WUGs have started working towards the conservation of the depleted aquifers. The communities felt that they have to do something against the misuse of groundwater.

Wa'alah WUG had been established in 2006. There were about 15 wells working day and night to supply water to tankers for transport to other areas for drinking and qat irrigation. The community realized that water levels in their wells were getting lower and lower which caused them either to invest in drilling new wells or deepening their recent wells. They got together and discussed the situation and realized that the transport of water outside the area is the main reason for the drop of the water levels in the wells. They agreed to prevent any well from selling water to tankers and prevent tankers to transport water outside the area. So they made a petition (Markoum) signed by every well owner and sheik, to establish a new regulation. This was approved by the local authority. The fine of 50,000YR is to be paid to the local authority as a penalty for the breaking of Al-Markoum. The community agreed with the Sheiks, who the violators belong to, to report the violators to their Sheiks to make the necessary judgment against them, and to prevent them from coming back to transport water outside the area. This agreement has prevented any conflicts between the different tribes in the area.

The community got very involved in implementing Al-Markoum. The result is that no more tankers are coming to the area for qat irrigation. They have agreed also to not stop small tankers who supply water for drinking. The outcome is that the water levels stabilized in the area and no significant drop was seen.

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 (Lichtenthaeller 2010). The cultivation of qat was enabled as elsewhere by deep wells but these were prone to failure. This was partly compensated by purchasing water tankers 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 on 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 Water Management Committee. Following the dispute the drilling was stopped and also 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.

Source: Lichtenthaeller (2010)

Wadi Al-Har, Anss, Dhamar

The area is located in Anss district. The main character of the area is the water scarcity and the qat plantations. People are aware of the problem since drilling of wells is costing a lot of money. In addition is the failure of finding groundwater. People are striving very hard to collect water for drinking and for household use. This is in addition to the need to irrigate the qat plantations which are the main income source. They agree (verbally) amongst them that there is no objection against anybody drilling a deep well for agriculture as long as the well will supply drinking water to the nearby communities. They suggested that the priority is for drinking as along as the owner is able to drill a well and bear the relevant costs. Most wells are drilled without licensing.

In the past before 1982, the area was cultivating vegetables and other crops that are irrigated from springs. After the earthquake, most of the springs fade away and the area faced water shortages. Several shallow wells and two deep (failed) were drilled to overcome the water shortages and irrigate the vegetables. However this has cost the farmers more money which was not covering the input costs of the vegetables. Therefore, they have changed to cultivate qat which earns a lot of money. They know that qat takes a lot of water, but they have no choice since it is the main source of income.

Wadi Akarem, Dhamar

This wadi is shared by two influential Sheiks. One of them is leading Bani Umar and the other one Abo Yabes. Both have rights to the Wadi Akarem and tried to drill deep wells to irrigate their qat plantations. Disputes concerned who should drill wells (more than 150m deep) in the wadi. To prevent any conflict, the two tycoons agreed verbally that no deep wells be drilled in the main wadi. Such agreement have been adopted by farmers and become a doctrine. The agreement added that deep well can be drilled at the outskirt of the main wadi and can be used for qat plantation as well as for water supply. The agreement also allows farmers to drill shallow wells in the main wadi (3050-m). Farmers are happy about this agreement since it settles the dispute which might result in unrest in the area. Farmers are depending on qat as the main source of income and don't want to shift to other crops unless they would provide the same income.

Mawia, Taiz

Mawia district is an important area for qat cultivation in Taiz. Wells became dry in some parts of the area, which resulted in outmigration by farmers, exporting the experience of qat plantation to nearby areas of Taiz such as Warazan causing the same water problem.

Other farmers in the area tried to drill more wells and deepen their own wells, in order to overcome the water scarcity problem and increase water productivity to cover the increased expansion of qat plantations. The farmers approached NWRA to obtain licenses. NWRA suggested that licenses will be provided if farmers are organized into WUOs served by the representative wells. Farmers agreed to that suggestions and organized themselves to about 26 WUOs. Most of the board of members of these WUOs are headed by the well owners who influence the decisions in the board. The WUOs tried to make arrangements related to water distributions and conservations such as:

If the area under the WUO has several wells and there is a need to increase well productivity, it suggests the well to be deepened and used by the beneficiaries under the WUO. If the water is not enough to cover the requirements of the farmers, the WUO may deepen or drill a new well. This means that water distribution amongst farmers will be scheduled and allocations will be set accordingly with cost of 15002000-YR/hr. Some WUOs are paying back ¼ the harvest to the WUO (well owner!). Some farmers argue that such system may affect the productivity of qat plantations since they will not receive enough water.

Suhail-AlGranee WUO has prevented the plantation of new qat trees and introduced mango trees (500 trees) so that in the long run there will be another alternative for qat.

Bani Garban, Al Kafr, Ibb

Bani Garban is located in Al-Kafr district. RWSSP has handed the water supply project to the WUO in 2003 when it started working. In the same site where the water supply well is located, there is an agricultural well drilled in an earlier time.

The idea came from NWRA during the starting period of the project to make the wadi as a protection zone to preserve the water and use it only for the water supply project. So NWRA established the protection zone aiming at preventing drilling of new agricultural wells. The community was very happy about the protection zone and worked very hard to implement the decision of NWRA.

The dilemma started in the beginning of 2009 where NWRA provide a license to drill a well in the protection zone to irrigate qat, which contradicts the earlier decision of NWRA to make the area as a protection zone. The community is striving very hard not allow any new drilling and has several letters supporting them from the minister of MWE, the parliament, RWSSP and other authorities. They even had support from the president.

Al-Gawaref, Ibb

This project was handed over to the WUO by RWSSP in 2006. The WUO has obtained a similar protection zone decision from NWRA resembling Bani Garban WUO. However this association has failed to prevent new drilling and a new well was drilled in the protection zone area with license from NWRA. Both areas suffer from water shortages and the communities completely agreed to prevent any use of the water for irrigating qat.

Source: Bruns and Taha (2009)

Zuberia, Wadi Siham, Hodeidah

Zuberia is located in the command area of Wadi Siham, one of the larger spate areas in the Tihama. In the last decades a large number of shallow wells developed providing supplementary irrigation for horticultura crops. Although in principle the recharge from the spate system is substantial over use of groundwater has occurred and water tables have declined. Encouraged by NWRA the community of Zuberia started to discuss the local management of groundwater and the development of several new wells was stopped. The community brings the cases to NWRA and the Local Council as it feels it lack the authority to enforce some restrictions on its own.

Source: Bonzanigo and Borgia (2009)

Al-Wahda, Al-Maafir, Taiz

The Al-Wahda Water User Association is in the Bani Khawlan area in the district of Al- Maafir in Taiz governorate. The association was established in January 2008 with help from the Community Water Management Project branch in Taiz and registered according to the Water Law and the law regulating voluntary organizations in the Ministry of Labor and Social Welfare. Total membership is now about 370 farmers, formed into a number of component water groups. The association is financed by membership fees and from the Community Water Management Project.

Activities have comprised primarily irrigation improvement, capacity building and some local self-regulation. The association obtained from the Groundwater and Soil Conservation Project three irrigation networks for demonstration on members' farms and 15 irrigation systems at the subsidized project prices. In the area of capacity building, the association has followed various training programs in management, accounting and water conservation. They have begun to install meters on their wells, and have been trained in monitoring of abstractions and in improved irrigation methods.

One practical achievement has been that the association has been able in the few short months it has existed to stop drilling in their area. The association reported the violations to NWRA, and the drilling was stopped. Now drilling even by permit is absent in their area. The association has decided that they "have enough wells" and they agreed among themselves to make water available to the members but not to allow any transfer of water to other areas except for drinking purpose. Nonetheless, the process was not perfect: the association complained of the lack of cooperation from the local council and the security authorities when they were trying to stop the drilling.

Source: Ward and Al-Aulaqi (2008)

Annex 2:
Excerpts from Water Law Bylaw, approved by the Cabinet of Ministers in 2011

Article 2:

(Definitions) WUAs/WUGs: assembly of water users who organize their efforts with the purpose for participation in water resources management and contribution in finance, management, maintenance and operation of water and irrigation projects and structures.

Article 4:

groundwater resources and surface water are owned by the state and can not be owned by a private owner except through transfer of ownership or acquirement.

Article 6:

principles of water demand management:

Encourage and develop community and users participation in water resources management at central and local levels.

Plan and allocate water resources for meeting the demand based on the sustainability concept, with special attention for protection of groundwater aquifers including imposing constraints on activities which harm water resources.

Article 8:

it is allowed to establish WUAs or groups or committees or unions whose goal to involve community participation in water resources management or operation and maintenance of water structures.

Article 9:

any type organization of community participation should abide to the following principles:

- The command area of the organization is the water basin regardless of the administrative districts in the area.
- The organization should coordinate with NWRA and the local councils, but each organization should manage itself independently as NGOs.
- All citizens in the water basin are entitled to participate in the organization and should be represented in a democratic way in the management of the organization.

Article 10:

(a) WUAs may form a union at the level of the water basin (b) No more than one union is allowed in the same water basin.

Article 12: goals of WUAs:

1. Organize water users to participate in water management.
2. Provide conditions needed for cooperation between water users and the government institutions.
3. Assist NWRA in implementing water rules through dealing with a single community based organization.

4. Enable water users to have access to the information and data related to water resources and participate in meetings, training and workshops.

Article 13: Responsibilities of WUAs:

1. Provide advice to NWRA, if requested, about well licensing and water structures.

2. Contribute to resolving differences on water rights

3. Coordinate and organize efforts of water users to protect flood water streams, springs, wells and water structures that are common.

4. Participate in financing different common water projects through collecting contributions

Article 14:

if the strength of membership in the WUA is reaching two third of all beneficiaries in a common water resource, then all decisions taken by the WUAs are mandatory for all beneficiaries.

Article 15:

all WUAs must abide with the water resources management plan and all laws, policies, strategies and rules.

Article 75:

the distance between a well and adjacent well is determined by a decree of the NWRA chairman based on studies of the basin, but the distance should not be less than 500 m in major basins. The following criteria should be considered:

1. Principle of participation in water rights if the water status is not threatened (No harm, no suffer)

2. Area of agricultural lands

3. Well productivity in such a way that each hectare will receive not less than 0.5 l/s in a season.

Article 76:

no well license shall be given for drilling a well in the area of springs except with the permission of NWRA chairman.

A number of 47 stone checkdams were constructed along the riverbed of wadi Qaradha, Sana'a Basin, to augment groundwater recharge. Water reappeared in the open wells located on the banks of the wadi which means reduction of withdrawal of deep groundwater

Springs are regarded the secured source of water in many mountainous areas, especially for drinking water. The community in Khrabat Muhyab, Sana'a Basin, prohibit well drilling within 2000 m distance to springs. Spring water is shared for drinking and irrigation

Farmers in wadi Areesha, Sana'a Basin, come together with support from the government to construct a dam for groundwater recharge. Well drilling is allowed around the reservoir area and water is pumped to the farms upto 4 km distance

The story of water in wadi Dhelaa can be felt from the existence of qanats, dugwells and deep tubewells. Now farmers are left with deep tubewells which go deep upto 300m. Quest after water pushed farmers to adopt the 500 m distance rule between wells. A recharge dam was constructed but the dam is never filled with water

In wadi Dhelaa, most of deep wells are under shared ownership, up to thirty families per well. The sharing is not only for agriculture but also for house connections. This is one type of community rule for domestic water supply