A technical-institutional analysis of small dams in the Sana'a Basin, Yemen

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- MetaMeta Research -

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Summary

The Sana'a basin in Yemen is confronted with rapid depletion of water resources. Rural agricultural communities build dams to recharge the shallow aquifer in order to benefit from raised water tables in their wells. The objective of the research was to get to a better understanding of institutional context in which dam implementation is embedded as well as dam recharge aspects. To do so, an overview of all the organisations involved in dam implementation and groundwater management was made. Besides, the national water law was discussed highlighting its base in customary and *shari'a* laws. To gather farmers' perspectives on recharge and water distribution, four case studies were performed. This brought forward that although the dams recharge groundwater; its benefits remain only for the closest downstream communities. The institutional analysis in this research brings forward that the communities are backed by customary and *shari'a* law in their surface and groundwater resource capture. Vis-à-vis this, the GoY would like to see dams and recharge thereof, fit into a basin water management approach so that benefits of recharge can be distributed. The progress towards implementation of this approach however, is hampered by an inappropriate water rights definition in the national water law, which leaves government agencies little mandate, in particular with respect to restricting groundwater abstraction.

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List of abbreviations

ACU	Agricultural Cooperative Union
AFPPF	Agricultural Fisheries Production Promotion Fund
GDI	General Directorate of Irrigation
GoY	Government of Yemen
IDA	International Development Agencies
IHSC	Irrigation and Hydraulic Structures Cooperative
MAI	Ministry of Agriculture and Irrigation
MWE	Ministry of Water and Environment
NWRA	National Water Resource Authority
NWSSIP	National Water Sector Strategy and Investment Programme
SAC	Sa'awan Agricultural Cooperative
SBWMP	Sana'a Basin Water Management Project
SDF	Social Development Fund
SMT	Social Mobilisation Team
WB	World Bank
WUA	Water User Association
WUG	Water User Group
YER	Yemeni Rial

Chapter 1. Introduction

Yemen is one of the oldest irrigation civilisations in the world. For centuries the resilient people of this mountainous south-western part of the Arabian Peninsula have developed highly sustainable farming systems, which include indigenous methods of water harvesting, water spreading and construction of small dams and irrigation systems (Vermillion & Al-Shaybani, 2004). As resource, groundwater has been and still is vital for Yemen's agriculture depending on recharge from rainfall and run-off (Al-Asbahi, 2005). In recent times the country has fallen into water shortage. Similar to other countries in the Middle east a rising demand due to population growth and market lead agriculture has put a great stress on the country's water resources (ibid).
The exploitation of groundwater through shallow as well as deep tube wells results in one of the highest rates of aquifer depletion. Where previously most of the wells for irrigation and municipal water were hand-dug and were self-limiting in terms of the amounts of water abstracted (Negenman, 1997), now the low import duties on pumps, the subsidised fuel pricing, inefficient irrigation practices and unclear water rights created an environment for uncontrolled extraction (Foster, 2003; PID report of the WB 2003; Al-Sakkaf et al. 2006). The annual withdrawals from groundwater resources are now exceeding renewable resources by up to 36% (Pelat, 2006). Although academic and development consensus in the 1990s was universal: water scarcity being the greatest threat, it was only in the late 1990s that water had also become a political battleground (Ismail, 2007).

As of yet there are 48 small dams[1] within the Sana'a Basin varying in height from 4 to 36 metres (from GDI dam inventory, 2001). The main purpose of the dams for the communities is artificial recharge of the water transmitting layer for agricultural purposes mainly downstream of the dam. Recharge, through the installation of dams, is seen as the starting point towards the increase of the usable life of the aquifers in Sana'a basin (Foster, 2003), however the recharge approach is still under debate and construction.

1.1. Objectives

The two objectives of this research are:

- to examine the institutional context of dam implementation and groundwater resources in Sana'a basin
- to contribute to a better understanding of dam recharge at local level

1.2. Problem statement

Developments in the last 30 years have caused modest demands to change into excessive demand exacerbated by the expansion of agricultural area. Sana'a Basin is experiencing a serious depletion of groundwater resources (WEC, 2004) and the worst case scenario for Sana'a basin put forward would be the complete desaturation of the permeable strata, which is already the case in some areas around Ta'iz (Moharam, 2006).

Some of the causes of the water resource scarcity are found to be the following;

- the rapid population growth[2] (Al-Hamdi, 1997)
- agricultural water consumption accounts to 90% of the basins total, with an irrigation efficiency of 35% (NWSSIP, 2005)

[1] The dams are referred to as being 'small dams', in literature on Sana'a Basin as well as at government agencies. The nomenclature of dams is briefly discussed in chapter 4.1
[2] Rapid growth which is mainly attributed to improved economic conditions in Sana'a Basin which stimulated internal migration from the rural areas (Al-Hamdi, 1997)

- agricultural area in the basin expanding from an estimated 7500 ha in 1984 (Mosgip., 1986) to 23380 ha in 2000 (WECITC, 2001) including cropping of qat[3] requiring high amounts of water (Pelat, 2006)
- more than 4000 drilled tube wells in Sana'a basin[4] (WECITC, 2001)
- unclear water rights and thus unregulated extraction (Al-Hamdi, 1997)

1.3. Research topic

The topic of this research is the implementation and management of dams and the related groundwater regimes placed in a context of local and national (basin) institutions. This topic assumes there is a relationship between dams and groundwater. Moreover the topic also assumes that a variety of actors exist which are involved in dam implementation and or groundwater management.
An important specification needs to be made concerning the word 'institutions'. In this research the word 'institution' will be used for referring to customs, traditions and laws and the word 'organisation' a group of people who form a committee, department, association, etc. in order to achieve a particular aim[5]. This research recognises the fact that the word 'institutions' can encapsulate both meanings and wishes to remind the reader that quotes from others in this writing may include another interpretation of the word.

1.4 Analytical framework

Kemper (2007) suggests an institutional framework for groundwater management (Figure 1). She distinguishes between "institutional arrangements", "management instruments" and organizational management forms". According to Kemper (2007: 155) the 'menu of institutional ingredients' "can be combined in a variety of ways in order to achieve improved groundwater management, depending on the specific characteristics of an aquifer, a country or a region". The framework is used with the theoretical reasoning that efficient, equitable and sustainable groundwater management and use requires: management instruments and management forms which are backed by institutional arrangements.

Experience, of groundwater management in different countries, shows that there is varying emphasis on the ingredients determined in the framework. In the east of the U.S. the groundwater rights are clearly defined according to 'the doctrine of prior appropriation', strictly distinguishing senior from junior rights, in addition to that the number of users is low (Kropf 2003 cited in Wegerich 2006:448). In Western Europe with a larger amount of users a strong state, which could be classified as 'organisational management' allows that formal institutions of resource utilisation are enforced. These two examples highlight already the interplay between the different ingredients for management and the water users.

[3] Qat (Catha edulis) leaves are chewed as a stimulant, producing a feeling of euphoria followed by depression (Varisco, 1986). It is the most important cash crop in Yemen as it accounts for one third of the country's agricultural sector and almost 10% of the gross national product (Leung, 1999)
[4] The implementation of which started in the 70s when pumps and diesel became accessible for farmers through government subsidy to both
[5] The differentiation in the definitions is made according to the various definitions for 'organisation' and 'institution' presented in Oxford Advanced Learner's dictionary

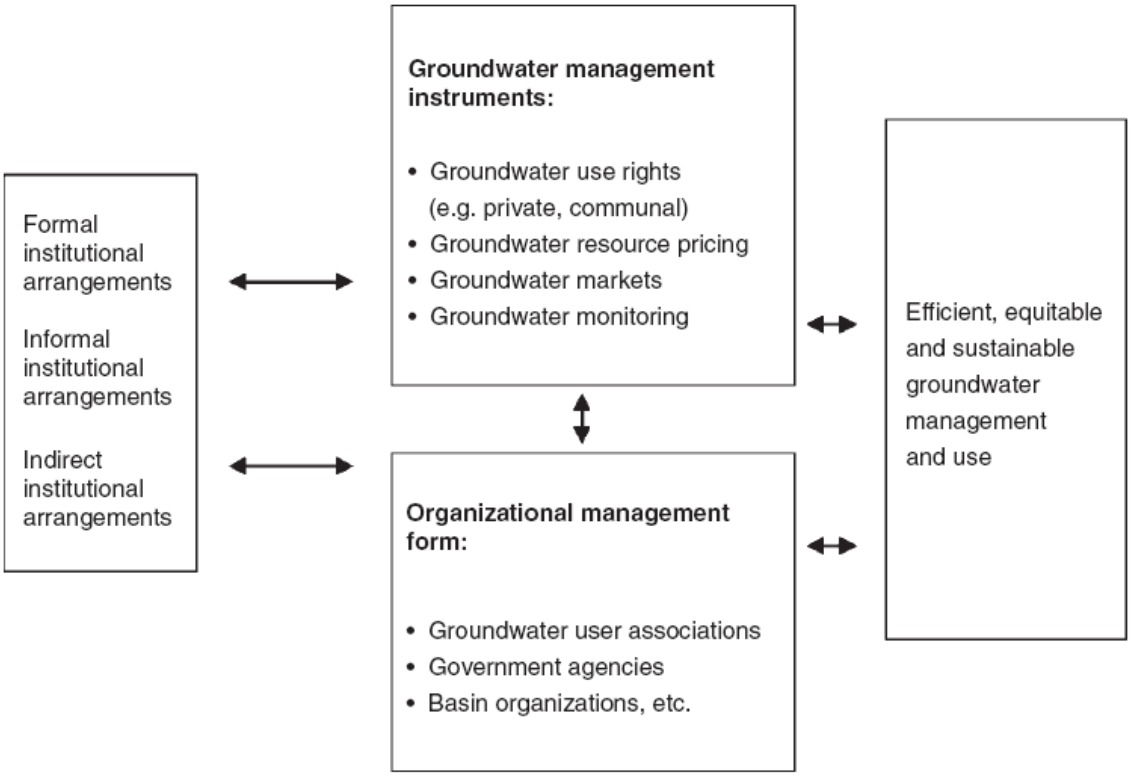

Figure 1: Institutional framework for groundwater management, source: Kemper (2007)

Kemper's framework, does not determine which ingredient is more important at a certain situation but gives an indication of what ingredients should be considered for groundwater management. Even though, the menu of ingredients suggests flexibility it leaves also non-clarity, what ingredient is more important and how ingredients interact. Hence, it leaves it completely open how efficient, equitable and sustainable groundwater management can be achieved.

Having stated this – it is not clear what the output is supposed to be. What is efficient, equitable and sustainable management and whether these goals are actually contradicting each other in terms of management? If it is equitable management – can it be efficient? If it is supposed to be efficient management can it be sustainable?

Hereafter follow some of the possibilities and also some of the difficulties in the given organisational management forms and groundwater management instruments.

- For efficiency in groundwater management it would first require the groundwater user (given she is the same as the abstractor) to have efficient usage e.g. efficient irrigation and little non-beneficial losses. Considering that industries or urban areas are more efficient than agriculture, the issue of water allocation towards more efficient usages come into play – this would have an influence on the water rights situation.
- Concerning equitable groundwater management and use, the rights and allocation also come into play. Kemper (2007) argues that with large shallow aquifers the horizontal distribution facilitates water resource capture for all those with the right to access groundwater. But this would be very different in the case of deep aquifers. Here, resource capture is more costly and therefore the right to access or if defined the right to the resource might be constrained by the financial situation of the right holder.

- Concerning sustainable groundwater management and use it would seem that particularly the instrument of groundwater monitoring and basin organisations and / or government agencies come into play. Concerning sustainability one has to critically ask whether the focus just on groundwater is enough – or whether it has to be considered together with recharge.

Organisational management forms

To start of with: it is unclear why the organisational form of a 'basin organisation' is chosen for managing groundwater, since this would seem to refer to a surface water hydrological unit. As aquifers do not follow surface hydrology but hydro-geological principles it would seem more appropriate to chose an aquifer covering organisational management form[6]. However, the approach of basin organisations towards for example, recharge dams and surface water allocation, would interlink[7] both organisational management forms. Government agencies, as depicted in the framework, are commonly not only responsible for instating the law, but also for up keeping thereof. In this, certain states keep both responsibilities in their own hands, as their role is more through exertion of (political) power through formal institutional arrangements, with technical-bureaucratic assets being instrumental and other organisational management forms being subordinate. E.g. the case of Western Europe where the government agencies have a 'sophisticated' groundwater monitoring instrument and thus have a tool but also the authority to regulate the abstractors. Or as in former Southern Yemen where 'the regime effectively used technical-bureaucratical assets to exert control over groundwater abstraction; imports and exports, drilling equipment could only be purchased through the Ministry of Agriculture, or loaned from it at the Machinery Rental Stations' (Ismail 2007: 51). The role of government agencies in certain countries could also be a one of delegation of responsibilities concerning the up keeping of groundwater laws. Since as Wegerich (2006) puts it that in cases of a weak state, 'the inability to enforce regulations makes it questionable whether any top-down approach to the restriction of groundwater withdrawals would be successful' Wegerich (2006: 450). In these circumstances Kumar (2000) advocates the creation of local community organisations, which could be scaled up for aquifer management (Kumar cited in Wegerich 2006: 450). In both roles however the government agencies could find themselves in conflict with; both 'aquifer organisational management forms' and 'groundwater user organisational management forms,' over issues of allocation. Moreover a consideration which should be made with all organisational management forms and their interaction (whether following a 'bottom up' or 'top down approach') are the power relations, the bureaucracy, corruption and the influence of large capital.

Groundwater users could be organised according to certain uses (urban, industrial, agricultural etc.), but could also be organised following certain area boundaries (perhaps hydro-geological units). In the first organisational form the uses would compete with each other; commonly it would be the user group with the highest return on investment in groundwater abstraction which wins. E.g. industrial user groups or urban water user groups would out-compete agricultural user groups since they are willing and able to pay more for the resource. In the second organisational form, particularly the resource capture capabilities amongst the users, becomes the factor which differentiates the groundwater users. Concerning this latter 'organisational management form' of groundwater users it could be that opportunity costs eventually determines the use of groundwater as groundwater pricing and markets come into play.

Groundwater management instruments

The framework has kept the content of groundwater use rights open for interpretation. Groundwater rights could be determined according to the amount of land someone has; the

[6] Transboundary examples of such organisational management forms are the Guarani Aquifer System and the Nubian Sandstone Aquifer System

[7] Examples of conjunctive water resources management are amongst others to be found in the Indus basin, Pakistan

amount of abstraction is then related therewith. In groundwater rich countries like the Netherlands groundwater rights could also be determined according to usage, enabling farmers for example to pump a certain amount per year (1000m^3) but requiring them to register their abstraction amounts. In both cases - a sophisticated monitoring network would have to be in place to verify whether there is no over abstraction. In addition, to that – since the point of sustainability is raised – a groundwater right might have to be flexible – since recharge might vary from year to year or season to season – this puts even more emphasis on the need to have a sophisticated monitoring network.
The differentiation of private and communal groundwater use rights in the framework perhaps refers to is the existence of informal institutional arrangements (over co-owned groundwater wells) within communities vis-à-vis the private groundwater rights of individuals or groups. Although the existence of informal institutional arrangements might be beneficial for these 'community groundwater user associations' (given the issue who benefits, and how within a community), the existence of these might conflict with: formal institutional arrangements as wells as the interests of the aquifer organisations.

Concerning the instrument of groundwater pricing which relates to the mentioned opportunity costs of those holding the right to the water, e.g. it is not uncommon that farmers sell their water to other uses as this may be more remunerative for them. In Ta'iz, Yemen, Ward (2000) describes the situation of farmers selling water to the city, the large demand and the price the city paid was a profitable deal for the farmers. As more tube wells were sunk neighbouring farmers were out competed and were unable to drill and pump deeper (Ward in Ismail 2007: 54). The selling of water would require clear definition of rights of abstraction and adherence thereof. As there are plenty more examples globally in which the more remunerative option is chosen[8] and abstraction amounts go far beyond the amounts respectable towards other users and towards sustainable management of the resource often with fierce conflicts as a result.

Groundwater monitoring would have to come into play as a 'restrictive conscience' of groundwater abstractors. Kemper (2007) brings forward the transaction costs of metered groundwater are high and tampering and corruption in meter reading are often quickly resorted to. In some countries, e.g. 'Mexico and France, industrial and municipal users pay, but because agricultural users are exempt and they use the largest share of the water, the impact on the groundwater resource is little' Kemper (2007: 166). However in some areas in India participatory hydrological monitoring of simply the fluctuations in groundwater levels has been able to 'overcome lack of understanding of limitations to local groundwater resources' and users have been able to 'come to common local agenda on groundwater management[9].' In this; participatory hydrological monitoring was built on informal institutional agreements but has proven to create coherence amongst users, something the formal institutional arrangements were unable to provide. However it is important to consider how local such arrangements are, as argued earlier there should be symbiosis between the informal and formal institutions. The relevance of monitoring, water savings or recharge at local scale should also be considered at basin and aquifer level and the bigger picture of allocation and usage.

[8] Often backed by the reasoning that the resource usage is a lot more efficient than that of other users in the area
[9] www.groundwatermanagement.org

1.5. Research Questions

The main research questions are the following:

- What is the organisational and institutional context of dam management and groundwater resources in Sana'a basin?

- Who benefits from the dam implementation?

Sub research questions

Organisations and Institutions

- Which organisations and institutions are involved in dam development and groundwater management?
- Which respective role do they play?

Dam functioning

- Who asks for dam implementation?
- Is there evidence of recharge?
- How is the recharged water distributed?
- Who is responsible for dam operation and management?

1.6 Research methodology

The methodology followed two main steps:

The first step was getting an overview of the organisations and institutions related to the research topic. For this a literature study was conducted, interviews were held with people and meetings were attended. The data sources are:

- Library of the WEC, Library of the NWRA, National Information Centre NIC, Arcadis Euroconsult, GDI, MWE
- 8 Interviews with people from the MWE and NWRA, MAI and GDI, ACU, WEC
- 3 farmer meetings were attended
- Lecturers and students at the WEC were frequently consulted

The second step was to get farmer's perception on recharge and to understand how water is distributed. To do so, four case studies in different communities located close a dam were carried out. During these case studies, individual interviews were conducted with farmers (21 interviews in total). To confront the findings and to get farmers to discuss with each other on a certain topic, group meetings were carried out (2). Thanks to them, some issues and the different relationships between members could appear.

To choose the communities for the case studies, the following criteria were taken into account:

- the dam should be functional so that can be spoken of a reservoir of water during the rainy seasons
- practicality reasons, the dams not too far away from Sana'a and safe to visit[10]

In annex 1 a detailed list of all the interviewees is provided as well as an overview of the group meetings which were attended and organised.

[10] After having chosen a dam (Al-Ghaida dam) it was strongly advised by the local sheikh to chose an other as there had been violent conflicts between upstream and downstream communities

Regarding the interviews conducted in the communities, some methodological limitations have to be mentioned:

- Almost all of the individual interviews turned out to be 'small group' interviews (2-5 people). As interviews were carried out outside or in public places (community building) other people would be curious and would be standing around and interfering,
- If an interviewee would not know an answer he would be assisted by those around him sometimes discussion breaking loose if debatable matters were dealt with,
- Practically being unable to go to field according to schedule.

To start with Sana'a basin and the dams are introduced and recharge is discussed. Following this the organizational and institutional context of dam implementation and groundwater management is detailed, where after the SBWMP is discussed including the formation of WUAs. As cases study the farmer's perception on recharge and water distribution is given. To conclude the findings are summarized and further topics of research are presented.

1.7 Critical reflection on the methodology of this research

A critical reflection on the methodology, rather said 'the way how things went' will be given. The initial methodology (as proposed in the research proposal) may have been adequate on paper to be able to answer research questions and work with a conceptual framework. However fieldwork turned out to be more a challenge than expected and the proposed amount of field work was not obtained. When eventually the initial concepts were revisited, the collected material could not uphold the desired outcome. The research underwent a refocus and now concerns the *'technical-institutional analysis of small dams in the Sana'a Basin, Yemen'* as how the research is now entitled.

A short recap of the initial proposed research

- the objective of the research was *'to find out whether the dams in Sana'a basin work according to their design and offer perspectives for the neighbouring and dependant farmers in managing water.'*

Through a comparative study of 4 communities closest to a dam, these findings were to come forward. With the main question being (how) have the communities benefited from the presence of dam. Within the communities the proposed concepts would help determine the benefits:

- equity was brought forward to determine the water distribution arrangements around the dam and whether the benefits of recharge were proportional or equal
- hydraulic property would help determining the sense of ownership[11], but more also the dam investment agreements amongst community members then related to the benefits of recharge
- social capital was put forward so as to determine what 'community' actually means and whether it encapsulates cultural values such as compassion, altruism and tolerance. If so have these influenced the decisions to build a dam, or agreements in water distribution

Asides the assessment of the benefits within a community it was speculative whether there was actually noticeable recharge of groundwater at the dams. This assessment was essential in the four different communities.

The choice for four dams was the following:
'The idea is to select 2 dams which have been designed and constructed through input and influence foreign to the community around the dams (for example dams built by the

[11] With regards to the study of Vermillion and Al-Shaybani (2004) in another part of Yemen where the sense of ownership amongst community members ensured responsibility for the dam, including operation and maintenance.

government or NGOs) and 2 dams which have been (co)designed and (co)constructed by community around the dams. The intention is to choose these four dams spread throughout the Sana'a basin considering the topographic, climatic, hydrologic and geological conditions. Thus a comparative assessment can be done focussing on the operational functionality of the dams.'

The necessary literature reconnaissance and the interviewing of various actors at basin scale were done to get a better picture of: dam design & construction, the implementation and the larger basin picture of governmental stakeholders. According to the methodology stipulated community visits were planned and 15-20 farmers were envisioned to interview, an amount which was a haphazard choice based on community sizes of 1000 – 1500 individuals.

The difficulties then encountered are listed as the following, some resultant of the other:

- It proved difficult to interview a lot of farmers per day: from early morning to lunch the maximum amount of interviews would prove to be 4, all of the individual interviews turned out to be 'small group' interviews as people gathered and this cost time.
- Although it was the researcher's urge to interview as much as possible, this urge was not always shared amongst those who came along, asides that the necessity of more interviews was not shared as farmers were giving similar answers (in particular because of the fact that the interviews turned out to become 'small group' interviews).
- One fieldwork day unfortunately the amount of interviews had been limited, because several guests had come along however constructive and critical observations were given.
- The amount of field work days proposed were not met (13 dates proposed, 6 achieved).

It is the researcher's opinion that all attempts were made to achieve the 'required' amount of interviews, however the circumstances in this quest were also part of the reason to have to drop the desired amount of interviews.

The lessons learned from the fieldwork experience

The interviews could have been more efficient with time if the questionnaire had been shorter and focused solely on community member differentiating factors. Although initial shortcomings in the questionnaire were dealt with, the researcher however decided not to change the questionnaire initially. Since it was unknown how much field visits were possible it deemed the researcher to be more appropriate to get few, but complete farmer's perspectives on all the aspects within a community, rather than more farmer's perspectives and shorter, with less detail. For both approaches something is to be said: coming to a new unknown community an extensive interview can set out the context, however considering the argument above, shorter questionnaires would have been more time efficient considering the objectives.

Although the perspectives of farmers were valuable - which came forward during the interviews - these also came forward during qat sessions. Farmers during these sessions also tend to have an unbiased opinion as it is their habit to gather with those they know. Moreover as interviews were carried out outside or in public places (community building) other people would be curious and would be standing around and interfering.

In retrospect, it can be said that the researcher was inadequately aware of the information the research, in particular certain assessments required. As will also become clear in the following paragraph, it was only during the revisiting of the concepts that the researcher fully became aware of these shortcomings in the data.

'The sense of altruism and everybody knows everybody' ruling within a community, lead the researcher and his companions to believe that all was well concerning concept 'equity' within a community. The researcher then thought the comparison with other communities could be made. However the determination of the concept required more: nothing had actually been proven.

The concepts revisited
As the amount of interviews were so little, the results would prove insubstantial to support conclusion specifically determining the benefits within a community and then following to make a comparison between the communities.
Following from the interviews and meetings a definite general feeling of altruism and religious and tribal behavioural codes came forward within the communities. This finding supports the concept of social capital as described above, however therewith are not described the water distribution agreements and the benefits of the dam. Essentially the farmer's situational analysis – including the location of the water abstraction point and water access right with the water distribution agreements – are matters which determine the equal or proportional benefits of the dam's recharge.
If for example the community agrees that all wells and their abstraction amounts are distributed amongst its members according to their shares in the wells then the benefits of the recharge can be said to be equal and the water distribution proportional. If on the other hand solely the abstraction amounts per single well are distributed amongst the share holders, then the location of the well from the dam would determine the wells relative benefit from the recharge. The community survey was too limited to be able to determine this difference, which is important considering that the investment in the dam in all communities was not according to proportionate investment related to the distance between the dam and the well.
The concept of hydraulic property was thus also only partly answered since all communities stated they were owner of the dam. This however is likely related to the land tenure of communities and the related run-off rights the communities have, since they have the right to build the dam (but this has not been explicitly asked).

The change of research focus
As has become clear it had become impossible to draw conclusions within the communities and then compare them with each other. The choice was then made to zoom out on to basin scale and look at the institutional arrangements which were involved in dam implementation. As an extensive literature study and interviews had been made at basin level the refocus of the research was possible. The water law, was scrutinised for rules and regulations concerning dam implementation, the harvesting of rainwater but most importantly it was scrutinised for its groundwater legislation. Using the institutional framework for groundwater management of Kemper (2007) the 'institutional arrangements' as well as the 'groundwater management instruments' and the 'organisational management forms' were analysed. Of particular attention became not only the benefits of the communities closest to the dam but also the issue of those who do not benefit from the dam i.e. downstream communities. The research objective was rephrased to encapsulate this institutional analysis and thus became:

- *to examine the institutional context of dam implementation and groundwater resources in Sana'a basin*
- *to contribute to a better understanding of dam recharge at local level*

The new content of the research

- A discussion on the dams and the recharge of the aquifer. It is relevant to know whether the dams recharge and at what scale the recharge can be considered, since other organisational management forms (communities, basin organisations, groundwater user groups, etc.) might become affected, therewith also potentially in conflict with their surface and groundwater use rights.
- A description of the organisational management forms present: describing their purpose and functioning, but also their interaction with each other and the instruments they use to be able to manage surface and groundwater.
- A description of the instruments, focusing particularly on the groundwater use rights.
- A description of the formal and informal institutional arrangements instated by respectively the government agencies and the *shari'a* / customary principles.

- Case studies which give the reader a further understanding of the local situation and also substantiate the surface and groundwater management discussion concerning the implementation of dams

Chapter 2. Sana'a basin, dams and recharge

2.1. The Basin picture Topography and climate

The research area concerns Sana'a basin which is located in Yemen. The Sana'a basin includes the capital of Yemen, Sana'a, the Wadi Al Kharid and the surrounding basalt rock mountains (see figure 2 for the global orientation of Yemen and the Sana'a basin). Sana'a basin is a highland area of some 3200km^2, the average elevation of the area is 2200 m., surrounded by a mountainous range elevated up to 2500 meter, see both figure 2 as well as figure 2 underneath. Sana'a basin has predominantly arid to semi-arid climatic conditions with rainy seasons mainly during spring and summer (pre-monsoon and monsoon seasons) and with high temperatures prevailing all through the year in low altitudes (Hassan, 2003). Characteristic for arid to semi-arid basins including Sana'a basin, are the large rainfall deficits and excessive evaporation losses due to high temperatures and wind speed (Moharam, 2006). The highest average rainfall rates (above 300 mm/a) occur across the mountainous terrain along the western boundary of the basin. An important consideration Hassan brings forward in his conclusion of his study of surface water hydrology in Yemen, is that in light of climatic fluctuations the agricultural dependency on the nature of the rainy season makes the vulnerability for the sector even higher (Hassan, 2003).

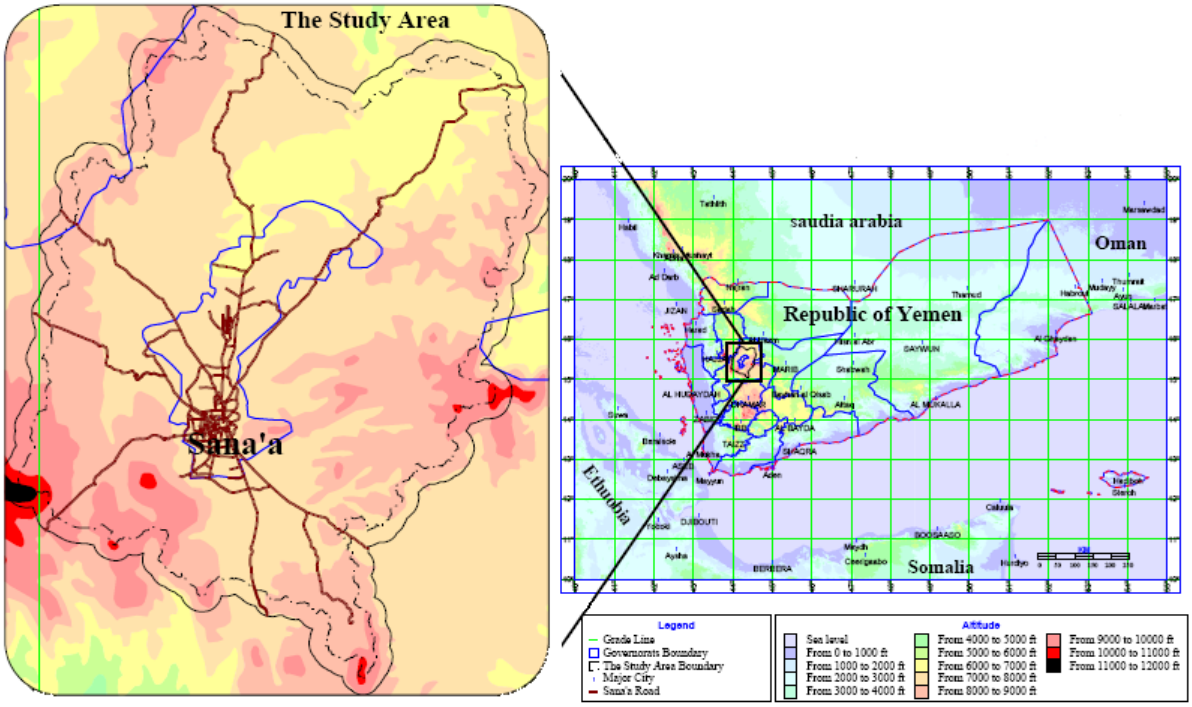

Figure 2: Orientation of Yemen and Sana'a basin, source: WEC 2004

2.2 Dams in Sana'a Basin

The dams are built by local communities, construction contractors or the ACU (these latter two commonly supported and supervised by the GDI) and are funded by the communities or the AFPPF (see annex 2 for a complete overview of all the dams in Sana'a basin). The main purpose of the dams for the communities is artificial recharge of the water transmitting layer for agricultural purposes mainly downstream of the dam (in chapter 3 this layer is specified

for each dam of the case study). The dams are scattered throughout the basin commonly blocking small tributaries of the Wadi Al Kharid and in this functioning, according to a monitoring and evaluation specialist at the NWRA[12], the dams in the wadi also redefine the water allocation, as floods are blocked their effect is not felt downstream anymore. In annex 2 a tabled overview is given of all these dams and underneath they are placed on a processed satellite image of the basin. The thick blue line represents Wadi Al-Kharid, the thinner blue lines show tributaries and the dark blue lines are major roads, the red line shows the boundaries of Sana'a basin and finally the dams are shown as red dots with their names. In Chapter 4.1 detailed maps are shown with the case study dams (underlain by a topography map).

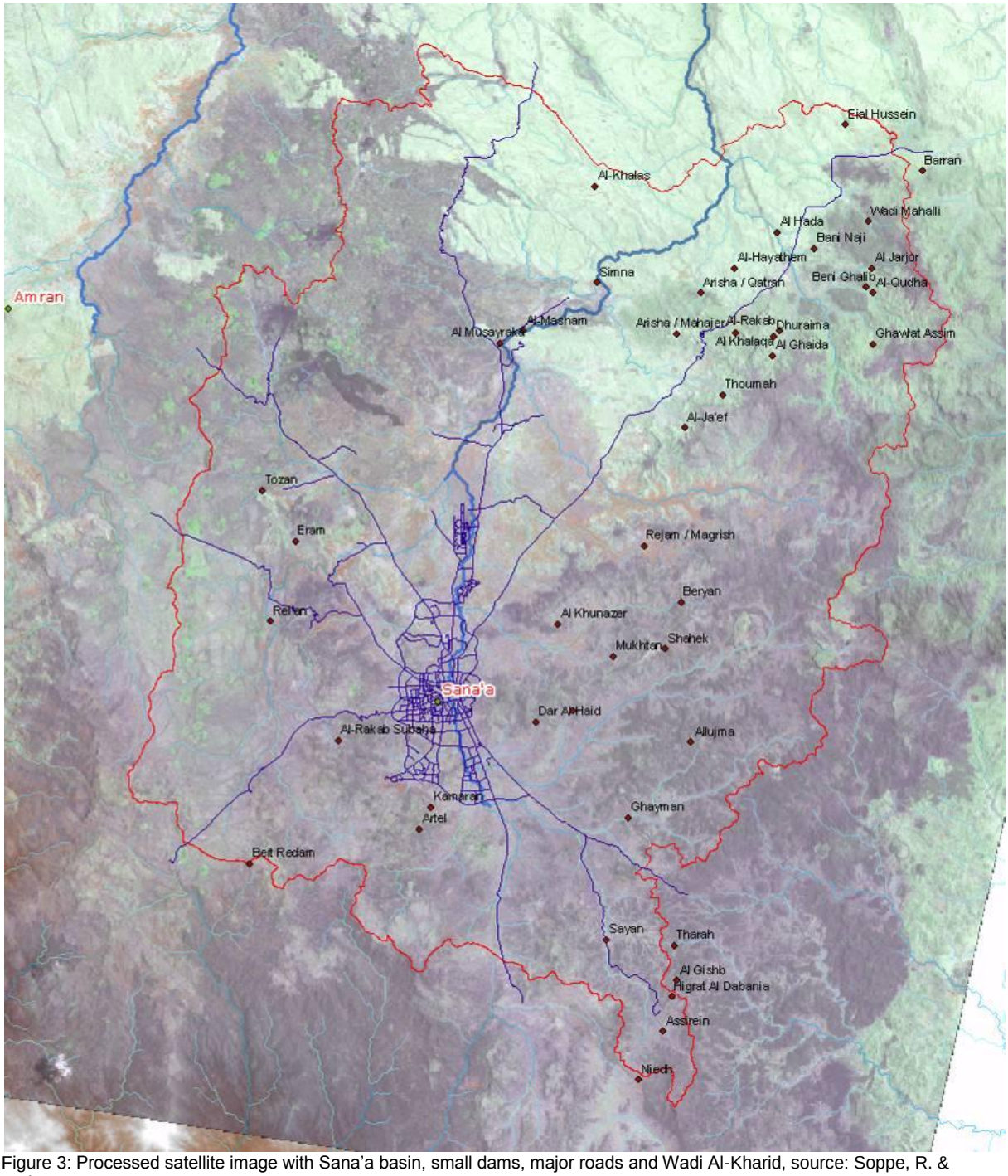

Figure 3: Processed satellite image with Sana'a basin, small dams, major roads and Wadi Al-Kharid, source: Soppe, R. & Author

[12] Ali Shuoiab, 11-03-2007

A note before the discussion on dams is the referring to them in spoken as well as written communication. Before the development of groundwater as main source for agriculture rainfall water harvesting structures in Yemen, like cisterns, pools and dams, commonly came with a surface water distribution system[13]. Also for example the Ma'rib dam which was maintained and operated for more than a millennium (750BC – 570AD) had a surface water distribution system. Notably it was the lack of maintenance which eventually caused the dam to deteriorate and break by the annual flooding (Eijk, 2000). The mentioned structures are primarily limited to surface water distribution amongst its beneficiaries. The dams this study aims at discussing, which are shown above (figure 3) are also referred to as rainfall water harvesting structures, however with the purpose to recharge groundwater and without surface water distribution structures (GDI dam inventory, 2001). In the discussion underneath and of the water law it will come forward that this difference of surface or groundwater distribution has different legal / institutional but also technical implications.

The development of mechanised groundwater pumping followed by the rapidly depleting groundwater resources was eventually the incentive for farmers to build recharge dams. Although Yemen has a long history with sustainably functioning dams[14], the dams as introduced in Sana'a these past decades and those part of the case study, are a mere attest of the green revolution and 'a society where resource capture is being actively pursued' (Lichtenthäler & Turton, 1999). In this resource capture communities block the wadis, and potentially harm the interests of downstream communities who were benefiting (from floods and recharged aquifers) and even had the right to the flash flood water (see also paragraph customary law 3.2.1). Thus, the 'successful' local efforts at recharge can cause problems further downstream as Sakthivadivel states, from a case study in the Semi-Arid state of Gujarat, India[15]. 'The possible impacts of local action on regional outcomes highlights the key challenge of community-based groundwater governance as one moves from local to basin scales[16]'. This challenge is also faced by the government organisations, which will be described in chapter 3.1.

2.3 Recharge discussion

Now over to the purpose of the dams namely the recharge. In capturing water behind the dams farmers aim to recharge groundwater, and be able to abstract and use water over a longer time of the year (considering the mentioned climatic conditions in 2.1).
An important consideration when wanting to discuss, let alone assess recharge is the substrata; meaning the layers which are being recharged by the stagnant water from the reservoirs. The path taken by the recharged groundwater is unique to each site with its varied geology and as monitoring of the performance of the dams has been neglected any evaluation on the benefits of existing structures in terms of their contribution to recharge of groundwater are hampered due to the lack of information (Arcadis Euroconsult, 2006). The path taken by recharged groundwater is not only relevant to those who incepted the dams as they seek to benefit, but it also highly relevant in the discussion for those who do not benefit from a recharged aquifer.
The debate and uncertainty concerning - which layers are being recharged and how local or how 'basin wide' the recharge (potential) can be considered[17]- brings two issues forward:

[13]Amongst others; cisterns of Hababah a must see for tourists, the 700 years old cisterns of Jaadan (YemenObserver, 29-9-2007), and the millennia old cisterns of Al Tawilah in Aden, rediscovered by the English in 1854 (Brigadier General Cunningham, 1899),
[14] As farmers and several organisation employee's proudly brought forward during interviews
[15] The case study concerns the watershed known as Aji1 in the Saurashtra region of Gujarat, which is considered water scarce and closed and has a high variation in rainfall, which in that is similar to the situation in Sana'a basin
[16] Sakthivadival,R. 2007 p. 209
[17] E.g. recharge of a layer may not be noticeable in the dams direct surroundings but perhaps further away

- first, are other communities downstream of the dam benefiting from the recharge, since they do not benefit from the wadi surface flows anymore;
- second, how does the functioning of the dams influence the surface and subsurface water flows within an entire basin, since basin organisations are particularly interested in this (this interest is further discussed in the organisations section of this chapter)

Regarding the latter issue, a basin characterisation made by the WEC in 2001 specified that only a highly detailed and worked out assessment of the basins hydro-geology would be able to determine flows in the basins (deeper) layers. Relating to the functioning of the dams; recharge estimates in Sana'a basin have proven to be difficult to produce. With the large amount of geo-hydrological factors involved; the assessment off infiltration, transmissivity (see annex 3) and the determination of which aquifer layers are where, make prediction of recharge, its extent and effects, difficult to make (WEC, 2001).
Using the case studies in chapter 3 the first issue is looked at amongst 4 different areas in Sana'a basin. The second issue comes in the discussion of a basin wide approach towards the dams, and their integrated role in the basins water management approach (more on this in the discussion of the organisations and institutions in this chapter). What the government would like to see in Sana'a basin is reduced pumping, in particular that of ground water from the deep aquifers (commonly tube well pumping), and usage of the shallow aquifers which are thought to recharge from the reserved water in the dam reservoirs (Al-Asbahi, 2005). In line with this the SBWMP (further discussed in this chapter 3.3) also having a dam rehabilitation component expects that 'the farmers would then pump from the shallow aquifers instead of deep aquifers, which are a critical supply source of drinking water for Sana'a City[18].

2.4 Recharge experiences from previous researches

The experiences from the field in Sana'a basin (in existing literature) up till now concerning evidence of recharge are ambiguous. Three different studies will be discussed below

During a farmer meeting (a meeting from which the WEC survey 2001 sampled the opinion of farmers) organised by the ACU on the recharge functioning of the dams farmers clearly brought forward that in their perception the construction of surface reservoirs and other water-retaining structures is the ideal solution for alleviating some of the pressure from the aquifer system. Moreover that recharge dams have proven effectiveness in several areas e.g. the Mukhtan dam in Bani Hushaysh (further discussed as case in chapter 3). The experience gained with the construction of these dams and recharge should be taken into consideration when developing other projects. However the pro-dam stance above came forward during ACU organised meetings and therefore as the WEC study stated the farmer's accounts of rising water tables to be put into context (WEC, 2001). Farmers may not have been to state there real opinions, but were influenced by the presence of ACU members during the meeting (see paragraph 3.1.5 for a detailed discussion on the ACU).

Al-Sakkaf et al (2006) find in their case study research of Al-Jaef (see map of all dams, figure 3) dam that famers[19] had experienced no benefit of the dam through recharge of their wells (Al-Sakkaf et al, 2006). This perception however was quickly explained during a random field visit (this research) as it was observed that the dam had been built just several metres upstream of a vertical volcanic vault through which no groundwater would be able to flow. The observed proved an interesting case of negligence in the geological reconnaissance before the construction of the government built dam. Further detail on this seemingly haphazard funding and construction of dams will follow in the discussion of the involved organisations (AFPPF and GDI, see paragraph 3.1.3).

[18] Component 2 of SBWMP Supply Management and Recharge Improvement - $10 5 million, Boydell etal 2003: 5
[19] 13 members of the downstream village of Al-Harrah were interviewed in this Al Jaef case study by Al Sakkaf et al (2006) p.5

A hydrology study conducted by Arcadis Euroconsult[20] does recognise the recharge capability of dams however their finding also include that reservoir water release strategies would offer greater recharge benefits than from relying on recharge in the reservoir alone. The study put forward that in light of diminishing recharges through sedimentation and the high evaporation rates; operation strategies such as controlled release for direct supply or uncontrolled release of water to promote recharge in the natural channel downstream (wadi bed) should be thought of (Arcadis Euroconsult, 2006). The non-beneficial losses from evaporation of reservoir water are thus minimised as water is recharged quicker. The latter operation strategy, of uncontrolled release, is supported by findings from the Basin Characterisation conducted by the WEC in 2001, in which they state that the recharge percentages of flows in main wadi channels and from runoff in other upland areas are respectively 40% and 20% indicating that wadis in themselves would be capable of recharging the aquifer (WEC, 2001).
Apparently from this technical perspective the dams are not as effective as they could be, however what would the proposed operation strategies mean for the distribution of water and the agreements thereon amongst those who built a dam and benefit and those who do not benefit.

In chapter 3 the perception of farmers on the functioning of the dams is brought forward and considering the above the water distribution will be analysed at the four different communities and a further specification of this question will be made.

[20] A component of the SBWMP is 'Supply Management and Recharge Improvement' in which the aim is to enhance and accelerate groundwater recharge through mostly small conventional dams (http://www.extranet.ecbmb.nl/news_archive.asp?id=22)

Chapter 3. Organisational and institutional context

3.1 Organisations

Already introduced in the previous paragraphs are those organisations involved in the funding, design and construction of the dams in Sana'a basin. Underneath an overview is given of the organisations, also showing the variety of ways how dams are implemented.

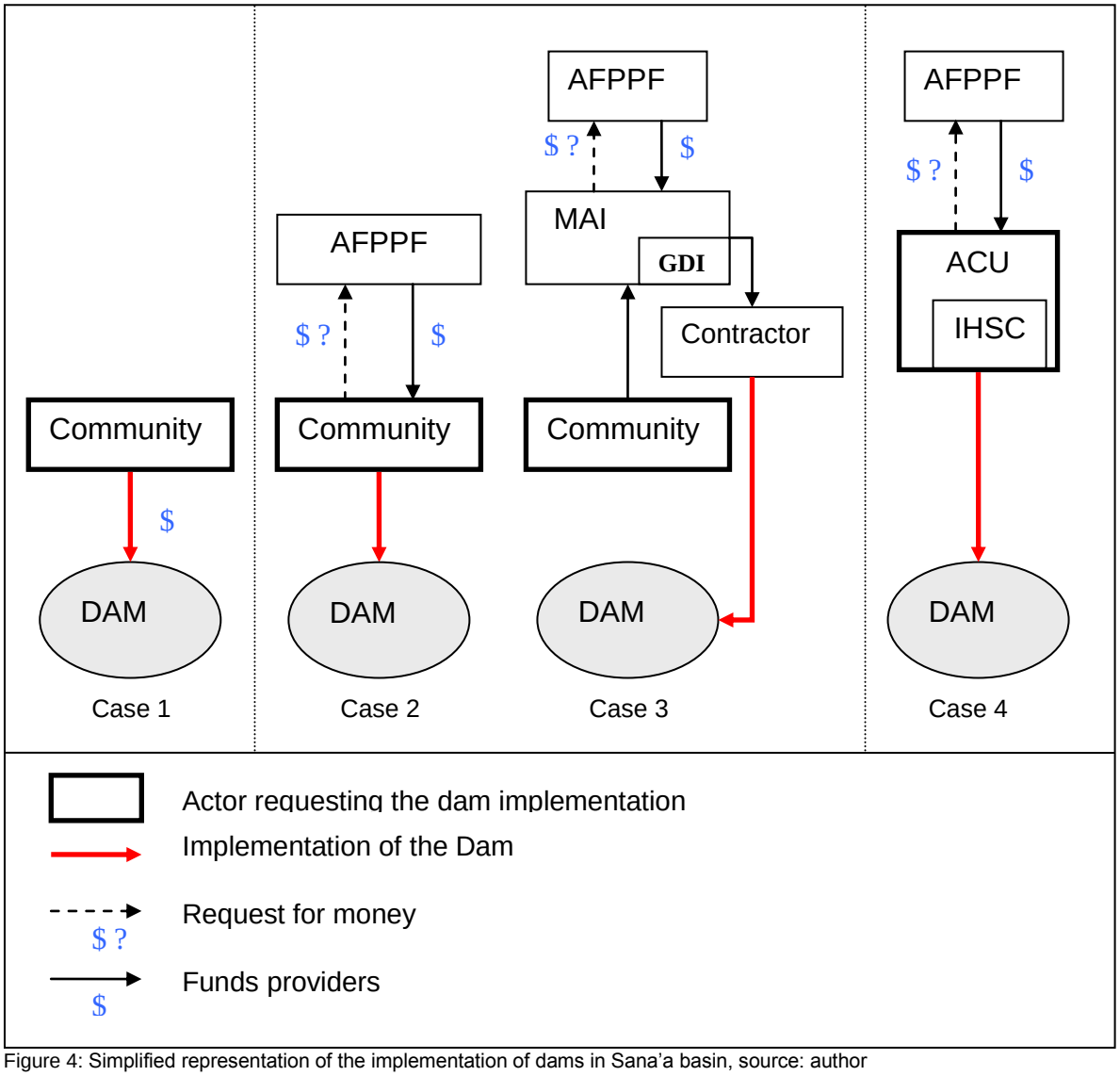

Figure 4: Simplified representation of the implementation of dams in Sana'a basin, source: author

The cases are simplistically represented in the overview; however they give a good insight into the variety of ways in which communities go around getting a dam built for their community. Case one and two show that the community builds the dams either with or without external funds. In some cases (case 4) dams are implemented with little or no cooperation or involvement of communities but are efforts of either both the ACU and its members or private corporations (see annex 2). Three of the dams in the cases study in chapter 4 are built by the communities, with or without support from the AFPPF and one dam is built on request (as case 3 shows in figure above) and the last is built by the ACU.

The organisations which have not been referred to in figure4 are the Ministry of Water and Environment, and one of its departments the National Water Resources Authority. These organisations are part of the debate on dams at basin level where although, the opinions and perspective should be the same for the GoY the Ministries of Water and Environment (MWE) and of Agriculture and Irrigation (MAI) both have as of yet not reached an understanding regarding jurisdiction over surface water infrastructure (deducted from NWSSIP, 2006). In the following sections an answer is sought to this 'not understanding between government ministries' and what effects this has for dams, and the development thereof in Sana'a basin. Moreover to manage dams in a certain area it is important to have rules, property rights and institutional arrangements (Vermillion and Al-Shaybani, 2004). In following paragraphs the dams are further contextualised in basin perspective including the involved organisations, institutions and projects.

Before the reunification of Yemen, the YAR's water management concerns were divided between the ministry of agriculture and water resources (MAWR), the ministry of oil and mineral resources (MOMR) and the ministry of electricity and water (MEW) each with different – sometimes conflicting – priorities, and representing specific political interests and stakeholders (Ismail, 2007). Since the reunification of the country in 1990 however notable efforts were made towards improving water sector governance. This included consolidation of water management functions under the NWRA (1995), and formation of the MWE (2003) with most water sector agencies administratively linked to it. This resulted in the water sector as a whole, and water management in particular, gaining representation at the Cabinet level (NWSSIP, 2005). However the responsibility for irrigation, dams and water harvesting, remained under the Ministry of Agriculture and Irrigation (MAI). MAI has been, and still is, heavily engaged in development of surface water infrastructure and is substantially financed by the AFPPF[21], particularly for dams. Moreover, although steps toward IWRM vision for future management of the water crises are made, the water sector is still a key political battle ground, pitching the state against parochial forms of organisation that continue to adhere to local arrangements based on customary law (Ismail, 2007).

All mentioned organisations concerned and involved with the development of dams are shown in the table 1. Their role will be further explained in the sub-paragraphs to come.

<table>
<tr><th colspan="2">Government bodies & institutions</th><th>Non Governmental Organisations</th><th>Water Resources Projects Yemen</th></tr>
<tr><td>Ministry of Water and Environment (MWE)</td><td>Ministry of Agriculture and Irrigation (MAI)</td><td>Agricultural Cooperative Union (ACU)</td><td>Sana'a Basin Water Management Project (SBWMP)</td></tr>
<tr><td>National Water Resources Authority (NWRA)</td><td rowspan="2">General Directorate of Irrigation (GDI)</td><td rowspan="2">Water Users Associations (WUA)</td><td rowspan="5"></td></tr>
<tr><td>Environmental Protection Agency</td></tr>
<tr><td colspan="3">Related Institutions</td></tr>
<tr><td>Water Law No. 33</td><td>Agenda 21A 2000</td><td>Cooperative Law No. 39</td></tr>
<tr><td colspan="2">National Water Sector Strategy and Investment Plan 2005 -2009</td><td></td></tr>
</table>

Table 2: Overview of the Organisations and Institutions in Sana'a basin, source; Author

[21] The Agricultural Fisheries Production and Promotion Fund was 'the source' of funds for building dams and as the MAI dominated its board this would be easy (NWSSIP, 2005). Now the AFPPF board also consists of MWE representatives (see annex 7 for detailed information on the AFPPF)

Also brought forward in the overview above are the ongoing water resource projects in which the various departments are involved. During this research the WB financed Sana'a Basin Water Management Project (SBWMP) and the GSCP were underway. The execution of the project brought forward the necessity of collaboration within the government (see chapter 3.3). The ongoing projects are also referred to in the description of the various (non) government organisation which follow.

3.1.1 Communities

Although the term 'community' may by vague and slippery, and seem to elude precise definition the assertion it makes as a sense of attachment to the land and a relationship to it that entails responsibility as with reciprocal relations in social communities (Barham, 2001). The reciprocal relations within the communities in Yemen are rooted in a tribal system which 'still provides an important mechanism for community organisation' (WB, 2006 p.35). This community organisation is also brought forward by Vermillion and Al-Shaybani in their case study of eight small dam projects in the mountainous province of Al-Mahweet in north-central Yemen. The concept they bring forward to describe this mechanism is the social capital within a community. As in their cases study, development assistance[22] incentives are taken on by the local communities around the dams this emerging of social capital as they found generally set of at a 'pattern of decisions, investment, and development of institutions (clear rights and rules and authority) that emerged incrementally' (Vermillion and Al Shaybani, p.19). An important note to be made to their research however is: that the 'network of civic engagement[23]' for dam development in several communities only consisted of groups within the community (read Vermillion and Al-Shaybani, 2004).
The role and position of *shaykhs* requires explanation also with regards to their role within certain areas or communities which are involved in dam development. S*haykhs* are considered to be tribal leaders ruling small political entities, and per village community it can generally said that one *shaykh* holds a leading position (Lichtenthäler notes on his study in the Sada'a region that; a *shaykh* from a specific village was commended in the area for his village uniting efforts Lichtenthäler, 1999) The GoY has attempted at incorporation of *shaykhs* into the states formal institutions (WB, 2006). According to the Country Social analysis of the WB, *shaykhs* can now draw on formal state systems to support them, which amongst others has reinforced and firmly instated the patron role they have in their communities (ibid.)

The case studies in chapter 4 will show: how community involvement compares with the findings of Vermillion and Al-Shaybani, as well as clarify the role the *shaykhs* have played in the instatement of dams.

3.1.2 Ministry of Agriculture and Irrigation (MAI)

The MAI constitutes a number of directorates amongst which also the General Directorate of Irrigation. This organisation is responsible for the design, construction of irrigation structures as well as dams (which is also institutionally backed). As fundamental policy the MAI has; how to increase farmers' income and contribute in reducing poverty, whilst cutting the over-abstraction of groundwater. Down-scaled to the irrigated agriculture sector the key goal is to help farmers use water resources efficiently and sustainable, whilst increasing their income (more income per drop) (NWSSIP, 2005).

[22] In the cases reported by Vermillion and Al-Shaybani, financial assistance came from; Agriculture and Fisheries Production Promotion Fund (AFPPF), German Agency for Technical Co-operation (GTZ), Agricultural Imports Fund sponsored by USAID, Social Development Fund (SDF), EU and other providers of bilateral assistance. Technical assistance in most cases came from the Ministry of Agriculture and Irrigation MAI, once by GTZ, once by SDF and by the AFPPF.
[23] As part Robert Putnam's conceptualisation of social capital (Putnam, 1995)

This policy and goal is implemented through the Agenda 21 (A21A)[24] reform program developed by the MAI which serves as blueprint for change. In this the MAI's focus is repositioned towards; efficiency, decentralisation, incentives, cost recovery and participation are targeted for.
The strategy will consist of;

- Developing Water User Associations to manage and eventually take over the responsibility of publicly managed irrigation schemes and dams (by-laws for this are already in place). The WUA phenomena will be discussed in the paragraph explaining the SBWMP as this research encountered WUAs being instated in Sana'a basin as part of that project.
- Investment plans in which the priority is set for the AFPPF to finance check structures and dams this in coordination between the MAI and NWRA with the basin framework in mind (see the working out of the '*water plan'* in the water law).

The coordination of these structure investment plans together with repositioned role of the MAI will require effort / funding and capacity (capable staff) from the involved government authorities (NWSSIP, 2005).

3.1.3 General Directorate of Irrigation (GDI)

The MAI has 8 directorates under which also the General Directorate of Irrigation (GDI). The GDI in its turns consists of 6 departments of which 4 are also involved in dam development namely; Central Water Monitoring and Irrigation Advisory unit Design Department, Survey Department, Studies & Planning Department. Appropriate dam location needs surveying, planning, designing and monitoring thus all the mentioned departments are involved. The GDI is amongst others responsible and supervises the construction and rehabilitation of dams, the work itself is commonly tendered for construction contractors.
According to an employee of the GDI[25], dams in Sana'a basin and in Yemen would be constructed according to an 'upon-demand approach' see case 3 in figure 4 (see also the Mukhtan Case in chapter 3). Meaning that if farmers or a community would request a dam it would be built, neglecting to perform EAIs, installing monitoring programs or having organised O&M[26].

3.1.4 Ministry of Water and Environment

Consolidation of the institutional water sector infrastructure started in 2003 with the creation of the new Ministry of Water and Environment (NWRA, 2006) and came as a natural development of previous government efforts to reorganise the water sector (Foreword prime minister in NWSSIP, 2005). The efforts which started with the establishment of the High Water Council in the beginning of the 1980s, then followed with the establishment of the National Water Resources Authority (NWRA) in 1995. The aim of creating the MWE was to create an institutional structure for integrated water management and to prepare the necessary institutional and investment conditions to face the exacerbating water problem in Yemen (NWSSIP, 2005). At the moment not all water development and management is under the MWE since irrigation (and dams) is still under the umbrella of the MAI.

According to the minister the symptoms, causes and even needed treatments of the water crisis in Yemen have been known since the mid-1980s. However the implementation of remedies remained slow which can be attributed to the following factors;

[24] In content Agenda 21 (A21 2000) adopted in 2000 by the MAI follows the Rio 1992 principles, the blueprint made however, resembles the global one and lacks implementation capacity
[25] Interview with the director of Sana'a Basin Dam Unit (08-04-2007)
[26] Interview with a dam design engineer of the GDI Studies and Planning Department he was also an M.Sc. student of the IWRM program at the Water and Environment Centre, Sana'a University

- the recognition of the water scarcity problem and its impact on development had not matured in the decision making circles to an extent compatible with the social cost of policies and remedies prescribed for its solutions;
- the policies and solutions were not comprehensive enough to take into consideration the extensive and varied role of water as a prime mover of economic development, both affecting and being affected by various sectors;
- the proposed policies and solutions were not supplemented by an action plan defining priorities, estimated costs and an investment program of implementation.

So although there was awareness of the problems, apparently the willingness (at higher political level) to solve them was not.

The ministers words further confirm that decentralisation and cost recovery are also part of the MWE's policy (see A21A described in 3.1.2 MAI). It is however, unclear how decentralisation can be part of a policy in Yemen. Since the unification of Yemen it is exactly the opposite what the government has attempted at doing. It is the rural areas which are brought into lineage with the national government. The self-governance of local communities has come to and end when local councils were instated and *shaykhs* became linked with the ministry of tribal affairs (Ismail, 2007)

The prime executive priorities of the new MWE, in addition to the role assigned to it in support of the implementation of, and adherence to, the Water and Environmental Laws (especially with respect to haphazard drilling of bore holes), are;

- awareness raising to protect water and other environmental resources from depletion and pollution
- special attention given to the updating of technical data on water basins
- support of expansion in using modern irrigation techniques

National Water Resource Authority (NWRA)

NWRA is responsible for managing the water resources of Yemen under the supervision and within the mandate of the Ministry of Water and Environment. NWRA faces numerous challenges such as; the enforcement of the water law and encouraging local communities to work together in a participatory manner to manage their water resources (NWRA, 2006). NWRA's objectives are the following:

- measure and analyse the country's water resources, through a national census of wells and other water structures (previously an overlaps with GDIs responsibilities)
- explore technical options for more efficient use and conservation of water, through developing plans for water resources management infrastructures and a strategy for its practical implementation including amongst others; pilot projects on dams recharge
- defining appropriate activities to be undertaken and ensure coordinated planning between all water institutions and donors
- implementing the water law, notably by controlling the use of water through compulsory licenses and some repressive measures against drilling and water use

The second objective clearly shows the overlap between the NWRA and GDI as water resources management infrastructures would seem to be the responsibility of the GDI. The NWSSIP underlines that 'there is need to establish better linkages between water sector agencies; i.e. the NWRA and GDI (NWSSIP, 2005).

The licensing of groundwater abstraction, points put forward as one of the objectives, is legislated through bylaws and decrees which relate to the water law. However as rules on the abstraction amount per well do not exist; NWRA would like to establish a system of groundwater rights with a rights-based water allocation system (NWRA, 2006). As this seems an ambitious goal NWRA mentions it may be essential to separate for regulatory purposes, the existence of a well from the permit to take water from that well. The concept of variable allocations or water markets could then be introduced. Such systems could also facilitate the trade in water abstraction licenses, allowing market forces to rationalise water use while

creating a means of effectively compensating well-owners affected by falling water levels. This proposition of the NWRA, would however not tackle the over-abstraction of groundwater since no concrete limits to the allocation are given. Moreover it would enable those with more capital to buy rights and abstract as they prefer, leaving behind those others also dependant on the aquifer, as the capture goes deeper and becomes more expensive.

National Water Sector Strategy Investment Plan 2005-2009
Already referred to several times the National Water Sector Strategy Investment Plan 2005-2009 (NWSSIP) represents the MWE's action plan for the specified years. It concerns a comprehensive assessment of Yemen's water sector and follows to draw action plans and defining priorities for investment. Regarding the assessment of the agricultural water sector frequent references are made as to collaboration between the MAI and the MWE according to the NWSSIP it is the intention and necessity for the MWE and the MAI to reach an understanding regarding jurisdiction over surface water infrastructure (read also 3.1.2 MAI). NWSSIP underlines again that it is very important that decisions regarding design and location of dams and reservoirs are made from an integrated water management perspective at the water basin level and concerning the dams, a review and evaluation of past experience will be undertaken. Within a basin wide master plan, guidelines will be developed for site selection and criteria, economic, social and water resources management assessments, and EIAs. A participatory approach will be adopted, involving both beneficiaries and the local councils (NWSSIP, 2005). This leaves to wonder if the mentioned beneficiaries includes the MAI and GDI, since the development of dams is their turf (see also 3.1.3).

3.1.5. ACU

The ACU is an NGO and the national Agricultural Cooperative Union for the Agricultural Cooperative Societies in Yemen. The objectives of agricultural societies are raising the levels of livelihoods of the members, generating income as cooperative. The societies can be considered as self dependant production cooperation with as main goal to reduce poverty amongst the rural poor[27]. There are also specialised societies, one of which is the Irrigation and Hydraulic Structures Cooperative (IHSC). Concerning the latter, the MAI gives concession to the ACU for the establishment of dams for example the Musaibih which has been built the IHSC (commonly these are subcontractors). The societies of the ACU fall under the cooperative law of 1998, which is the same for WUAs (see 3.3, WUAs).

Next to the upcoming WUAs in Yemen, the ACU and their societies have been and are attributed a large role in the decentralisation policies of the MAI as even the 'Prime minister of Yemen, Ali Mujawar affirmed the necessity of determining priorities of the Agricultural Cooperation Union (ACU). In a meeting which brought together officials of the Union, Mujawar affirmed the importance of enhancing role of the union to serve farmers across the country' (SabaNews.Net, 12th May 2007). It would seem that government policies are thus better guaranteed of success as the NWSSIP states that the MAI will want to work more with NGOs including the ACU, to improve agricultural water management.

Scepticism concerning ACU's influence however came forward from the farmers survey (WEC, 2001) discussed in paragraph 2.4. During the mentioned farmer's meeting the WEC notes: 'It was clear that these participants had their own agenda by steering the meetings towards the interests of the ACU and repeatedly emphasizing the important role played in the region by the IHSC[28].' Because of the dominating role of the meeting facilitators, 'the farmers

[27] From an interview with an ACU official
[28] WEC 2001, volume 3: 38

played submissive and passive role as naturally they would not like to have any confrontation with such powerful individuals.[29]'
The political – tribal affiliation of the ACU mentioned by the WEC (2001) encapsulates, as UNDP puts forward in their Microfinance Assessment Report, 'a potential drawback for a micro finance cooperation between the UNDP and the Cooperatives[30]' was identified to be the ACU's linkage with the government, officials in the ACU are seconded from the government and the ACU receives most of its revenues from the government[31]. Because of this situation, caution is in order when considering cooperatives as potential partners.' This caution put forward is further confirmed as the Water and Environment Centre in its Sana'a basin Characterisation Study finds that 'it has been evident that decisions made by the ACU and its Irrigation and hydraulic structures cooperative society (IHSC) can be very biased depending on its management tribal affiliation and/or personal interests, such that certain communities may favour a lot while others could be deprived from their services. It is therefore important to assess the role of local cooperatives, particularly in relation to the issue of fairness of the services to the different communities[32].' However trying to counter the ACUs political affiliation Al-Kartas[33] states that 'the political burden attributed by many to the ACU and the cooperatives (choice of) activities is exaggerated and that the current system in which the ACU collaborates with the MAI and is cooperating with the Ministry of Planning, the Ministry of Social Affairs and the Labour Ministry is a 'genuine' system.' Al-Kartas does however identify the challenges which remain for the ACU namely 'to ensure personal and administrative efficiency, development of a savings bank.' This is an important point considering an average cooperative has an annual business volume of YR 20 million (= 151.515 US$), with some in the YR 70-100 million range (UNDP, 1997).

The accounts and reflection above show that the ACU has powerful and influential members and cooperation is preferably avoided. In chapter 4 the role of the ACU and more specifically the cooperatives will be closer looked at - at local level - since one of the case study dams is built by the IHSC (see chapter 4.6.2).

3.2. Institutions

3.2.1 Customary and *shari'a* law and practices

The upstream - downstream issues amongst communities, brought forward in paragraph 2.3 leads to consider that in an area where communities are close by catchment areas for run-off collection and recharge might be too limited (from a communities perspective) and the benefits (flood water collection and recharge) they had from the floods in the wadis have vanished. On the other hand, where communities are further apart the catchments for run-off collection and recharge may be perceived large enough as well as benefits from wadi flows (see also description of dams, this chapter). Rules and rights in Yemen on surface as well as groundwater matters are based on a complex of *urf* (traditional law and practice) and *shari'a* and has been practiced in the rural areas for centuries[34].
In Sa'ada Lichtenthäler (Lichtenthäler & Turton, 1999) found that customary law stipulated that the right to run-off is stronger than the right to the land. This was in the context of communally owned and managed land. 'The communities were not permitted to use their grazing lands agriculturally since the run-off collected from its surface area fed the fields of other communities downstream' (Lichtenthäler & Turton,1999 p.4). The rules and practices

[29] Ibid: 39
[30] UNDP 1997: 18
[31] UNDP report purposely does not connect the ACU with MAI in its choice of words although as the reports states 'the MAI is principally involved in and exercises technical supervision over the Agricultural Cooperatives'
[32] WEC 2001, volume 3: 42
[33] Former government official in Lebanon interviewed at a seminar on the training of Agricultural Cooperative candidates, YemenTimes 22nd May 1999.
[34] In Wadi Zabid in the mid-1980s, for example it was found that the existing surface water distribution system was based on stipulations provided by an Imamic ruling made some 220 years earlier, Ismail 2007: 46

died out as communal land was privatised. A religious scholar stated that the communities were to give up half the grazing land (read non cultivated land) to those owning rights to the run-off from it (the most likely situation would then be that, grazing lands were in the downstream part of a community's borders). Many tribal communities in Sa'ada then privatised communal land[35], drilling equipments started conquering terrain and a hydraulic mission was born (Lichtenthäler & Turton,1999)[36].
It is a likely that similar privatisation of communal grounds also took place in Sana'a basin as also Sana'a basin manifested a 'relentless quest'[37] for access to groundwater water. The implication of this would be with reference to the dams and the communities there around, that run-off rights for downstream communities had diminished[38] and that there was no more counting on surface water in the wadi, since it is blocked by the dams. Customary law arrangements best positioned to respond to sudden rainfall or flooding, and harness potentially huge water dividends from the wadis (Ismail, 2007) would seem inapplicable and redundant.

On top of all this, the mentioned hydraulic mission further made the resource water refutable. Lichtenthäler in his research in the Sada'a basin found that the established 'Islamic belief is that land owners have the right to utilise and abstract groundwater on their own property, as long as they do not waste the God-given resource'[39]. The effect of this normative system is 'the amazing absence of tension and conflict over groundwater resources where land rights are firmly established'[40], notably it also provides for the legitimisation of resource capture (ibid.). Lichtenthäler & Turton further their argumentation that as, water tables fall and resource capture becomes evermore costly, further pressure is put on marginal farmers as they are forced to mobilise capital by selling land. Ismail (2007) in his reflection on the control of Yemen's water resources states that as mechanised groundwater abstraction is a 'comparative novelty the customary law mechanisms to regulate it have yet to emerge' and 'the broad division between the two kinds of water resource is complicated by their interaction with principles of land tenure' (Ismail, 2007, p.46) as have come forward in this discussion. The practice of *harim* however does require final attention. Although it is not mentioned by the authors quoted above, *harim*; a prohibited zone in the vicinity of wells, in which no other well can be made,[41] is practiced in the Southern Arabian peninsula (Wilkinson, 1983) as wells as in Yemen. The zone in Yemen was specified to be 500m[42]. whether this rule is stringently applied in Sana'a basin is unknown, asides that the tremendous depths of tube wells in Sana'a basin and the drawdown of groundwater would make the distance insignificant.

It has become clear the customs and ***shari'a*** laws and practices show gaps and debate, however the rulings are still lived by, widespread in water management and agriculture practices in Yemen. The customs and laws fall short under the situation of expanding agricultural areas with increasing numbers of mechanically pumped wells.
In NWRA Quarterly Magazine a written *Sunna* (practice) of the Prophet Muhammad mentions that 'we should not waste water and we should try our best to conserve it for future generations' (NWRA Quarterly Magazine, 2007). Perhaps as part of the necessary change in water management practices the exegesis of this *Sunna*[43] could lead to a more sustainable future.

[35] Each household receiving land according to the number of males, children or adults (Lichtenthäler, 1999)
[36] The study of Lichtenthäler also showed that there were differences within a community as certain members were more (financially) able to capture the water as were others
[37] Lichtenthäler & Turton, 1999, p.4
[38] provided that the downstream communities hadn't bought the upstream communities' communal lands
[39] Lichtenthäler & Turton 1999: 5, Ismail (2007) is inline with this describing of water rights as: 'water on private property was the province of the landowner' Ismail 2007: 46
[40] Lichtenthäler & Turton 1999: 5
[41] Steenbergen 1995: 311
[42] Heard during a presentation of IWRM in Yemen, 26th October 2007 as part of WEC scientist visiting the IWE-group
[43] the detailed explanation of a piece of writing, especially religious writing (Oxford Advanced Learner's Dictionary)

3.2.2 Water Law No. 33

At national level the GoY has made several attempts at defining a comprehensive, but also clarifying law, in particular the defining of water rights proved to be very difficult (Ismail, 2007). The government alternatively either followed the line of groundwater being state property or as ***shari'a*** 'defined' good if captured (see previous paragraph). Eventually (including this law) 'the basic legal understanding of water was seen as res nullius'[44], meaning if water is acquired by someone it becomes property of this person, in line with the *shari'a*[45]. In combination with the large-scale privatisation of land that had taken place Lichtenthäler (2003) writes that 'this destructive piece of legislation – a reflection of the growing power of *Islah*[46] in the political sphere – showed little evidence of consultation with development professionals, or with the local communities it was intended to serve[47].
As the situation is, it would make any further reference or analysis of the water law focussing on groundwater abstraction unnecessary because essentially the rights of land owners is paramount in this discussion, unless otherwise restricted in their actions, they hold the 'right' to groundwater.

However certain interesting points will be discussed with each point the full article from the water law is first cited where after it is discussed.

> *Article 2. 8. Water Basin and Water Zone:*
> *Water Basin: Any land surface area, the water resources of which are dispensed naturally, and which constitute one unit, whereby any water works that occur in any parts thereof affect the availability of water in the rest of that area accordingly.*

In the definition of a water basin a reference is made to any 'water work' which might affect the availability of water in the rest of the area wherein water is dispersed naturally. Here the intricacies of water retention and recharge come into play; since the effects and extent of recharge is often an unknown. Recharge may benefit shallow (alluvial) aquifers locally or also increase water availability in deeper (sandstone or volcanic) aquifers in other (surface) water basins. The definition of water zone underneath may allude to this inter connection of basins and the hydrogeology, where it speaks of management of water as a single unit in part or several parts in basins with similar water conditions.

> *Article 2. 8. Water Zone: Any part or several parts of water basins with similar water conditions, or which necessary dictates for the management thereof as a single water unit, whether the borders thereof coincide with the administrative divisions of the country or not.*

> *Article 2. 11. Water Well: Any opening or borehole dug manually or mechanically into the subsurface for the purpose of extracting groundwater, regardless of the depth, diameter of the well and the quantity or quality of the water so extracted.*

As far as the definition of water well is concerned, no distinction is made between dug wells and tube wells. Which would appear strange since both exist and although farmers as of now use both, it is particularly the shallow dug wells to which farmers should be resorting according to the policies (NWSSIP, 2005). According to these policies the deep wells are destined for urban water supply (see also recharge discussion).

> *Article 2. 18. Traditional Water Rights: inherited and recognized sustained rights, traditionally, legally or both, and which are based on the individual, family or collective rights of use of*

[44] Ismail 2007: 52
[45] Wilkinson, 1983 describes that acquisition of wells and the cultivation of crops there around was one of the essential features of land exploitation by the nomads in the Southern Arabia Peninsula, hence the fact that a well was normally associated with the name of its owner or builder (Wilkinson, 1983)
[46] reform based on Islamic principles
[47] Lichtenthäler 2003: 211 in Ismail 2007

rainwater, rainwater runoff, streams, springs, water wells and water installations and the purposes and limitations of such utilization and the associated common rights thereof.

In Article 2-18 the traditional rights are 'defined'. More to the point there existence is affirmed. The 'definition' mentions limitations of the utilisation of water wells and water structures, but no further specification is given of these limitations, the question comes forward; when does a dug well end and a tube well begin.

Article 2. 33. Harvesting Rainwater: The process by which water accumulating from rainfall is accumulated from areas owned by the beneficiaries thereof or those authorized to utilize them immediately or to store them in cisterns, dams, dikes, pools, etc.

The definition of rainwater harvesting underlines the findings that land tenure authorises capture; as the process of harvesting is authorised for those who own the land or those otherwise authorised. Relating this to the dams it would require those who benefit from the dams also to own the catchment (Art. 2-33). This underlines the point made earlier that customary law ruling wadi water is redundant

Objectives and General Principles

Article 4. Water is a right that is accessible to all and does not become privately owned except by means of transport, acquisition or any other related methods an it is optimal and is secured by its similitude.

Article 5. The watercourses in the wadis are property in common to all the beneficiaries, and all the water installations and water wells set up by the Government are considered public property, and notwithstanding the ownership thereof they are subjected to a registration and licensing regime in accordance with the provisions of this Law.

Article 6. All beneficiaries of any of the water resources shall enjoy the right to benefit from this Resource, in such a way as not to harm the interests of other beneficiaries, and shall carry out all the duties required of him with respect to the conservation of these resources and safeguard them from depletion and pollution. The exploitation of groundwater resources is prohibited unless a prior permit thereto has been obtained. The Government shall intervene to regulate the rights and responsibilities of benefiting from these resources in accordance with the provisions of this Law and the procedures regulating the implementation thereof accordingly.

Article 4 is the spill in the groundwater resource capture (also referred to above), as it spells out *'Water is a right that is accessible to all and does not become privately owned except by means of transport, acquisition or any other related methods an it is optimal and is secured by its similitude.'* Had the word 'except' in the above been replaced by 'neither' the introductory comments to this paragraph would have been rather different. However in article 6 the free card for resource capture is limited and made into a warning as it says that '*All beneficiaries of any of the water resources shall enjoy the right to benefit from this resource, in such a way as not to harm the interests of other beneficiaries, and shall carry out all the duties required of him with respect to the conservation of these resources and safeguard them from depletion and pollution.'* The Article goes on to say that *'the exploitation of groundwater resources is prohibited unless a prior permit thereto has been obtained.'* What is stated in the permit is left open, would it solely concern a permit for a well or also a permit for abstraction.

Article 5 brings forward the surface water courses and says: *'The watercourses in the wadis are property in common to all the beneficiaries.'* Here mentioned are two very confusing statements in one line. Firstly; 'in common' could be interpreted as the wadis to be common property. Secondly it leaves to guess who and what are the beneficiaries (is for example the environment a beneficiary and how would 'environment' have its rights defined). If we take the second definition of wadi water being common property in the case of dam development,

this law would then seem to clash with the definition of rainwater harvesting, since from this definition the dam owners would be in their right to capture water, but this article states that wadis are common property, ironically put: how common can property (water) be if there is none in the wadi.

Water resources management and planning

> *Article 8. RoY shall be divided into Water Basins and Water Zones, in which the water resources will be assessed in each one of them, and for which the plans will be prepared for their development and use, as autonomous units, that are indivisible that shall be regulated on the basis of the principle of Integrated Water Resources Management, with a view towards conforming to the social and economic orientations and conserving the environment.*

Article 8 brings forward the concepts of water basin and water zone, both concepts are mentioned to be autonomous units which are indivisible and both are to have IWRM plans prepared for their development and use. This would seem a case of contradictio interminus as one could think that zones were part of a basin or vice versa.

> *Article 10. Water users and beneficiaries associations, groups, committees, leagues, or federations may be formed for the purpose of involving the public and the beneficiaries of water in regulating water resources or in operations and maintenance of water installations. The Procedures for the implementation of the provisions of the Law shall set out the purposes and all the detailed rules related to such organizations accordingly.*
>
> *Article 11. NWRA, in coordination with the relevant concerned entities and local authorities, shall set up Water Basin & Water Zone Committees under the supervisions of NWRA, with appropriate representation for the relevant NGO's and the water users thereof. The Executive Procedures of this Law shall set forth the composition the active duties of such committees, as well as their tenor and relations with the local authorities, so as not to violate the uniformity of water resources in accordance with the provisions of this Law and in such a manner as to conform to the articles of the Law for the Local Authorities No (4) for the Year 2000 that are related to this matter.*

Article 10 brings forward that water users organisations may be formed for *'regulating water resources or in operations and maintenance of water installations,'* it notably does not say who forms them, or who is responsible. Article 11 on the other hand states the NWRA *'shall set up Water Basin & Water Zone Committees under the supervisions of NWRA, with appropriate representation for the relevant NGO's and the water users thereof.'* It would seem that spontaneous eruption of water users' organisation is expected, where after the NWRA will organise these at water basin / zone level. The responsibility of forming WUAs is left open, is this mentioning of WUAs and further organisation simply a follow up of IDA's involvement and incentive with projects with money hanging in the air (see 3.3 SBWMP).

Articles 13 through to 19[48] concern the obligations of NWRA which are not too few and in particular concern a draw up of an extensive national water plan. The plan amongst others includes setting out activities and measures related to the development and improvement of the benefits derived from the use of rainwater, surface waters and reinjected groundwater. Further in Article 18 the plan is also expected to delegate authority *'in a manner that will enhance decentralization and the participation of the beneficiaries in the regulation and management of water resources.'* However what which authority would there be to delegate toward water users as they already have in hands. This formulation gives a clear example of the legal – conceptual confusion and an attempt of the water law to override or surpass it.

Water Use

[48] See annex 8 for Art. 13-19

Article 20. The use of water for drinking and domestic purposes shall have absolute priority.

Article 21. Without prejudice to the provisions of the previous article, water may be allocated for any of the following water uses:

1. *Watering livestock.*
2. *Use in public facilities.*
3. *Industrial Purposes.*
4. *The minimal limits to meet environmental requirements.*

Article 20 states that the use of water for drinking and domestic purposes shall have absolute priority. Article 21 furthers on this provision and states where water may be allocated for strangely enough irrigation water is not mentioned and consequently not allocated for. It is unclear why the water law disregards the irrigational sector, whilst it accounts for a large part of the existing water allocation.

Article 25. Without prejudice to the provisions herein stipulated, the Ministry of Agriculture and Irrigation and the authorities and institutions that are affiliated with the Ministry shall operate their installations, regulate and ration the use of water allocated for irrigation and potable water use in the rural areas in accordance with Water Plan, in light of the general strategies and policies for water resources, irrigation policies and other relevant policies. In respect thereto the MAI shall carry out the following:

1. *Prepare irrigation policies and executive plans, which ensure the optimal benefit of the agricultural sector's share of water.*
2. *Undertake theoretical and practical studies, implement the extension programs, and take all the measures that will lead to the rationing of water use, increase of productivity of water and agricultural crops, encourage the modern irrigation methods, in keeping with the economic feasibility and adjustment to the set allocation of water for such use and for the conservation of water and the environment.*
3. *One. Set up, operate and maintain water installations, so as to lead to benefit from the use of rainwater and rainwater runoff, within the context of the indicators of the water plan for RoY, the water budgets for the Water Basins and Zones and the Water Plan.*
   Two. Draw up a plan for protection from rainwater runoff and flooding, and also set up the meteorological agricultural surveillance stations, analyze, record, document and exchange the information picked up by these stations with the NWRA and the with the beneficiaries thereof and make use of the output of the national hydrological station network.
4. *One. If any entity in the areas where water is used for irrigation purposes are exposed to rainwater runoff and flooding while dealing with them in the field and there is risk of imminent danger to life and property, while the public interest would dictate that urgent measures are taken with respect thereof, the Ministry of Agriculture and Irrigation may take any appropriate measures it deems suitable of such measures, including the wreckage, breakage, removal or setting up of dikes or water barriers within the narrowest limits that will enable MAI from deterring or avoiding such damages, and MAI shall pay the fair compensation to the beneficiaries for any damages they suffer due to such measures being taken within six months from the date that such measures were taken accordingly.*
   Two. In this respect, the Executive Procedures shall set forth the controls for coordination between the MAI, NWRA and the other relevant concerned entities accordingly.
5. *Preparation and implementation of the plans and programs related to the subjugation of the wadi routes and general canals; monitoring the flow of rainwater runoff and floods and monitoring the use of irrigation water and installations, so as to ensure the safety of such installations and the protection of water from waste and pollution.*
6. *Preparation of the indicators for the short, medium and long term demand for irrigation water, including the need of the private sector projects for irrigation water, whereby, they constitute – after the review and assessment thereof – one of the inputs of the water plans stipulated in Article (13) of this Law.*

In article 25 the MAI is mentioned as they are to abide 'without prejudice' to the water law. Here it is furthermore stated that the MAI *'shall operate their installations, regulate and ration the use of water allocated for irrigation and potable water use in the rural areas in accordance with Water Plan.'* Two interesting points come forward, firstly, apparently there is water allocation for irrigation (see previous article) and secondly, the mentioned water plan is notably made by the NWRA which now falls under the MWE. In day to day practice it would mean that the NWRA, under the MWE makes a plan for the whole of an other ministry. The installations mentioned include those that '*lead to the benefit from the use of rainwater and rainwater run-off*', meaning also the dams. The dams are placed under the responsibility of the MAI and thus also the operation and maintenance thereof (more on this in the explanation of the SBWMP)

Water rights and permits

> *Article 27. The right of water use authorizes the holder thereof to dispense the water, in such a way as not conflict with public interest and the prevailing customs and traditions in each Water Zone or Water Basin, and in all cases, the existing and acquired water rights, whether prior to the issuance of the Law or thereafter, shall be maintained and shall not be touched upon, except for the utmost necessity thereof and with fair compensation provided therefore.*

The water law clearly makes provisions for the local customary law and the rights acquired there from however in the whole section the actual right to water is not clarified; article 27 does state that the holder of a water usage right should *'dispense'* water in such a way that it does not conflict with public interest but amounts of abstraction are not specified (also brought forward in the general principles of the law, see above). Further article 28 clearly states that consideration should be made towards the customs and traditions in rainwater harvesting and natural run-off flow (see for explanation of these customs and traditions the previous paragraphs)

> *Article 29. The traditional rights of benefit from natural springs, streams brooks, creeks and maintained surface wells, the depth of which does not exceed sixty meters, and the common rights associated with them, prior to the issuance of this Law, on which the holders thereof maintain their currently hold as existing rights. This is without prejudice to the rules for registration and these rights remaining allocated for the purposes, for which they were originally granted. In the event that such rights are transferred to other parties, then such rights shall be compulsorily transferred to the new owners, and in the event that the land benefiting form the water are partitioned, the water shall be apportioned according to the land areas resulting from the partitioning of such land.*

Eventually in article 29 it becomes clear that a water right is connected with land tenure as it states with regards to the transfer of water rights that the rights shall be transferred to the new owners, specifying that *'in the event that the land benefiting form the water are partitioned, the water shall be apportioned according to the land areas resulting from the partitioning of such land.'*[49]

> *Article 30. Without prejudice to the sanctified and water quarantine areas, quantities of water may be acquired in cisterns, pools or streams, by means of directly harvesting the water from rainfall that falls on the surrounding land thereof, which is owned by the beneficiary thereto, or in the neighbouring areas, where the beneficiary has been authorized to benefit from harvesting the rain there from. Such acquisition is considered as an acquired benefit, if it does not harm the benefits previously acquired thereto and does not conflict with acquired water rights, in accordance with the recognized traditional rights and customs related to the right of benefit from rainfall water. The beneficiary may also, according to this article, set up the required water installations, which take advantage of the water quantities gained, as well as the construction of*

[49] the formulation of article 29 is rather confusing since it starts of with mentioning traditional rights of amongst others maintained surface wells no deeper than 60m. it furthers to account the registration of the wells which includes allocation of water according to its purposes originally granted and finally to end with that mentioned here above

small irrigation structures and to excavate for subsidiary canals, in accordance with the procedures and controls that are set forth in the Executive Procedures.

Article 30 states that water is allowed to be acquired in a dam when the catchment area is owned by the dam beneficiaries or when beneficiaries have been authorised to benefit from neighbouring area. This leaves to question in which cases beneficiaries are authorised. It is the researcher perception that this would concern those areas where there is no land tenure. Vis-à-vis this permission for 'beneficiaries' the GoY *'shall undertake the projects that develop water resources and water harvesting projects'* and the NWRA may if necessary *'review the amount of water to extracted from any groundwater aquifer or surface water, in keeping with the total water resources available or exploitation from such reserve'* (Art 41). Whether the construction of these water harvesting structures (/dams, check dams etc) would be on government owned land is unclear[50]. Clearly the article attempts at bringing forward the interests (different uses and users) of water resources at basin level. However firstly; if the GoY undertakes water harvesting projects with the aim to recharge groundwater, the question arises, who benefits from this: those with land and wells closest to the dam (see also chapter 4, experiences with recharge), secondly the review would require to know the effects of the water harvesting projects and the amounts of abstraction (see chapter 4.3 and the difficulties therewith), thirdly would a review lead to the restriction in abstractions (how would this be executable) and then significantly to benefit the governments objectives.

Article 32. All holders of rights of utilization in accordance with Articles (28 - 29) of this Law are required to come to NWRA to register their rights accordingly within a period of three years maximum from the date of announcement accordingly issued by NWRA after the issuance of this Law.

Article 32 states that all holders of water utilisation rights *'are required to come to NWRA to register their rights.'* This would imply that the NWRA should register all landowners since they are actually holders of water utilisation rights, which involves an extensive inventory (however considering that a lot of farmers are unable to benefit because of the high costs involved with resource capture).

Article 15. All government entities, legal private and public personalities shall present the plans for their water projects to NWRA or any of its branches in the governorate offices, for review and approval thereof within sixty days from the presentation thereof to NWRA. If NWRA does not issue its opinion thereto within such a stipulated time period then it will be construed as having implied approval thereof, unless otherwise there is a convincing justification (for such delay).

Article 35. Without prejudice to Article (72) of this Law:

1. *No individual, group or entity of the government, civilian or military, or any private legal entity, may dig water wells, or the establishment of any water installation for holding back any flowing rainfall runoff, flood or stream water in or above the wadi beds, or the diversion thereof unless the appropriate license, as such, has been previously obtained from NWRA.*
2. *A water well may be deepened without prior permission from NWRA, but only once and for no more than twenty meters.*
3. *With respect to previously approved projects by NWRA, in accordance with Article (15) above, the respective entities need only present such projects to NWRA for registration only.*

Article 45. Without prejudice to the stipulations of Article (29) of this Law, surface water wells may be dug without prior approval from NWRA, in order to obtain limited amounts of water, up to a depth of sixty meters (60 m.), under the following conditions:

[50] Article 52 does state that land will be bought in the case NWRA or any other government entity wants to erect 'hydrology stations, sites for measurements, tests and studies or for setting up installations for protection from floods and for utilization of rainwater runoff or other projects' in 'forbidden zones' the determination of which will be issued in a ministerial decree (Art.49)

1. *Adherence to the controls and restrictions of the Forbidden Water Resources, and their respective installations, the water quarantine areas, and to insure that no harm is afflicted on others.*
2. *They should be without prejudice to the recognized traditions and customs that re related to right of utilization of water, and the common rights duly associated therewith.*

Licensing (Art.35) is required for all new water projects; these should be presented to the NWRA for review and approval (Art.15). A water well may once be deepened and a surface water well of 60m. deep may be dug (Art.45) without prior approval or permission (Art.35-3) the registration thereof however is necessary. The article however does not continue with specifying further restrictions, so although registration and a license is required it is left open what the limitations and restrictions are (in accordance with the landowners rights)

> *Article 12. NWRA is responsible for estimating the water budgets, evaluating demand of water and the quantities that may be exploited by the sectors that utilize water, by means of monitoring and assessing water resources and the uses at the Water Basin Level, and for collecting the data and information that is required for the regulation and development of such resources through the hydrological stations for each basin and the national hydrological stations. NWRA will also undertake all the measures that insure equity in benefiting from the available waters and the protection thereof from depletion and pollution.*

Water monitoring as part of the assessment of the water resources and its uses at the water basin level is the responsibility of the NWRA (Art.12.). In its execution NWRA *'has the right to use selected wells or water installations in the water basins and water zones for undertaking studies and making observations and monitoring'* (Art 53). The MAI is responsible for the monitoring of rainwater runoff, floods, the use of irrigation water and installations. The responsibilities of monitoring are somewhat puzzling as the boundaries are not clearly fixed; during an interview with the director of the water monitoring unit at the GDI it became clear that. The GDI/CWM and irrigation advisory unit is responsible for the monitoring at field level (wells of farmers, efficiency etc). This would adhere to the regulations more clearly set in article 59 for water quality monitoring in which the *'NWRA shall monitor the quality of water at the level of the water resources, to ensure the soundness of their use and the other entities are responsible for monitoring during conveyance, distribution and usage thereof.'* Under the situation of who does what and conflict in jurisdiction the interviewee stated that their department had more changed its focus on the irrigation advisory unit and water demand management

In the discussion of the water law at heart is also the discussion of water rights. The water law has used as a base the out mechanised customary and *shari'a* law and then subsequently attempts at restricting that right. Landowners are still allowed to have wells and abstract water, but through registration of wells and related activities, licensing and permits (unclear for both what the content of both might be) the governments attempts at getting a grip on the resources, but lags behind: the already vast amount of wells in Sana'a basin need to be restricted in their abstraction.
It could be argued that considering the *shari'a* law base[51], direct means to regulate or install sanctioning mechanisms on groundwater abstraction could legally not exist. Moreover it the indirect means, such as raising diesel, pump and well installation prices, are a hindrance to the right holders in their legitimate efforts in resource capture[52]. On a basin level it would mean that those who do not own land are completely dependant on those who do. With the increasing population pressure in Sana'a Basin groundwater markets are born and if the government would want to have water allocated for the environment or for other purposes it would have to own land or buy the water from those who have it.

[51] No law shall stand in contradiction to the *shari'a* law
[52] In the former South Yemen however the regime effectively used technical-bureaucratical assets to exert control over groundwater abstraction; imports and exports, drilling equipment could only be purchased through the Ministry of Agriculture, or loaned from it at the Machinery Rental Stations (Ismail 2007:51)

Ismail (2007) writes on the water law that the government has attempted at introducing a new legal framework in the water law it 'did so from a basis of profound legal-conceptual confusion'[53], and relied for implementation on a unsuitable institutional apparatus in the rural areas. The water law it is clear that it lacks a lot of detail, although it is quite comprehensive little authority is given through them (NWSSIP, 2005). That stated this discussion has limited itself; as a number of other official regulations such as Republican and Cabinet Decrees, Prime Minister Resolutions and MWE's Decrees have already been issued to enforce some of the water law.
The water law reads more as a strategy formulation influenced by the IWRM discourse, than as a law, as it contains a lot of; shall do's and will do's rather than set out responsibilities and jurisdiction to tackle the water crisis situation in Yemen, but also down scaled to those areas where dams are developed.
Finally, the water law might have benefited from a review of legal specialist (jurists) as well as water management experts as concepts are misused[54], contradictions and gaps are to be found and the understanding of rural reality is inexistent.

3.3. Research Conducted and Ongoing Projects: the particular case of Sana'a Basin Water Management Project (SBWMP)

In and around the Sana'a basin research has been conducted; from geological and geomorphologic surveys to analyses of dams and their construction. However no studies have gone into the operational and institutional aspects and functionality of the dams in the Sana'a basin[55].
Through numerous projects funded by the Yemeni government, bi- and multilateral aid and assistance of NGOs the scarcity of the resource water is countered. Incited by the experience in other basins and abroad, the Government of Yemen had set its priority on the development of Small dams in upstream tributaries of the Wadi Al Kharid in the Sana'a basin. However in the ongoing Sana'a Basin Water Management Project a hesitant execution was observed regarding the dams.

The objective of the SBWMP is to increase both the quantity and the useful life of the available resources within the Sana'a basin and to increase the efficiency of agricultural use and so allow time for a gradual shift to a less water-based rural economy, by the following[56]:

- Conserve water by introducing farmers to modern irrigation/improved equipment and methods that may save up to 40% of water (demand management).[57]

The necessity of demand management

- Change pumping and water use behaviour in the basin through a comprehensive Information and Public Awareness Campaign (IPAC) that would touch all segments of the basin population (demand management).
- Accelerate recharge, so as to save precipitation run-off from evaporation (supply management).
- Obtain a better understanding of the basin's hydraulic situation, including through systematic monitoring, leading to improved water management (Institutional development).
- Build a strong and sustainable institutional base for central and local water basin management, including water regulation and enforcement, planning and water allocation that may be replicated in other basins (institutional development).

[53] Ismail 2007: 55
[54] perhaps the English translation is poor, as the researcher was unable to compare or verify with the Arabic version of the law
[55] no studies have been found in the course of this research
[56] from the '*Updated Project Information Document (PID)'.* The World Bank Group. 2003
[57] The groundwater soil conservation project (PCU under MAI), also aims at (i) improving irrigation water use efficiency, and creating the conditions that would allow them to reduce groundwater pumping from aquifers towards sustainable levels. Although the GSCP is nation-wide some of its objectives resemble those of the SBWMP remarkably

The SBWMP project as a whole is a pilot project and the experience gained is to be used in other basins of Yemen. However as has become clear in previous paragraphs of this chapter the issue of accelerated recharge and dams is debated on. In figure 5 a small part of the projects contents is shown, which highlights those organisations involved in the development of the dam and the WUAs (read more below).

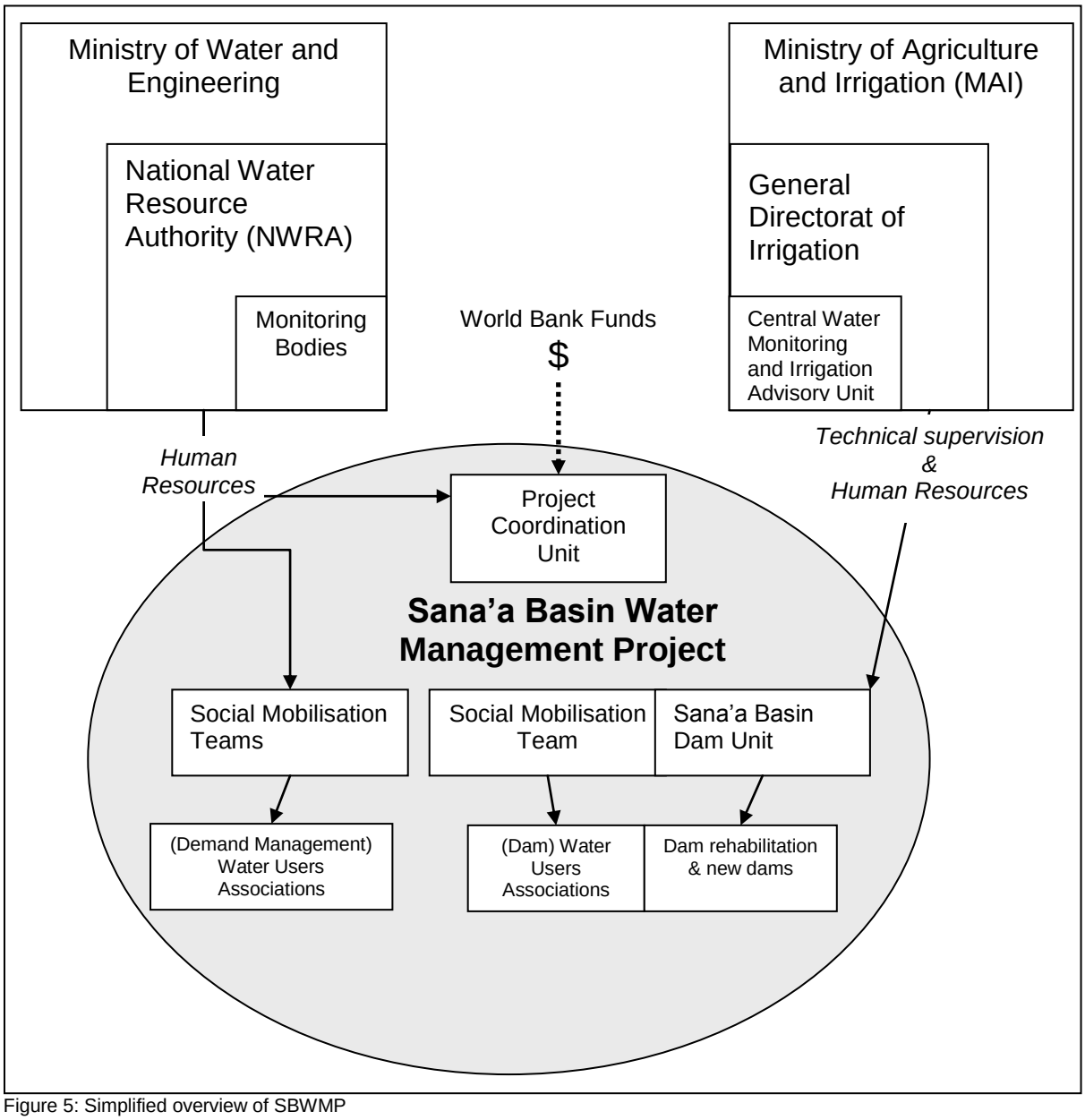

Figure 5: Simplified overview of SBWMP

Concerning the Supply Management and Recharge Improvement component the project mentions to enhance and accelerate groundwater recharge through mostly small conventional dams, sub-surface dams and other structures. The project will (1) build recharge structures, including four dams (amongst which is the Beryan dam, case in chapter 3) and a series of low cascading check structures (see also in the figure above). During implementation, other potentially viable recharge technologies, such as underground dams to catch sub-surface flows in the Wadis, spate breakers and water harvesting structures, would also be studied (2) rehabilitate 11 existing hill dams to prevent potential dam failure as well as to recover recharge capacity diminished by accumulated sediments (amongst which is the Arisha Qutran dam, case in chapter 3).

Concerning the recharge aspect of the new and to be rehabilitated dams, all of them are designed to be fitted with valves, which according to dam design reports will enable water to pass downstream in a controlled fashion at the required rate to empty it in two or three weeks and enhance recharge of reservoir water (Halcrow Group Limited, 2006).

The proposed design would enhance recharge (also following from the results of the Arcadis study mentioned in paragraph 2.4) the operation and implication for the recharge of wells is left open. This issue is elementary to the rehabilitation since farmers may have constructed the dam there where their wells were located and the maximum profitability of recharge was expected (amongst others the topography of the catchment also being an import criteria for the location of a dam, see 4.1 cases studies), or vice versa they may have constructed wells close to the dam's location to have this maximum profitability of recharge (e.g. the Al Jarjor and Mukhtan & Musaibih case see 4.2 discussion on recharge).

Water Users Association (WUA)

The water management in the basin (SBWMP objective 5 see above) includes the establishment of WUAs of which two kinds are to be established; pilot WUAs consisting of Water User Groups (WUG) organised around wells (water demand focus) and dam WUAs; users organised to operate and maintain the dams. The latter WUAs are to be instated prior to rehabilitation or construction works as they are a precondition[58].
Building on Yemen's tradition of community based water management; these WUAs will be the most decentralized legally established institutional entities, supported by the technical and managerial training and extension programs (The World Bank Group, 2003). Accordingly since 2003 the SMT from the GDI and a SMT from the NWRA have been active in installing WUAs[59]. NWRA installs WUAs in Sana'a basin plains; organizing farmers in well-field WUAs (focussing on the demand management aspects of farming) and the GDI & SMT organizes farmers who are considered as local beneficiaries of dams in WUAs[60].

WUAs are institutionally almost the same as the Agricultural Cooperatives as they both fall under the Cooperative Law No. (39) of the year 1998 (see also table 1). In annex 4 a detailed description is found of the institutions to which a WUAs is bound. Once registered as NGOs, WUAs can benefit from the SBWMP as they can participate in the irrigation modernisation program, which includes pilot areas and subsidies. Further those WUAs organised around dams have to be trained in O&M, de-siltation, water regulation and conflict management as they will be responsible of maintaining the recharge capabilities of the dam (The World Bank Group, 2003)[61]. 'These WUAs will have to play the spill role in the sustainability of the dams' according to a NWRA official. Vice versa the GDI is held responsible for the structure, performance and safety of the dam including repairs to the dams.

It would seem that the SBWMP was written exactly according to the new water management concepts as Vermillion and Al-Shaybani state that to ensure positive and sustainable results of water resources development projects, creation of local organisational capacity should be given at least as much attention as the construction of infrastructure (Vermillion and Al-Shaybani, 2004). However, the question is whether the organisation of water users is feasible through this formalised approach. Although communities in Yemen commonly do have strong informal and religious ties, the formalisation might give the *shaykh* of a community an even more 'patron like' role (a role also described in 3.1.2 and 4.5.2).

WUA Formation

[58] from an interview with a Mott Macdonald Euroconsult employee
[59] Notably WUAs are only erected in the areas identified as pilot area in the first phase of the SBWMP (2003 – 2009)
[60] Notably these WUAs are only erected around those dams which are identified for rehabilitation (11) (one of which Arisha Qutran) and around newly proposed dam sites (4) (one of which Beryan)
[61] According to a member of the SMT 2 training sessions had already been performed in both Arisha Qutran and Beryan areas

Since 2003 as already mentioned the MAI / GDI is working on installing WUAs around dams. The idea and objective is that the entire community is involved in the WUA which main concern will be the O&M of the dam. Through the *shaykh* contact is made with the communities to mobilise the people and make them aware of the project objectives and components. All households are requested to participate in the WUA, those farmers who do not participate will still be bound to the agreements made by the WUA , commonly those farmers who do not have problems with water shortage are not easily incensed to participate however the *shaykh* has a leading role and if he takes on the idea for a WUA, the community is 'bound' to follow. Following variable amount of meetings in a village, commonly during a qat session, a WUA can be formed (see for further explanation of WUA formation annex 4) During a WUA formation session[62] not all farmers could be present, the reasons that came forward;

- not all the farmers live in the village and are able to come together at the same time
- some farmers do not see the benefits of organising in a WUA
- the different families choose a representative to go to the WUA meetings and represent their cause.
- some farmers also let the *shaykh* represents their cause

According to a SMT-member (spoken during a WUA formation meeting) the WUAs are also part of the GoY's strategy to get in contact with the farmers in rural areas, necessary to convey the message of groundwater depletion and the countering thereof. Important note he gives is that the government does not want to create problems / conflict between the government and the farmers. The SMT approach is thus that of conflict avoidance; after visits to an area it might be wise to let it rest and come back after a few months[63].

Another important issue which remains is how and who will allocate the budget from the ministry of financial affairs for the dam WUAs. A NWRA employee[64] stated that the government as mentioned could share the costs of O&M starting from a full reimbursement towards shared payment and eventually full payment by the WUA. However the initial distribution of money and the responsibility therefore is unclear should it be done by GDI, the districts or local councils, he stated that the GDI refused this responsibility.

The SBWMP has brought forward some of the organisational as well as institutional issues in Sana'a basin. The NWRA would rather see money spent their way; focused on demand management and monitoring, the basin framework) and the MAI/GDI their way (focused on supply / dam development). As the GoY has for the time being decided that dams and irrigation should remain under the aegis of MAI, rather than being transferred to MWE, vis-à-vis all plans affecting water resources (including dams) should be screened by MWE/NWRA based on the water planning mechanism set in the Water Law (see also paragraph water law). However Vermillion and Al-Shaybani mention that as organisations such as GDI and NWRA are young and have critical shortages of skilled staff and resources they may lack the support to plan small dam development according to basin level analysis and planning for integrated water resource management (Vermillion and Al-Shaybani, 2004).

Adding to the unusual situation (a department of one ministry ruling a complete other ministry), according to a water consultant[65], is now that the MAI/GDI amongst others earns a portion of the donor money for dam development, but is controlled in its execution by the MWE, since they steer project coordination unit. Aggravating the situation for the MAI was that they were responsible for the SBWMP preparation phase but eventually saw the coordination and steering (PCU) be awarded to the newly erected MWE. This situation has

[62] Farmer meeting WUA instatement in Al-Asha, 13-03-2007
[63] If farmers get violent and want the SMT jeep etc. let them have it the SMT member stated, an SMT member's life and conflict avoidance is more important than anything else
[64] Monitoring and Evaluation Specialist, interview 11-03-2007
[65] from interview with Arcadis dam construction consultant, 06-03-2007

induced a poor working environment between the two which especially surfaced with the execution of the SBWMP as contractual and payment issues have started to inhibit work.

Chapter 4. Recharge and water distribution. Case studies

This research as introduced in chapter 1 includes a cases study of 4 community areas including 5 dams located in 2 districts in Sana'a governorate. The locations of the 5 dams are in the east and north-east of the Sana'a basin and all concern barrages of tributaries of the main wadi in Sana'a basin; wadi Al Kharid, see the figurers underneath.

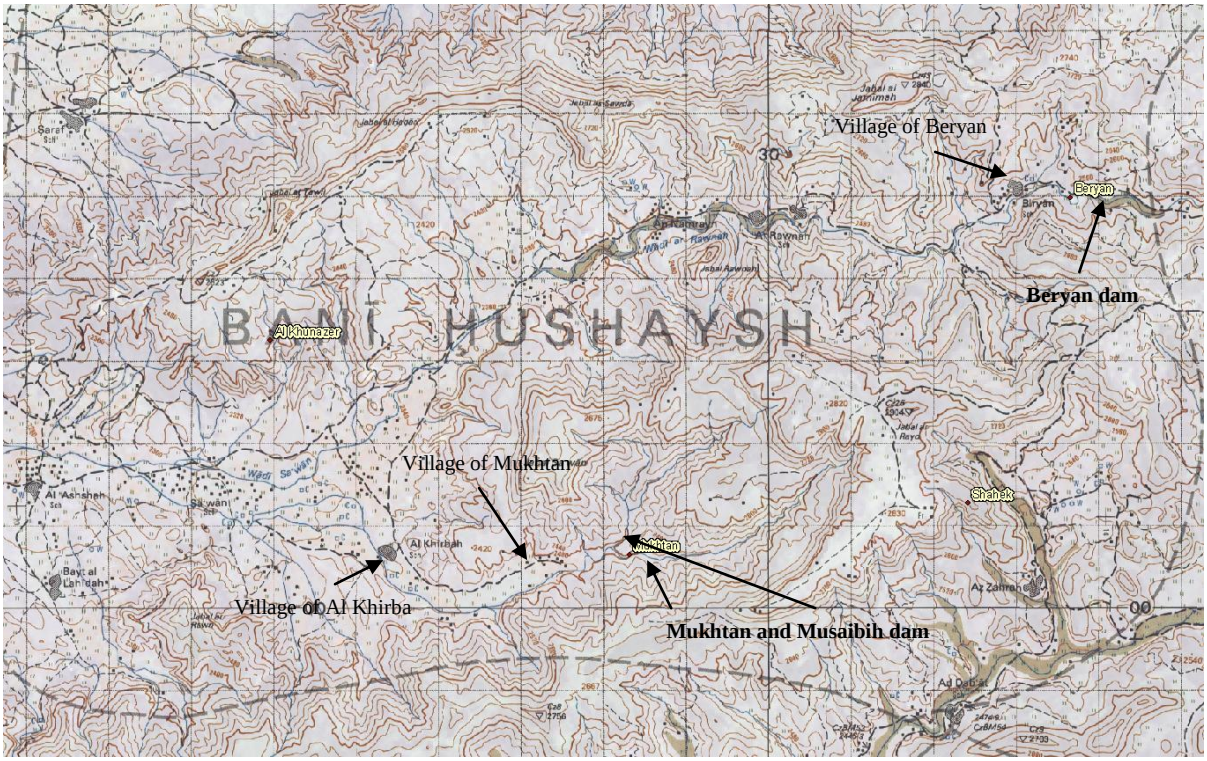

Figure 6: Bani Hushaysh district including Beryan and Mukhtan and Musaibih dams (1 length of a square is 1km.)

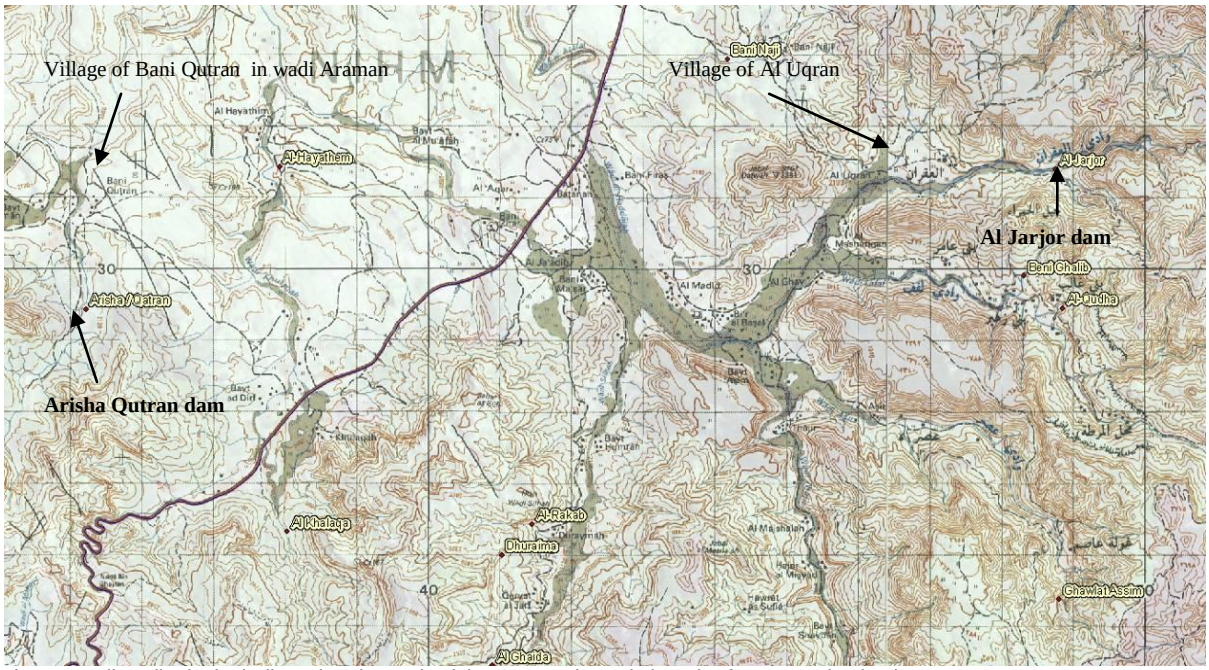

Figure 7: Nihm district including Al Jarjor and Arisha Qutran dams (1 length of a square is 1km.)

In table 2 an overview is given of the chosen dams and the surrounding communities. Before the case studies are elaborated the fieldwork methodology and the justification of the choice for these particular dams is described. The paragraphs show, tabled data concerning the aspects of recharge, water distribution methods and agreements and application amounts which all be backed-up by the farmers' accounts.

4.1 Dam and area specifics

In order to have a better picture of the dams in question specifics are given in table 2. During the fieldwork an interesting debate arose whether to be speaking of small or medium sized dams. World Bank representatives clearly stated that the dams were considered to be medium sized[66], however all those interviewed at government departments called them small. Comparing the dams with the Marib dam (38 m high, 763 m, storage capacity of 398 million m^3), it could definitely be said that these dams are small. All except the Musaibih dam are earthfill dams, in appearance the Beryan, Mukhtan and Arisha bear resemblance; slanting upstream downstream faces, whereas the Al Jarjor dam has large boulders defining the near vertical upstream and downstream faces. Important to notice is the variation in height; there where the valleys are narrow with steep slopes the dams are significantly higher than where valleys are more open. Structurally however these high dams do require a higher level of sophistication as higher levels hydrodynamic pressures are to be dealt with.

Dam	**Features**					
	Year of Completion	Type	Top of dam (m.a.s.l.)	Top width (m)	Max. height (m)	Length
Arisha Qutran	1997	Earth fill	2113	9 - 25	13	400
Al Jarjor	1999	Earth fill	2231	15.7	16	188
Beryan	1997	Earth fill	2555	10	25	223
Mukhtan	1999	Earth fill	2425	6.5	25	104
Musaibih	2003	Masonry	NA	NA	NA	NA
NA: no data available						

Table 2: Dam features, Source dam features; GDI dam inventory 2001

In the following table the hydrological aspects of the dams and there are brought forward. The high maximum amount of rainfall compared to the average annual rainfall makes the dams all the more reasonable for local communities to instate. Since the dams are able to capture the rainfall, coming in relatively large quantities over a short period of time, in a reservoir with the purpose of its release to the aquifer.

Dam	**Catchment, rainfall and annual flow**				
	Catchment Area (km^2)	Average annual rainfall (mm)	Mean annual flow (10^3 m^3)	Max. rainfall in 1 / 2 days(mm)	Reservoir capacity x 10^3 m^3
Arisha Qutran	6.45	140.9	181,76	70.5	980
Al Jarjor	8.575	191.4	246,19	96.5	325
Beryan	10,33	106,60	165,10	54,2	750
Mukhtan	5.1	194.8	198,70	100	550
Musaibih					
Note: both Arisha Qutran and Mukhtan have a run off coefficient of 0.2, Beryan and Al Jarjor have a coefficient of 0.15 (WEC 2001) Source catchment area & reservoir capacity; GDI dam inventory 2001, Source rainfall data; WEC 2001					

Table 3: Dam and catchment area specifics

A more detailed account of all four areas is given in the following paragraphs.

[66] Whether the reason for this is because the WB has a dam rehabilitation project running and according to their global standards certain dimensions are kept as reference

Arisha Qutran
The Arisha Qutran dam is the longest dam of all four and is located 1km. south to village of Araman with 100 villagers and 3km. from Bani Qutran with approximately 1000 inhabitants (GDI dam inventory, 2001) both in wadi Araman (see topographical map). On the downstream side the dam wall is near vertical however in its length the dam is not straight. Morevover the crest width varies considerably being about 17m. at its widest section (Halcrow, 2006). The dam has a spill way of about 5m. long and 5m. wide, but at certain places the dams crest is lower than the spillway itself (Halcrow, 2006). In the reservoir a vertical perforated outlet pipe of 200mm diameter (ibid) is connected to a pipe through the dam. This pipe is sealed with a welded steel plate. The thickness of sediment accumulation was measured at seven locations in the reservoir upstream and the measured thickness ranged between 0.3m and 0.8m. (ibid).
The dam retains water for a few months of the year but fissures in the geological formations beneath the dam enable water to seep through into the wadi downstream. Two main wells are located immediately downstream of the dam and contain the main pump systems.

Al Jarjor
Al Jarjor dam and Al Uqran village are located to the north-east of Sana'a at 48 km. The dam is located 2km. upstream of the village itself in which an approximate of 1500 – 2000 people live (GDI dam inventory, 2001). The dam has near vertical walls on both the upstream as well as on the downstream side. The dam is located shortly after the meeting of two wadi tributaries, which from observations would be the logical location for the dam. During the rainy season the depth of the water behind the dam may reach up to 10-15metres[67], according to farmers accounts, this however combined with the GDI's estimation of the dam's height may lead to think one of the two accounts is faulty. In 2001[68] and at present the dam has been observed to be in good condition. All the dug wells benefiting from the dam are located within 5 to 30 metres from the dam and the water is conveyed through galvanised pipes towards the plots around the village of Al Uqran.

Beryan
Beryan village and its community has a long history with dams; remains of a Himjarite dam (pre Islamic) can still be seen near Beryan village only 500m. downstream of the current dam's location[69]. Beryan village is a community of approximately 1300 people (Stanley, 2006). After its original construction, Beryan dam has been altered for safety reasons; a spillway was dug in the dam as it had not been constructed under auspices of the farmers. Regardless of the alterations made; the existing dam still appeared 'weak in strength, and it presents a danger to the population living downstream of the dam[70]', moreover the inception of the dam lacked the required 'proper engineering design and supervision'[71].
Beryan dam has sloping upstream and downstream faces and was the only dam not to contain any water at all, as observed during the fieldwork period (February – April). Farmers of Beryan village also accounted that there was less water in the reservoir, which in their opinion was due to less rainfall, climate change and pumping from surface water as well as more groundwater. During the rainy seasons there are also springs feeding the reservoir but in the dry season these are dried up.

Mukhtan & Musaibih
Both dams are located at a distance of 15.6 km. from Sana'a to the east. Both dams block wadi tributaries which meet at approximately 200m. downstream of both dams. The nearest downstream village of the Mukhtan and Musaibih dams is Mukhtan at a distance of 800m. and a population of 100 people (source; GDI dam inventory, 2001). At 2.5 – 3 km. from the

[67] March 2001 and in April 2007 the water depth in the reservoir was stated to be around 12m.
[68] GDI's dam inventory, 2001
[69] As mentioned in chapter 2; the Beryan dam is part of the WB financed Sana'a basin project and is up for total reconstruction
[70] Stanley Consultants. 2006. Beryan dam design report. volume 1, section 3 page 2 of 13
[71] ibid, volume 1, section 3 page 3 of 13

dams where the wadi opens out to on to wider area the village of Al Khirba is located with a population of 4000 people. The Mukhtan dam has sloping upstream and downstream faces, whereas the masonry Musaibih dam has a vertical upstream face and a slightly sloping downstream face. Since the construction of both, the dams have been able to trap water each year and filled up to considerable heights. Farmers however account that the Musaibih is leaking (also seen during sight visits) which might be caused by the fact that 'the dam was not constructed according to design specifications, because the engineer of the SAC was not interested and there may have been corruption.' Both dams are fitted with valves which both are dysfunctional because the wheels are not on them.

4.2. Recharge

The substrata in the basin and the various case study sites is of importance in the recharge assessment of dams and the subsurface distribution of water. Since the fieldwork revealed that groundwater is the principal source of water (particularly in the dry season) at the various dam sites in the region. The main source is from three layers namely the alluvial deposits (commonly on top), volcanic units (crossing the layers) and the Tawilah sandstone (deeper / deepest layer). In annex 3 the mentioned geological formations are described and, their hydrological contribution for the areas is highlighted.

What follows from a description of the geology is the reference to the role of dams, and their underlying geological formations. A dam needs a solid underlying and surrounding layer, however such layers may not be the optimal layers for water conveyance and transmissivity (read also chapter 2.3). From the case studies it came forward that dams as what is known do not recharge the deep but rather the shallow aquifer. In shallow / dug wells the rise in the water table is witnessed in the rainy season and at those dug wells closest to the dams. Also in boreholes there are accounts of temporarily rising water tables, this however is most probably encountered when they stop pumping.

Arisha Qutran
The groundwater level in 1985 was around 20 to 25 metres in depth and a year later reduced to 50 to 80m in depth (Mosgiprovodkhoz, 1986). Once the dam was constructed however in 1998 the groundwater depth levelled to around 50m. (Halcrow, 2006). In contrast, the farmers interviewed (GDI dam inventory, 2001) stated the dam only recharges those wells located upstream of the dam, the discharge in the wells increase while there is water in the reservoir. This would seem rather logical as the aquifer upstream of the dam was identified to be the alluvial deposits. The 2 farmers now made clear that in the rainy seasons they would experience recharge slightly but if when there was no reservoir water (which has been the case for a few years) they had to bore the wells deeper. They also stated that they had no direct benefit from the dam, but admitted that they had been pumping more water since its construction of the dam. Those wells closest to the reservoir generally contain more and longer the water

Al Jarjor
Immediately after its installation the dam proved to recharge the wells nearby the dam when there is water in the reservoir, according to the four farmers interviewed. As the rise in the water table was very noticeable; the farmers had dug more wells since the dam's construction. As long as water remains in the reservoir behind the dam the wells have given significant yields, the wells do require a recharge period each day as pumping exceeds the recharge amounts; as they stated 10 hours of pumping would cause a 10m. drop in water level. With the situation as such, only one well behind the dam operates 24hrs, the others are all stopped for recharge, the recharge amounts have diminished however because of sedimentation 'clay' in the reservoir.

Beryan
In 2001 the farmers interviewed, [72] by the GDI dam inventory team, stated that 'the dam caused a rise of the water tables in the wells of the nearby village.' The discharge in the wells increased when the dam filled up. The farmers were very satisfied with the dams performance and its benefits.
When there is water in the reservoir the water levels in the dug wells rise and the farmers only depend on the dug wells. Before the construction of the dams the dug wells would be useful for 3 months (natural recharge). Immediately after the construction of the dam the reservoir had water continuously for 3 years consequently the dug wells were used for the whole of that period.
According to the 4 farmers interviewed and from the farmer meeting it was gathered that since the dam was destroyed[73] 2 years ago the reservoir remained dry and because of that; the dug wells are also dry and they depend mainly on tube wells.

Mukhtan & Musaibih
From the GDI dam inventory, 2001 the impact of the dam[74] is written to be; that there is 6 – 8 metre rise of the water table in the wells of nearby villages. In the survey conducted by the GDI the farmers stated to be very satisfied with the performance and benefits of the dam. Important note to make is that if this survey was held only in the upstream village of Mukhtan naturally particularly these farmers are most likely to be satisfied with the dams.
This perception of the dam was also found during this research as the *Shaykh* of Mukhtan clearly exclaimed; 'before the construction of the dam there was draw down, now the water level is constant.' Interestingly all of those interviewed (3 farmers) who were member of the SAC (further explained in paragraph 4.6.2) stated that the dam had brought them benefits through recharge of groundwater[75], including one farmer living as far downstream as Sa'wan.

However a group of approximately 30 farmers from Al Khirba clearly put forward the following;

- only 4 dug wells close to the dams (2 of which were dug after the dams construction) and a limited number of families benefit from recharge, these wells are located within 500m. from the dams
- before the construction of the dam, their dug wells were full for ¾ of the year benefiting from wadi run-off, now however they were exposed to drying up completely, with one farmer's dug well becoming completely dry after the construction of the dams
- perhaps if the upstream wells would not be operated continuously then the downstream wells might recharge, this however does not happen
- The farmers had to resort to tube wells

A note has to be placed; concerning the deep tube wells farmers were not unanimous whether groundwater had stabilised since the construction of the dam. Those farmers who encountered benefits in their dug wells pumped less from their tube wells and did not encounter dropping water tables as they stated that they did not have to install more pipes[76]. Those who did not benefit from recharged dug wells, were also stating that the deep water tables were dropping.

[72] four farmers were interviewed, notably some of which were also interviewed for the present research
[73] farmers stated two reasons for the dam's 'destruction'; 'in the election time the government destroyed some parts of the dam promising another new dam', and 'the government had opened up the dam for geotechnical survey upstream of the dam' this latter reason would correspond with the surveys conducted by Stanley (end 2005)
[74] At the moment of the GDI inventory the Musaibih dam had not yet been constructed
[75] According to those interviewed no deepening of boreholes had been necessary and the groundwater level had remained the same
[76] these accounts are to be put in perspective since they have had to significantly deepen their tube wells since construction in 1979

The outcome differs and confirms the perception brought forward in chapter 2.3 that the dams would seem to work since the dug wells close to the dam are recharged. In the communities around Arisha Qutran dam farmers perceived there to be recharge, however they agreed that there had also been more pumping since the construction of the dam. The Al Jarjor dam delivered significant benefits for the community of Al Uqran as wells constructed close to the dam delivered water for as long as a third of half a year depending on the water amounts in the reservoir. In the Beryan area recharge was also considered to benefit the shallow wells downstream of the dam as long as there was water in the reservoir, which hadn't been the case the past years. Both the Mukhtan and Musaibih (providing the same area) are perceived to have influence on the upstream aquifer close to the dams, as the dug wells there encounter recharge. However the perception of farmers from the downstream community of Al Khirba was unambiguous, since they all stated that they had not benefited from the dam, except those who were member of the SAC.

4.3 Agricultural and domestic water sources

In the four dam communities[77] it has come forward that pump unit / groundwater represents the main water source for all of the farmers during the dry season. During the rainy season, where possible the farmers try to benefit from run-off or spate irrigation from small tributaries and during the dry season farmers use dug wells if they have water or tube wells if they have access to them.
In the village of Al Uqran at Al Jarjor dam the water source for the local community is piped groundwater from the dug wells during the wet season and during the dry season they buy their water and bring it in water tankers.

Water abstraction, distribution and application at each dam
In trying to unravel the ratio behind the construction of each dam and relating this to the alternative of having none, it is important to know what is actually being done with water in each of the communities. This becomes of particular importance when discussing agriculture's vast water demand and the potentials of savings furthering on towards sector water exchanges.
Farmers can account how long a pump is pumping and for how many days a year etc, however it has proven very difficult to get accurate and justifiable data on water abstraction amounts (for reference see annex 5).
In trying to circumvent the vicious circle of iteration of data on abstraction amounts each well owner (preferably the well operator) would have to answer the questions concerning well yield (wet / dry season variations), pumping time per day (wet / dry season variations), pumping days per year (wet / dry season variations). This requires a lot of information, which is not possible to acquire on a large scale over a large period of time simply by asking questions, or deducing dry wet season variations from meteorological data. A metered well (metered pump on a well) could already answer the abstraction totals per year.
However, it would appear to be clear that there is over abstraction meaning. In those areas where deep tube wells are present farmers have had to deepen the tubes.

The water conveyance methods can be summarised as follows for the two districts.

	Water conveyance methods (all values in %)			
	Earth canals	Galvanised	Plastic pipes	Hose pipes
Nihm	22	22	33	22
Bani Hushaysh	4	63	23	11
all districts	14.15	46.7	21.7	17.45

Table 4: Water conveyance methods in Bani Hushaysh and Nihm districts, source; WEC 2001

[77] following from 21 farmer interviews and 2 farmer meetings

Table 4 shows that in Nihm still 22% of the water was conveyed by earthen canals, but it was observed during fieldwork that, for both Arisha Qutran and Al Jarjor areas this was seldom the case[78], in particular concerning groundwater[79] conveyance. Concerning conveyance efficiencies, piped water distribution methods are considered almost 100% efficient, since there is no evaporation or infiltration of water (for lined canals the average conveyance efficiency is 95%, source FAO).

The WEC study conducted in 2001 came with an expected 'irrigation practice which is likely to be close to high efficiency conditions (75 %)[80].' If this value is compared with the FAO indicative values for field application efficiency the values resemble that of sprinkler irrigation; with border, furrow or basin irrigation application efficiency being 60% and drip irrigation ea being 90%[81]. Comparing these application efficiencies there would seem no reason to implement modern irrigation technologies.
Other studies and reports, however mention that the irrigation efficiency (assuming this to be conveyance and application efficiency) is a mere 35% (Bazza 2001; MWE-NWSSIP, 2005). This figure appear to be conflictive, if both the statements of the WEC and that of Bazza are true however, then it would imply that the conveyance efficiency is falling short, but this was already stated to be almost 100% (see the previous paragraph).

Asides these findings this research has also asked farmers for their opinion on new irrigation technologies and water saving methods. What ought to be considered though is that if the above is all to be considered true; the application efficiency and the fact that almost all water is piped, then less reasons remain for the installation of modern irrigation technologies.

Adopting new irrigation technologies
From the survey Sana'a basin survey conducted by the WEC in 2001 in the results followed that in general 78% of the respondents reported knowing other irrigation methods that can save water (of which 84% stated they knew of sprinkler and drip irrigation), while 22% of the respondents stated that they do not know other methods. However 98% of the respondents in all districts indicated that they had not used or adopted any of these modern irrigation water saving measures. As the research found that although the farmers are willing to adopt modern irrigation methods they would first want to let the government convince them that it actually works as an effective water-saving mechanism without affecting crop yield. From this research it can be said that 4 farmers (of 21) to adopt MI as the stated to be sceptical as the roots of their qat plants were adopted to small basin irrigation and a shift to drip irrigation might bring the roots into water stress. This was also experienced in Sada'a basin where farmers abandoned drip irrigation, Lichtenthäler & Turton suggested a phased introduction might allow the roots to adapt rather than to make the switch in one sudden event (Lichtenthäler & Turton, 1999). The price would also have to drop significantly.

Farmers in the during the fieldwork area stated that they do already take water savings into consideration;
- Using exactly enough water, no over irrigation
- Making the basins around the crops smaller
- Reducing the water volume which used for irrigation
- Performing night irrigation

Concerning modern irrigation technologies they thought that;
- The roots of the qat plant would have to adjust to the different irrigation pattern

[78] From farmer interview and observations
[79] Surface water channels were observed, however these were not used for groundwater but for rain run-off water
[80] WEC 2001, volume 2: 70, this research is puzzling however, since it does not specify if the efficiency concerns application or distribution efficiency, this research assumes the former since the values in the mentioned study are compared to application efficiencies of other studies
[81] http://www.fao.org/docrep/T7202E/t7202e08.htm

- They want a demonstration farm, maybe the farmers can be convinced seeing a demonstration farm
- The modern irrigation technologies were identified to be too expensive and they might also only benefit certain crops[82]

4.4 Pumping costs

An important economical factor in the farming community is the price of acquiring the resource. Although pumps and fuel had been subsidised by the government for a long time, farmers now fully cover all the costs themselves which, contrary to what Sahooly (2001) state makes water far from free[83]. In the governments water sector strategy investment plan (NWSSIP, 2005) it states that fuel accounts for a relatively small part of pumping costs if one considers the total cost of pumped groundwater, which includes not only amortized capital costs (drilling, pump and engine etc.) but also the cost of prospecting for water; i.e. the cost of failed or dry wells. This highlights the importance of costs concerning groundwater exploration and abstraction.
Underneath an overview is given of farmers responses to the costs of installing a well (including; drilling, pump and engine) and of the operational costs. Important note is that this overview concerns tube wells (except Al Jarjor). The service costs and coherent methods of distribution dependant on the distance to the resource (wells or communal pools, see 3.3.5 & 3.3.6) varied per household in the areas[84], which may also partially explain the variations in operational costs underneath.

	Pump owning	Diesel / Electric	Installation costs million YER/well	Operational costs YER/hour	selling water to others
Arisha Qutran	shared	diesel	4 - 8	163 - 340 (**)	no
Al Jarjor	shared	diesel	0.5 - 3	83.3 - 340	no
Beryan	shared	diesel generator & electric pumps	37	500 - 1500 (***)	no
Mukhtan & Musaibih	shared (*)	diesel pump / diesel generators with electric pumps	15 - 27	566 - 1020[85]	1/2 no & 1/2 yes (****)

*Upstream *shaykh* owns own pump
** Conveyance by pipe to the field (1500m.) costs 270 YER extra
*** Costs for non well owners can reach up to 2000YER/hr
**** Water sold for 500 – 600 YER / hr, plus the price of diesel (34YER/litre,042007)

Table 5: pumping costs, Source: Author

Although table 5 is limited in its content, it gives an interesting overview of the difference between the communities. As groundwater and tubes have to reach deeper for water the costs logically rise as well. The distribution distance, which may vary between community members, however has not been taken into account in the table above. At the Beryan and Mukhtan & Musaibih dams it was found that electric pumps were powered by diesel generators, some of wells were in reach of an electricity network connection however this had proven to be too unreliable and also more expensive than diesel generators.
Costs and shares related to pumping are organised similarly in the four the communities;

- Fuel costs made for running the pumps are directly paid by the household which is abstracting at that moment

[82] one local farmer representative, however stated that 'the IHSC had started blackmailing the simple farmers and denying them of their services, particularly when it comes to supplying them with government funded irrigation equipment at reduced prices' WEC 2001, volume 4 page 38. Could this account explain why farmers claimed modern irrigation technology was too expensive
[83] Sahooly (2001) argues that since no pricing policy exists water is free.
[84] This research has not specified the distributive services costs and variations thereof within the communities
[85] As of April 2007, an average of 20 litres of diesel are spent per hour at a cost of 34YER/liter; totalling 680 YER/hour

- The length of time for pumping varies per household and is determined according to the share in the well
- The pumps are owned according to the same share principle as the wells
- Differences in groundwater levels in tube as well as dug wells makes the price of pumping also accordingly different
- Only in the Mukhtan & Musaibih dam area, groundwater is sold to others, farmers here also stated they sometimes sell their shares[86]

In Arisha Qutran dam area because most of the wells are situated close to the dam (according to the 2 farmers and field observations) the transport of water to the plots spread out in the wadi, can be costly. Conveyance using pipes over 1.5km. may cost up to 270 YER. For the more distant plots in the area this piped conveyance method is not physically possible and small water tankers are used to transport the water (at unspecified costs).

Farmers in the Al Jarjor dam area reacted laughingly at the question whether they sell water: "sell water? No of course not, we used to buy most of our water and still do at the end of the in dry season." For a water tanker of 16m^3 they pay 10.000 YER (625YER/m^3 or 3.14US$/ m^3)[87]. This large amount of money includes all service provision costs (including transport over 20km.) but is an incomparable price with locally abstracted water; which - when solely considering pumping costs - would be 23.60YER/ m^3. As Ward etal, (2000) put forward in their report on water management in Yemen only 'the profitability of *qat* can justify irrigation by tankered water at a cost of over US$1/m3,[88]' and it is exactly qat which is primarily being cultivated in the community of Al Uqran

In the area of Beryan dam the farmers stated the first 2 tube wells in the area were installed by the SAC, however after that the SAC's price became to high they went for others. Further cost details concerning the area were also provided by Stanley Consultants as farmers had indicated that 'to replace the Dynamo for a well pump, 12 million YER are required (approximately $60,000 USD). Yearly maintenance costs for a well are around one million YER ($5,000 USD). According to Stanley (2006) 'both of these figures seem to be exaggerated,' however the indicative installation costs shown in table 5 also cover this range and the statement would not seem properly backed.

In the Mukhtan & Musaibih area the farmers stated that the old wells were connected with a diesel pump and the new wells have electric pumps supplied by diesel generators. Some of the farmers had also agreed that a farmer can use water if it's not his turn, making agreements with the farmers whose turn it is. If the farmer is poor only the price of the diesel will have to paid, if the farmer is rich then he will pay proportionally more. Sometimes if a farmer has enough he can sell his share to others 600 YER/hr.
Also specified by the farmers was their biggest difficulty; when the pump breaks. A new pump used to cost 8000-9000YER now they cost 4 million YER

The pumping costs for the farmers vary according to the depths of the resource and according to the distribution distance. These costs for resource capture limit the farmers to cropping qat, as this is remunerative enough for the farmers. Qat, as comes forward in the statements of farmers in Al Jarjor area and Mukhtan & Musaibih area is a highly remunerative crop.

[86] Apparently there is differentiation between; using your share(time agreement) but selling the water and selling shares themselves, this has not been furthered in this research
[87] As comparison average domestic water prices in the Netherlands are an average of 1.90US$/$m^3$ (VROM, 2007)
[88] Ward etal, 2000: 25

4.5 Dam ownership, water distribution agreements

4.5.1 Dam ownership and operation maintenance agreements

In the unravelling of the dams; their inception, their life line and interaction with the community the survey of this research includes an overview of the investors and constructors of the dams (table 6).

Dam	Funded by	Constructed by	Additional Information
Arisha Qutran	Farmers	Farmers	
Al Jarjor	Farmers + AFPPF	Farmers	
Beryan	Farmers + AFPPF	Farmers	The spill way was implemented (/ funded) by the AFPPF
Mukhtan	AFPPF	Al-Nasr Corporation	Construction supervised by the GDI
Musaibih	AFPPF	IHCS	Association under the ACU

Table 6: Dam construction and funding, source; GDI dam inventory, 2001

As shown above both Mukhtan & Musaibih are the dams that have been built by the government and the ACU – IHSC and the others by the communities themselves.
The issue of operation of the dams is out of the question, the dams do not have distribution systems, except at Mukhtan and Musaibih, where both dams were observed to have dysfunctional valve. Farmers were asked whether there was operation of the dam, however all responded negatively.

	Farmers responses					
Dam	When was the dam built	Who is the owner of the dam	Informed prior to construction	Maintenance of the dam	Responsibility maintenance of the dam	Permission to abstract reservoir water
Arisha Qutran	1994 - 1999	local community	yes	none (*)	no	no
Al Jarjor	1994 / 1995	local community	yes	none	local community	no
Beryan	1995	local community	yes	none (**)	no	no (***)
Mukhtan & Musaibih	unknown / 1995 – 1999 & Musiabih unknown / 2000 - 2003	local community	2 no & 8 yes	none	unknown / MAI / ACU	no

* sediments are sporadically removed
** emergency repair
*** since the establishment of the WUA

Table 7: Farmers perspective, construction and O & M of the dam, source; Author

Arisha Qutran

In wadi Araman, at Arisha Qutran dam, the communities and all of the households were aware and involved with the development of the dam, the development of which was an effort lead by the *shaykh* (this according to the 2 interviewed farmers). The total investment for the dam was 6 million YER (30.000US$), of which 2millionYER was covered by the AFPPF (see also dam implementation case 2, figure 4) and the rest was divided in equal shares amongst all the wells in the community (300.000 YER/well). Each investment per well was then divided amongst the share holders according to their share in the well. In return for

their investment in the dam they were promised recharge of their wells. However, the wells are not equally deep and the benefit of the dams is thus not equally shared.
Concerning maintenance the farmers replied that some had taken silt from behind the dam, however at times this removing was denied by others. The build up of silt behind the dam was considered a problem though (this study & Halcrow Group Limited, 2006). The chairman of the newly established WUA however specified that as of late, maintenance had become the responsibility of the WUA within the program of the SBWMP (see chapter 3.3)

Al Jarjor
All 4 interviewed farmers stated that the situation in the village of Al Uqran was dire, prior to the construction of the dam; 'the community suffered, so something had to happen.' A farmer had voiced his concerns, because the dam and reservoir was planned on his land, however he was compensated and the land was considered his as his investment. The Al Jarjor dam was for its construction co-funded by the AFPPF, this however only for the final stages of construction. The community had managed to have this funding through communal meetings which were held where after the *shaykh* contacted the minister and governor who came to visit the area and their turn convinced the AFPPF to co-fund the building of the dam (see case 2 in figure 4). The remaining amount of investment needed was brought up by the community. The shares per household were decided according to the amount of land each household owns and their ability to contribute. The investments could mean investing unpaid labour in days (worth 30000 YER/month/labour day) or cash.
As in the Arisha Qutran area the farmers in the Al Jarjor area recognise that maintenance, in particular removing the sediments, is necessary however no regulations have been made. They would like to take the sediments however as they say it has to mature into usable clay for 2 years; however since the dam's construction a lot of 2 years have past already. Although maintenance is considered to be the responsibility of the local community, the community has been thinking to ask the MAI to remove the sediments.
The community is aware that the GDI could be requested to perform the maintenance and they might even get it done, if the GDI follows the upon-demand approach (see 3.1.3)

Beryan
The inception of Beryan dam started with the recognition by the whole community that wanted to meet their water needs; because of the high abstraction rates measures were necessary. The idea of a dam was proposed by the *shaykh*[89], which at first met with opposition because some had land and crops in the reservoir area, but these households were soon convinced by the community of the potential benefits of a dam.
The whole community participated in the investment for the dam (see case 1, figure 4). The shares of investment per household were decided according to; the amount of people in the community, amount of members each household has and the amount of animals and land this household owns. The principle being those with more, invest more.
Participation in the investment and construction was done, with labour and or materials and or capital;

- they donated land
- labour in days
- materials in kind, the borrowing of a truck
- money (YER)

All according to the shares that the households agreed to have. The later constructed spillway was funded by the AFPPF. Concerning the construction of the new dam the farmers considered the costs to be paid by the bank (AFPPF or others) as they had already invested in the first dam. The appeasement is given, since the costs would fall under the SBWMP (see chapter 3.3).
From the Beryan dam reservoir operation / abstraction has been possible. Initially for reservoir water no abstraction restrictions had been made, and thus after the dam's

[89] Perhaps remembering Beryan's rich Himjarite history with dams (see also 4.1)

construction each farmer with his own pump could take as he wanted. A farmer however accounted that under that situation he did not have the possibility to pump so there may have been dam water, but his plants died. Since the instalment of the WUA, it is the WUA decides that only in critical dry situations the farmers are allowed to use the dam water.
The WUA is only to come into full operation after the new dam has been built, for which a proper operation and maintenance manual has been written by the SMT (also for Arisha Qutran dam).

Mukhtan & Musaibih
Investigating the two dams has proved to be difficult during fieldwork as not in all interviews a clear separation between the two dams was made. However in general concerning the Mukhtan dam most farmers (8 from 10) agreed that they as farmers asked / demanded the dam and the government then informed them about the dam building plans. The upon-demand approach worked and the farmers got the first dam.
Concerning the second dam, the Musaibih, clearly not all the farmers were aware of the fact that it was to be built;

- 2 came to know about the plans when the former prime minister and the chairman of the ACU came and inaugurated the construction[90]
- 2 had seen engineering team had visiting the site and thus became aware
- members of the SAC were told by the chairman (*Shaykh* Mohammed Bashir)
- 2 were told by a team from the government, when they visited the area

Those member of the SAC or otherwise related to the ACU were informed about the construction of the dam some of which also participated in the construction (amounting to 20% of the total costs). Participation meant that one donated clay, soil, and met the needs of the workers building the dam and yet another encouraged the building of the dam and gave soil voluntarily
Concerning the operation of Mukhtan dam the GDI dam inventory writes that this is the responsibility of the MAI and Sa'awan Irrigation Association[91]. Concerning the operation of the last built dam, the Musaibih, farmers mentioned that they initially may have wanted the construction of the dam but this was based on the promises that a divisionary system/structure would be built. Thus apparently operation had been mentioned as part of the plan, but never carried out. Both dams do however have valves which particularly the downstream farmers[92] would want to see opened when there is water in the reservoirs. The taps to the valves were however gone during, field observation and according to some farmer's statements in the hands of the SAC chairman. According to a SAC member the valves at the Musaibih dam are opened by permission of the SAC 2 times / year for recharge. All of the farmers in Al Khirba denied this statement moreover saying; 'were it to be so that the valves were opened then only the upstream farmers (those living in Mukhtan, 2 interviewed) may have benefited from it.'
Next to operation the maintenance of Mukhtan dam according to the GDI dam inventory is the responsibility of the MAI and Sa'awan Irrigation Association[93]. This clearly establishes that not only the Musaibih dam but also the Mukhtan are placed under the auspices of the ACU's local SAC. This would correspond with some of the farmer's accounts.
According to the accounts of farmer the responsibility for maintenance is either unknown or that of the MAI or that of the SAC. Concerning the latter a couple of farmers specified that the chairman[94] of the Sa'wan agricultural cooperative society should organise the maintenance. The Society is and investment cooperative so they should also be held

[90] A calendar depicting government officials at famous Yemeni dams (particularly the masonry or reinforced concrete ones), was found at a government department; as civil engineering feats become prestigious
[91] This is probably meant to the Sa'awan Agricultural Cooperative, however the nomenclature of the ACU's organisation may have changed or not correspond within this research
[92] From 4 farmer interviews and 1 group meeting, all in Al Khirba village
[93] GDI dam inventory, annex 33: 2
[94] *Shaykh* Mohammed Bashir, described by farmers as being a powerful man with important connections in the government is also the main man of the ACU (namely the head of the chairman office of the executive board of the ACU) as from an interview with an ACU staff member

responsible for maintenance. Another farmer thought that the cooperative is to demand the government to pay for the maintenance the execution can then be done by the society / contractor; in short making MAI pay the SAC to perform the maintenance work. In his opinion the chairman takes the maintenance work and uses contractors.

Dam investment agreements vary per community: full community investment or partial or full government investment. The dams in all cases are considered the ownership of the community[95]. In all the three cases in which the dams were built by the community, the *shaykh* had a leading role in the collective implementation. He also upholds a mediator role within the community, but also towards the government. In the case of government or ACU built dams, as are the Mukhtan and Musaibih; farmers from the different communities are more sceptical about the development of the dams, some even unaware of the plans to construct a dam.
In none of the communities there are maintenance agreements which would be necessary to uphold the collective ownership and the vested interests of those who invested in the dams.

4.5.2 Communal water distribution agreements

Having had the hardware of water distribution specified, the actual software; the agreements within communities will highlighted.
From the fieldwork conducted in the 4 different communities it can be said that in general all tube wells are shared owned, dug wells are more commonly household property or within the extended family (see annex 6 for ownership details of interviewees). The agreements on sharing water are based on the investment a household has made for the construction of a well. Shares can vary per household and within a community certain agreements may exist concerning the pumping time per tube well as specified below. In Al Khirba and there around the farmers stated that they abide to general set abstraction rules that; during the rainy season all pumping is stopped, using only surface water (water from recharged dug wells) and no more than 12 hours / day of pumping during the dry season.
Although within the communities the wells were at a varying distance from the dam and from the household (see also pumping & distribution costs 3.4.1) the farmers did not consider this a problem, although complaints - concerning the high costs for pumping and the installation and maintenance of the wells - were outspoken.

It would seem that within communities of this research there is a genuine sense[96] of altruism as seemingly the benefits of dam and its recharge are equally valid for a large as a small farmer. Most likely the system of shares in a lot of different wells is part of the reason for this seeming sense of shared benefits. Moreover in the communities the poorer farmers can count on other farmers for supply in domestic water. This cooperation amongst households within a community in the different case study areas was as made clear by the interviewed farmers as they stated that 'communal values and norms are rooted in both Islamic as well as tribal tradition in Yemen.' These findings would seem to make the slippery and vague term 'community' described in chapter 3.1.1 more a day to day reality.
Asides this farmer in Beryan community stated he was able to apply for a financial benefit for the poor from the *shaykh* (the *shaykh* certifies if a household qualifies for receiving a benefit). The country assessment of the WB writes on this role of the *shaykh* as serving 'an important means of developing patronage relations within the community.[97]' However it continues in saying that 'the fact that *shaykhs* can now draw on formal state systems to support them has severely weakened the traditional sanctions open to local people for holding accountable or

[95] Although a MWE employee stated that MAI/GDI owns the dams they construct and they are the users as well (agricultural sector). Ownership in his opinion should actually fall under the MWE, they want the best for everybody
[96] This is not merely a common statement from the researcher, but is backed by the experience of the researchers who participated in the fieldwork for these cases (WEC – lecturer and WEC – student, both with significant fieldwork experience)
[97] WB 2006: 36

removing them.[98]' However in Yemen there is also a 'strong tradition of promoting consultation and consensus' … 'to counter balance tendencies towards fragmentation.[99]' (WB, 2006 p.36).
The practice of Harim, brought forward in chapter 3.2.1 has not been observed to happen in the case study areas of Arisha Qutran, Al Jarjor has several wells dug close to the dam and very close to each other.

4.5.3 Extra-communal water distribution agreements

The issue of; which communities are considered to be beneficiaries of the dam vis-à-vis also those who do not benefit from the dam, comes forward in particular in those areas and wadis where there are more communities involved. Before the dams were constructed the communities lay claim to flood waters, which were flowing through the wadis. Since the development of the dams the reservoir water became of use for the communities who developed them or those living close by. This situation, according to a GDI-official[100] must change, as the beneficiaries of the water behind the dam are to be the same farmers who were able to use the flood waters. Moreover the distribution arrangements are envisioned to go according to the prevailing flood rules and rights because each dam ought to have water distribution systems. This is however still in development; accordingly any new dams that might be built will be built with irrigation structures, according to the GDI official[101]. However the existence of communal grounds did not come forward during any of the fieldwork which would leave the practice of irrigation structures and distribution arrangements without a water right base.

The issue of non-beneficiary downstream communities did not come forward during the field work in Nihm district at Arisha Qutran dam and Al Jarjor dam. Although conflicts have been known to happen elsewhere in the district, notably Al Ghaida dam was destroyed after an upstream downstream community conflict. Notably the GDI was unaware of this conflict and the inexistent status of Al Ghaida dam[102]. Fieldwork at the Beryan dam and Mukhtan & Musaibih dam did raise issues, brought forward in the following paragraphs.

Beryan
During interviews (4 farmers) and farmer meetings in the area (23 farmers), farmers agreed that having built the dam was good for the 'whole area' believing that the dam brought good development to the downstream area. They indicated that four other downstream villages benefited from the dam, i.e. Rugam, Al-Hesn, Al-Rowna[103], and Sa'wan (see topographical map 4.1). However when the farmers was asked how they could ascertain this, they acknowledged only the dug wells close to the dam benefit and that they honestly don't know whether other areas benefit.

Mukhtan & Musaibih
In the village of Al Khirba (see location on topographical map) it became clear that farmers were not satisfied with the dams. They put forward that Yemen has a history of dams as part of the civilisation, but all of these dams would have divisionary structures. Concerning the Mukhtan and Musaibih they were told that irrigation infrastructure would be installed but this has not happened yet. The farmers in the village of Al Khirba complained as the surface waters became significantly less after the dam was constructed. Also minor conflicts are known to have happened around the dam though. One time the downstream farmers opened the valve but the upstream farmers denied this water going through the wadi. Farmers in Al

[98] Ibid: 36
[99] Ibid: 37
[100] Interview director of the Sana'a Basin Dam Unit, GDI, 08-04-2007
[101] The GDI-dam inventory in 2001 had also specified the command area of the dams. Having used a topographical map as tool; ambitious amounts of ha. were reckoned under the 'water command' of each dam.
[102] On the researcher's initiative the local *shaykh* was consulted and he stated that there had been problems.
[103] The dam design report from Stanley Consultants 2006 also considers these three villages as beneficiaries for the new dam that is planned to be developed

Khirba stated that the only people benefiting from the dam were 4 households in the upstream area; specifying it was those households who had also dug new wells close to the dams after these had been constructed. These farmers - considered to be in the upstream town of Mukhtan - did benefit, but as stated this group is very small. A farmer and member of the SAC further downstream of Al Khirba in the village of Sa'wan stated he experienced no extra difficulties in accessing water and that he does benefit from the dam. The farmer said that: "the complaints from the farmers in Al-Khirba stem from envy, and that their complaints were unreasonable."

4.6 Institutional arrangements, farmer organisations, interaction with governmental organisations

4.6.1 Water User Organisations

Introduced in chapter 3.3 WUAs have been instated at Arisha Qutran at Beryan dam under the SBWMP. The reason that this chapter has not directly referred to the WUAs jurisdiction and action is that in both areas the members are waiting for the dam changes that are promised to be made. In the two other communities farmers' opinion on a future WUA was polled. In the communities close to Mukhtan & Musaibih dam the role of the ACU / SAC.

WUAs in Arisha Qutran and Beryan area

The WUA in Arisha Qutran area was established, three years ago. Every farmer in wadi Araman is represented or member of the WUA (according to the 2 farmers interviewed). According to the instated rules every well has to pay 15.000YER (75US$) which is divided amongst the shareholders according to their share[104]. As of yet not a lot of meetings have been organised and the members are becoming sceptical about the promised rehabilitation of the dam. The farmers thus also stated that they had experienced no benefit of being member.

The WUA in the Beryan area consist of 5 different water user groups (WUG) which were created. The WUGs were formed, based on zones within the Beryan community, it is unclear however what the boundaries of these zones are and whether they cover the downstream villages of Rugam, Al-Hesn, Al-Rowna, which were mentioned to also be dam beneficiaries by SMT-members and the GDI (see 3.5.3.1). The membership fee for each member of the general assembly is 300YER/month. The benefits of being a member of the WUA are access to modern irrigation techniques, which as of now the WUA is trying to get, however due to administrative problems this has not yet been possible. Another member further specified that some people think there will be commercial benefits, in the maintenance work for the dam.
Contrary to the situation in the Arisha Qutran area, not all farmers are member of the WUA in the Beryan area. Reasons farmers gave for not being member were that the idea, aim or goal behind the WUA was unknown to them. Furthermore a farmer mentioned that the *shaykh* had been choosing the governing members of the WUA, but others contradicted this and said that the process had been democratic.
According to the farmers however, a tribal rule brings comfort to those not participating as it says that 'even if you are not a member you can use water, there is a tribal rule that you can not exclude anyone'

Al Jarjor

In this area farmers were asked to about there ideas of setting up a WUA. They said they hope to form an association, however the constraints were said to be; the lack of awareness and responsibility amongst farmers. Up to now the local community had not come up with the

[104] every farmer has a well share

idea to form a committee. A farmer said he expected the Sana'a basin water management project to come to the area and form an Association, potentially a WUA. This might happen if the pilot WUAs which fall under the SBWMP are successful (see also chapter 3.3)

Mukhtan and Musaibih
Already introduced in chapter 3.1.5 and coming forward during the previous paragraphs of this chapter is that this area has no WUA but a agricultural cooperative, namely the Sa'awan Cooperative Society (SAC).
Concerning the formation of WUA farmers[105] (non-SAC members) in the village of Al Khirba said they had attempted to get together in a collective. Their experience however was discouraging as they found it difficult to form an association; some farmers don't cooperate. They had also wanted to involve the chairman of the SAC but he disappointingly has never turned up and neglected the appointments. A WUA could only root if both the *shaykh* and government are willing to do this, as farmers conclude.

4.6.2 Agricultural Cooperative Union

In this paragraph the operation of the ACU is highlighted through farmers' accounts of the Beryan and Mukhtan and Musaibih areas and from precious fieldwork efforts. The presence of the ACU in the area has become clear from their involvement in the development of dams. A presence and involvement described as being 'heavy' also through the work of the cooperative society for irrigation and hydraulic structures (IHSC) see 3.5.1 (WEC 2001).

Next to dam development in which particularly the IHSC was involved, the local SAC has also been involved in developing tube wells.
The farmers in Beryan area had been member of the SAC but stated that now SAC is of no influence and there is no cooperation in the village of Beryan. At a certain moment the chairman of the SAC warned it was going bad financially and there was no more benefit to be a member. He then offered the shares back to the farmers who then stepped out of the SAC.

Mukhtan & Musaibih and the SAC
The opinion of non-members came forward in the previous paragraphs; the members however have a different perspective. According to a member the coexistence of a WUA and SAC would be possible if farmers want this, in his opinion the SAC has no related activities to the WUAs. The main tasks then of the SAC are mentioned to be providing fertilizers, agricultural equipment and well drilling for all the farmers including non-members. During the farmers interviews various farmers however stated that instead of selling the goods with subsidised prices they try to sell at exorbitant prices[106].
According to a member there is no membership fee, since the association has income from the mentioned services; the member gets a portion of the profit returned in YER. In 1978 he did pay 8000YER like others to become a member. The general association meets one time per year, to discuss the budget, the committee members however meet 1 time per month to discuss the benefits, the equipments and the budget and extra when necessary.
Stuttering sounds also came from some members as in their opinion there are no benefits of being member. Moreover it was claimed that although the president of Yemen supported the instalment of the agricultural cooperative societies, there is a mismatch in the organisation of the Agricultural Cooperative Societies (in particular their own SAC[107]).

The SAC and the ACS are organisations with a long past; as membership of the farmers date back from before the unification of Yemen. All farmers who were member now and

[105] In interviews and in the group meeting (see overview annex 1)
[106] A farmer and business man mentioned that if he were to buy drip irrigation systems in Saudi Arabia he could sell them at a third of the price of the SAC
[107] One farmer, was alarmed and confused when he was told that the wealthy sheikh from Mukhtan had claimed to be a member, whilst according to his membership books this was not the case

interviewed stated that only farmers who are member of the SAC from 'the beginning' can be member. Membership dates varied from 1978 to 1983, so it is unclear when this beginning was and for how long.

The coexistence of a WUA responsible for dam operation and maintenance and the SAC would give difficulties since it is the chairman of the SAC who holds the keys and responsibility over the (dysfunctional) valves. The jurisdiction and function of both entities would have to be clear.

4.6.3 Community – Government Interaction

In chapter 2 attention has gone out to the larger scale; the basin, the national government its organisation and institutions. Where and how these organisations come forward has become partially clear in all of the proceeding paragraphs, this paragraph aims at completing the picture of interaction by bringing forward the experience of farmers.
Certain polemical issues came during the previous study of the WEC in which farmers and local leaders expressed their anxiety and mistrust towards the government in the capital. The negative feelings, according to the mentioned study survey, were engraved in them over many years of contact with NWRA and the MAI, particularly the irrigation bodies attached to the latter mainly the GDI and the ACU (WEC 2001). The bitter relationship sometimes came forward in interviews and group meetings with farmers in particular what was heard that

- Government officials involved in water resources projects should "first respect their words and we are ready to fully cooperate with them"
- Stakeholder meetings in the past have not brought anything for the farmers and scepticism rules when new meetings are planned with local leaders and farmers

Downstream of Arisha Qutran dam the WUA organised community was further more waiting for government action concerning the dam and its rehabilitation. In the Al Jarjor area the farmers seemed curious to develop interaction with the government; concerning maintenance (see 3.5.1) and modern irrigation systems (see 3.3.7). In 2001 this open attitude was different as the GDI dam inventory field team avoided contact with farmers, because as they state; 'due to disputes between the farmers and the MAI, we avoided getting in touch with the farmers to prevent harm done[108]'.

In the Beryan dam area farmers mention that since the involvement of the SMT they have been invited to see dam designs in Sana'a, the farmers have been invited to see a demonstration farm, from the SBWMP (part of the training mentioned in chapter 3.3). But that not all is well between the community and the government came forward during a farmer meeting. Farmers explained that in advance of the previous elections the government (a political party) had promised a new dam for the community (as the a channel had been built because of safety hazards 3.3.1.3). The farmers now are upset that nothing has happened yet as it has been 2 years ago since the promises were made.

The involvement of the government is quite particular in the area of Mukhtan & Musaibih dam as the relations would seem to pivot around the SAC but then in particular also its chairman, *shaykh* Mohammed Bashir[109] mentioned in nearly every interview and during each farmer meeting. He is not only the local chairman but also the chairman of the national ACU. As various government inputs are offered through the SAC the farmers who are not member stated that they did not benefit from this facilitating role in agricultural services. From the WEC's experience with stakeholder meetings (with mentioned *shaykh* present) there exist

[108] GDI dam inventory 2001, annex 6: 5
[109] Not the same as the wealthy sheikh of Mukhtan but the one also mentioned in 3.5.1.4 at the Musaibih's inauguration and in 3.6.2 as the chairman consulting the members in the Beryan dam area

‘certain powerful social groups / individuals with strong links to the government (e.g. the irrigation cooperative, *shaykhs*, etc.) who monopolise the water related issues’[110].

[110] WEC 2001, volume 4: 35

Chapter 5. Conclusion

5.1 The analytical framework revisited

In Yemen, the government has instated a water law which would have to function as base for the groundwater management instruments and give authority to the organisations using them. In reference to the analytical framework given in chapter 1 (figure 1) it would seem that - although the government of Yemen has attempted at instating stronger formal institutional arrangements - the only organisational management form for sustainable groundwater use is through the communities as they hold the relevant instrument: the surface and groundwater use rights. The reconstructed 'menu of the institutional ingredients' are shown below in figure 8.

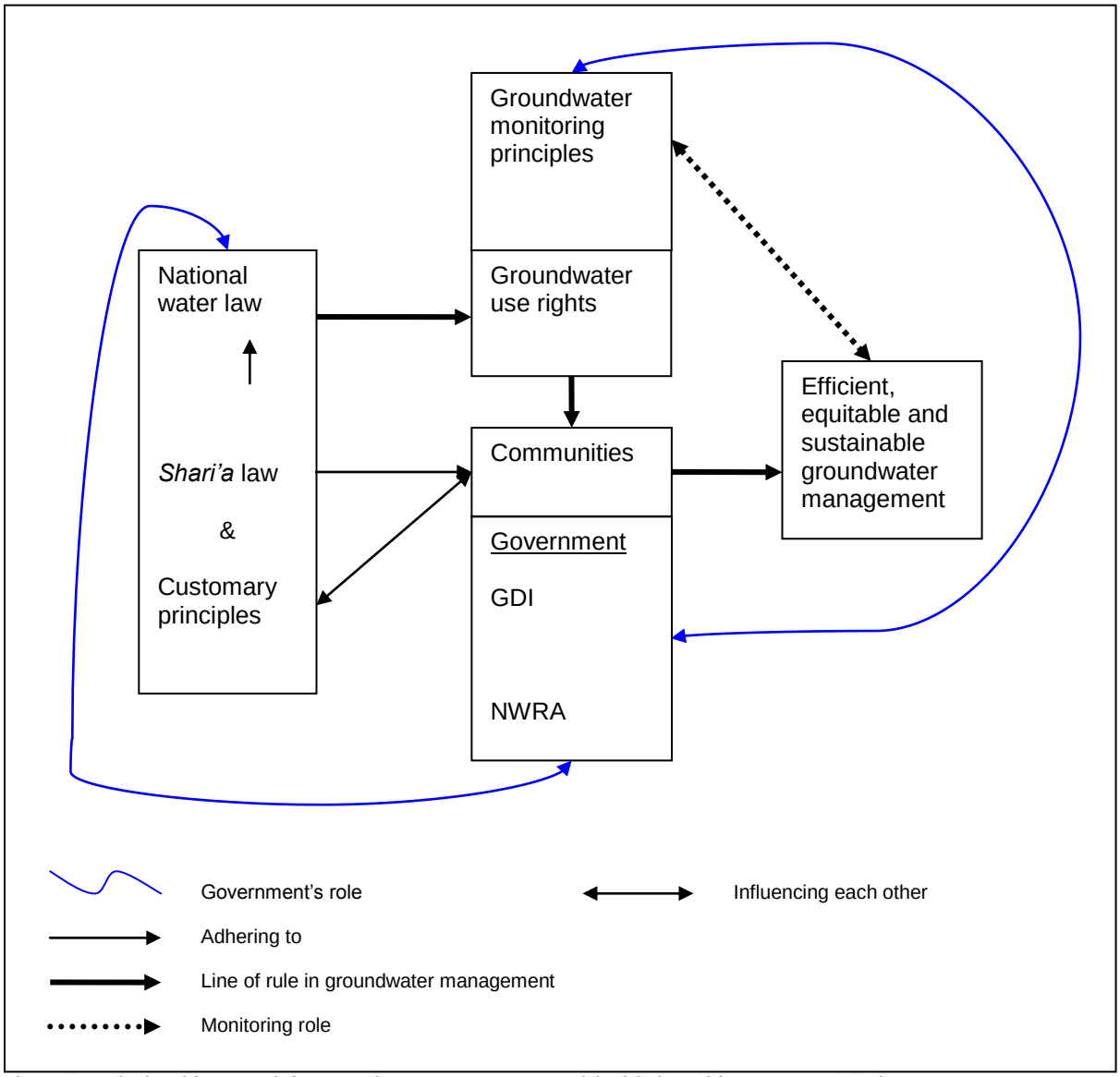

Figure 8: Institutional framework for groundwater management revisited (adapted from Kemper 2007)

Customary and *shari'a* laws upholds communities in their right to build dams since they stipulate the right to utilise surface and abstract groundwater on their own property. This in part has also caused the unrelenting abstraction of water, to which no restrictions were spelled out.

Unfortunately the GoY choose the above - right to water for those who own land - as a base to their water law. As a result of which the water law may recognise the water resources problems within the country but encapsulates no concrete tool and upholds no authority to limit the amount of groundwater abstraction. Moreover, the water law wants to focus on benefits on a larger basin scale which seems to conflict with the local practice of capturing water in the dams.

5.2 Answering the research questions

Small dams in Sana'a basin are built either by the communities themselves or by the GDI or by other non-governmental organisations. Almost all are built for the communities to benefit from artificial recharge of the water transmitting layer for agricultural purposes.
Following from what was found during the case studies, it can be said that the dams recharge the shallow aquifer. The community around or closest downstream benefits from this recharge through raised groundwater levels in their dug wells. Communities further downstream do not experience raised groundwater levels and the recharge benefit from the dam. The raised groundwater levels in the aquifer would seem to be limited only around and close to the dam.
Within those communities closest to the dams, the benefits of raised water tables in the different dug wells might vary. However, these differences would not seem to lead to discord: the benefits are shared through intra-communal water distribution arrangements based on principles rooted in customs, tradition and Islam. These arrangements apparently do not exist amongst communities and consequently the communities further downstream are not part of the shared benefits. Moreover, the communities downstream can not count on flood flows in the wadi since it is blocked by the dam. The flood flows could be used directly by the farmers (spate irrigation) or it could recharge the dug wells in the downstream areas.
As dam communities are able to sustain their agricultural practices on water resources coming from a certain catchment area, their practices can be argued to be unsustainable within Sana'a basin. Since the basin has experienced an enormous population growth the pressure on the available water resources has logically risen and the water tables are still dropping. The groundwater resources are simply not enough to sustain the whole population and the agricultural practices[111].

The NWRA is to devise water plans at this larger basin scale. It appears that the NWRA (as department of the MWE) is in a position to rule through water the plans how a whole ministry, namely the MAI, is supposed to manage agriculture water. Moreover, as the PCU of the SBWMP is in hands of the NWRA, they would rather see money allocated for dam development spent their way, that is to say focused on demand management and monitoring within the basin framework. On the contrary, the MAI/GDI would want to see the money allocated for dam development.

The GDI is involved in the development of dams. As part of the SBWMP, dams have come up for rehabilitation and new ones are proposed to be built. The work involves design and construction as well as the prerequisite instalment of WUAs who will be responsible for operation and maintenance. As of now there is no operation of the dams in Sana'a basin, since there are no distribution networks installed. Besides, maintenance of the dams is only done sporadically. Rehabilitation studies and construction of new dams included the assessment of alternative operation strategies as brought forward. These strategies and the proposed placement of valves however are a fundamental part of the rehabilitation of dams. Farmers may have constructed the dam where their wells were located and the maximum profitability was expected Vice versa, they may have constructed wells close to the dam's location to have this maximum in profitability (e.g. the Al Jarjor and Mukhtan & Musaibih case see 4.2 Discussion on recharge). The alternative operation strategies might also infringe the

[111] The largest water consuming sector in Sana'a basin (Al Hamdi 1997, WEC 2001, Foster 2003)

rights of the community closest to the dam. As the community is benefiting from the run-off and capture of water from their own land, they might not want to see the downstream communities benefiting from this as well as when water is flowing through the wadi (and subsurface) towards them. WUAs instated for the maintenance and operation of the dams might be able to bridge water distribution rules amongst beneficiary and non-beneficiary communities. Although the WUAs will be trained in operation and maintenance, de-siltation, water regulation and conflict management, the mentioned tasks and responsibilities may well be a bridge to far and end up in more disappointment in the government and unrest amongst the communities.

Finally, confusing and conflictive accounts within literature on irrigation efficiencies make the bases for demand management unclear. If irrigation efficiencies are already high (see chapter 4.3), the implementation of modern technologies would be unnecessary and the focus on demand management would then more have to be on the unsustainable amount of cropping area and the cultivation of crops which require a lot of water. The serious depletion of groundwater resources in Sana'a basin, as introduced in chapter one, has its causes but also has its remedy: less water should be abstracted from the aquifers and a more sophisticated dealing with the water that comes from the sky should be done through enhanced artificial recharge.

Figure 9 resumes all the stakeholders involved, their role and their different scales of action

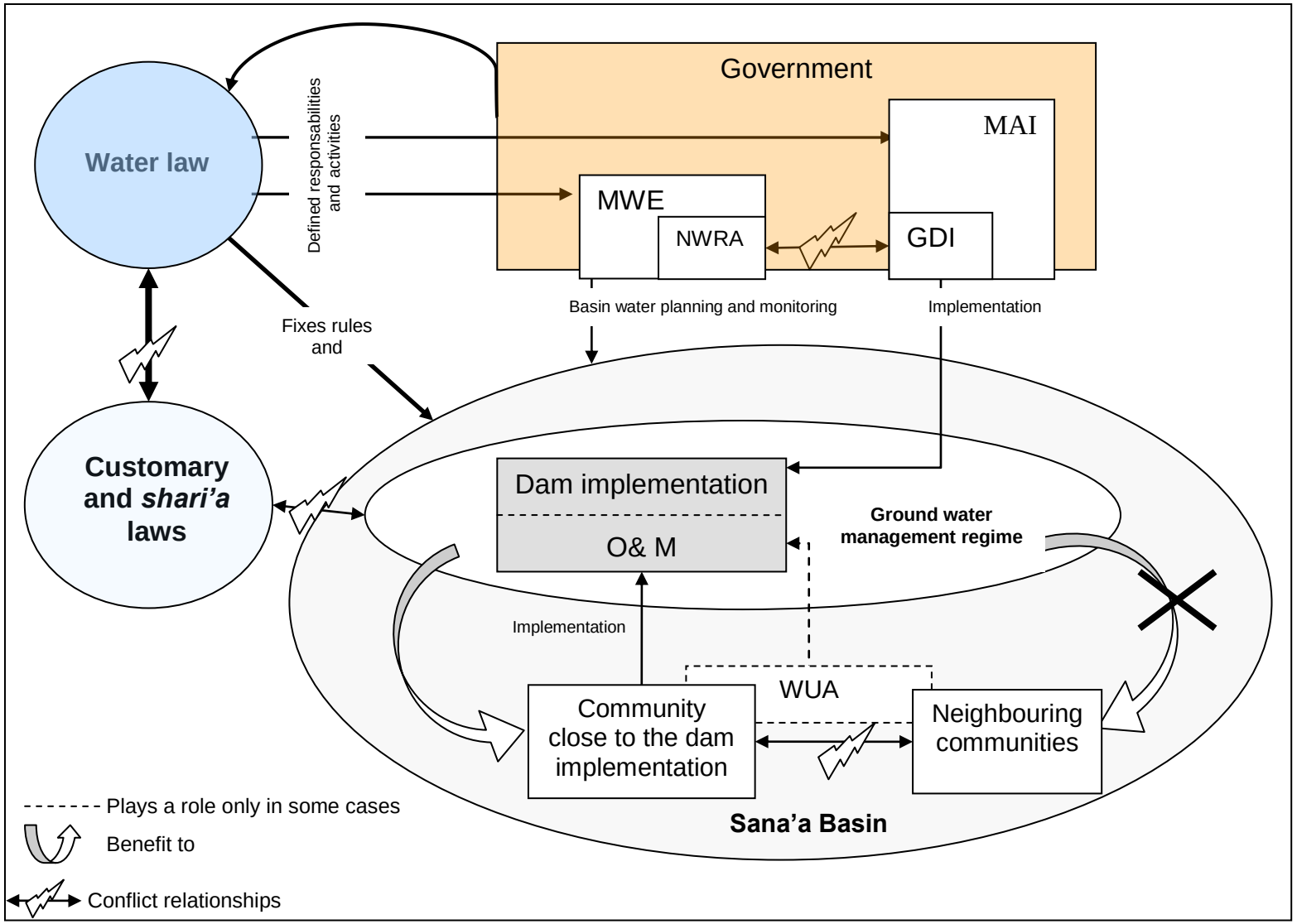

Figure 9: Stakeholders analysis

5.3 Future research agenda

Demand management and related policies

- Irrigation efficiencies: how efficient are the conveyance and application practices in Yemen (for certain crops e.g. qat and grape in Sana'a basin): Shedding light over the confusing and conflictive accounts within literature, with field data and research
- Demand management: How can a demand management approach be sustained if the irrigation efficiencies already seem to be close to optimal? Alternative cropping and reduction of cropping area. (it would seem that there is an unsustainable amount of cropping area and a cultivation of crops which require a lot of water)

Water distribution in communities

- Water distribution agreements within a community; how is water shared, amongst shareholders
- Water distribution agreements within a community; how are the benefits of recharge from a dam distributed within a community (does one benefit more than others), what are the internal mechanisms of sharing water, How was the locations of a dam decided within a community

Institutional / Organisational Policy

- Irrigation water within the MAI or the MWE: Irrigation as water or an act of Agriculturalists

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Annex – Additional presentation slides

(International Seminar on Challenges of Integrated Water Resources Management, March 15 – 17, 2010. Water and Environment Centre, Sana'a University, Yemen.)

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Putting ideas forward

- controlled releases of the dam (spate rules & recharge of dug wells, distribution network, multiple basins)
Note: rehabilitation, placement of valves (alternative operation) – infringement of water rights

- Involving Local People in Monitoring
Note: participatory hydrological monitoring - common local agenda on groundwater management

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Putting ideas forward (cont'd) – shared responsibility

- Shift in subsidies, from pumping stimuli to fallow land / agricultural commodity (less m^3/ha/yr) subsidies

- focal shift from demand management to the unsustainable amount of cropping area and the cultivation of crops which require a lot of water

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Future research agenda

Demand management and related policies

- Irrigation efficiencies: how efficient are the conveyance and application practices in Yemen (for certain crops e.g. qat and grape in Sana'a basin): Shedding light over the confusing and conflictive accounts within literature, with field data and research
- Demand management: How can a demand management approach be sustained if the irrigation efficiencies already seem to be close to optimal? Alternative cropping and reduction of cropping area. (I
- Sana'a basin plan, combining water accounting with landuse and alternatives (economically attractive for agricultural sector

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Future research agenda (cont'd

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