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Support to Local Actors in Water Scarce Regions for Sustainable Management of Water Resources on Community Level

Short-term Mission Report:
Preliminary Evaluation of the Potential for Improving Sanitation and Water Management

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Preliminary Evaluation of the Potential for Improving Sanitation and Water Management
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TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

SUMMARY

The aim of the executed mission was the evaluation of existing drinking water and sanitation systems to provide information on major opportunities and obstacles to water use and reuse as well as sanitation improvement in the project area.

14 villages in four districts Dhi Bin, Kharef, Khammer and Al Sudah have been visited with the focus on the situation of water supply and sanitation.

Most of the villages have a cistern for rainwater collection and use of water in households. In a few regions cisterns are the single water source and in all regions the poor people also use the water for drinking purposes. In a few villages the cisterns are too small for sufficient supply. In most of the cases the water quality of the cisterns is poor because of shortcomings in the construction and the missing of regular, proper maintenance.

Sanitation systems, which meet hygienic standard requirements, hardly exist. Only few houses are equipped with bathrooms and toilets and have an open disposal without any further treatment. In most of the houses liquid excreta and wastewater (personal cleaning) are disposed manually or through an open outlet. Human excreta (faeces) are widespread by open defecation or by open disposal of the faeces. The existence of diseases is an indicator for the limited knowledge towards water related infections caused by water supply by cisterns as well as by sanitation.

The proposals made in this report for the improvement of the water supply situation are very close to the existing situation. Cisterns can be improved by constructional measures, but have to be supported by a regular maintenance service and supervision of a cistern management committee.

The sanitation situation is characterised by the difference in use by genders and being a shameful issue. Therefore, an improvement of the sanitation system has to be in accordance with the tradition and cultural constraints. The proposal for improvement is based on the reuse of water and its nutrients (grey water beds) and the use of excreta as organic material (compost). A dry toilet system is suggested.

For most of the villages various improvements of the water supply can be identified, three villages with an urgent demand are proposed with priority.

For the sanitation improvement one village is proposed for the implementation of a demonstration project. In another village an integrated project of water and sanitation management for the mosque and school appears to be possible.

Based on results of the report an awareness campaign concerning the relation between health and water and sanitation has to be prepared.

The next mission should be focussed on the development of technical guidelines for the improvement of existing cisterns and their management and the preliminary design of the sanitation demonstration project.

For water management and sanitation, it can be stated that the success and long-time improvement depends to a big extent on proper operation and maintenance of the systems.

1 INTRODUCTION

The Water Sector Programme “Institutional Development of the Water Sector” supported by the Federal Republic of Germany consists of five components aligned with the National Water Sector Strategy and Investment Plan (NWSSIP) supporting the Yemeni Government on macro, meso and micro level projects. Component 5 of this programme is named as “Community-based Water Use in Water Scarce Areas (Amran)” and is the most locally focused activity in the programme and works with its first phase from 2007 - 2009. The project team is providing support to district and governorate administration and to non-governmental actors in 4 districts (water poor areas) in Amran governorate. Special support is being provided to women’s groups.

In the context of this component a preliminary evaluation of the potential for improving sanitation and water management should provide information on major opportunities and obstacles to water use and water reuse improvements as well as to sanitation in the project area. An initial selection of appropriate technologies for the improvement of water use and sanitation technologies should be identified taking in consideration the socio-economic and physical conditions of the project area.

Opportunities and obstacles to improve the use and reuse of water as well as to improve the household and community sanitation in the project areas will be described. This is done in partnership with the project team and local partners.

Based on this information, specific recommendations for activities and their timing will be made for the improvement of the prevailing situation concerning water and sanitation systems.

2 VISITS OF THE PROJECT DISTRICTS

2.1 Situation of villages and water supply

During four days 14 villages in the four districts Dhi Bin, Kharef, Khammer and Al Sudah have been visited together with a local expert and members of the project team. The villages, their specific data and their supply status are given in Table 1.

The villages have a size from 262 (Dobr Kanet) up to 1,546 (Markas) inhabitants (34 – 217 houses). The average density of population is 8.5 capita per house with a range from 5.0 (Al Akhwa) to 12.4 (Kharfan).

The houses in Dhi Bin are mainly located on a plateau above Amran basin. The same situation is found for the villages of Kharef, but Bait Al-Gerba is located in the Amran Basin, and Al-Dimnah is on top of a small plateau located in the basin surrounded by agricultural land. The villages of Khammer are found on the slopes of the mountains with partly very limited access for trucks. Small vehicles only can reach the Al Sudah region because the road is unpaved and only suitable for 4-wheel-drive vehicles.

Four of the 14 villages have a fulltime supply of electricity, two have electricity only 6 hours per day (6 pm to 12 pm). In the other villages electrical installations are found in the houses, but the connection to a generator will only take place for specific events (weddings, visits etc.).

Table 1: Villages visited during the mission and their supply status

District / Village	Altitude [m AMSL]	Population [capita]	Houses [-]	Popul. per house [cap/house]	Electricity	Source Drinking Water: pipe	Source Drinking Water: tanker	Cisterns	Cisterns [m^3][4]
Dhi Bin									
Khaseini		616	74	8.3	-	+	+	+	
Kharfan		1,028	83	12.4	+	(+)[2]	+	+	
Solan		566	49	11.6	-	-	+	+	4,100[5]
Khuhol		625	83	7.5	-	-	+	+	144
Kharef									
Dobr Kanet	2,641	262	34	7.7	+	-	+	+	
Beyt Hagairah	2,647	345	38	9.1	?	-	+	+	
Sudah Village	2,701	436	50	8.7	-	-	+	+	
Bait Al-Gerba	2,237	510	56	9.1	+	-	+	+	
Al-Dimnah	2,224	646	65	9.9	+	-	+	+	
Khammer									
Al Mawajel	1,873	410	66	6.2	-	-	(+)[3]	+	
Al Sabha	1,906	589	79	7.5	-	-	(+)[3]	+	
Al Sudah									
Al Khoff	1,818	n.a.	n.a.		(+)[1]	-	-	+	
Al Ahkwa	1,934	860	171	5.0	(+)[1]	-	-	+	
Markas	1,788	1,546	217	7.1	(+)[1]	-	-	+	
All villages		8,439	1,065	8.5					

Legend:
+ yes
- no
? unknown
n.a. not available

[1] from 6 pm to 12 pm
[2] no connection to water source
[3] only 300 L per ride (pick-up)

[4] when data available – has to be specified
[5] two cisterns (3,600 + 500 m^3)

Only one of the villages is supplied with water from a well by a network (Khaseini). The well is located in a distance of approx. 500 m from Khaseini and supplies Upper Khaseini as well as Lower Khaseini. The inhabitants have to pay a fee for the water supply; the water committee of the village operates the technical installations. Most of the houses are connected to this network, only poor people, who cannot afford to pay, have to use other water sources like the waterholes in the Wadi nearby. The village Kharfan has a water network, but the connection to the transfer pipe from another village is still interrupted.

Tankers can deliver the other villages in Dhi Bin and Kharef. In Khammer the access by roads can be managed by pick-ups only, which deliver approx. 300 litres per ride. Due to the condition of the unpaved road in Al Sudah the supply by vehicles is not possible. This will change partly when the road will be paved; this has been agreed with an Indian contractor and will begin soon.

All the visited villages are equipped with one or more cisterns, which are fed with rainwater during the rainy season (May – August (September)), this water has to be stored in the cistern and used during the dry season.

The officials of the village frequently gave the information that the water from cisterns is not used for drinking purposes. The delivered water is used for this purpose. But obviously the population uses the cistern water for drinking, especially the poor people who cannot afford to pay the delivery of water (up to 5,000 YR per tank) (Figure 1). Also the region Al Sudah with no other water sources has to rely on water from the cisterns.

Figure 1: Young boy using the cistern water for drinking

3 PREVAILING METHODS OF WATER USE

3.1 General

The cisterns are an important factor for the supply of the population in remote areas of the districts. They are located as public sources either inside of the village or nearby; only small numbers of private cisterns exist. Most of the cisterns are open basins; only in two villages caverns in the rock are used as a cistern. In Beyt Hagairah they are still in use (Figure 2), in Sudah village 150 of these caverns are known but not in use any longer. Because of the size of the access holes and the low water level the water uptake is a painfully slow process.

Figure 2: Water uptake from a cavern in Beyt Hagairah

The assessment of cisterns as a water source is linked to the quantity (volume, time of availability) as well as to the quality of the water.

In general the water of cisterns is used for different purposes: Washing and cleaning, feeding of animals and as drinking water for human beings. In a few cases the water is also used for the water flush of toilets (flushing with a cup or a small bin), but this depends on the existence of a Turkish toilet and the transport capacity for water fetching.

These topics are discussed in the next chapters in detail, before recommendations for the improvement of the cisterns as a water resource are given.

3.2 Health issues

As a result of the prevailing water use the health of users is affected. The knowledge about these health risks is often very limited. In various villages the people report the existence of different water related diseases: bilharzias, kidney diseases, malaria. In Al Mawajel people assume one person dying yearly by the use of water from the cisterns.

The pollution of the cisterns is made both naturally and by human beings. Dust from the air as well as transported by the pots or users' shoes pollute the water and can be seen at the surface of the water (Figure 3). In addition garbage is thrown into the cistern and can be found at the surface as well as on the bottom in the sludge. Because of the open surface the sun heats up the water, algae are blooming and pathogens may survive easily in the organic matters. Supported by organic material which is transported by the rain from polluted catchment areas (see below) a biological degradation by microorganisms takes place, which can be seen by gas bubbling up (methane produced by anaerobic degradation processes).

Figure 3: Pollution of the water in different cisterns

Furthermore, larger microorganisms (worms, larvae, insects) can be identified in the water and have a good reproduction environment in the warm water. Thus it is not surprising that pathogens and other health related organisms might survive in the cisterns easily and find a way into the human body by different intakes (oral and via the skin).

In Al Akhwa where three latrines are located nearby, people use one cistern for drinking purposes (green colour - Figure 4 left) and two others for other purposes (brown colour - Figure 4 right).

Figure 4: Water uptake from a cavern in Beyt Hagairah

Due to the open construction and the possible pollution by the dirt from outside (air, catchment area, waste disposal etc.) the water from these cisterns has a significant negative impact on the health situation of the population.

3.3 Gender issues

The water business is women's activities and responsibility in the household. Women use different containers for the transport of water (jars, buckets, open bowls). They are filled in the cistern (Figure 5) and carried on the head upstairs and to the households.

The survey undertaken by the project shows that women are complaining about the elevation of the filled containers on their heads, the different ascent on the steps in the cisterns and the heavy loads on their heads during the way of transport. Women can carry approx. 20 litres as maximum per ride. In rare cases donkeys are used for the transport; then approx. 60 litres are transported.

Figure 5: Water uptake from a cistern

A few cisterns have a baffle installed (Figure 5 bottom centre) as an access from outside the cistern. Sometimes a pulley for a rope is installed (Figure 5 bottom right). But women prefer descending into the cisterns instead of using these installations. Probably the handling is too complicated because of the difficulty in dumping the empty jerry cans as well as in handling the filled jars from the rope.

3.4 Cultural constraints

The use of water from the cistern is well accepted by the population because the tradition of the use of cisterns is a very old one. Cisterns are mainly public installations, but taking the responsibility for proper operation is very low (see chapter 3.6).

3.5 Construction

Old cisterns are mainly made of stones plastered for water tightness („Kahdad“) (Figure 6 left). The form is circular and integrated into the rock. The walls are not vertical because of the lack of stability; the walls have a slope and therefore the bottom area is slightly smaller than the top area. Sometimes the walls of the cistern end 1.00 – 1.20 m above the ground as a protection for children and animals not to fall into the cistern.

Most of the new cisterns are rectangular and made of stones and sometimes plastered with a cement plaster (Figure 6 right). Only the cisterns funded by the Social Fund of Development have a fence as a protection.

All of the cisterns in the villages have an open surface. Through this, an open access exists for many kinds of pollution: Birds can enter the water surface, garbage is disposed into the cistern, and dust is fixed at the surface. Cisterns, the top end of which is on the same level as the surrounding area, additionally have an open access for any kind of garbage, and there is a risk that children or animals may fall into the cistern (Figure 6 centre). Furthermore the exposition of the surface enables the input of UV radiation and the growing of algae and other water plants (supported by the input of nutrients by the human beings and the material transported into the cistern). The related increase of temperature also accelerates the growing of plants and microorganisms. The green colour of the water caused by algae and duckweed is an indicator for this mechanism.

Figure 6: Different types of cisterns

The direct radiation and missing coverings of the cisterns lead to a substantial evaporation of the cisterns water. A theoretical calculation shall show the huge impact of the evaporation:
Evaporation rates for another area in Yemen are stated as 12 – 16 mm/d with a yearly average of 14.3 mm/d [1]. Based on the given monthly values evaporation for the period August – February can be calculated as 2,844 m. This means for a cistern with a depth of 6.0 m a loss of 47 %. Although the data for the Amran area may be different, the magnitude will be analogical and documents the huge loss of water by evaporation.

The identification of the catchment areas of the cistern is often very difficult. The size of the catchment areas varies from the area of the cistern itself to areas located nearby with a decline towards the cistern. The catchment areas are often very dirty, polluted by civilization waste (plastic parts, cans etc.), mud, dust and straw as well as by excreta from animals and human beings. During the rainfall this garbage is flushed into the cistern and will be collected at the bottom of the cistern as bottom sludge. Here the biological degradation process described above takes place.

In many of the installations a stone and sand trap was constructed that should reduce the input of polluting material (Figure 7). This trap can only work if the velocity of the incoming water is reduced in order to allow the solid materials to settle in the sand trap. When the chamber is very small and has the same cross section like the inflow (shown in Figure 7) water will overflow the chamber only, and no sedimentation will occur. In this case the trap has a limited effect and all the material will be transported into the cistern. Many sand traps were found undersized.

Figure 7: Catchment area and sand trap of cistern

3.6 Management

In all villages the management of the cisterns was found poor. People reported the frequency of cleaning the cistern in a range of several years or even in some cases never occurring. The amount of mud, sand, stones and garbage in the cistern confirms this attitude (see Figure 8).

The condition of the catchment area in which all forms of garbage can be identified is also an indicator for inappropriate management. In one case animals have been seen directly nearby the cistern (Figure 8 right), allowing animals excreta to pollute the water easily.

Figure 8: Dirt due to lack of management

Missing awareness and limited responsibility of the cisterns users may cause the inappropriate management of the cisterns.

3.7 Cisterns at the mosques

Cisterns at the mosque are different from public cisterns concerning their smaller size and the use of their water. Usually roof runoff of the mosque buildings feeds these cisterns.

Whereas water from public cisterns is used in households for different purposes, the cisterns at the mosques provide water for body cleaning purposes only. The water is taken out for the washing procedure in nearby small washing cabins or the cabins are located at the cistern and the water remains in the cistern after washing (Figure 9). In the last case water and dirt remain and accumulate in the cistern and will be biologically degraded. Each addition of mainly organic material (urine, garbage etc.) affects the quality of the water.

Figure 9: Cistern at a mosque and washing place (Al Mawajel)

In many cases the quality of the water is much better than in public cisterns, which may be explained by the protected locations (walls around the mosque area) and the lower user frequency.

3.8 Social Fund for Development activities

The Social Fund for Development (SFD) supports the villages with the building of cisterns. For the construction of the cisterns the SFD uses the following design criteria:

Yearly precipitation:	h = 250 – 300 mm/year
Specific volume cistern	
until 2007	V_{sp} = 25 L/(c x d)
since 2008	V_{sp} = 20 L/(c x d)

The specific volume is calculated for each location because it is the difference between the water consumption rate (20 L/(c x d) and the water volume, which is transported by trucks or manually from the well for drinking water purposes.

Volume of the cistern:
V_{cist} = I x V_{sp} x 30 days x 6 months
(6 months because of 2 rain seasons – February - July)

With this data the volume for every inhabitant can be calculated:

Cistern volume per person:

V_{pers} = 1 c x 20 L/(c x d) x 30 days * 6 months / 1,000 = 3.6 m³

The catchment area is calculated on the base of a mass balance: The volume of the cistern must be less - or equal - than the volume of rainwater from the catchment area:

$V_{cist} \leq V_{RW}$

$V_{RW} = A \times h / 1{,}000 \times \varphi$

A [m²] catchment area

h [mm] yearly precipitation

φ [-] run-off coefficient – range 0.2 – 0.5
depending on the sealing of the surface of the catchment area

With these equations the size of the catchment area can be calculated as follows:

$$A \geq \frac{V_{cist} \times 1{,}000}{h \times \varphi}$$

For an area, which is less sealed and where water can infiltrate easily into the ground (φ = 0.2), a catchment area of 72 m²/c has to be foreseen for each person. For an area that is more sealed and on which the water is not so much infiltrating (φ = 0.5) the specific catchment area can be calculated to 29 m²/c.

The catchment area is the sum of the area of the cistern and the area from which the water flows into the cistern.

The SFD usually supports open cisterns, only in areas where no drinking water is available the cisterns will be covered.

The construction costs for the cisterns given by SFD are attached as Annex 1. Normally the excavation has to be done by the community as well as the delivery of the stones for the wall. SFD finances the additional materials and the labour costs.

Remarks to the design criteria of SFD:

There are a few things, which need further investigation by the GTZ project:

The specific volume of the cistern is equal to the daily water consumption rate of 20 L/(c x d). This target has to be specified by the project through a survey.

The evaporation of water in the cistern has not been taken into consideration. This has to be measured and calculated or otherwise the cistern has to be covered to avoid evaporation.

The duration of the rainy season and the rain intensity have to be checked on the basis of the rainfall data.

4 PREVAILING METHODS OF SANITATION

4.1 Situation of sanitation in the four districts

The situation of the existing sanitation facilities is very similar for all the 14 villages in the rural areas of the four districts.

Sanitation facilities generally do not exist; therefore the prevailing methods can be described very easily and without any further differentiation.

Only a small number of houses have a toilet room. This room is normally equipped with a Turkish toilet, which is flushed with water stored in a container nearby (Figure 10). Of course this equipment needs water, which has to be transported from a water source nearby.

The outlet from the bathrooms ends out of doors (Figure 11). Here the faeces accumulate at the surface of the soil and liquid rinses away or infiltrates into the ground. From these places pathogens can be transmitted by flies, direct contact or by rainwater to the human living cycle and may cause infection and diseases (see chapter 5.2.1).

Figure 10: Toilet rooms with water cans for flushing

Figure 11: Outlet of the toilet room

In one village the house owner uses faeces and wastewater from the outlet (Figure 11 right). He covers the faecal matter occasionally with ash and uses the material later on his fields as fertiliser. The liquid part of wastewater feeds plants (reed); there is a small benefit from the wastewater use. Nevertheless this is also a kind of open accumulation of faeces and has negative health and social impacts, particularly in terms of diseases such as diarrhoea and cholera.

Most of the people do not have a toilet room as described above and use other ways for their excreta. The way and people's behaviour are gender-related. Inside the houses there can be found washing places (Figure 12), which are used for washing and also for urination. The liquid rinses either via a pipe outside the house or is collected in containers and is emptied outside the house. Women and old people use this place also for defecation; the faecal material is collected and also discharged in the out-of-doors. Sometimes the defecation takes place into plastic bags and the bags are thrown outside through the window.

Most of the men and some of the women are defecating in the open nature. This has also a very strong relation to health issues and can cause diseases as well.

The knowledge and acceptance of the use of faecal matter as fertiliser is not very widespread in the regions. Only in one village a farmer is collecting the faecal matter on a specific place and adds ash on it (Figure 13). During the cultivation time he uses the material as fertiliser. Animal excreta are not added because these are dried and used as fuel for cooking in the kitchen. But the ash after burning is added to the faecal matter like described above and used then afterwards.

Figure 12: Traditional washing places inside the houses

Figure 13: Place for disposal of faecal matter

Only in one village was found a public toilet (Figure 14). A stone building is equipped with four chambers for defecation with a very low entrance. The faeces fall down into a collection chamber, which has an access from the back on a lower level. This is a typical dry toilet, in which the faecal matter is stored and dried during the storage. Unfortunately the rear entrances were not closed; hence the contaminated stones are reused for anal cleaning and widespread around the toilet. Through this the toilet is used in a wrong way due to missing maintenance.

Figure 14: Public toilet in Al Mawajel (Khammer)

Following the explanation of the inhabitants of the village the toilet is mainly linked to the mosque and the small school nearby. They have not been very willing to give information about the toilet, its use and its operation.

4.2 Cultural constraints

The discussion about sanitation issues like urinating and defecation is a very private one and the people are not very open-minded talking about this.

Mainly men were not very willing to talk about their behaviour. During the questioning about the public toilet in Al Mawajel and its use and maintenance the answers have been very vague and the men intended to change the talks to another topic. In opposite to this the women were more willing to answer the question, but only when asked by a woman.

Only the farmer, who sees the faecal matter as a resource for his fields, was more willing to give detailed information.

It is very obvious that finding improvements on sanitation issues with the inhabitants of the village will be a very sensitive topic.

4.3 Gender issues

The behaviour concerning the human excreta is gender related. Women are mainly using the facilities inside, although any comfort is missing. Only in rare cases women are doing an open defecation on the fields.

For men the open defecation is very common and it seems they prefer open defecation instead of using the rooms inside the house.

Normally women are responsible for the cleanliness of sanitation installations and they keep them useable. Women assist children, the aged and the sick with their hygiene and sanitation needs. Therefore it should be ensured that women are involved in the decision-making processes for sanitation systems.

5 RECOMMENDATIONS FOR THE IMPROVEMENT

5.1 Water use

It is obvious that also in future the use of rainwater for household remains an important water source. The utilisation of rainwater is an effective solution to provide rural drinking water because especially in locations with a higher altitude the access to drinking water from wells is not possible, nor its transport to the villages.

The water is used for different purposes in the households:

- Consumption (drinking and cooking);
- Hygiene (including basic needs for personal and domestic cleanliness);
- Amenity use (for instance car washing, lawn watering);
- Productive use (animal watering, construction, small-scale horticulture).

The first two categories ‘consumption’ and ‘hygiene’ have direct consequences for health both in relation to physiological needs and in the control of diverse infectious and non-infectious water-related diseases. The two other categories ‘amenity’ and ‘productive use’ may not directly affect health in many circumstances.

An estimation of the volume of water required for hydration is given in Table 2.

Table 2: Volume of water required for hydration [2]

	Volume [litres/day]		
	Average conditions	Manual labour in high temperatures	Total needs in pregnancy/lactation
Female adults	2.2	4.5	4.8 (pregnancy) 5.5 (lactation)
Male adults	2.9	4.5	-
Children	1.0	4.5	-

The high number of kidney diseases reported by the people is a hint for low drinking water consumption. In [2] it is stated: “Urinary stone formation is significantly increased when the urine volume excreted is below 1 litre per day; urinary volumes exceeding 2 to 2.5 litres per day can prevent recurrence of stones in previously affected patients (Kleiner, 1999). White *et al* (1972) suggest that in order to reduce the risk of kidney stones, a minimum of 1.5 litres should be passed as urine each day.“

The daily water consumption depends mainly on the distance to water sources and the time for transport of water from the source to the households. In [2] the relation of the daily water consumption and the return trip travel time is given:

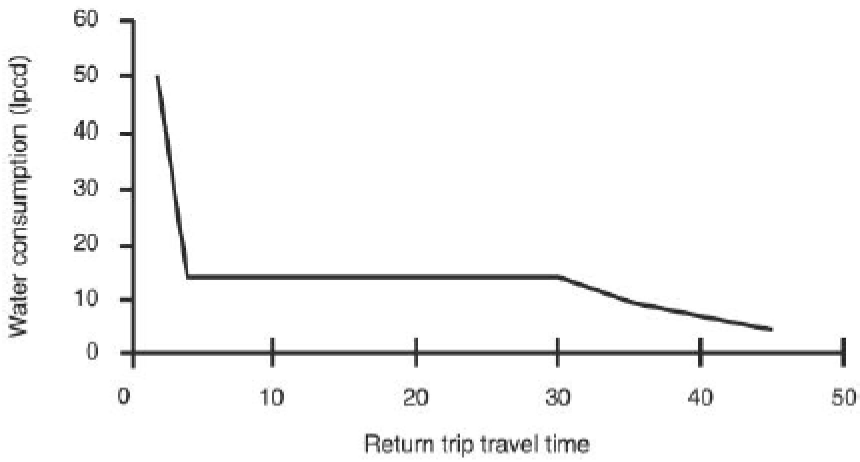

Figure 15: Travel time (in minutes) versus consumption [1]

The design criteria 20 l/(c x d) of SFD seem to be in accordance with the data given in Figure 15. An improvement of the water service (see chapters below) will have an impact on water consumption rates.

Consumption rates for the water use in the households in the four districts have to be determined in a survey to gain a database for the proper water consumption.

5.1.1 Awareness

Bad condition of the rainwater harvesting installations is an indicator for a missing awareness of the population towards their drinking water supplies.

The main message of all awareness campaigns has to be:

Water is essential for living;

Good water quality means strong health;

Cisterns control living conditions and health.

A local cistern committee should be installed for the management of the cistern. Such a committee is responsible for the cleanliness, the regular cleaning and the proper operation of the cistern. Furthermore it supports activities of awareness campaigns.

Awareness campaigns have to create the awareness with the following targets:

- People know the hygienic impacts of the cistern. Bad water quality caused by bad conditions of the cisterns can cause diseases and has an impact on health;
- The relation between bad water quality and pathogens is known;
- Cistern water for drinking purposes has to be purified (e.g. by clay filter) to get a healthy drinking water;
- People get aware of how using the cistern. They know about the proper use of the cistern and take care of the cistern (e.g. no garbage thrown into the cistern);
- Entering the cistern increases the pollution of the water;

- The area around the cistern has to be tidy and has to be cleaned at least before and during the rainy season. This includes the surrounding of the cistern as well as the catchment area;
- Cisterns have to be cleaned frequently. This includes the removal of sludge as well as the removal of algae, duckweed and water plants;
- The surrounding of the catchment is a protected zone. No animals and other activities, which can cause pollutions, are allowed around the cistern;
- The sun warms up an open cistern. This increases the temperature of the water, supporting the growth of plants, microorganisms and pathogens in the water body. A cover can avoid this and may cool down the water. Furthermore it reduces the dissemination of malaria because of a reduced mosquito breeding.

Cisterns at the mosques are in most cases closed water systems. People wash themselves in this area. Urination into the cistern during washing has to be avoided. Water from the cisterns at the mosques is not for drinking purposes but only for washing.

5.1.2 Construction issues

The improvement of cisterns by constructional changes may work on different levels. Different possibilities are listed below and can be seen as a guideline for the actions. First topics are quantity-related ones; all others are focussing on the quality of water.

Location

Cisterns are mainly located outside the village with the disadvantage of long distances for water fetching. Only in cases with limited space for the villages in the districts Khammer and Al Sudah, the cisterns are in the inner part of the village. In the last case the catchment area as well as the cistern may be more polluted by animals and users.

Volume

The volume of the cisterns depends mainly on the water consumption of the users. Too small cisterns will be emptied before the end of the dry season and people have to look for other water resources, mainly transport of water from other sites. Therefore, the volume of storage is the most important factor.

SFD works with a specific volume of 3.6 m^3/person (20 litres/(c x day), the Public Works Project in Sana'a with 40 litres/(c x d) [1]. This specific volume depends mainly on the water consumption of the users. This will probably increase when the access to water becomes easier and the water transport less time-consuming.

Before the number of specific cistern volume is fixed for next steps the water usage in the households should be confirmed by the survey.

Based on this data the specific volume of the cistern can be estimated in discussion with the existing values.

Catchment area

The catchment area should be marked as a protected area (e.g. by stones) to be recognisable for everybody. Furthermore, the catchment area has to be distinguished in natural areas and areas, which are used by animals and human beings. Natural catchment areas with less usage have a low pollution potential. For the other areas the protection should be enhanced, e.g. by a fence. It is not allowed to use these areas for animal grazing, defecation, and disposal of garbage.

The area as well as the canals leading to the cistern have to be kept clean. It needs to be controlled and cleaned regularly at the beginning of the rainy season.

In case the cistern never completely fills, the dimensions of the catchment area has to be controlled (length, width etc.).

The catchment area has to be sufficient to deliver enough water into the cistern for filling itself. The way of calculation of the catchment area is described in chapter 3.8. Based on meteorological data (rainfall, evaporation etc.) the way of calculation has to be verified. Furthermore an addition of 20 % should be made for the consideration of climatic changes.

Coverage of the cistern

The coverage of the system is the main issue for the improvement of the water quality. By this way the entrance of all undesirable substances, the UV radiation and heating can be minimised. Entering of human beings as well as animals will also be reduced.

For an increase of the useable water volume, coverage is strongly recommended. The coverage reduces the evaporation and more volume of the water can be used.

For the coverage of the cistern different material can be used:

- Ferro cement (mainly for small cisterns);
- Steel beam construction with painted iron plates;
- Reinforced concrete with columns of concrete or bricks for the structure;
- Steel beams with fibreglass plates.

All materials have to be protected against corrosion by condensed water and UV radiation.

Rainwater from the roof of the cistern has to be given into the influent of the cistern.

Following details are important for the construction of the coverage:

- Ventilation of the cistern;
- Entrance of light has to be reduced.

An example for the coverage of a cistern can be seen in Al Abr (Figure 16). The cistern was covered with a steel beam and painted metal sheets approximately two weeks ago. The costs for this were 5,000 US$ financed by SFD. The village Al Abr has contributed 1/3 of the costs. The cistern is closed by a door, which is locked. Opening times for access to the cistern is daily from 9 am to 10:30 am.

For water fetching women have to enter the cistern by steps and get up water from the open surface. Because of the coverage the temperature in the cistern is relatively low and the humidity is acceptable.

Figure 16: Covered cistern in Al Abr (Khammer)

In spite of coverage the inner part of the cistern is rather bright and no obstacle for mosquito. An optimisation of the coverage is given in Figure 17. Here the light entrance is minimised and good ventilation can take place. For this construction an opening for a light entrance during maintenance works is necessary. Furthermore the water uptake has to be made with a pump because the entering of the cistern is not longer possible.

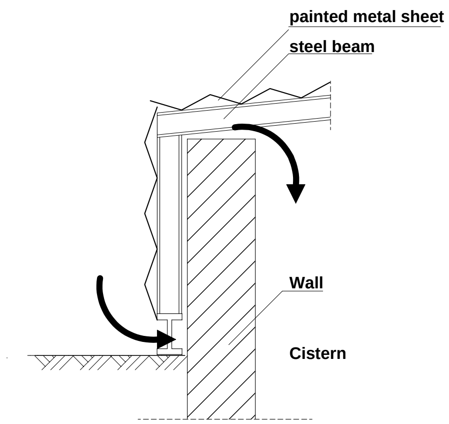

Figure 17: Optimised coverage for a cistern with ventilation

The effort of coverage is largely influenced by the cistern shape. Small and long cisterns can be covered more easily than square ones. Therefore, the long tall forms should be preferred when building new cisterns.

Entrance

When the cistern is covered a controlled entrance is necessary. Therefore a metal door with a lock should be installed. The cistern will only be entered for maintenance purposes. An access for the women for water uptake is not necessary because the water withdrawal will be made through a pump or a pulley outside the cistern.

Withdrawal

Withdrawal or uptake of water shall be separated from the cistern for protection purposes. Different solutions are possible and will be described. For all withdrawal solutions a separate manhole inside the cistern is recommended. An example for the installation is given in Figure 18. A filter composed of gravel and sand keeps the pollution out of the manhole. The filter is connected with the manhole by a drainage pipe. The water level will be the same in both compartments.

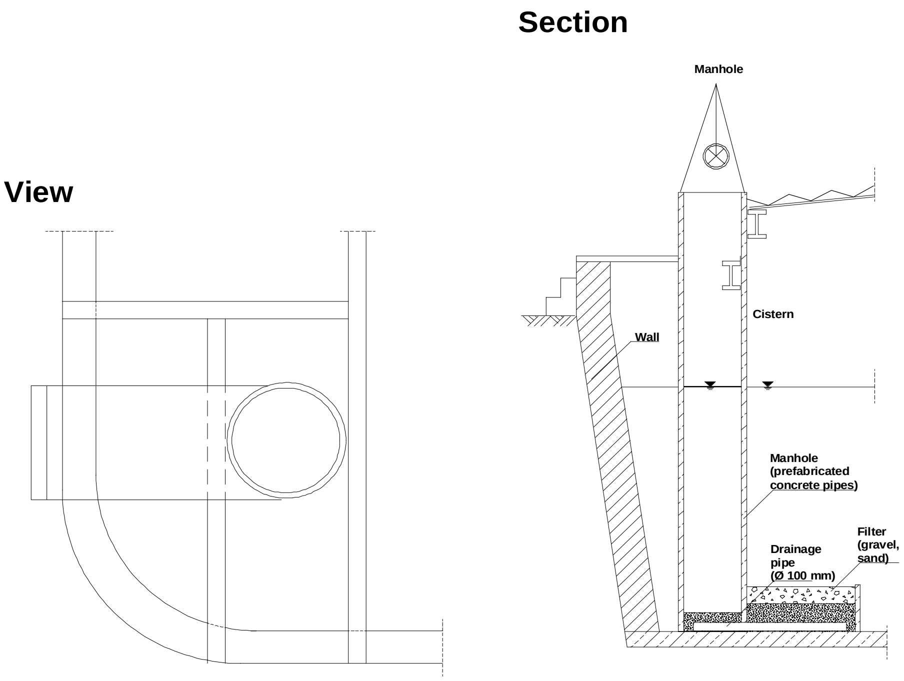

Figure 18: Installation of manhole and pulley at the cistern

The size of the filter depends on the water taken out by the manhole. Dimensioning figures for the design will be given in the next phase after determination of data for water consumption etc.

This installation can be adapted to existing cisterns in most circumstances. In addition to the coverage, this is a very cheap way of upgrading a cistern.

Pulley

An easy way for water withdrawal is the installation of a pulley. At the end of the rope a bucket is fixed for the water extraction. This solution is similar to the traditional well system. This system avoids descending down to the water level into the cistern for the women. The rope as well as the bucket fixed at the rope are part of the installation and have not to be transported by the women.

Hand pump/ pedal pump

The next step of development is a pedal pump or a hand pump installed at the manhole. The women's water containers can be placed under the pump and will be filled by pumping. In this case the distance for water transport is the same but the water extraction is easier. SFD reports about places where people did not like the hand pump as water withdrawal was perceived being time consuming. With the awareness campaign the benefits of such a system may be promoted.

Electrical pump

The luxury version for water withdrawal is the installation of a solar-driven electrical pump. This pump can even pump the water in a small storage tank or basin nearby the cistern, from which the water is taken up by the women or pumped into a water tank for the village (Figure 19 - top). This minimises the time effort for water transport significantly.

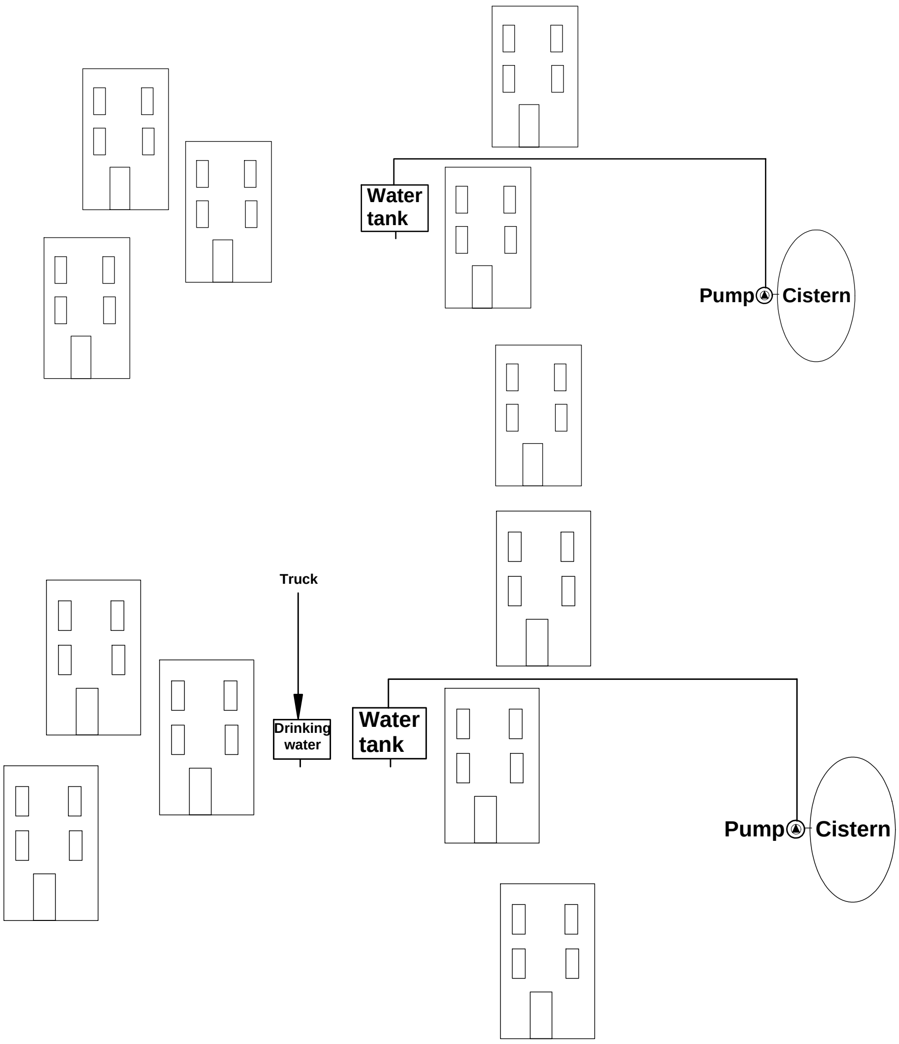

Figure 19: Possibilities of operation of the system with a pump

In villages with access to imported well water a second tank can be installed, which will be filled with water from tankers (Figure 19 - below). Management of both tanks is consequently necessary.

In both cases the water use will increase notably because the effort of fetching water is reduced by short transport times.

<u>Sand trap</u>

The sand traps can only operate when the inflow velocity of the water is reduced and the sand has the ability to settle. Traps described in chapter 3.5 do not assure this because the inflow section is not widened and the flow velocity therefore not reduced.

An improvement of the sand traps is given in Figure 20.

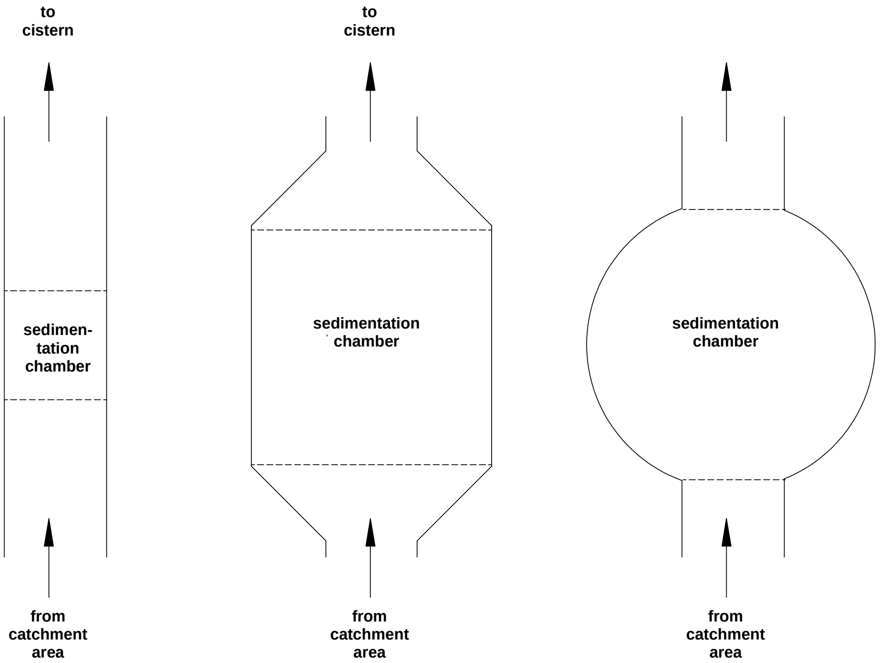

Figure 20: Different forms of sand traps
(left: existing traps, centre and right: improved sand traps)

The dimensioning of the sand traps can be improved when the data that have to be determined are available.

Fencing

With regard to cisterns that are difficult to cover, a fence should be installed for their protection as a first step. This fence can either be a mesh wire fence or a fence of columns and metal elements. This fence shall be equipped with a door allowing maintenance staff only access to the cistern.

Other aspects

Especially in the village areas, roof areas may extend the catchment areas. Rainwater from roofs usually contains less pollution and shall be used directly for cistern filling.

As a conclusion the described improvement measures for rainwater harvesting are listed in Table 3 with identification of risks and benefits.

Table 3: Overview on the possibilities of the improvement of rainwater harvesting with cisterns

Action	Benefits / Advantages	Risks / Disadvantages
Enlargement of the volume	More water available	High investment costs for construction
Regular maintenance (cleaning etc)	Reduction of the pollution of the cistern	Maintenance will not be done or not properly
Improvement sand trap	Removing of sand, mud before entering the cistern	Removal of the sludge will not be done
Marking/Fencing of the catchment area	Protection of the catchment area Reduction of the pollution of the cistern	Marking will not be accepted Fence will be destroyed
Fencing of cistern	Protection of the cistern	Fence will be destroyed
Single access (manhole)	No descend to the water level No contact with the water in the cistern	Manhole will not be accepted
Single access (manhole) with filter	Removal of solids, algae, insects etc.	Filter may clog Filter will not be cleaned during maintenance
Covering	Protection of the cistern Reduction of insects in the cistern Reduction of evaporation	High investment costs
Hand pump/ Feet pump	No access to the water level No lifting of the filled containers	No acceptance because of longer filling times No maintenance of the pump
Electrical pump (solar pump)	No access to the water level Quick filling of the containers	Higher technical equipment Maintenance required
Electrical pump (solar pump) with piping	Short ways of transport of the water Time saving Quick filling of the containers	Higher maintenance (pump) Management necessary

5.1.3 General remarks

For the future the following aspects should be taken into consideration:

- Enhancement of the catchment areas and cistern volumes for an increase of the water volume and the improvement of individual hygienic conditions;
- Increasing of crop production by additional cistern volume for irrigation purposes. For this also natural reservoirs can be used;
- Rain water use is equivalent to the drilling of wells and supply a natural resource.

5.1.4 Improvement in the visited villages

Proposals for the improvement of the water supply by cisterns can be given for most of the 14 villages. These proposals are listed in Table 4. The proposals are given with consideration of the local conditions found during the visits.

Priority is given to three villages; this priority is marked in the Table 4 in bold.

Khuhol

Khuhol, located on top of a mountainous plateau in Dhi Bin has a cistern outside the village. This is the only water source for the village. Due to the lack of finance the cistern could not be constructed in the designed size. Approx. 25 % is still missing and the rocks are still there. An additional excavation could enlarge the cistern easily; furthermore coverage would reduce water losses by evaporation. With the coverage a fence becomes unnecessary. This is important because people are complaining about animals falling into the cistern. Due to the distance between the village and the cistern, and the difference of altitude an electrical solar driven pump could pump the water to the village to a central public post.

Beyt Hagairah

Currently this village has no cistern. Women are fetching the water from holes in the rocky ground. These holes have only small water amounts and with each withdrawal a small water volume can be achieved only. Therefore, a new cistern would enhance the water supply situation of the village significantly. Because of the small distance to the village and the small difference in altitude a hand or a pedestal pump is sufficient.

Al Ahkwa

Because of the bad road condition tankers cannot supply this village and cisterns are considered the only feasible water supply. The village has three cisterns at the same location, one for drinking water purposes, the two others for non-drinking purposes. The improvement of the drinking water cistern could serve as a demonstration project and a comparison with conventional cisterns becomes possible.

Table 4: Improvement in the villages visited during the mission

District Village	Pop. [c]	Volume	Improv. Sand trap	Fencing/ marking catchment	Wall / fencing cistern	Single access (manhole)	Single access (my + filter)	Covering	Pulley with rope	Pump: Hand-/ feet pump	Pump: Electr. Pump (solar)	Pump: Electr. Pump + piping
Dhi Bin												
Khaseini	616	X[1]										
Kharfan[2]	1,028											
Solan	566	✓	X	X	✓		X	X				X
Khuhol	**625**	**X**	**X**	**X**			**X**	**X**				**X**
Kharef												
Dobr Kanet	262	✓		X	X		X			X		
Beyt Hagairah[3]	**345**	**X**	4)	**X**				**X**		**X**		
Sudah Village	436	✓	X	X			X	X		X		
Bait Al-Gerba	510	X										
Al-Dimnah	646		X	X			X	X	X			
Khammer												
Al Mawajel	410	X[5]	X	X			X	X		X		
Al Sabha[6]	589	X	X	X			X	X	X			
Al Sudah												
Al Khoff	n.a.	✓	✓	X			X	X	X			
Al Ahkwa[7]	**860**	✓	**X**	**X**			**X**	**X**		**X**		
Markas	1,546	✓		X	X		X			X		
All villages	8,439	Cleaning and management of the cistern										

Legend:
✓ sufficient
X action recommended

1) cistern for poor people, who are not connected to water network
2) rehabilitation of pump for water network
3) no existing cistern, only water holes
4) only rocks
5) improvement of all cisterns
6) various cisterns
7) only drinking water cistern (one of three)

5.1.5 Cost calculations

New constructions

Based on the costs used by SFD (Annex 1) for a cistern as constructed in Solan village (dimensions 30 x 20 x 6 m) the costs are calculated for different coverage materials.

Cost calculations base on the assumption that the excavation work and back filling are done as a contribution of the village. The construction costs include the cistern, coverage of the cistern, protection of the catchment area and a water-lifting device with a pulley.

Cost calculations are made by Eng. Mohammed Saad, Ghayth Aquatech, Sana'a. Of course these cost calculations can only serve as a rough estimation because the local conditions could not be taken in consideration in detail. But for a relative comparison of the costs these calculations are suitable.

Detailed calculations are listed in Annex 2; the summary can be seen in Table 5. Construction prices given by the population in the villages are much lower because in the meantime the price level has increased about 20 – 30 %.

Table 5: Construction costs for cistern 30 x 20 x 6 m

Steel beam with zinc sheets	31.363.400 YR
Concrete roof	42.259.500 YR
Dome with concrete beams and blackstone dome	46.649.300 YR
Dome with concrete beams and red brick dome	45.669.300 YR

Cisterns with coverage of steel beams and zinc sheets are the cheapest solution, a concrete slab with beams is 36 % more expensive. The use of other stone materials as coverage material increases the sum up to 50 % more.

Upgrading of existing constructions

For upgrading an existing cistern with a coverage, a protection of the catchment area and with a water-lifting device (pulley) costs are calculated too (Table 6). The detailed calculations are given in Annex 3. In addition variants with steel sheets and glass fibre sheets as coverage have been calculated.

Table 6: Construction costs for the upgrade of a cistern 30 x 20 x 6 m

Steel Beams with steel sheets	4.528.500 YR
Steel Beam with zinc sheets	5.147.600 YR
Steel Beams with glass fibre sheets	5.510.000 YR
Concrete roof	10.509.500 YR
Dome with concrete beams and blackstone Dome	14.899.300 YR
Dome with concrete beams and red brick Dome	13.919.300 YR

Here the upgrade with steel beams and steel sheets is the less expensive one. The use of glass fibre sheets, which have advantages concerning the corrosion issue, is only 22 % more expensive than the first variant. Because of the large size of the cistern the use of concrete or stones is much more expensive than the use of steel beams.

New construction of household cisterns

Instead of a central public cistern the volume of the cisterns could be constructed at the household level. For the case of Sudah with an average population of 11.6 persons per household each household would need a cistern volume of

V_{cist} = 11.6 c/hh x 25 L/(c x d) x 30 d/month x 6 months / 1,000 m^3/L = 52 m^3

The costs for such a cistern are calculated as 1,410,095 YR for the cheaper circular form (Annex 4), this means per capita:

Steel beam and zinc plates:
1,410,095 YR / 11.6 c = 121,560 YR/c

The central cistern costs for different variants per capita:

Steel beam and zinc plates:
31,363,400 YR / 566 c = 39,204 YR/c

Concrete coverage
42,259,500 YR / 566 c = 74,663 YR/c

Despite of the higher specific volume of the central cistern:

20 m x 30 m x 6 m / 566 c = 6,4 m^3/c
6,4 m^3/c / 6 months / 30 d = 35 L/(c x d)

The central cistern is significantly cheaper than the distribution of the volumes in household cisterns.

The construction of cisterns at household level can only be a way to increase the existing volume of a central cistern with additional volume and must be investigated in detail for each application.

5.2 Sanitation

5.2.1 Awareness

Cleanliness and proper disposal of human drop-off (faeces and urine) are necessary for good health. If not considered in an appropriate way, faeces and urine can pollute the environment and cause serious health problems, such as reported by the inhabitants of the villages (diarrhoea, worms, cholera etc.). Many of these problems can be prevented through:

- **Public cleanliness (*sanitation*)** — using clean and safe toilets, keeping water sources clean and safe disposal of garbage;
- **Personal cleanliness (*hygiene*)** — washing hands and dishes, bathing and wearing clean clothes.

The knowledge of transmission ways for water-related diseases seems to be limited in the local population. Therefore the knowledge of the population has to be enhanced by appropriate awareness campaigns. People were found only rinsing their fingers with water instead of washing them with water and soap (or ash). Good hand washing helps to stop germs and dirt from getting into food or into the mouth. Washing hands can also prevent infection with worms. Soap and water or ash and water should be placed conveniently near the latrine or toilet.

A way to increase awareness is the use of the F-diagram, which shows the transmission routes for pathogens (Figure 21).

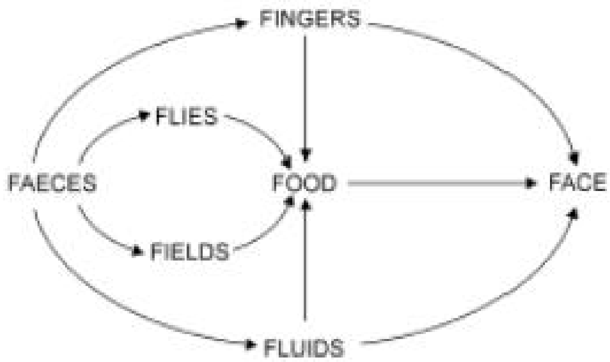

Figure 21: Transmission routes for pathogens

The main protection concerns are with the faeces, in particular when they are disposed untreated into the environment and when a later contact with them is possible. Fingers, food and fluids play a major role in transmitting diseases. Face stands here for the actual entry of pathogens to humans. Transmission of pathogens may come direct through dirty fingers or contaminated fluids or indirectly through contamination of food. In this case the food is polluted by pathogens either through flies or by faeces in the fields.

Key behaviour for breaking the cycle of faecal-oral diseases are quite simple. This behaviour is named as barriers in the following Figure 22 and disrupts the transmission of the pathogens by different actions.

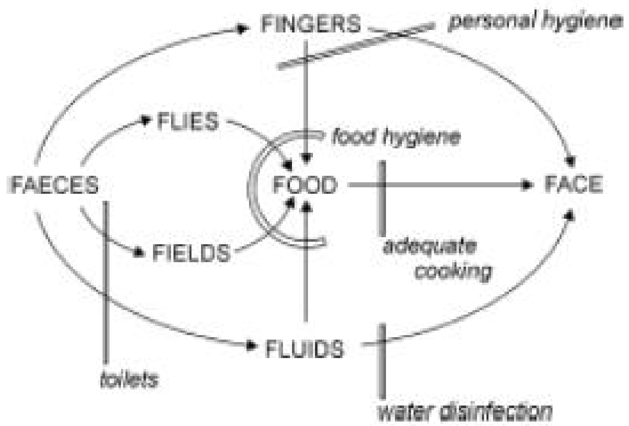

Figure 22: Barriers required for the transmission routes for pathogens

- The introduction and consistent use of **toilets** keep faeces out of the environment;

- Hand washing after use of the toilet, after cleaning up the faeces of others (children, old people) and before food preparation (**personal hygiene**);
- **Food Hygiene:** washing of vegetables, fruits and Khat, save food storage and **adequate cooking;**
- Measures for **water disinfections** (or water purification) by filtration or proper maintenance of cisterns.

Establishing a proper sanitation management needs promotion in awareness campaigns. These campaigns shall create knowledge about the faecal-oral transmission cycle and shall create the demand for a toilet system, which is appropriate to the conditions of the local population.

Delivering just the “hardware” (e.g. proper cisterns, toilets etc.) will not have the desired positive health impact, if a suitable hygienic behaviour (keeping toilets and washing places clean, washing hands after toilet use, following guidelines when treating the excreta) is not adopted as well. Improving hygienic behaviours (washing hands) only will not be able to improve health conditions to the desired level, too. A broad approach for breaking the transmission cycle is therefore necessary.

5.2.2 Construction issues

An appropriate toilet system has to fit to the very specific, local conditions, mainly in the rural Yemeni areas. These conditions can be identified as followed:

- No water use for flushing purposes is available (water has to be transported to the toilet);
- Keeping separate the liquids (urine) from the solids (faecal matter) for better management;
- Squatting use of toilets;
- Use of ash, sand or stones for anal cleaning.

Therefore only a dry toilet system is suitable. For the right operation a good separation of the liquid part (urine) from the solid part (faecal matter) is necessary. An appropriate toilet for this application is shown in Figure 23. This toilet is a Turkish toilet with a separate outlet for urine and faecal matter. This model is produced in Ethiopia and the price will be approx. 7,000 YR (plus taxes). For the very poor people the toilet form can be made also of concrete.

Figure 23: Turkish toilet for separation of liquids and solids made of ceramics (left) or concrete (right).

The use of the toilet is similar to the use of the known Turkish toilets. Urine rinses in the front part of the toilet and the faecal matter falls downwards via the large hole in the back. The toilet is working for men as well as for women.

Because of the dry system water is not necessary for the operation of the toilet. After the use ash, sand or soil can be used for covering the faeces. This avoids smell and the existence of flies. If water is used for anal cleansing this has to made beside the toilet because of the avoidance of the water entrance into the dry toilet system.

It is important that the entrance of liquids in the faecal outlet is avoided to obtain a proper operation of the system without any odour.

The integration of the toilet and the sanitation system is shown in Figure 24. The existing washing places in the house are equipped with a pipe system; in most of the houses this still exists. The urine outlet of the toilet is connected to this pipe as well. The treatment of the grey water/urine takes place in a grey water bed. This is a constructed bed of sand, which is planted. A perforated pipe distributes the water; the sand bed cleans the water and the plants can use the water. As a pre- treatment a small sedimentation tank removes sand and solids substances, which are usually very low in grey water. The water will be either taken by the plants or infiltrated into the soil under the sand bed. In parallel the plants are fertilised by the nutrients form the urine. These small grey water gardens are well known for grey water treatment worldwide. Useful plants like cactuses, and tomatoes should be used for the grey water bed. The water is reused for food production.

Because of the lack of data about water consumption in the houses a specific design for the grey water garden will be done in the next phase when the data are available.

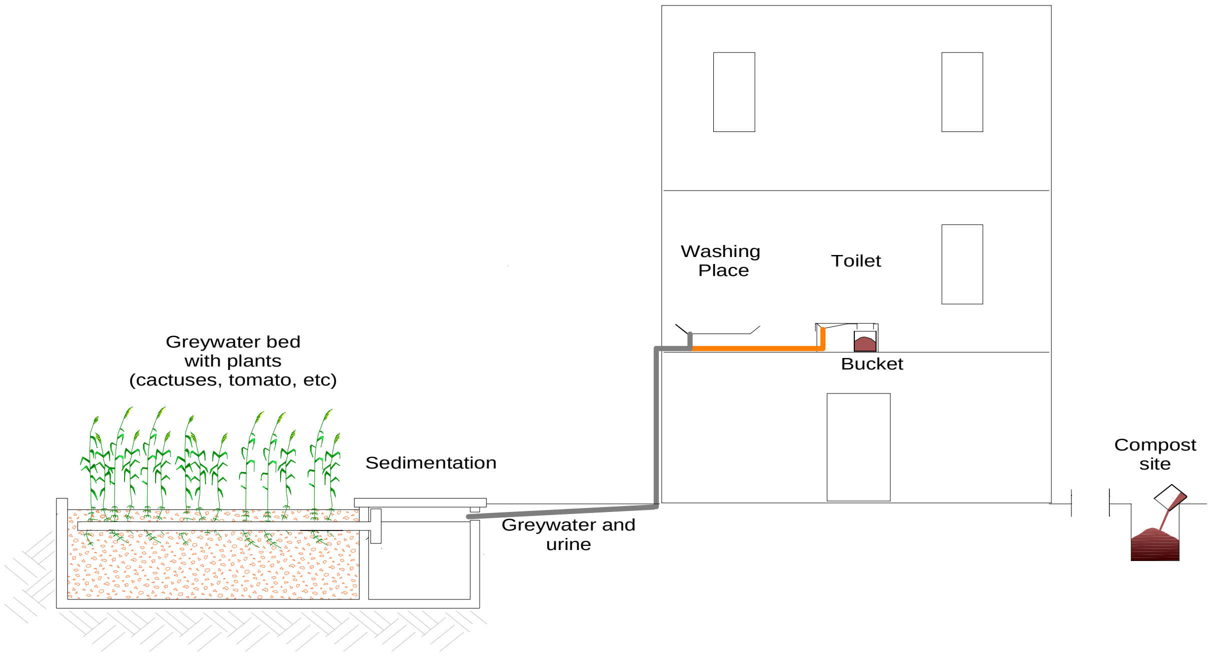

Figure 24: Sanitation system

Faecal matter from the use of the toilet falls into a bucket and has to be covered by ash, sand or soil. The common use of stones for anal cleansing does not hinder the proper operation of the toilet. This bucket has to be replaced regularly by an empty one. The filled one has to be emptied in a composting ditch. In this ditch the faecal matter as well as organic waste from other sources are filled. After the filling time (0.5 – 1 year) the bed will be closed by covering with soil and a new ditch has to be started. The composting process will continue. In accordance to the regulations of the WHO a storage time of at least 1 year is recommended.

After this year different possibilities are given:

- Removal of the composted material and use on agricultural land;
- Planting of a tree at this place.

The maximum of volumes for a household with an average of 8.5 capita per family are:

Weekly volume: 8.5 cap x 0.25 l/(c x d) x 8 d/week = 17 kg per week

Yearly volume: 17 kg per week x 52 weeks/year = 884 kg/year

(The volume is calculated as faecal matter including the added ash).

5.2.3 Management issues

Management issues have to be seen on two levels: the private one and the public one.

Private level

On the private level the use of the toilet for all of the inhabitants of the house is mandatory. The toilet must be kept clean and tidy after the use. This is an important issue for the health of the users as well as for their acceptance of the toilet.

Ash, sand or soil added after each use have to be provided in a basket in the toilet with a cup or a container for dispersing the material.

Strictly forbidden is the use of water in the toilet. To keep the faecal material dry and avoid odours and flies no water is allowed in this compartment. All liquids should only be given to the urine compartment of the toilet.

Public level

The replacement of the buckets has to be organised. For a better acceptance the bucket should have a lid for closing the bucket during the transport.

One person has to be responsible for the transport of the buckets from the households to the composting place. The composting place has to be installed on a remote location, so that the access of children and animals is reduced.

The material of the bins should be emptied weekly in the compost ditch. Coverage with soil or other material is recommended.

For each household a volume of approx 600 litres should be foreseen. This is lower than the calculated number above because not all people will use the toilet regularly.

The person has to be trained and should be aware of the hygienic risks handling with faecal matter.

5.2.4 Improvement in the visited villages

Two villages are identified for a demonstration implementation of the dry toilet sanitation concept.

Al Khoff

The village is located in the district Al Sudah on the top of a mountain. The houses are very densely constructed in the village; there is little space around the houses. Some houses have an outlet to the surroundings of the village. Some outlets lead to the top of the terraced field, on which the water infiltrates in the ground.

Water is available by a cistern located at the edge of the village.

Washing rooms are available in the houses; toilets have to be added. On the terraced areas, which are muddy, grey water beds can be installed and vegetables or other plants can be grown.

With the awareness campaign people should recognise the necessity of a sanitation system. The proposed dry toilet system (Figure 24) is appropriate because most of the elements are there and the existing structure is used. An example for the location of the grey water bed is shown in Figure 25; here the bed is located at the fields terraced at the mountain slope.

Figure 25: Position of a grey water bed at the terraced field

Khuhol

In Khuhol the mosque is equipped with a cistern, which is fed by the roof of the building. The coverage of the cistern with a concrete slab has been started, but is not finished yet because of the lack of finance. Nearby the mosque is the school building of the village.

To create awareness for sanitation installations at village level and to enhance knowledge dissemination, the mosque and the school are integrated into the water and the sanitation concept (Figure 26).

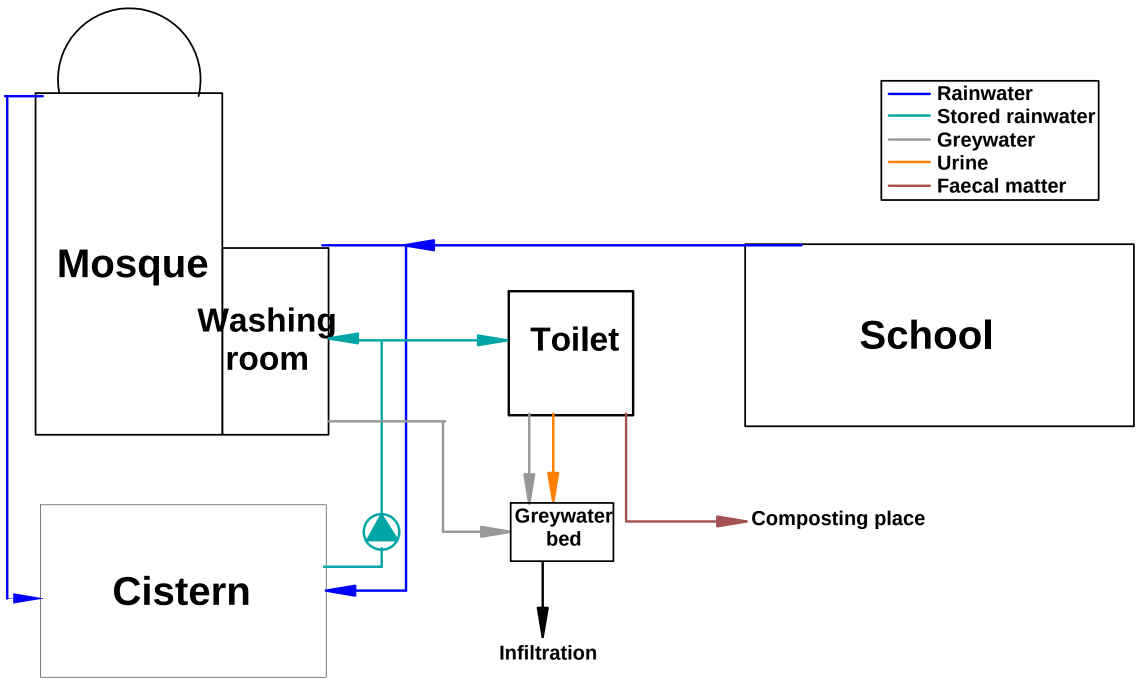

Figure 26: Sanitation system for a public installation in Khuhol

The cistern at the mosque should be finished. Water of the cistern supplies the washing room of the mosque. In addition a toilet building with a dry toilet system is added. This toilet building contains at least two toilets and a hand washing facility; the main users should be the visitors of the mosque and the pupils of the school. The toilet is equipped with a dry toilet system and a separation of the liquids from the faecal matter as described above. Cistern water will also supply the hand washing facilities of the toilet building.

Grey water effluents from the washing room as well as from the toilet are treated in a grey water bed, which is planted. The faecal matter is treated on a compost site and will be used as fertiliser on the agricultural area.

This concept may only work if the maintenance of the washing room and the toilet building is good organised. Therefore a person has to be responsible for cleaning the building and the proper operation.

For both installations (Al Khoff and Khuhol) the design can be made when the basic data area available.

6 FUTURE TASKS

6.1 Local project team

For continuation of the work and a successful implementation of the concepts described above various details have to be investigated by the local project team:

- Survey of water consumption and use in households;
- Rainfall data, e.g. yearly precipitation, distribution of the precipitation on the months, duration of single rainfall events, intensity of single maximum rainfall events;
- Data about the potential of evaporation;
- Evaluation of the number and the sizes of cisterns in the 14 visited villages; this could also be extended to other villages;
- Evaluation of the catchment area of different cistern;
- Start of the awareness creation for the management and improvement of the cisterns with the stakeholders;
- Start of the awareness creation for the attitude towards sanitation with the stakeholders.

6.2 International expert

The tasks of the international expert for the next follow-up missions can be described as follows:

- Based on the experience obtained in this mission a manual for design criteria of cisterns should be elaborated. This has to include information on:
  - size of the cistern,
  - size of catchment area,
  - dimensions of sand trap;
- Elaboration of a guideline for proper maintenance of cisterns (in cooperation with the local project team);
- Elaboration of a design for the sanitation facilities (grey water bed, etc.);
- Support of the local project team during the preparation of the awareness campaign for water and sanitation related issues;
- Support of the local project team for the implementation phase;
- Supervision and support during the realisation of the demonstration projects;
- Elaboration of a strategy for the implementation of the sanitation concept.

7 PROPOSAL FOR THE PROCEDURE OF CONTINUATION

Specific recommendations for timing and duration of activities for the improvement of the prevailing water and sanitation management situation are listed in the table below.

Table 7: Timing and duration of the activities

When	What	Who	
		Local project team	Internat. expert
Feb – Apr.08	Evaluation of the meteorological data Preparation of the awareness campaign	X	
May 08	Elaboration of design criteria for the cisterns Elaboration of guideline for proper management		X
Jun – Jul 08	Awareness campaigns Decision on the implementation of demonstration projects (cisterns) Decision on the implementation of demonstration projects (sanitation) Beginning of improvement of cisterns as demonstration project	X	
Jul/Aug 08	Design of sanitation demonstration projects Supervision of the improvement of cisterns		X
Sep – Oct 08	Planning of the implementation of sanitation demonstration projects	X	
Oct/Nov 08	Supervision of the implementation of sanitation demonstration projects		X
Dec 08 -	Supervision of the operations	X	

8 CONCLUSION

The visit in the 14 villages manifests urgent needs for the improvement of the cisterns and their management. A sanitation system, which fulfils any hygienic requirement, does not exist. In most cases human excreta are widespread by open defecation or by open disposal of excreta. The existence of diseases are an indicator for the limited knowledge of water related infections coming from the water supply by cisterns as well as from sanitation.

The proposals for the demonstration projects are very close to the existing situation. Cisterns can be improved by constructional measures, but have to be supported by a regular maintenance and supervision through an effective cistern management committee. The suggested sanitation system bases on the adaptation to the existing tradition and the reuse of water (grey water beds) as well as of the organic material (compost).

In general the success and long-time improvement will depend on improvements in operation and maintenance.

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A N N E X E S

Annex 1: Construction prices for cisterns (given by SFD)

Position	Unit	Price [YR/unit]
Excavation loose material	m^3	600
Excavation rocks	m^3	1,440
Fundament (Wadistones)	m^3	9,000
Slab	m^3	19,200
Reinforced concrete (8 mm steel)	m^3	39,000
Wall (Wadistones)	m^3	14,400
Filling material	m^3	1,200
Plastering	m^2	1,080
Protection catchment area	m^2	4,200
Columns and metal fence	m	4,550
Columns	item	3,900
Metal fence	m^2	3,900
Coverage (Zink + profiles)	m^2	4.550
Metal door	m^2	9,750
Construction with wheel	item	48,000

Annex 2: Construction costs for cistern with different coverage (20 x 30 x 6 m) on the base of the unit prices of SFD with participation of the community

Cost estimate of cistern Capacity 3300 m^3
Steel Profiles and Zink coverage

Pos		Unit [U]	Quantity	Unit price [YR/U]	Total [YR]
1	Excavation of loose materials	m³	3.000	600	0
2	Wadi stone for the foundation	m³	400	9.000	3.600.000
3	Bedding of wadi stone under bottom Slab.	m²	117	1.800	210.600
4	15cm blinding concrete under bottom slab. Concrete grade 200	m³	89	19.200	1.708.800
5	20cm thick R.C. bottom slab 8mm steel concrete grade 300	m³	150	39.000	5.850.000
6	Outside walls of the cistern of lack stones and wadi stones 1.50 cm Base thickness and 60cm top thickness.	m³	986	14.400	14.198.400
7	Roof coverage (Zink + profiles)	m³	755	5.920	4.469.600
8	Protection of the catchment area	m²	150	4.200	630.000
9	Backfilling round the cistern	m³	0,0	1.200	0
10	Construction lifting		1	48.000	48.000
11	Plastering inside walls of cistern	m³	600	1.080	648.000
	Total Cost of the cistern				**31.363.400**

Cost estimate of cistern Capacity 3300 m^3
Concrete Roof

Pos		Unit [U]	Quantity	Unit price [YR/U]	Total [YR]
1	Excavation of loose materials	m³	3.000	600	0
2	Wadi stone for the foundation of the outside walls of the cistern	m³	400	9.000	3.600.000
3	Bedding of wadi stone under bottom Slab.	m²	117	1.800	210.600
4	15cm blinding concrete under bottom slab. Concrete grade 200	m³	89	19.200	1.708.800
5	20cm thick R.C. bottom slab 8mm steel concrete grade 300	m³	150	39.000	5.850.000
6	2.5 x 2.5 x 0.1 m R.C. foundations concrete grade 300	m³	93,8	59.000	5.534.200
7	50 x 50 cm in dim . R.C. column concrete grade 350	m³	23,25	72.000	1.674.000
8	Outside walls of the cistern of lack stones and wadi stones 1.50 cm Base thickness and 60cm top thickness.	m³	986	14.400	14.198.400
9	15cm thick R.C. slab + Beams of 50x50 cm in Dim + Beams Concrete grade 300	m³	125,5	65.000	8.157.500
10	Protection of the catchment area	m²	150,0	4.200	630.000
11	Backfilling round the cistern	m³	150	4.200	0
12	Metal fence	m²	0	1.200	0
13	Construction of lifting water from the cistern	m²	1	48.000	48.000
14	Plastering		600	1.080	648.000
	Total Cost of the cistern				**42.259.500**

Cost estimate of cistern Capacity 3300 m^3
Black Stone Roof Dome

Pos		Unit	Quantity	Unit price	Total
		[U]		[YR/U]	[YR]
1	Excavation of lose material	m³	3.000	600	0
2	Wady stones for the foundation of the outside Walls of the cistern	m³	400	9.000	3.600.000
3	Bedding of Wady stones under bottom slab	m²	117	1.800	210.600
4	15cm Blinding concrete	m³	89	19.200	1.708.800
5	20cm bottom slab	m³	150	39.000	5.850.000
6	R. C. Foundation	m³	93,8	59.000	5.534.200
7	50x50cm Concrete Columns	m³	23,25	72.000	1.674.000
8	The outside Walls of the cistern of black Stones	m³	986	14.400	14.198.400
9	Dome Beams concrete	m³	34,7	59.000	2.047.300
10	DOME ROOF Black stones	m²	700,0	15.000	10.500.000
11	Protection of the catchment Area	m²	150	4.200	630.000
12	Backfillng round the cistern	m³	2.000	1.200	0
13	Fence Cistern	m²	0	4.550	0
14	Construction lifting		1	48.000	48.000
15	Plastering	m²	600	1.080	648.000
	Total Cost of the cistern				**46.649.300**

Cost estimate of cistern Capacity 3300 m^3
Red bricks Roof Dome

Pos		Unit	Quantity	Unit price	Total
		[U]		[YR/U]	[YR]
1	Excavation of lose material	m³	3.000	600	0
2	Wady stones for the foundation of the outside Walls of the cistern	m³	400	9.000	3.600.000
3	Bedding of Wady stones under bottom slab	m²	117	1.800	210.600
4	15cm Blinding concrete	m³	89	19.200	1.708.800
5	20cm bottom slab	m³	150	39.000	5.850.000
6	R. C. Foundation	m³	93,8	59.000	5.534.200
7	50x50cm Concrete Columns	m³	23,25	72.000	1.674.000
8	The outside Walls of the cistern of black Stones	m³	986	14.400	14.198.400
9	Dome Beams concrete	m³	34,7	59.000	2.047.300
10	DOME ROOF Red bricks	m²	700,0	13.600	9.520.000
11	Protection of the catchment Area	m²	150	4.200	630.000
12	Backfillng round the cistern	m³	2.000	1.200	0
13	Fence Cistern	m²	0	4.550	0
14	Construction lifting		1	48.000	48.000
15	Plastering	m²	600	1.080	648.000
	Total Cost of the cistern				**45.669.300**

Annex 3: Construction prices for roofs and catchment protection (20 x 30 x 6 m)

Cost estimate of cistern Capacity 3300 m^3
Steel Profiles and Zink coverage

Pos		Unit	Quantity	Unit price	Total
		[U]		[YR/U]	[YR]
1	Steel sheets with steel beams	m²	755	5.100	3.850.500
2	Protection of the catchment area	m²	150	4.200	630.000
3	Construction lifting		1	48.000	48.000
	Total Cost of the cistern				**4.528.500**

Cost estimate of cistern Capacity 3300 m^3
Steel Profiles and Zink coverage

Pos		Unit	Quantity	Unit price	Total
		[U]		[YR/U]	[YR]
1	Roof coverage (Zink + profiles)	m²	755	5.920	4.469.600
2	Protection of the catchment area	m²	150	4.200	630.000
3	Construction lifting		1	48.000	48.000
	Total Cost of the cistern				**5.147.600**

Cost estimate of cistern Capacity 3300 m^3
Steel Profiles and Zink coverage

Pos		Unit	Quantity	Unit price	Total
		[U]		[YR/U]	[YR]
1	Fibre glass sheets with steel beams	m²	755	6.400	4.832.000
2	Protection of the catchment area	m²	150	4.200	630.000
3	Construction lifting		1	48.000	48.000
	Total Cost of the cistern				**5.510.000**

Cost estimate of cistern Capacity 3300 m^3
Concrete Roof

Pos		Unit	Quantity	Unit price	Total
		[U]		[YR/U]	[YR]
1	50 x 50 cm in dim . R.C. column concrete grade 350	m³	23,25	72.000	1.674.000
2	15cm thick R.C. slab + Beams of 50x50 cm in Dim + Beams Concrete grade 300	m³	125,5	65.000	8.157.500
3	Protection of the catchment area	m²	150,0	4.200	630.000
4	Construction of lifting water from the cistern	m²	1	48.000	48.000
	Total Cost of the cistern				**10.509.500**

Cost estimate of cistern Capacity 3300 m^3
Black Stone Roof Dome

Pos		Unit	Quantity	Unit price	Total
		[U]		[YR/U]	[YR]
1	50x50cm Concrete Columns	m³	23,25	72.000	1.674.000
2	Dome Beams concrete	m³	34,7	59.000	2.047.300
3	DOME ROOF Black stones	m²	700,0	15.000	10.500.000
4	Protection of the catchment Area	m²	150	4.200	630.000
5	Construction lifting		1	48.000	48.000
	Total Cost of the cistern				**14.899.300**

Cost estimate of cistern Capacity 3300 m^3
Red bricks Roof Dome

Pos		Unit	Quantity	Unit price	Total
		[U]		[YR/U]	[YR]
1	50x50cm Concrete Columns	m³	23,25	72.000	1.674.000
2	Dome Beams concrete	m³	34,7	59.000	2.047.300
3	DOME ROOF Red bricks	m²	700,0	13.600	9.520.000
4	Protection of the catchment Area	m²	150	4.200	630.000
5	Construction lifting		1	48.000	48.000
	Total Cost of the cistern				**13.919.300**

Annex 4: Construction prices for small cisterns

Private circular cistern
Capacity 52 m³

Pos		Unit	Quantity	Unit price	Total
		[U]		[YR/U]	[YR]
1	Excavation	m³	66	600	0
2	1m x 1m Wadi stones foundation	m³	18	9.000	163.800
3	15cm stone bedding under bottom slab	m³	2,60	1.800	4.680
4	10cm blinding concrete	m³	3,63	19.200	69.696
5	15cm R.C. bottom slab	m³	5,45	39.000	212.550
6	Outside walls of black stones	m³	35,51	14.400	511.344
7	R.C. beam (on top of outside wall)	m³	2,50	81.250	203.125
8	Plastering	m²	50	1.080	54.000
9	Coverage (circular roof dome 8cm thick)	m³	2,66	65.000	172.900
10	Non corrsion steel steps		10	1.800	18.000
11	backfilling	m³	0	1.200	0
	Total Cost of the cistern				**1.410.095**

Private square cistern
Capacity 52 m³

Pos		Unit	Quantity	Unit price	Total
		[U]		[YR/U]	[YR]
1	Excavation	m³	72	600	0
2	1m x 1m Wadi stones foundation	m³	19,2	9.000	172.800
3	15cm stone bedding under bottom slab	m³	2,70	1.800	4.860
4	10cm blinding concrete	m³	3,84	19.200	73.728
5	15cm R.C. bottom slab	m³	5,77	39.000	225.030
6	Outside walls of black stones	m³	42,90	14.400	617.760
7	R.C. beam (on top of outside wall)	m³	3,00	65.000	195.000
8	Plastering	m²	50	1.080	54.000
9	Coverage (zinc + profile) roof provided with door for entering the cistern	m²	35,00	4.550	159.250
10	Non corrsion steel steps		10	1.800	18.000
11	backfilling	m³	0	1.200	0
	Total Cost of the cistern				**1.520.428**