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Subject **Rainwater harvesting and shallow groundwater solutions in Budunbuto, Somalia**

1. Introduction

Budunbuto (http://www.geonames.org/63938/budunbuto.html) is a village located in the Nugaal Region of Puntland, Somalia. The village has around 500 inhabitants, excluding nomads living in the surroundings. In the past years the population has grown because many internally displaced persons (IDP) have moved to the village.

The Dutch NGO Stichting Kaalo Nederland is working together with Wilde Ganzen and Aqua for All on a project to improve water availability in the village.

To improve water availability in Budunbuto there are generally three options:

1. Motorised deep boreholes
2. Rainwater harvesting
3. Shallow groundwater storage and recovery

The construction of (deep) boreholes is very expensive since the drilling equipment is not available locally and suitable aquifers are deep (generally >100 m). Furthermore the water quality of the boreholes in the area varies. Many boreholes have high salinities because the main aquifers contain gypsiferous deposits. Despite these drawbacks, boreholes are still a option, since they can supply large quantities of water and are less sensitive to periods of drought. Conscientious siting needs to be done.

Aqua for All has requested SamSamWater to give technical and hydrological advice on the possibility to improve the water situation using rainwater harvesting and shallow groundwater solutions, such as sub-surface dams.

Little (detailed) information on the area is available. This report tries to combine the scarce information to give an advice on the options to improve water availability using rainwater harvesting or shallow groundwater resources in Budunbuto.

All locations mentioned in this report are marked on an online map which can be accessed here: http://www.samsamwater.com/maps/index.php?kml=59/data/budunbuto.kmz

2. Water demand

According to the available information, Budunbuto has about 500 inhabitants, excluding nomads. If we assume a total population (including nomad) of 750 people and a domestic water demand of 20 litre per capita per day, the total domestic water demand for Budunbuto is about 15 m^3/day, which equals to 450 m^3/month or 5,500 m^3/year.

The number of animals that (potentially) come to Budunbuto for watering is unknown. To get an estimate of the number of animals the data from the village of Heema is used. Heema is located in the Mudug region of Puntland, about 280 km southwest of Budunbuto. Here, the number of inhabitants and the number of animals are known (OTP / CAS Basaaso, 2005).
The population size and the number of cattle using the water sources in Heema are given in Table 1. The number of animals per capita in Heema can be calculated and is given in Table 1.

Table 1 Water users and number of animals per capita in Heema (source: OTP / CAS Basaaso, 2005)

Water users in Heema	number	number of animals per capita
humans	3,500	
camels	5,500	1.6
cattle	13,000	3.7
sheep/goats	25,000	7.1

Since the actual number of animals around Budunbuto is unknown, these have been calculated based on the number of animals per capita in Heema. The results are given in Table 2.

Table 2 Water users in Budunbuto

Water users in Budunbuto	number
humans	750
camels	1,179
cattle	2,786
sheep/goats	5,357

According to the EC Somalia Unit (2004) the estimated water consumption for humans and livestock in the Nugaal region of Somalia are given in Table 3.

Table 3 Estimated water consumption rate (EC Somalia Unit, 2004)

	Per capita consumption rate
humans	5 l/day
camels	80 l every 7 days
cattle	20-25 l/day
sheep/goats	1.3 - 1.6 l/day

The human water consumption rate of 5 litre per capita per day is an absolute minimum.
The WHO and UNICEF (2000) describe 20 litres per capita per day as a 'basic access' service level. For the design of a water supply system for Budunbuto this value of 20 litre per capita per day is used as a minimum requirement.
For the water consumption by animals, the average of the range indicated in Table 3 is used.

Based on these numbers the total water demand for Budunbuto is calculated in Table 4. The total water demand for Budunbuto is 100 m^3/day.
15 m^3/day is used for domestic purposes and therefore has to be fresh (salinity preferably below 1,000 μS/cm, maximum 5,000 μS/cm).
85 m^3/day is used for animals and could be slightly brackish (salinity below 8,000 μS/cm).

Table 4 Water demand for Budunbuto

		consumption rate	**water demand**	
	number	**(l/day)**	**(m^3/day)**	**(m^3/year)**
humans	750	20	15	5,500
camels	1,179	12	14	5,200
cattle	2,786	22.5	63	22,900
sheep/goats	5,357	1.5	8	2,900
total			**100**	**36,500**

3. Solutions: rainwater harvesting

3.1. Rainwater harvesting from roofs

Annual rainfall in the area is around 170 mm (source: http://www.samsamwater.com/climate). Since there is little rainfall and the rains are unreliable (Banks, 2008), rainwater harvesting from roofs isn't very promising.

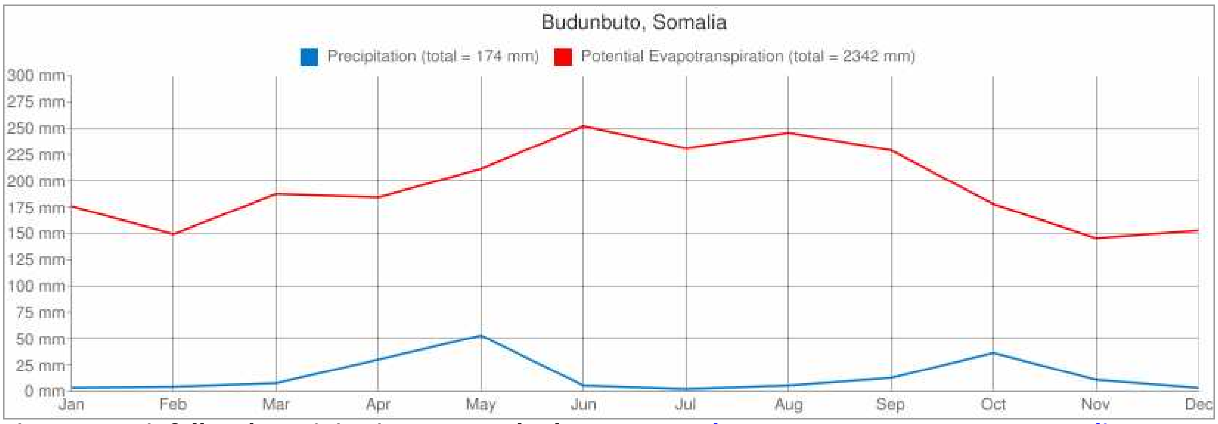

Figure 1 Rainfall and precipitation near Budunbuto (source: http://www.samsamwater.com/climate)

The required surface area is simply too large to provide a significant water source for all inhabitants, which makes the system expensive. However, small scale (personal or small community) systems may provide a good water source for part of the population.

3.2. Rainwater harvesting by berkads

A berkad is a ground tank, usually lined with masonry and/or concrete, which collects surface run-off during intense rainfall episodes.

Figure 2 An example of a berkad

Since berkads collect surface run-off water, the risks of contamination by animal excrement is high. Also. many berkads are not covered by a roof, so evaporation losses are high and salinity of the water increases.

According to Banks (2008) the average dimensions of a berkad in this area are about 20 x 8 x 4 m, which means a volume of 640 m^3. So to satisfy the complete domestic demand we would need more than 8 berkads (5,500 / 640; excluding losses through evaporation).

To satisfy the complete water demand we would need almost 60 berkads, which does not seem realistic to construct.

4. Solutions: shallow groundwater storage and recovery

4.1. Introduction

To determine the potential for shallow groundwater storage and recovery solutions, it is important to understand the local (shallow) geological and hydrogeological situation. All available information (Zhang et. Al, 1986, OTP / CAS Basaaso, 2005 and Banks, 2008) show that the groundwater table is generally more than 100 m below surface level. But OTP / CAS Basaaso, (2005) and Banks (2008) also explain that shallow wells (generally < 10 m deep) are used to fetch water from shallow (perched) groundwater sources, such as within wadi beds.
The water quality, yield and how long they provide water during a dry period varies strongly from well to well. Local geological deposits (mainly gypsum) influence the water quality (salinity). Porosity and permeability of soil and upper layers determines how much runoff water infiltrates. The (im)permeability of the of the underlying layers determines how much will infiltrate to deeper layers, or flow downstream in the riverbed.

The best setting for shallow groundwater storage and recovery solutions is a highly permeable upper layer (such as sand or gravel), confined at the bottom by a layer with a very low permeability (such as clay or impermeable bedrock). Surface run-off during rain episodes will infiltrate into the soil and the low permeability confining layer will prevent the water to seep further down into the ground. Naturally, the groundwater will flow downstream within the riverbed. Local topographic conditions (gradient of the land surface) and natural barriers (such as bedrock outcrops) play an important role in how long groundwater is available in the riverbed.

If the local conditions are suitable, man-made structures such as sand storage dams (http://www.sanddam.org/) or sub-surface dams (http://www.wateraid.org/international/what_we_do/sustainable_technologies/technology_notes/2057.asp) could prevent the water to flow downstream and therefore increase water availability at the site.

There are many advantages in the use of sub-surface or sand storage dams compared to surface dams; these include (WaterAid):

- Losses from evaporation are very much lower than those from an exposed water surface in a dry tropical area
- The breeding of insects and parasites such as mosquitoes and bilharzia parasites is prevented
- Contamination of stored water, by people and animals, is greatly reduced, particularly as a well and hand pump can be provided to abstract water in a hygienic and controlled manner. Depending on local conditions and protection measures, water can be stored safely for months.

4.2. Hydrogeology

In the "Completion report on the water well drilling project in the Northern four regions of the democratic republic of Somalia" (Zhang et al., 1986) two boreholes in the Nugaal region are described. Unfortunately this information is of little value to shallow groundwater solutions.

The first borehole 'Gudubjiran' (Nu-1) is assumed to be located in the village of Godob Jiraan. (http://www.geonames.org/maps/showOnMap?q=godob%20jiraan), about 120 km south of Budubunto in a different geological formation. From the second borehole (Nu-2) at Owulos no information is available on the first 90 meters of the drilling.

The only source of information on the shallow geology is the Geological map of Somalia (Abbate et al., 1994). According to this map, Budunbuto is located on the boundary of the Pleistocene and Holocene 'sands and gravels filling main ephemeral streams' and the Eocene 'Karker (Karkaar) Limestones'.

Photographs on the website of Stichting Kaalo Nederland (http://www.kaalonederland.org) seem to confirm that the surface is covered by coarse material such as sand and gravel (Figure 3).

Figure 3 Details of photographs showing the soil around Budunbuto (source: Stichting Kaalo Nederland)

Based on the geological map, it is assumed that the sands and gravels are overlying the Karkar limestones. One of the photographs shows a solitary rock (Figure 4). Possibly this rock is a part of the Karker limestone formation (although it is hard to judge since it is only a small part of the photograph), the rocks seems to be permeable.

Figure 4 Detail of a photograph showing a piece of hardrock near Budunbuto (source: Stichting Kaalo Nederland)

4.3. Suitability for shallow groundwater storage and recovery

If the soil indeed consists of sands and gravels, this is very suitable for shallow groundwater storage and recovery solutions. Rainwater and run-off water can easily infiltrate in sands and gravels.

The main point of concern is the underlying layer, which shouldn't be too permeable. Most probably this layer consists of limestones. If these limestones have a high permeability (because of fractures or karstification), the shallow aquifers will empty rapidly. However it is possible that a clay layer is present under the upper aquifer, which can prevent water infiltrating to deeper aquifers.

Information on the current water supply system might give clues. If there are shallow wells in the area, it is important to investigate how much water is available (per day) and how long water is available from them during a dry period. If there are shallow wells which provide water during some weeks or months in a dry period, a sub-surface dam could potentially increase the amount of water stored and the duration in which water is available.

Even though rainfall is little (about 170 mm per year), sub-surface dams could provide a significant amount of water. If, for example, we assume that of the annual 170 mm rainfall, only 10 mm would recharge the shallow groundwater, a catchment recharge area of about 750 x 750 meters would be enough to satisfy the complete domestic water demand of Budunbuto. A sub-surface dam of a few tens of meters length (depending on the width of the wadi) might be enough to achieve this. Since the population density is low and wadi channels are abundant, shallow groundwater storage and recovery might be a very suitable solution. But local investigation, design and siting has to be carried out.

Even if shallow groundwater storage and recovery might not be enough to satisfy the complete water demand, it would be a good addition to a borehole, especially since these shallow options are more failsafe in case of fuel shortages or technical interruptions. Also, if water from a borehole is too saline for domestic use, it might still be suitable for cattle and water for domestic use can be fetched from the shallow groundwater wells.

If a sub-surface dam is going to be constructed, it is important to create a protection area around the groundwater reservoir, to prevent contamination by cattle and humans (e.g. latrines). Depending on the local situation (location, depth, etc.) a suitable solution has to be found.

Shallow wells have to be fitted with a (hand)pump, to prevent contamination by dirty buckets, ropes, etc.

To determine whether a sub-surface dam is an option, the following steps have to be undertaken:

- Inform whether there are shallow groundwater wells presently in use.
- If so, how many, how deep are they, what is the water quality (saline or not), how much water do they provide (litre/day) and how long do they provide water during a dry period (weeks/months).
- If available, any further information (i.e. drilling logs) on the area has to be gathered.
- To get more detailed information and to determine the best location for a potential sub-surface dam, a hydrogeological reconnaissance survey has to be carried out. With the use of augers and/or geophysical equipment the thickness of the upper aquifer and depth and permeability of the underlying layer can be determined. Based on the field observations and measurements, the best location and dimensions for one or more potential sub-surface dams can be determined. Profound siting and design is essential for a sub-surface dam to work.

5. Conclusions and recommendations

The total water demand for Budunbuto is estimated to be around 100 m^3/day, of which 15 m^3/day is used for domestic purposes and 85 m^3/day for animals.

Since the annual rainfall in the area is only 170 mm per year, the possibilities for large scale rainwater harvesting systems are limited. Berkads and rainwater harvesting from roofs may provide a good water source for part of the demand. Especially regarding berkads it is important to pay attention to the water quality, since the contamination risk is high.

The potential for realising water supply through shallow groundwater storage and recovery systems (for example sub-surface dams in riverbeds) seems high. This is promising, since stored volumes are higher and water quality is (in this case) expected to be better compared to berkads and roofwater harvesting systems.
Based on photographs, the soil seems permeable, resulting in high infiltration during rainfall. Depending on local topography and geology, sub-surface dams might increase the volume of water stored in riverbeds. This will prolong water availability during the dry season. Further research on currently used shallow groundwater resources and geology (permeability of the soil and underlying layers) should be performed to determine whether the area is suitable for shallow groundwater storage and recovery systems.

Proper siting and design is important for a sub-surface dam to work and store the water without the risk of failure or contamination.

6. References

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All locations mentioned in this report are marked on an online map which can be accessed here:
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