Water in the Rundugai area
Mission report

Rundugai, Tanzania
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Introduction

Outline

About eight years ago the Dutch entrepeneur Joop Paauw got aquainted with father Erasto Cawau of the Catholic Mission in Rundugai, Tanzania. He decided to set up a project to build houses for the local poor people in Rundugai. Together with Dutch volunteers they built about 30 houses to date.

Figure 1 *The old house (left) of a family in Rundugai and the house Joop Paauw has built (right)*

Housing is a problem for the very poor in the area. However, providing clean and safe drinking water remains a problem to all people in the area.

We, Sander de Haas en Lucas Borst, are both hydrogeologists by profession with a keen interest for arid land hydrology and water supply in arid areas. Together with Mr. Paauw we got the idea to investigate the area of Rundugai for the possibilities of water supply. During a two week field trip in June and July 2007 the local hydrogeology was investigated, as well as the local methods of water supply.

This report gives an overview of the findings and results of this field visit. The field visit was carried out by the authors on a voluntarily and independent basis. The contents of the report are for the responsibility of the authors and do not automatically reflect the opinions of the involved parties.

Location

The research was carried out in the area of Rundugai, Tanzania (UTM 302.600, 9.621.700 m, or 37°13' 25"E, 3°25' 14" S). The project area is located in the Hai District, about 15 km Southwest of Moshi.

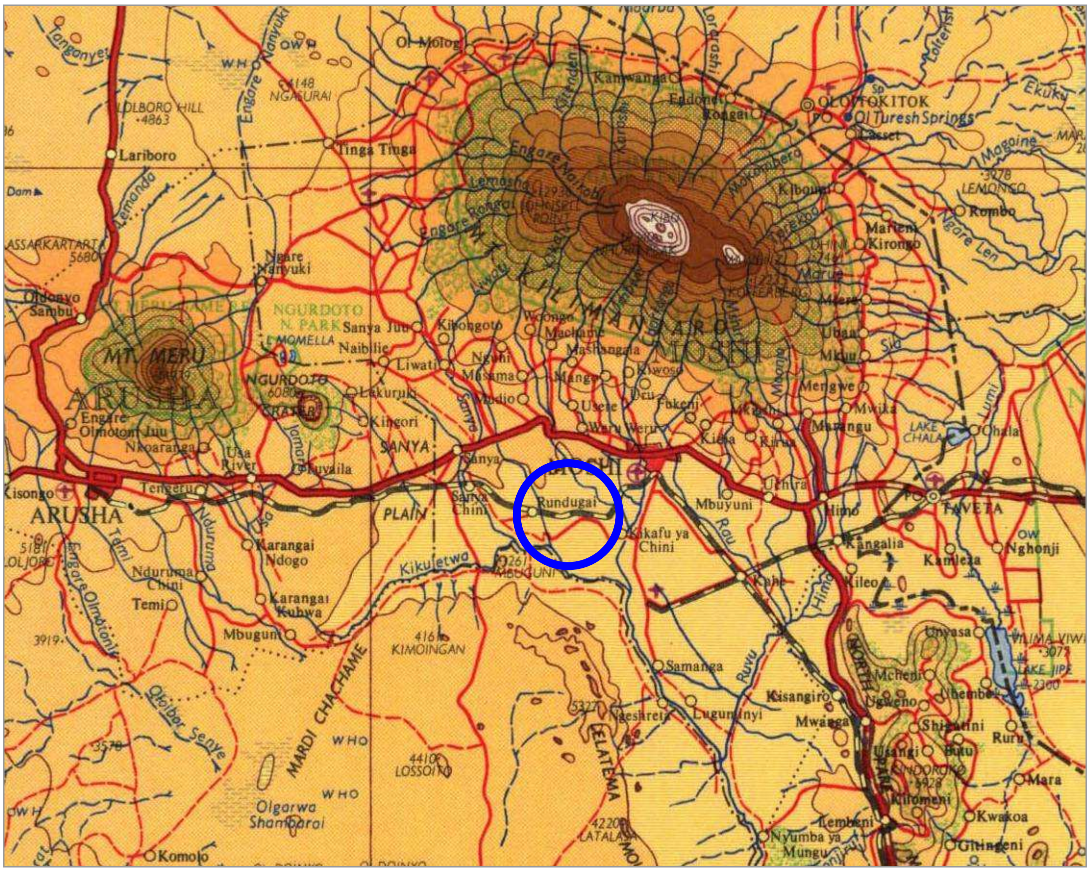

Figure 2 *Location of the research area*

During the mission we stayed at the Catholic Mission in Chekereni (about 3 km East of Rundugai town). The whole area is referred to as "Rundugai", but within the Rundugai area several villages exist (Rundugai, Chekereni, Kawaya, Tindigani, Ngulu, Kisiwani, Kikafu, Mbuguni, Kilimamshwaki, Patakero and Longoi). Most villages consist of scattered buildings with some small kiosks at the village center. In total around 19,000 people are living in an area of about 40 km^2. The people are mainly living of subsistence farming and small scale trading.

Figure 3 *Overview of the area. From dry plains (left) to thick bushes near springs or rivers (right)*


Figure 4 *Agricultural lands in the Rundugai area: onions (left) and sunflowers (right)*

Figure 5 *Erosion on the non-cultivated lands*

Water in the Rundugai area

Hydrology and hydrogeology of the area

The area is located on the southern slopes of Mount Kilimanjaro. The area has gentle slopes and occasional hills. The area is consists of volcanic material, which is all of Quaternary age at the surface.

Figure 6 *A woman carrying water with the mount Kilimanjaro in the background*

A number of rivers are crossing or bordering the Rundugai area. The main ones are Kware (through Rundugai village), Sanya (West), Kikuletwa (South), Kikafu (East), Longoi (East). All rivers originate from Mount Kilimanjaro, except for the Kikuletwa river in the South which originates on the slopes of Mount Meru and is flowing over the Sanya Plain towards Rundugai.

Figure 7 *River Kikafu*

Water from the rivers is often diverted into small canals that are used to irrigate the cultivated land. These irrigation canals are not only used to obtain water from rivers, but also to redirect water from springs, swampy wet areas or pools that are formed by rainwater.

Figure 8 *Irrigation canal*

Because only a part of the irrigation canals are getting their water from perennial sources, a large number of them dry up during the dry season.

A number of natural springs occur in the area, such as Chemka (meaning “to bubble up”). The springs are generally located at the boundary between two different levels of plains.

Figure 9 *The spring Chemka*

The water that is surfacing at the spring is generally forming a pool and flowing away in small streams or canals. The water is very clear.

Water supply

A part of the area gets it’s water from a tap water system. The water is collected at springs and pumped to large reservoirs from where is flows trough the pipes by gravity, or it flows from the spring directly in the pipes by gravity. Public tap points are created at central places. Some taps are closed of with a lock, others are freely accessible.

Figure 10 *Tap points open (left) and locked (right)*

More remote areas get their water from deep boreholes (i.e. Kilimanshwaki, 80 m deep) or through small canals. These canals are also being used for various other purposes, such as irrigation and washing. Due to the different usages and the open water the quality of this water is known to be deteriorating during the season. At most places the availability of water reduces or stops during the dry season. People then have to find different sources of water.

When no water source is available in the near vicinity people (especially women and children) walk for several kilometers to fetch water from wells or pools. The water is then carried in jerrycans on the head or by bike.

Figure 11 *Children carrying water for the family*

At several locations water is collected from rooftops. These rooftop catchments are mostly being used at communal buildings, such as schools. The water is collected and led through gutters to a tank. The Ministry which is charged with water supply builds roofcatchment systems and concrete water tanks. The problem with these tanks is that poor construction results in poor water quality. At different sites the local people told that the water is only used for cleaning, since the quality is too bad.

Figure 12 *Concrete tank for storage of water, collected from the roof*

Water quality

During the field trip around 30 locations were tested for electrical conductivity (EC), temperature (T), nitrate (NO_3^-), nitrite (NO_2^-), Total Hardness (TH), Total Alkalinity (TA) and acidity (pH).

EC and temperature were tested using a handheld conductivity meter (pIONeer 30) Nitrate, nitrite, TH, TA and pH were tested using indicator test-strips (ECO-check).

The locations of the test sites and other interesting or remarkable locations were stored using a GPS (Garmin Etrex).

The EC of the water in the area varied between 400 and 500 µS/cm. With the exception of the river Kikafu which has a very low EC of 57 µS/cm and the spring Chemka which had an EC of 1512 µS/cm.

The water is the river Kikafu probably consists mainly of melt water and rain from the higher slopes of the Kilimanjaro. The spring Chemka is located in the Western part of the area and has a much higher EC.

Nitrate values varied between 5 and 10 mg/l for all locations. Nitrite was absent everywhere. TH varied between 0 and 17°. TA varied between 17° and 40°. pH varied between 8 and 9. However it must be said that we have doubts on the quality of the test strips used for these measurements.

Fluoride

In some areas the soil is covered with a thin (few mm's) thick layer of Magadi. Magadi (or Trona or ash-soda in English) is a salt-like crystal which is formed as a residue when water evaporates from pools. It is found mainly near (temporal) streams or canals, but it does also occur at a number of (nearly flat) places without clear traces of flowing water.

The magadi is collected by the inhabitants and used as a food additive.

Figure 13 *Woman collecting magadi*

Magadi contains high concentrations of Fluoride (Yoder et al, 1998). Most inhabitants of the area show signs of Dental Fluorosis (brown spots on their teeth).

Findings, considerations and recommendations

Water supply

Traditional methods

The few rivers and natural springs in the Rundugai area show a reliable and good source of water for the inhabitants. Rivers and springs have water perennially and the water is generally of good quality. The water of the rivers and springs is thus used by the inhabitants in the vicinity of these sources.

But for a large part of the inhabitants these sources of water a (too) far away. Distances of over 6 km that have to be covered to reach a water source are not rare. During and shortly after the rainy season smaller streams, canals and pools are filled with water. During these periods this water is used for irrigation of the land, cleaning, washing and also for cooking and drinking.

The systems of small streams and canals that distribute the water during and after the rains seems to work well. Large parts of the area are being irrigated. Some locations however cannot be irrigated since the topography doesn't allow water to flow there. This is a problem which is hard to overcome and may have to be accepted.
At some locations overflowing irrigation canals that were losing their water to non-cultivated lands were found, while on other locations dry irrigation canals between dry cultivated land were found. A better management and maintenance of the waterlevels in the canals could possibly improve the availability and effectiveness of the system.

The area has (as far as we have seen) no shallow (potential) aquifers that could be used for (artificial) recharge of water. An aquifer from which water can be harvested is at around 80 m depth.

Possible options for increased (drinking)water supply for the areas at a large distance to a perennial water source are deep boreholes with a pump, or reservoirs for harvesting rainwater from (e.g.) roofs.

Technically based methods

A number of deep boreholes exist in the area. They provide good quality drinking water, although attention has to be paid to the chemical quality of the water, since it is known that other nearby boreholes have a high level of fluoride in the water. The main disadvantages of deep boreholes are:

- The high costs of drilling, contruction, etc.
- The need of electricity to pump up the water.
- The costs of maintenance.
- The required equipment, materials and knowledge for maintenance.

If the above mentioned disadvantages can be overcome boreholes provide a good source of water.

Considering the large area that is lacking nearby perennial water sources we think that the number of boreholes needed and the costs required are (too) high.

Some towns, such as Chekereni and Longoi have a water supply system. The mission post of Father Erasto managed to pipe spring water and supply the people with good quality drinking water. Along the route of the pipe taps make the water available, where people can fill their jerrycans. The only down point is that some taps are leaking, which leads to substantial losses.

Rooftop catchments

Introduction

A good option that could provide safe drinking water, and probably at a lower cost, is rainwater harvesting on rooftops. Rainfall in the Rundugai area varies between 370 and 780 mm roughly (based on estimations with New LocClim v1.10, FAO 2005). That means that on every square meter of roof about 370 to 780 liters of rain is falling every year. Most of this water falls during the rainy seasons. When this water could be collected and stored it would provide a good source of water during the dry periods.

Attention should be paid to the quality of the water. Dust, insects and other organic material will pollute the rainwater, either on the roof itself, in the gutter, or in the reservoir. This is the reason that the locations (e.g. schools and hospital) in the Rundugai area that have a rooftop catchment are only using the water for cleaning and washing. The people using the systems themselves told that the water is not used for consumption since the quality is poor. This is partly because of the lack of a good filter and poorly constructed water tanks.

Opportunities
With some simple adjustments to the system of the rooftop catchments these pollutants can be removed. It is, for example, possible to place a so called “rapid sand filter” in between the gutter and the reservoir to remove the pollutants that are washed away with the water from the roof or the gutters. When the reservoir itself is constructed (and maintained!) in such a way that it is closed of properly and it is cleaned regularly, it can provide a safe storing facility for the drinking water. It is even known that the longer the water remains in the tank, the better of the water quality will be since bacteria will die in time.

Since this water project originates from a house constructing project, the link between these two is obvious. We think that Joop Paauw, Dorcas, and all other organization that are financing and constructing houses in the area should invest a little more money per house and install some gutters, a filter and a tank at every new house they build. A rooftop surface of only 25 m^2 (the size of the houses that are being constructed) and a 3 m^3 (= 3000 liters = 560 Imperial gallons) reservoir can provide 30 liters of safe drinking water every day.

A larger system can also be build, which provides water at a community level. A rainwater harvesting system can be build near churches, schools and hospitals. With a roof area of 500 m^2 (such as the church in Ngulu) and a tank of 75 m^3, around 700 liters of water per day can be provided. This amounts to 50 people having 15 liters of clean water per person per day.

We think that harvesting rainwater from rooftops can provide a decent source of water for drinking and cooking for many people in the area, at reasonable costs. However both the larger (community level) and small-scale systems have both benefits and drawbacks. An overview of these is given in the table below.

Table 1 *Overview of benefits and drawbacks of larger and smaller systems*

Large	**Small**
+ Small investment per m^3 water	**–** Larger investment per m^3
– Large overall investment	**+** Small overall investment
+ Water is shared with entire community	**–** Only for the house-owner
– Possibly far away from the homes	**+** Close to the house, place of use
– Problems related to responsibility	**+** User is entirely responsible for maintenance/rationing etc.
+ Easier to schedule maintenance for filters etc.	**–** People have to have money/time/means to do maintenance
– Distribution (who gets how much water?)	**+** Owner gets all, no sharing issues
– Too large for people to invest for themselves	**+** Possibly good example inspires people to build their own
– If build at a church possibly water is attached to religion	**+** Independent
+ Water is available for everybody	**–** Poor people cannot afford to pay for them selves

Water tank design
The tank in which the water is stored can be made of different materials. For the large scale tanks, masonry or concrete seems the best way to build a tank. To waterproof the masonry the walls have to be plastered.

Small scale systems can be fitted with a plastic tank. A 2000 liter tank will cost around € 600, which is quite expensive for local people. This is a major disadvantage!

Example
The church in Ngulu has a roof area of around 400 m^2. With a cost of around TSh 11.000 for one metal roof panel (3 x 0.8 m^2 effective) the roof will cost around TSh 2 million (€ 1250). When all rain of one rainy season has to be captured, a total storage capacity of 100 m^3 is needed. In ASALs (Arid and Semi Arid Land) people use 5 liters of water per person per day on average (Nissen-Petersen, 2006). According to the WHO standards 20 liters is the minimum required for a substantial living. This means that 25 people can be supplied with water all year around according to the WHO quantity standards. However, it has to be taken in mind that years with low rainfall can occur. The rooftop catchment systems can only supply part of the water needs and has to be implemented as one of the methods of water supply, not as the only method .

Conclusions and recommandations

Water supply
Different methods of water supply are being used in the area. The methods used can not yield much more than they already do. The effectiveness can be raised by repairing and maintaining drainage canals and water supply pipes.

A method which has high potential are rooftop catchments. With relatively low costs a substantial part of the water needs can be fulfilled. When the system is fitted with a filter and well built storage tanks, good quality water can be obtained. This good quality water can be used for drinking. For other uses such as irrigation other means will have to be used.

Using a large roof area (i.e. church, school, nursery) a communal reservoir can supply 10 – 30 people of clean drinking water.

A pilot project can be executed to make the benefits clear to local people. Together with Father Erasto a good location can be picked. Possibly an old existing tank can be restored in stead of a new build system.

Magadi
Magadi is used for flavouring food. Since this is the main source of fluoride people should stop using magadi.

Further research on feasibility
Before starting to build rooftop catchment systems a clear view has to be obtained on the construction of the tank and the filter. Literature and (local) experiences have to be gathered. The costs and benefits have to be calculated for a single project and compared to other methods of water supply (i.e. borehole).

Possibly the construction of a roof catchment system can be (partly) subsidised by other organisations, such as Aqua for All in the Netherlands.

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Appendix 1
Mission story

Wednesday 27-06-2007
Early morning arrival on Kilimanjaro International Airport. Transport to Rundugai.
Field visits to construction sites of houses and visits to recently constructed houses. Walk through Kilimamswaki area.
Afternoon: visit to Rundugai town.

Thursday 28-06-2007
Visit to Mister Mtoi Kanyawannah, key hydrogeologist of the Pangani Water Basin Office (PBWO) in Moshi to aquire information on the hydro(geo)logy of the area and to make copies of topographical and geological maps. Bought some equipment and materials. Taken measurement of river Kikafu near Moshi.

Friday 29-06-2007
Exploration of the area around Kilimamswaki. Taken measurements of pools, streams and (irrigation) canals.

Saturday 30-06-2007
Processing data and measurements in the computer.
Visit to Moshi.

Sunday 01-07-2007
Walk from Rundugai to Ngulu. Collection of measurements on the way. Visit to Chemka springs.

Monday 02-07-2007
Exploration of the area around Longoi. Processing data on the computer.

Tuesday 03-07-2007
In Kilimanshwaki locals claim to be able to hear water flowing in underground rivers and want to make a borehole/well. We tried to pinpoint location using dowsing rods, without any result. Common sense also tells us that this is not a good location.
On 28/6 river Kikafu was measured near Moshi. Today measured again downstram.

Wednesday 04-07-2007
In the morning we visited a person of the Hai District Council. He builds tanks for water storage from roofcatchments.
In the afternoon the spring which is tapped by the Checkereni-pipeline, was visited.

Thursday 05-07-2007
Preparing the report.

Friday 06-07-2007
Field visit to Kwemakame Power Station and Chemka spring.

Saturday 07-07-2007
Visit to Arusha

Sunday 08-07-2007
Visit to Tarangire National Park

Monday 09-07-2007
Helping at the construction site for one of the houses and finishing the report .

Tuesday 10-07-2007
Finishing everything and packing.

Wednesday 11-07-2007
Leaving back to the Netherlands (Lucas) and starting vacation (Sander).