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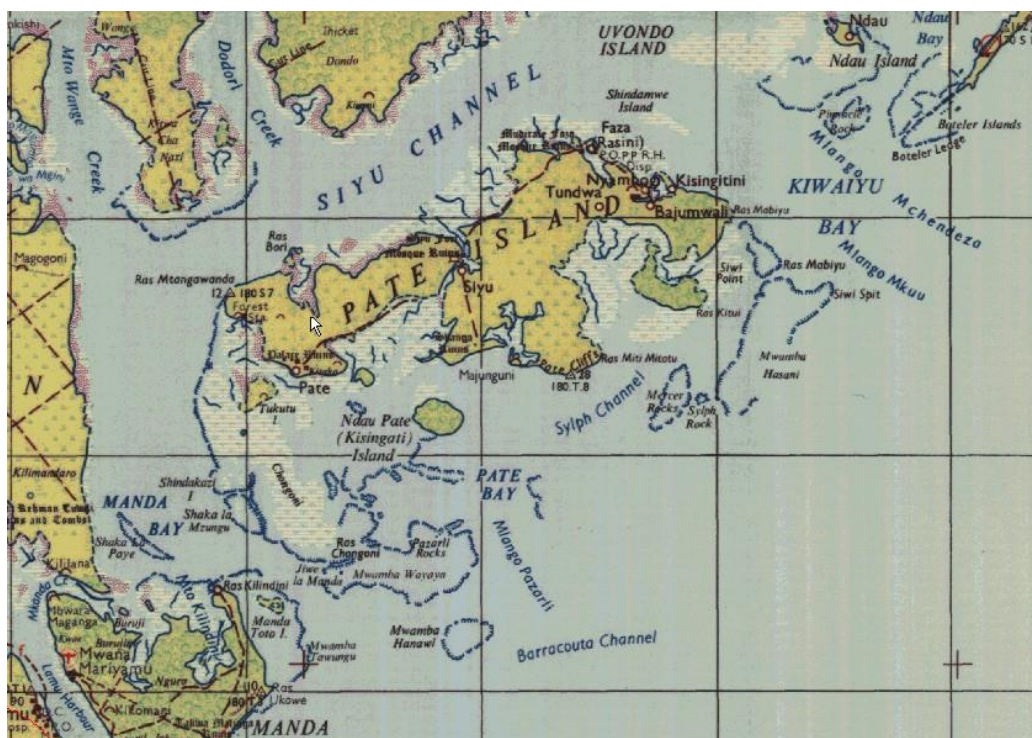
**International Committee of the Red Cross  
Regional delegation of Nairobi**

Simon Peter Ochieng, Kenneth Omondi Ogutu  
University of Nairobi as industrial attachments

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Red Cross volunteers of the islands  
Djabia's owners

**Access to water in Pate Island and in Ndau**

**Djabiah's baseline survey**



January 2006

## Important foreword

This survey has been carried out with the assistance of many people, between July and October 2005. It has to be considered as a preliminary survey, and, would need to be re-conducted, if the verification of some parameters is required.

A questionnaire was used to collect the data. Some parameters were measured, like the length, depth, width of the collection surfaces or of the “djabiahs”, the geo-graphical position of the premises, name of the owners, etc. These data can be used to understand the present situation of the access to water within the different villages and may be useful to define priorities.

Other information was provided by the djabiah’s owners themselves. The last one is somehow less reliable, as it depended on the understanding by the different stakeholders on the exact purpose of the process. The conditions of the different premises are also depending on the appreciation by the surveyors and, as such, the results of the analysis may be biased.

Despite these drawbacks, we do know now where all these premises are and it is now easier to target those which are in need to be repaired. We are also able, using the database and the query function of the GIS software, to assist the communities in the selection of the premises which they would like to see rehabilitated.

The selection of such premises has been done with the representatives of the different villages and a targeted technical survey has been planned for early 2006.

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## Water supply in Pate Island

### Introduction

Data on current access to water within the island are scanty. According to the existing bibliography and recent studies<sup>1, 2</sup>, most of the groundwater resources within the Lamu district are saline and in general, not suitable for human and animal consumption, except for dunal and coral reef formations.

Dunal formations bearing relatively good aquifers are present and represent the main water supply for the town of Lamu. They also provide water around Pate village with relatively fresh water from open shallow wells. Unfortunately no water bearing formation is present north of Pate village and the inhabitants of Siyu, Faza, Chundwa, Kisingitini, Mtawabanga, Mybogi and Mb wajumwali, as well as those living in Ndau island, depend on rainwater collection for their drinking water needs, while shallow well tapping relatively salty water are mainly used for cleaning and other domestic purpose.

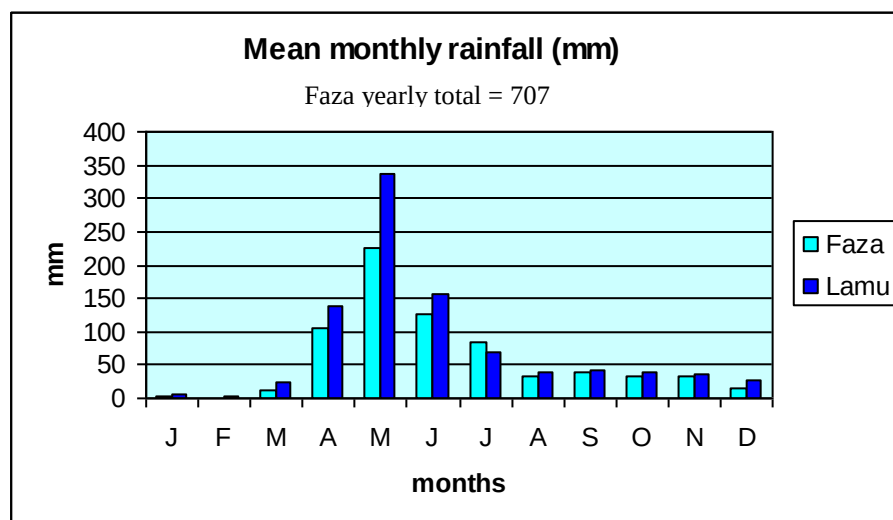
Rainwater is collected from roofs but also using “djabias”, which are man made sloping concrete collection surfaces conveying water into an underground tank.<sup>3</sup>

A possible water systems tapping water from the Pate fresh water wells and pumping it throughout the island, approximately 15 km north, to other villages, has never really been investigated and remains a dream for the inhabitants of Faza and Kisingitini.

Under these circumstances two factors appears essential for an appropriate fresh water availability:

- good rainfalls
- distribution of djabias properly designed and maintained.

As shown in the tables and graphs below the rainfall in Lamu/Faza coastal area falls during the wettest months of April, May, June and July with the remaining months being almost dry. However, in 2005, the first showers were experienced only end of May. According to the villagers, though, even after a good rainy season, most of the djabias are not filled up. This is mainly due to poor design as very often the storage tank is oversized or the catchment area is under-designed. Further poor guttering, cracks on both catchment areas and within the storage tanks and bad to none maintenance, reduce



significantly the effectiveness of the systems. Indeed, maintenance is in general very poor. It seems that most of the djabias, mainly private, were constructed around ten years ago, when the island experienced a much better economical situation. So far, nowadays, internal family disputes and lack of financial means are the main reasons behind the poor

maintenance. Moreover, the recent GOK/WWF policy to ban/limit mangrove tree cutting (1998) and coral quarry (2002) made the economical situation even worse.

<sup>1</sup> Data from District Public Health Officer, Lamu district

<sup>2</sup> “Djabiah rainwater harvesting systems for domestic water supply in Lamu, Kenya: E.K. Biamah, JK Choge and R.K.K. Cheregony, University of Nairobi

<sup>3</sup> ibid. 2





**Faza** Communal djabia concrete: v.good surface



**Ndau** Mosque Djabia: v. good surface



**Faza** Communal djabia v.good collection



**Ndau** Abandoned djabia



**Siyu** School collection surface : fair condition



**Faza:** communal djabia: v.good collection surface



**Kisingitini:** Helath centre v. good collection surface



**Ndau:** Dispensary djabia: v. good collection surface





**Faza School** poor conveying system



**Kisingitini** iron sheets oor collection and fair conveying



**Faza School** poor conveying step



**Faza** poor conveying step



**Faza** School damaged iron sheet cover of storage tank  
**Ndau** Rehabilitation work on the dispensary tank



**Ndau**: Mosque collection, conveying and storage tank  
**Ndau** Completed rehabilitation of the djabia



Finally, the poor quality of the collection surfaces (rusted corrugated iron sheets, poor concrete surfaces) leads to a poor quality of the harvested water enhanced by poor drawing methods, as most of the people are using their own bucket and rope to collect the water.

Although the poor maintenance of the water harvesting structure is a weakness of these systems, the way that water is managed may be another weak point. Djabias are mainly privately owned, but also communal, run by a committee, or the property of the County council. More recently, in several locations, some new ones were built by Women users associations, financed by different donors. The communal and those owned by the County council as wells those run by the women water committees are in general the better maintained ones.

An estimated 20 % of the resident population own a djabia, while the remaining 80 % of the population use to buy djabia fresh water as any other essential good. Somehow, the fresh water is considered and managed the same way of commercial goods such as coconuts and lobsters.

As a matter of fact, the owners of the djabia deal with the water selling without taking into consideration their own needs along the whole dry period. The same applies to a village. For instance when the djabia water is finished, the villagers of Kisingitini, the most well off village, begin to buy water from other villages, sometimes already in October. But, although the fresh water harvested during the rainy season belongs to private businessmen, it is shared on a fair economic basis amongst all inhabitants. At the same time fresh water selling is also the main income activity for some people, particularly for those who are providing transport facilities either by donkeys or using the dhows.

In other words, when the water reserves ran over, it is for all, including the owners of the djabias. So far, regardless to the fact that the djabia is private or communal, the water is systematically sold at a price varying from 3 to 10 K.Shillings/ 20 liters jerry-can<sup>4</sup>.

Although water is provided at the Navy base free of charge and is also quite cheap in Lamu, transport by dhow brings the cost of a 20 litres jerry-can at 30 to 50 KSh. The water collected by the County council djabias is usually sold at public auctions and normally purchased by one of the well-off businessmen of the village. If the rainfall is scanty, he may make some extra profit.

As a consequence of all these factors the total amount of fresh water harvested during the rainy season and stored at the end of it does not last more than 4 to 5 months. Initial information reveals that in general the fresh water reserves ran out around December. After that time, fresh water is obtained from the Kenyan Navy at the Magogoni base.

## Baseline study

Because of the difficulty to obtain a clear picture of the situation of the different villages, in terms of access to water, a baseline study had to be carried out. A questionnaire was prepared and explained during a two days training session to the Red Cross volunteers based on the island, who were in charge to collect the data. The survey began simultaneously in all the villages and lasted for about a month, with some villages receiving a more specific attention, like Siyu, where some wells were reported to be in use for the entire year. The collection was completed by beginning of September and the data codified in Nairobi. For Siyu the location of the djabias and of the wells used by the inhabitants was also completed using a GPS and data about the level of salinity were collected using an instrument combining pH and conductivity (Hanna Combopen), calibrated with a standard solution. The positions of the wells and of the djabias were then reported on a map digitized from the Landsat 2000 mrsid 15 m resolution image, the best available one at the time of the study.

## Main data collected

The type of data collected are shown in the next table:

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<sup>4</sup> September 2005 1 USD = 75 K.Sh. and 10 K.Sh. = 0.13 USD which makes the cost of 1 m<sup>3</sup> over 6 USD. Water is sold at a rate of 4-5 K.Sh./20 litres by water vendors where water is accessible from the network. In Lamu a 200 liter drum is purchased for K.Sh.....

**Table I.** Type of data collected

|                                                                                                                                |                                                                                                                                                                                                                                             |
|--------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| date<br>site or name of the djabia<br>sublocation<br>location<br>division<br>owner of the djabia<br><br>Gps latitude/longitude | no. of djabia users<br>no. of users (no. of people per season)<br>length of water availability in months<br>month of the year when the djabia is empty<br><br>year of construction<br>year of last rehabilitation<br>type of rehabilitation |
| <b>collection surface in m2</b><br>type of collection surface (cement, iron sheets, makuti)<br>condition of the catchment area | <b>capacity of the djabia in m3 (l x w x d)</b><br>type of material of the djabia (cement, metallic, plastic)<br>condition of the storage reservoir (djabia)                                                                                |
| water quality (taste, treatment)<br>chlorination (quantity of powder used in g/m3)                                             | type of management (individual, association, government, communal, other)                                                                                                                                                                   |

## Results and discussion

Geographical information software (ARCVIEW 3.2) allow to query properly codified information. In this study we have located the position of the interesting features on a geo-referenced map. A LANDSAT 2000 TM (false colours) with 15 m/pixel ground resolution has been used and features, mainly djabias

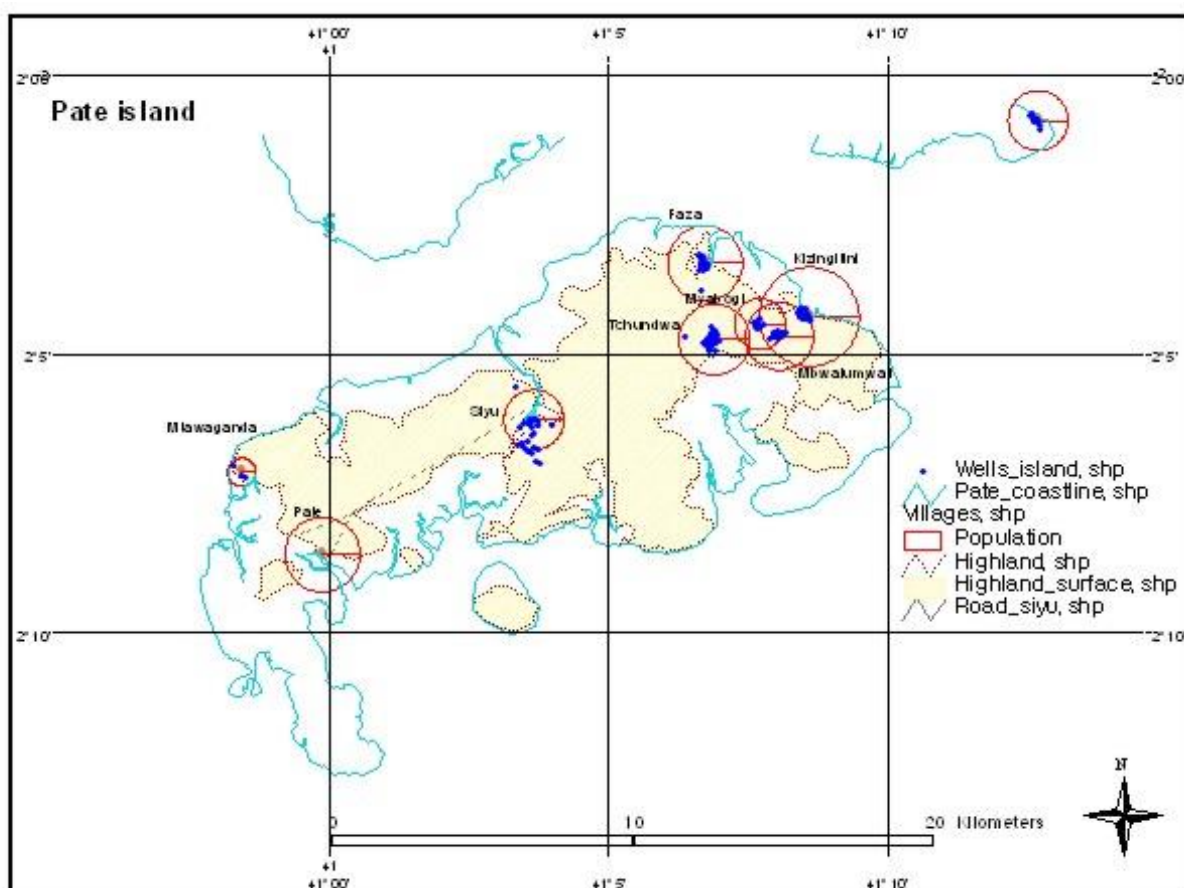


and wells have been located using a GPS (global positioning system). The coastline and the highlands have been digitized from the Landsat image. A tile from the Kenya topographic can also be used but the registration is poor as well as the details, as it can be seen from the two images shown hereafter. Population figures are estimates and have been plotted according to their relative importance. The location of the wells and of the djabias has also been

reported in the figure, where the limits of the mangrove coastline and the highlands are also shown. We have surveyed Pate village only lately and the collected information is not reported here.

The image shows clearly the concentration of the population in the North-Eastern part of the island, where almost 70 % of the population of the island is concentrated. The location of Ndau, with a population of about 2000 inhabitants is also shown.



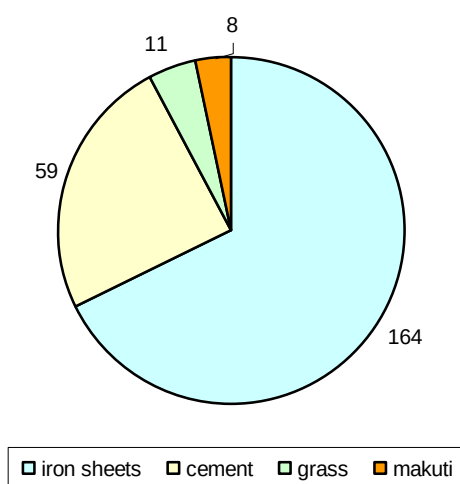


### Type and condition of collection surfaces

The majority (68%) of the collection surfaces are built with corrugated iron sheets and with concrete,

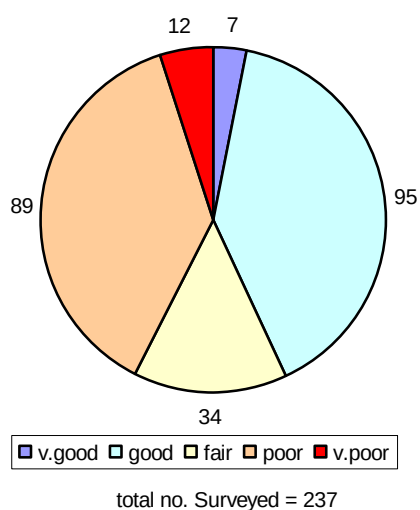
Pate island

Types of collection surfaces



Pate island

Condition of the collection surface

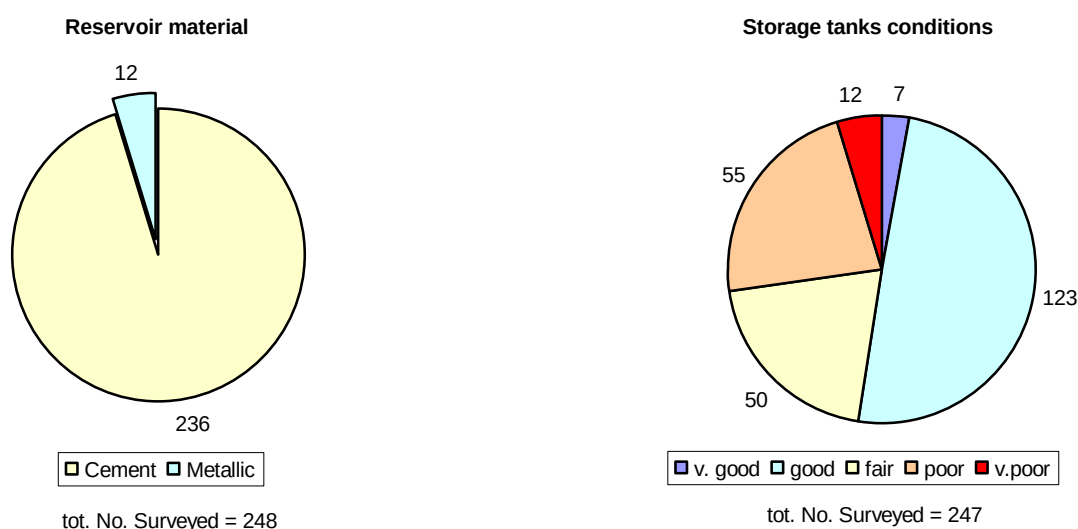




the last ones representing about 24 %, with only a minor part consisting of grass or makuti. This is due to the fact that corrugated iron sheets, of different gauges, are the most accessible ones to cover the roofs and also the djabias. Grass and makuti are not popular as the water collected from these surfaces is coloured and has also a particular taste, restricting its use to domestic purposes.

## Type and condition of the storage tanks

The majority of the storage tanks are built in concrete, with some, mainly elevated, in metal. Plastic is used only in a few health centres, in Kizingitini for instance, and represents only a limited %. Many of these underground tanks are leaking. They have been repaired, but some of them are beyond any improvement and have to be rebuilt. At several locations, in Ndau and in Siyu, the only way to repair them was to rebuild an internal wall and lay concrete in between. This method has given good results but is quite costly, as it is almost equivalent to the construction of a new storage tank, except the excavation works. Other ways will have to be explored.



## Detailed analysis of the data per village

### Assumptions

Collection surfaces (loss factor **f** between 0.5 to 0.8)

Precise data are lacking. There is a difference between the types of the collection surfaces. We have assumed that most of the concrete surfaces are in fact collecting the quasi-totality of the water, up to 80%. Iron sheets surfaces have a slight less efficient collection capacity as water may be spilled out of the roofs in intense rainfalls. The collection capacity of the makuti roofs has been estimated to be of about 50 %.

Condition of the collections surfaces (loss factor **c** between 0.65 to 1)

This is an appreciation of the data collector. The condition of the collection surfaces have been defined varying from very poor to very good, that is in 5 categories, with correction factors from 0.5, for the very poor ones, 0.75 for the poor, 0.85 for the surfaces considered as fair, 0.95 for the good ones and 1.0 for the very good surfaces. As this factor is left to the appreciation of the surveyor we expect to observe some consistent reporting for the data collected for the same village as the same person is

the ones who appreciate the level of this condition. It is certain that there must be a difference between the villages as the appreciation has been done by different surveyors. It is clear that a too large number of categories have probably created some difficulties in the appreciation and it would have been wiser to reduce them to 3. An attenuation factor can be introduced to reduce the importance of this parameter.

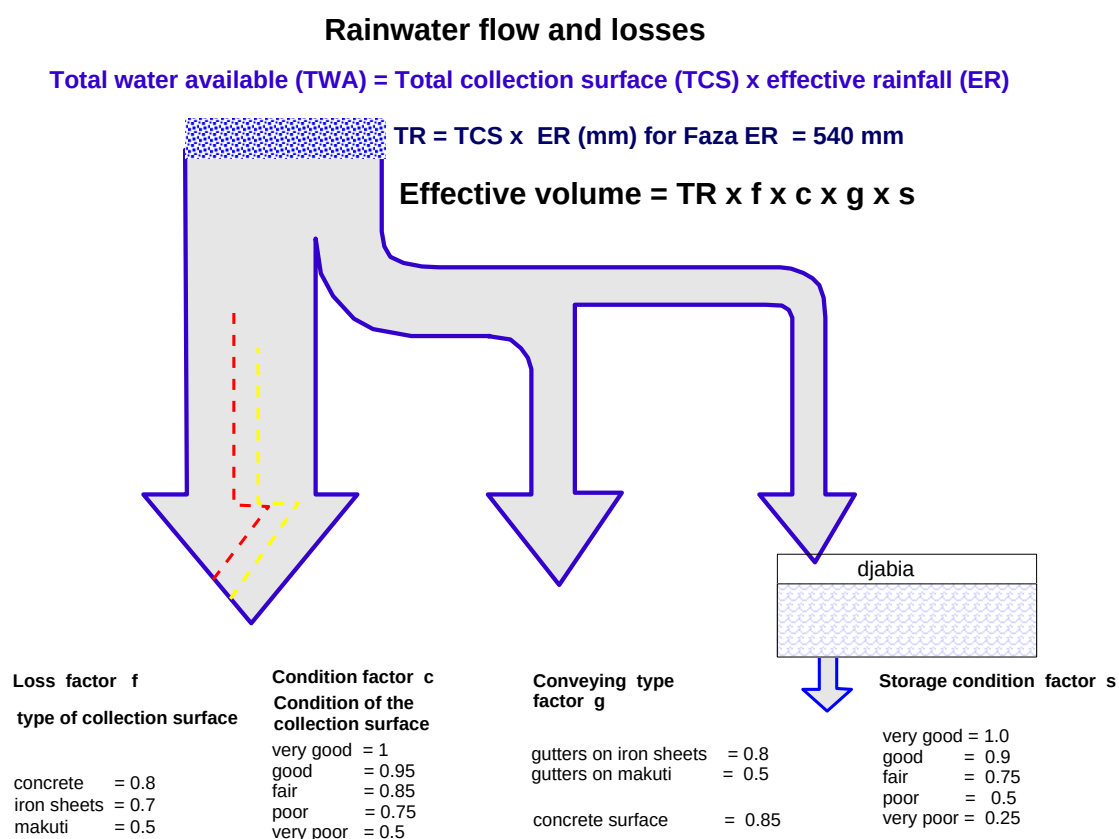
Conveying systems ( loss factor **g** fixed 0.75 and 0.85 )

No data have been collected about the conveying systems. It is assumed that gutters collecting water from the iron sheets roofs or from the makuti roofs are in poor condition and losses from such systems are high, up to 50%. On the contrary most the conveying capacity of the concrete collection surfaces is better and it is assumed that 80 % of the water reaching the surface is finally reaching the storage tank.

Storage condition (loss factor **s** between 0.25 to 1.0)

This factor is taking into account the losses due to leaks within the storage tanks, as they are reported by the owners or by the users. There is always a small loss due to evaporation, this is why the factor is never equal to 1.0.

Figure 2 shows graphically the global problems of the systems and the values assigned to the different factors to be used to compute the effective amount of water available for the inhabitants of given village.



**Fig. 2** Graphic representation of the systems and of the different losses.

## Results and analysis using the model for the losses

The analysis has been carried for every village, except Pate, where the access to water has never been a problem. At least it was never reported as such. This will allow to comparing the situation among the villages and address specific problems linked with one or two key steps of the collection system.

### Total amounts of water available from rainfall

We have based our calculation on the data obtained from reference (1), reported in figure 1. We have considered here only the 4 more rainy months, with mean monthly rainfall higher than 50 mm/month, for a total of 540 mm, over a yearly total of 707 mm. The levels of rains for the dry months are too scanty to allow for a consequent replenishment of the underground storage tanks and, in case, people will use most of the water available.

We can therefore calculate the total volume of water available by multiplying the different surfaces by the total of the mean monthly number of mm specified above. Then the loss factors are also included in the calculation to obtain the effective volume available per village at the end of the rainy season. This volume is what will be used throughout the dry period, and will last for several months, eventually for all the dry ones, if its use is properly managed.

The following equations has been used:

Total rainfall (in liters) = Total collection surface (in m<sup>2</sup>) x effective rainfall (in mm)

Effective volume (in m<sup>3</sup>) = Total rainfall (liters) x f x c x g x s / 1000 where

f = loss factor related to the type of the collection surface

c = loss factor related to the condition of the collection surface

g = loss factor related to the conveying system

s = loss factor related to the storage

The calculation has been performed for every djabia and reported per village in the following table:

| Village     | No. of djabias | Total collection Surface (m <sup>2</sup> ) | Effective collection surface (m <sup>2</sup> ) | Storage volume (m <sup>3</sup> ) | Pop. | Useful rainfall mm (4 months) | Effective volume EV (m <sup>3</sup> ) | Theoretical volume TV (m <sup>3</sup> ) | System efficiency ratio EV/TV |
|-------------|----------------|--------------------------------------------|------------------------------------------------|----------------------------------|------|-------------------------------|---------------------------------------|-----------------------------------------|-------------------------------|
| FAZA        | 55             | 7287                                       | 4048.80                                        | 4725                             | 3000 | 540                           | 1203.00                               | 3934.98                                 | 0.3057                        |
| KIZINGITINI | 68             | 10318                                      | 5988.90                                        | 9713                             | 5000 | 540                           | 2086.00                               | 5571.72                                 | 0.3744                        |
| MBWAJUMWALI | 36             | 3195                                       | 1919.10                                        | 2851                             | 2500 | 540                           | 683.00                                | 1725.30                                 | 0.3959                        |
| MTANGAWANDA | 4              | 821                                        | 514.00                                         | 346                              | 500  | 540                           | 142.00                                | 443.34                                  | 0.3203                        |
| MYABOGI     | 10             | 1277                                       | 649.30                                         | 1368                             | 1500 | 540                           | 216.00                                | 689.58                                  | 0.3132                        |
| NDAU        | 37             | 3638                                       | 2175.00                                        | 2696                             | 2000 | 540                           | 798.00                                | 1964.52                                 | 0.4062                        |
| SIYU        | 20             | 2288                                       | 1267.00                                        | 2190                             | 2000 | 540                           | 426.00                                | 1235.52                                 | 0.3448                        |
| TCHUNDWA    | 22             | 2755                                       | 1781.00                                        | 2848                             | 2700 | 540                           | 693.00                                | 1487.70                                 | 0.4658                        |

What is of course of interest is the amounts of water available per village. Precise data on population figures are not available, for all the villages. For some, population projections based on a census carried out in 2003 can be used<sup>5</sup>. Knowing the population number, even if only relatively precise data are available, it is possible to calculate the amounts of water available per village from the djabias.

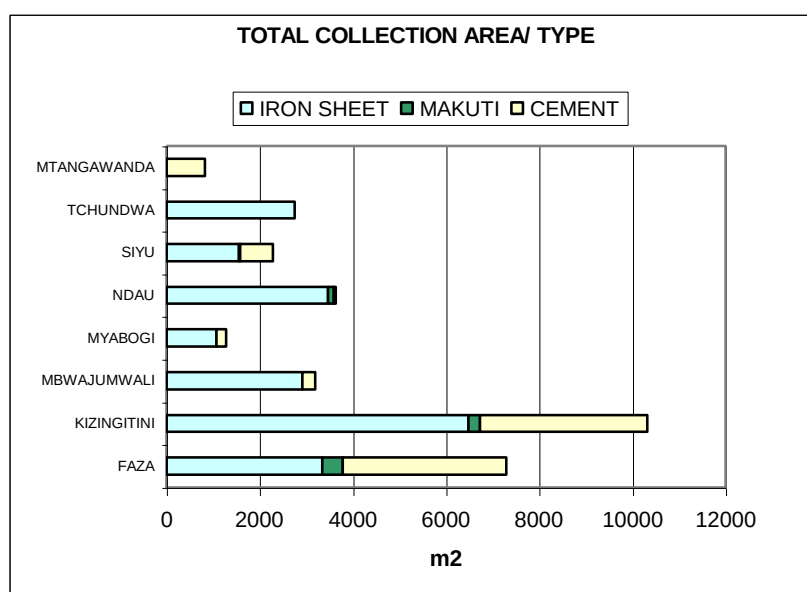
The results are reported in the above table. In fact, the total effective collection surfaces per village are of course much lower than the total collection surface, bearing in mind all the losses, outlined above. The assumptions made can be field tested but this will be quite time consuming and we put our emphasis on obtaining data on a global way, in order to sort out possible priorities of intervention.

<sup>5</sup> KMIS District population Projection Results (2003)



The **efficiency of the system**, defined as the ratio between the effective volume available for the people and the total theoretical volume computed from the total surface is also given in this table. With the assumptions made, this ratio is in principle never higher than 0.68 but is generally lower. In our situation this ratio is always less than 0.5 and decreases down to 0.3 for some villages, namely for Faza (0.30), Mtangawanda (0.32) and Myabogi (0.31). Surprisingly, Tchundwa has the highest ratio (0.46), with Ndaou and Mbwajumwali close to 0.4 and Kisingitini just a bit below. It takes into account the efficiency of the collection but also the efficiency of the storage.

The data available do allow for a separation of the type of surfaces. For instance, we can calculate the total area for the concrete collection surfaces, for those done with makuti and for the iron sheet ones for every village. This more precise analysis gives the following results, outlined in the next figure, showing the relative proportions per village of every type of surface and the cumulative surfaces per type and per village in the figure below.

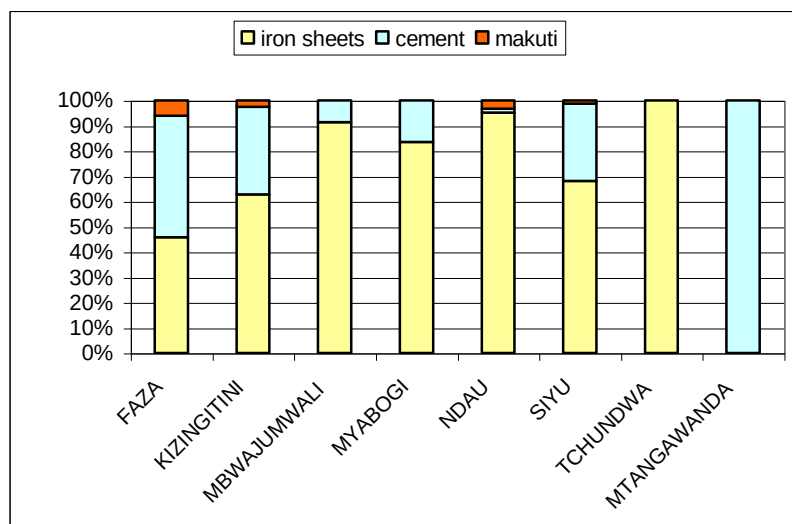


As a matter of fact the total area of the collection surfaces from makuti roof is quite negligible in most of the villages. Even in Faza the area represents about 6 %, with even less in Kisingitini, close to 3 % and can almost be neglected in the other villages.

The proportion between iron sheet and cement is varying from about 50 % for Faza to 60 % for Kizingitini and Siyu and reaches levels higher than 80% in Myabogi, Ndaou and Mbwajumwali. In Tchundwa all the collection areas are iron sheets ones and in

Mtangawanda the surfaces are all in cement.

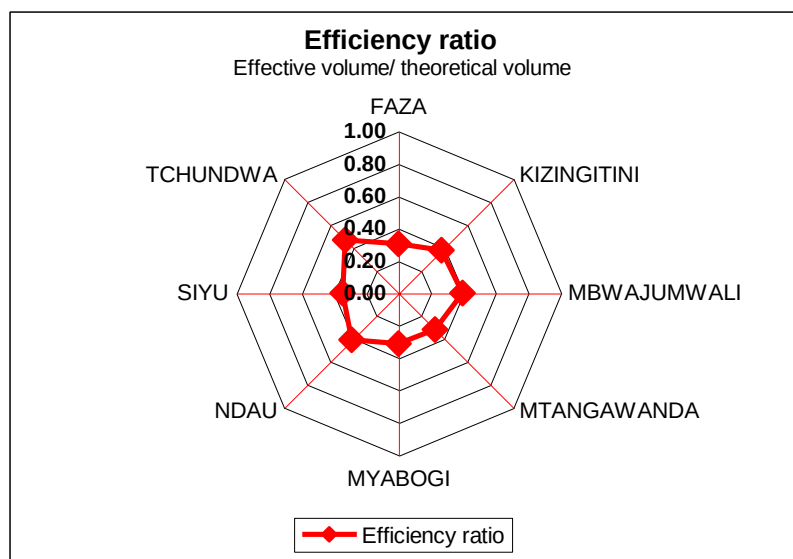
The interesting fact is that in most of the villages a large part of the collection surfaces are made of iron sheets. In this case we have assumed that spillage is important as the water will need to be conveyed from the roofs to the reservoirs and we know that most of the conveying systems (gutters) are of poor quality, responsible for a large part of the losses. We would then expect a low **system efficiency ratio** in the villages with an important proportion of iron sheets as collecting surfaces, and consequently a decrease on the effective volume collected in the djabias. As a matter of fact we



indeed observe a high efficiency ratio in Tchundwa, in Ndaou and in Mbwajumwali, where the proportion of the iron sheets collection surface is higher than 80 %, reaching 100 % in Tchundwa.

This shows that it is of paramount importance to make the distinction between the relative losses due to the collection surfaces and those due to the condition of the underground tanks in order to understand where the effort will have to be done. The data

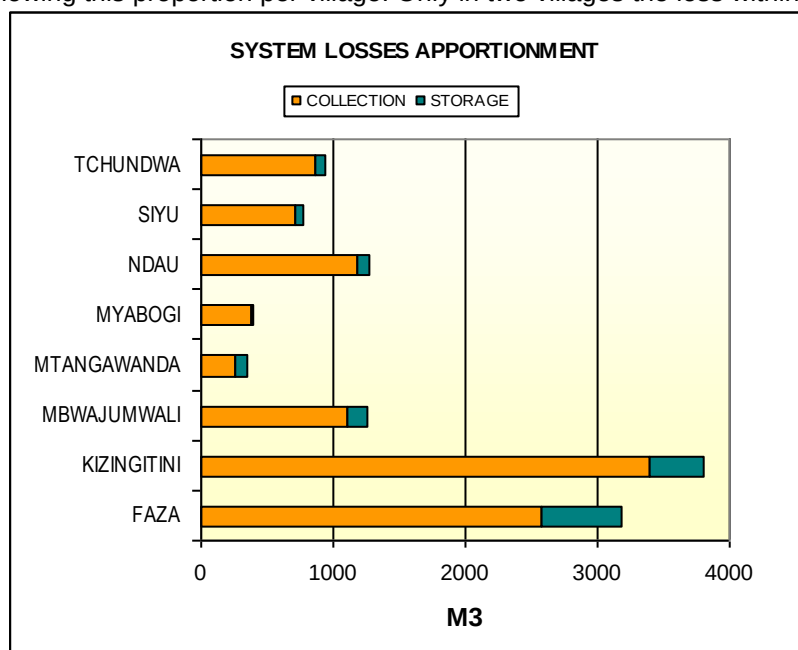
again allow for such an analysis. The individual collection surfaces of every djabia can be multiplied by the respective loss factors to obtain the volumes lost within the different steps of the collection system. The same can be done with the storages losses. We can then represent the total respective losses per



village and analyse their relative importance. The following figures show the results of these calculations, carried out individually, within a village.

Unfortunately we will not be able to see the relative importance of the loss factor for the conveying step, as it was considered that almost all of the conveying systems using gutters were in bad condition, with a loss factor of 0.80, not appreciated by the surveyors. Those related to concrete ones were weighted just a bit better, to 0.85. The value for iron

sheets is probably too small. For this particular way of conveying rainwater to the tanks we should have introduced a more variable factor, as it was done for the other steps of the system, where the condition of the steps were appreciated. Despite this pitfall in the data, we should be in position to distinguish between what is lost in the collection from what is lost in the tanks. The following graph is showing this proportion per village. Only in two villages the loss within the tanks is important: in Faza



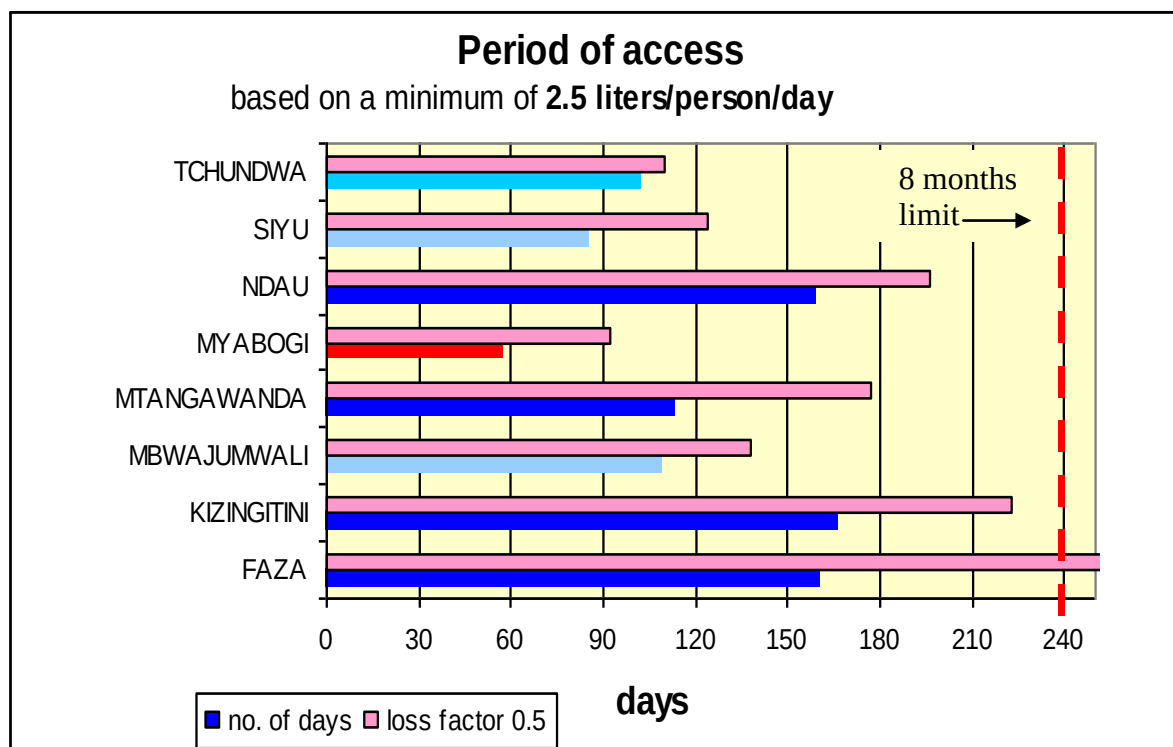
and in Kizingitini, where the loss within the tank is representing 19 % and 11 % respectively. In Mbwaumwali this percentage is close to 12 % and in Mtangawanda it reaches 27%. Within the djabias of the remaining villages, the loss within the tanks is less than 10 %. The importance of these losses is related to the relative condition of the tanks observed by the surveyors, with an important proportion rated poor or very poor. A detailed analysis per village for the two parameter, collection and storage, may allow us to give an answer.

## Calculated period of access

The effective available volume, computed as described above can be used to estimate the length of the availability of water in days, by dividing the effective available volume by the estimated population and by assuming that every person will use a given amount of water daily. The following graph shows the results of such a calculation when the consumption value of 2.5 l/p/day is used. The value of 2.5 is

higher than the reported volume used by the people during a week, which is of 3 jerry-cans, according to the data collected. That means about 9 liters/day for a family, which corresponds to 1.8 l/p/d for a family of 5 people.

Two ways to calculate losses have been applied here. The first one, in blue, with the exception of the village of Myabogi, takes into account the assumptions made above, with all the different losses per steps and weighing parameters. For the second one, shown here in magenta, a global loss factor of 0.5 has been applied using the available collection surface. This 0.5 factor is what we were using initially as nothing was known about the importance of every step. The results show that if the more sophisticated approach is chosen the water will last for about 160 days for Faza, Kizingitini and Ndaou,



if the 2.5 liters/p/day rate is used. For Mbwajumwali Mtagawanda, Tchundwa the number of days is close to 100 and for Siyu this value is just slightly below 90 days. The worst case is for Myabogi, with about only 60 days of access. If the second approach is chosen the number of days with water, assuming a constant collection per person of 2.5 l/p/day, is proportional to the total area and is not affected by the different correction factors. The length of the availability of water is in general more important.

The only conclusion which is evident is that in Tchundwa the results are quite close and the net effect of the correction factors are close to the applied value of 0.5.

Most of the owners have reported that the majority of the djabias are running dry in January. This is consistent with our findings for the villages of Faza, Kizingitini and Ndaou but not for the other villages, where they should run dry before. However, our calculation has been based on a constant use of water and this is probably not the case when the water becomes scarce and when the cost is increasing.

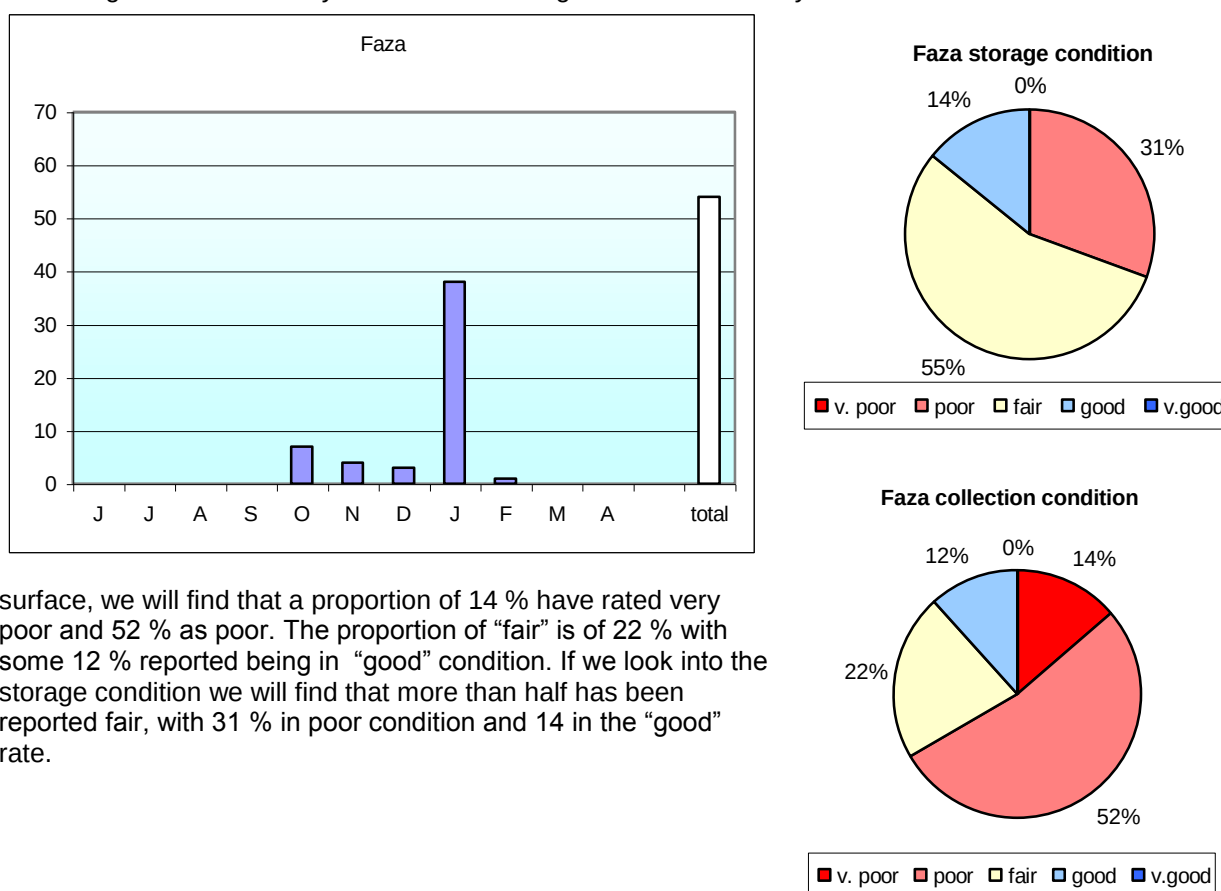
## Results from the questionnaire

The months when the djabias were running dry was one of the key questions asked during the survey. The answers are of paramount importance to understand the burden of the inhabitants and to validate, if possible, the results of the calculations. As pointed out previously one of the key loss factor, the

conveying one, has probably not been weighted correctly and may play an important role in the availability of water. If this is the case we will observe, in the villages where the conveying factor plays a greater role than what has been assigned, an important difference between the calculated number of months with water and the reported one. In fact, the **reported data** are probably less biased and any reasonable intervention will have to be based on what has been observed by the owners or by the users.

If we plot for Faza and then Kizingitini the number of djabias reported running dry in a given month we will obtain the following figures:

In Faza the majority of djabias have been reported to run dry in January. Over a total of 54 djabias for which data have been collected, 38 have been reported to run dry in January, with only a small part having problems in the preceding months, as it can be seen from the graph. Only a few are still containing water in February and in the following months. If we analyse the condition of the collection

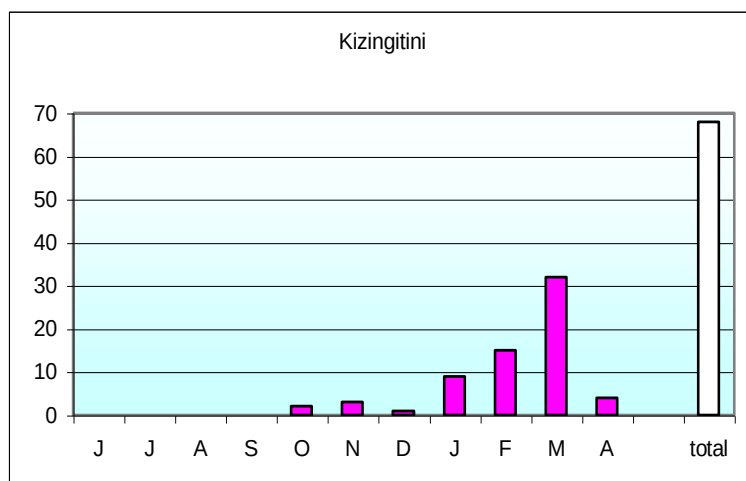


surface, we will find that a proportion of 14 % have rated very poor and 52 % as poor. The proportion of "fair" is of 22 % with some 12 % reported being in "good" condition. If we look into the storage condition we will find that more than half has been reported fair, with 31 % in poor condition and 14 in the "good" rate.

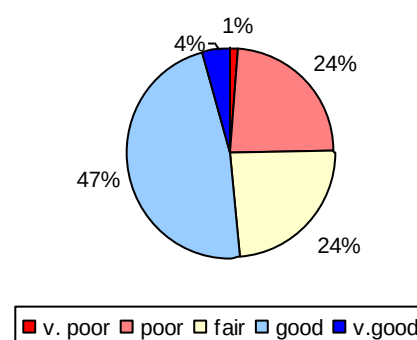
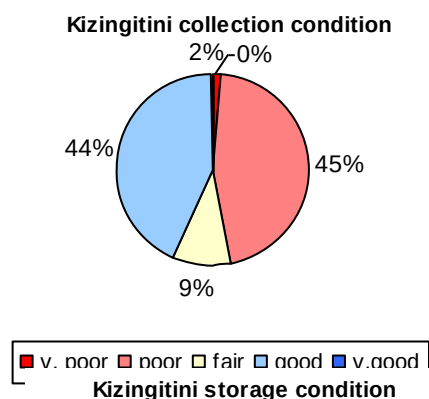
Similar graphs can be plotted for Kizingitini. They are shown in the next page.

Over a total of 68 djabias only 9 are reported to run dry in January, with 15 running dry in February and 32 running dry in March. 4 are reported to run dry in April, when rains can be expected. If we do the same analysis than for Faza we will find that a larger proportion (44%) of the collection surfaces have been reported in "good" condition, with a smaller "fair" contribution (9%) and with only 45 % of the surfaces rated poor. The significant difference is that almost none of the collection surfaces have been rated "very poor (2%) and that the proportion of "good" surfaces is also significantly higher in Kizingitini than in Faza. If we look into the condition of the storage tanks we also find a better situation than in Faza. 47 % of the storage has been rated good with 4 % rated "very good", with a relative consequent decrease of the "fair" and "poor" rates, down at 24 % each.





This can explain why most of the djabias in Faza will run dry earlier than in Kizingitini. As a matter of facts several new djabias, with concrete collection surfaces have been built in the recent years in Kizingitini and are efficiently run by different associations. Kizingitini is also a wealthier place with a larger economic activity, based on the lobster trade, capable to generate the necessary funds to built and repair.



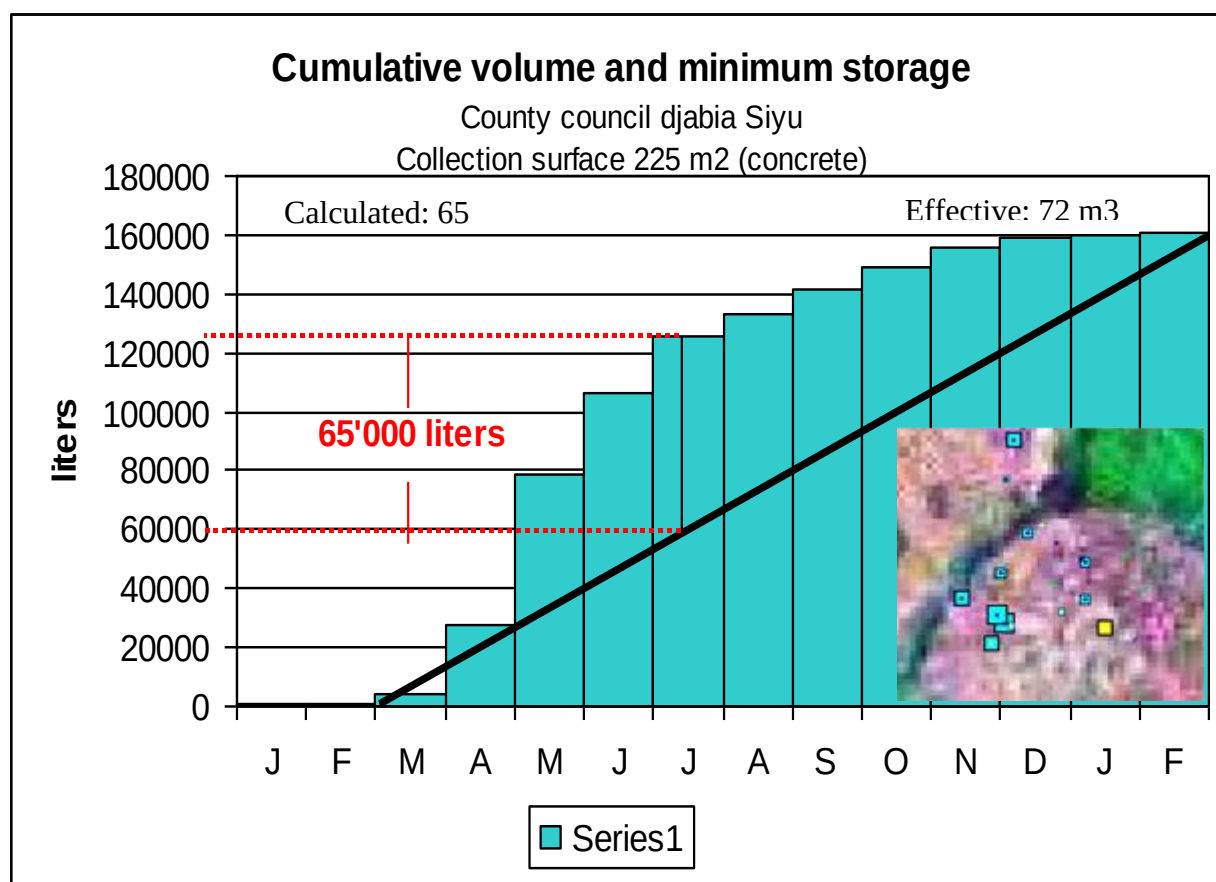
## Sizing of the djabias

Djabias are sized according to the available roof surface and the daily consumption. From the mean monthly rainfall and a give collection surface it is possible to calculate the volume of water than can be collected per month. Plotted on a graph in a cumulative way the following graph can be obtained:

The example given here is from the County Council djabia in Siyu. The figure included in the box shows the location of the djabiah within the village. The total amount which can be collected from the available surface is close to 160'000 litres, if we assume that all the water is reaching the underground storage tank. Divided by the number of days per year, the amount that can be used every day is 438 litres. If we assume that every person is using 2.5 litres/day, the number of persons that this particular djabia can sustain is 175, that is, about 35 families, if we assume that the mean number of people per family is 5. If the amount of water is of 5 l/p/day, the number of families has to be divided by 2.

To compute the size of the tank, the consumption line is plotted on the graph for a yearly period, from February to February. The largest amount that can be collected per month is the difference between the total amount collected and the consumed one. In this case the volume of 65'000 litres can be obtained, corresponding to the month of July, that is, at the end of the rainy season. The tank has been sized at 72 m<sup>3</sup>, which is consistent with the maximum volume that can be collected. Its size is slightly more important in order to take into account any fluctuations in the rainfall patterns. In this analysis we have not taken into account the losses due to evaporation, conveyance or eventual leaks.

A similar analysis can be done for all the djabias. In general most of the tanks have been oversized. It is not clear why, as this has an important financial aspect, a larger tanks is more expensive than a smaller one. It is also possible that the owners had in mind to increase the size of the collection area and this may explain this general trend



## Conclusions

The survey has been completed and a lot more is known about the different systems used to collect rainwater within the villages of the two islands of Pate and Ndau, located north of Lamu. About 250 systems were surveyed in 9 villages. At the same time data on about 260 wells were also recorded, but the results have not yet been compiled.

The data of the rainwater collection systems have been codified and analysed using GIS techniques. We know now where every djabia is located, by whom it is owned and managed and we know the technical specifications of every system.

A theoretical analysis based on mean monthly rainfall data, collection surfaces, losses and storage capacities, has been performed in order to evaluate the potential storage capacity within every village, with the exception of Pate, mainly supplied with underground water, and Bori, located close to Mtagawanda. For some villages, Ndau, Kizingitini and Faza, the analysis has been completed with data obtained during the interviews, combined with measured ones.

Systems in need of rehabilitation have been selected together with the representatives of the villagers, during a workshop held in Lamu, where the results of the survey have been outlined, and where the basic principles of rainwater management have also been presented.

Some of the information collected will have to be taken with the necessary precautions as it is not as precise, being dependent on the answers of the owners or of the users and prone to be biased. But stakeholders do know now a bit better what was the aim of the survey and how they may improve the information we may receive, which will allow the villagers to better manage the existing systems, while rehabilitating the djabias they consider of common interest within every village.