1.0 INTRODUCTION

1.1 Kitui background information.

Kitui district is one of the twelve districts in eastern province. It covers an area of 20,402 km^2 (CBS, 2001). Its altitude ranges from 400 to 1800masl. The district border Machakos and Makueni to the west, Mwingi to the North, Tana River to the East and Taita Taveta to the South .It is located between latitude 0 degree 37inches and 3 degree 0 inches south and Longitudes 37 degrees 45 inches and 39 degrees 0 inches East (map 1).

Fig 1.1.1 Location of Kitui district

The district consists of ten divisions (map 2) whose total area is 20,402km^2. The total population is 515,422. Table 1 below shows the population of each division, number of household (h/h) and the area occupied by each division.

Table 1.1.1 Population per division in Kitui

	DIVISION	AREA km^2	MALES	FEMALES	TOTAL	H/H
1.	Central	808.6	59069	64673	123742	24792
2.	Yatta	175	20019	21627	41646	7648
3.	Mutitu	837.2	11245	12615	23860	4988
4.	Chuluni	521.5	34298	38043	72341	12977
5.	Mwitika	836	9246	10456	19702	3871
6.	Mutonguni	398.1	27361	31537	58898	11043
7.	Matinyani	269.7	19173	21665	40838	7552
8.	Motomo	1394	24103	27683	51786	9608
9.	Mutha	4454.1	17927	21212	39139	7126
10.	Ikutha	7707.8	20604	22866	43470	7591
	TOTAL	20402	243045	272377	515422	97196

Fig. 1.1.2. The ten divisions that make up Kitui district

1.1.1 *Geology, soils and topography*

The geology of the district is characterized by metamorphic and igneous rocks of the basement complex system (Mailu G.M, 1993). The southern side of the district is composed of Permian deposits and tertiary volcanics are predominant in the western part. These rocks hold extractable water only in small cells, which generally occurs in low areas near stream channels. The central part of the district has soil, which is mainly derived from the metamorphic rocks of the basement system although there are some small areas of black cotton soil [vertisols], which are tertiary sediments. These (vertisols) are usually high in fertility.

The eastern parts of the district have red sandy soils, which are low in natural fertility. The comparatively low rainfall in the region worsens the possibility of any successful food production. These soils are very rich in sodium and are considered to be the best grazing grounds.

Towards the western part of the district are black cotton soils, which are generally low in fertility (Mailu G.M 1993, Jaetzold and Schmidt 1983). The vegetation of the district consists of natural grasses and shrubs of lantana camara and other species. The grasses and other species of plants have short life cycles to enable them take advantage of the short and unreliable rainy seasons.

The topography is undulating and gives way to plains towards the east. The Yatta plateau is towards the west. There are also the ranges of hills in the central part of the district. Various gneisses of the basement system are the bedrock and are exposed in the hills east of Kitui, Mutomo and North east of Endau (Jaetzold and Schmidt 1983).

1.1.2 *Sources of water*

Kitui district is classified as semi-arid with rains being erratic in the better part of the district especially towards the south (Thomas D.B 1999). Rainfall is bimodal in nature with short rains occurring between October and December and long rains between March and May. The rainfall totals range between 250 mm to 750 mm per year. The hill masses, which constitute only 30 percent of the district, receive more rainfall while on the low lands which constitute 70 percent of the district, rainfall totals range from 250 mm to 500 mm (Mailu and Mutiso, 1993). The rainfall received in Kitui is unreliable both in amount and distribution. Dry spells are common within the rainy seasons and they discourage farmers from investing in modern farming methods. Due to this crop failure is a common occurrence. There is a prolonged drought from June to October during which most of the vegetation dries up. There are high temperatures that result to very high evaporation rates of water from the few available sources. The pan evaporation is estimated at above 2000 mm per year.

River and ground water resources are scarce. River Athi, which forms the southern boundary of the district, is the only permanent river. The river is highly polluted with

sewage and industrial wastes from the city of Nairobi. River Tiva however carries water for a long time after rains but in prolonged drought it dries off.

Boreholes and wells have been constructed to lessen the water shortage but the problem persists. A lot of homes have shallow wells but most of this wells dry up during drought periods. Most boreholes are dry while others have saline water, which is unsuitable for human, livestock, and irrigation uses. The salinity problem is very severe in the southern part of the district especially Mutomo and Mutha division.

There are rainwater-harvesting structures, which help in easing the water problem.
They include:

- Sand and subsurface dams
- Earth dams
- Roof catchment
- Rock catchment

In some of the man-made sources mentioned above, rationing is necessary to prolong water availability. This is common among the well-run sources. For majority of the population, obtaining water during drought means a daylong exercise especially by women. Consequently manpower is not available for other activities on the farm and lack of water has put the community in a vicious cycle of poverty.

1.1.3 Sources of income

The community practices growing of crops and keeping of livestock. Crops grown include:

1. Legumes; Cowpeas, Pigeon peas, beans green grams, Dolicos lablab.
2. Oil crops; Sunflower, Caster seeds, Groundnuts, Sim sim and Soya beans.
3. Cash crops; Cotton, Tobacco, Coffee.
4. Cereals; Maize, Sorghum, Millet.
5. Root crops; Cassava, Sweet potatoes.
6. Fruits; Mangoes, Bananas, Paw paws and Citrus.
7. Vegetables; Tomatoes, Cabbages, Kales.

Livestock animals kept are:

1. East Africa small zebu, crosses of boran and sahiwal.
2. Goats; East African small goat, galla, crosses between galla and boar.
3. Sheep; Red Maasai sheep.

Donkey and Oxen are used for providing draught power on the farm especially cultivation, carrying water and farm produce.

Pigeon peas, green grams and Dolicos lablab are food crops that are also grown for sale other than home consumption. This is because they fetch good prices in the market.

Industries found in the district include cotton ginning, flour milling, honey refining, tiles making, handcraft and brick making.

During this evaluation it was noted the success of food production and consequently livestock survival is highly dependant on rainwater harvesting. Farmers who practice rainwater harvesting for crop production have an added advantage of having their crops reaching maturity.

1.1.4 The Kamba people

Like other societies in Kenya, the man is the head of the family among the Kamba people. However, due to the high poverty levels, most men don't stay at home. The men leave to look for paid employment in urban centres of Kitui, Machakos, Mombasa and Nairobi. This places the woman in the situation where she is the one responsible for the farm and the family. The men come home on weekends or month ends. The success of rainwater harvesting in women led homes depend on whether the women is free to make important decisions on farm development or not. Where she can make the decision, there are tremendous differences and a lot has been achieved. This is because they are able to implement what the extension officers have to offer.

Their success is boosted by money availability from men, which is used for buying farm inputs and equipments. On the contrary, where the women have to wait upon their husbands to make decisions, little has been achieved as these men spend little time on their farms.

Among the Kamba people, it is a common practice to sell food soon after harvest even in bad seasons only to purchase the same at exorbitant prices some few weeks later. This sometimes cost the farmers three times more per unit of what they sold some few days earlier. Reasons given for this include the danger of loosing the harvest to pest, acute need for money e.g. for paying school fees, medical expenses etc and gender conflicts because the woman provide most of thee farm labour while the man would insist on the harvest being sold so that they have some money for beer. The women therefore sell the crop to make sure little is available for sale by the men. Whatever the reason, opportunistic traders hope for a good harvest. Because genuine reasons for selling the harvest exist, there is need to introduce a buyer with the intention of giving more per unit of production to the farmers and therefore keep away opportunistic traders.

Another source of income is sale of livestock animals. Livestock are the measure of wealth by farmers in Kitui district. The farmers hold onto them and sell when need arises. The prices of livestock animals are high when the crops have yielded well. During drought some livestock animals are sold to obtain money for buying other foods. During periods of severe drought the prices drastically fall sometimes to just a tenth of their normal price and once again the opportunistic traders lay in wait. Training on rainwater harvesting for pasture production and pasture conservation need to be enhanced. Also training on controlled sale of livestock in anticipation of severe drought

need to be enhanced and a buyer introduced to ensure there is no exploitation of farmers by traders.

Provision of water is more the responsibility of the women than men. It is the responsibility of the women to make sure the children have food and the animals are well watered.

1.2 Background information on technologies being evaluated

1.2.1 Terraces

A) Fanya juu

These are structures laid and excavated along the contours with soil being thrown uphill in farms with slope of above 5% - 30% to reduce the slope, retard runoff and increase infiltration, thus conserving soil and retaining moisture.
The embankment traps the water giving it more time to infiltrate while the channel acts as a retention ditch. The vertical distance (VI) in meters between one fanya juu and the other is determined by the formulae;

VI =(% slope/4 +0.2) 0.3 Where VI = Vertical interval

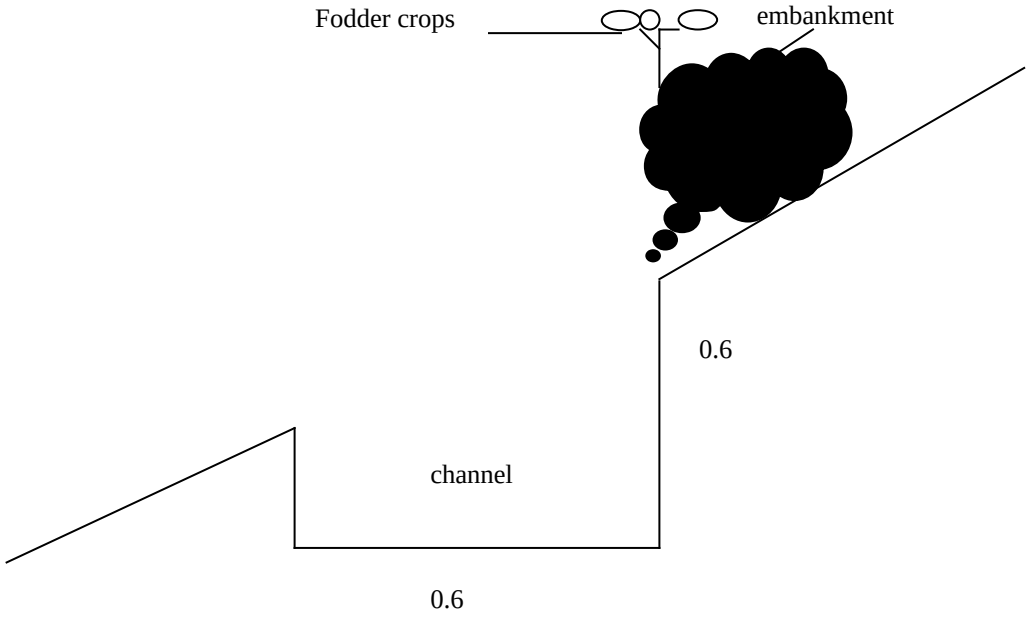

Figure 1.2.1 side view of fanya juu terraces

B) Retention ditches

These are earthen structures dug on the contour with the scooped soil thrown on the lower side. The harvested water gets into the dug channel and slowly infiltrates onto the soil.

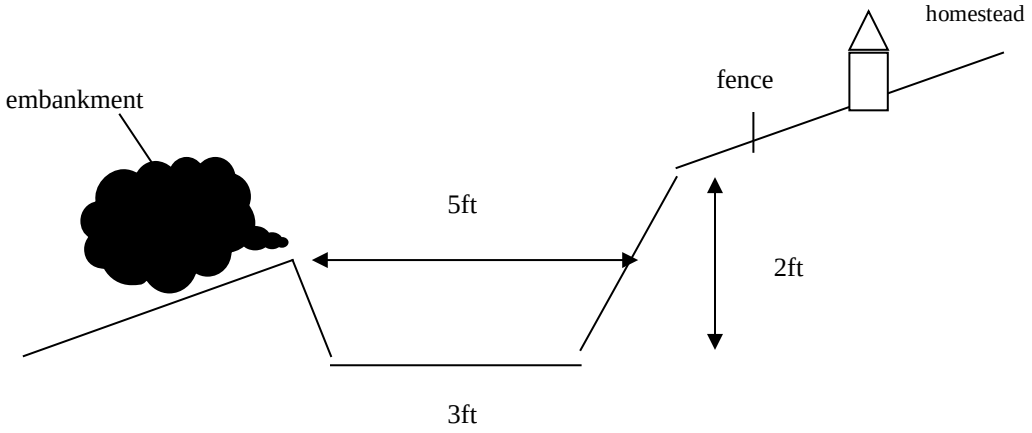

Fig 1.2.2 Side view of a retention ditch

1.2.2 Pawpaw Pits/ Semicircular bunds

This is a network of earth bunds shaped as half-circles with the tips facing upslope and on the contour. They are used in areas of 200-750mm rainfall, deep soils and low slopes (Hai, 1998). They require even topography. The space between tips of consecutive bunds is used for discharge of excess runoff. The side slopes are 1:1 although flatter sides have been used. A minimum height of 0.10 m for the bund is used and the height increases with slope.

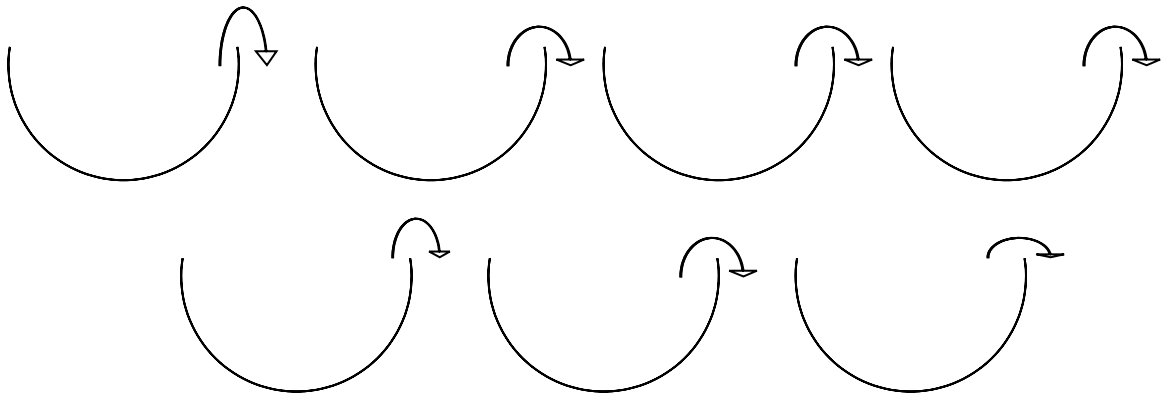

Fig 1.2.3 Arrangement of pawpaw pits

Details on sizing the semicircular bunds are available from Hai, 1998. The diameter of the bund is a factor of rainfall amount expected while the slope determines the height of the bund. The higher the amount of rainfall expected the shorter the diameter and vice versa. Low slopes require shorter heights of the bunds while bigger slopes require bunds of bigger heights.

1.2.3 Surface runoff water harvesting

It utilises ground surface runoff from homesteads, roads, cattle/human tracks, gullies and grazing areas to add soil moisture to cropland and pasture. This ground surface runoff is deliberately channelled into various soil and water conservation structures especially the fanya juu and retention ditches. It is estimated that about 4,080 ha in Kitui district benefit from this additional water input (source; Kitui district soil and water conservation office)

Runoff harvesting is important for Kitui district due to the erratic and unreliable rainfall. This calls for compensatory runoff harvesting for cropped and pasture/fodder land. The most practiced is road runoff harvesting.

1.2.3.1 Road runoff harvesting

This is harvesting of runoff that is yielded by roads and directing it into a cropped land. Road runoff involves identifying the runoff and then digging a small channel to direct this runoff into a channel dug along the contour in the farm. In some cases raising the level of the runoff is necessary to enable it to get into the intended farm. The water then infiltrates into the soil. In some cases the water is directed into well-levelled land and the runoff infiltrates into the soil. Roads yield a lot of runoff because the soil has been compacted during road construction. Use of roads by the vehicles, cattle and human movements results to more compacting. As a result there is little infiltration of rainwater and most of it ends up as runoff. Where measures to hold the water from roads are not present e.g. excavation of terraces, the runoff results to severe erosion and therefore it should not be done

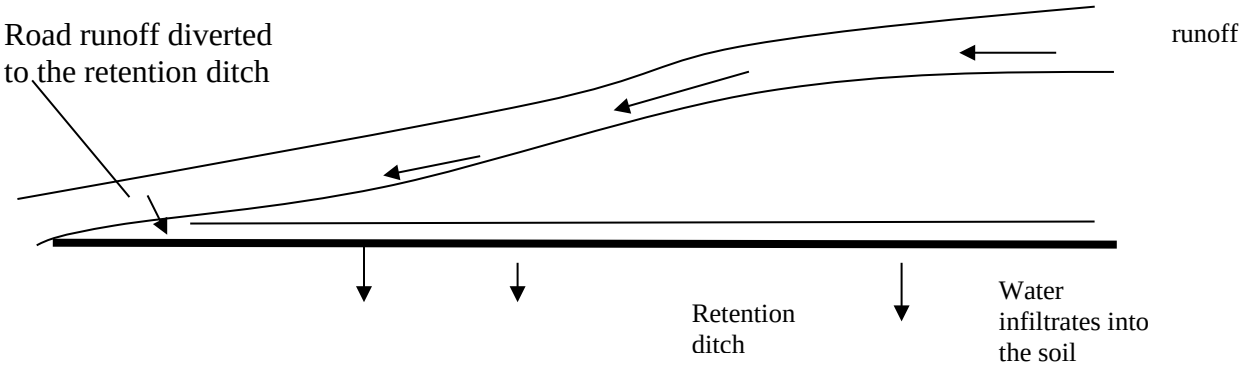

Fig 1.2.4 Diagram showing road runoff harvesting

The systems are made such that, once the first channel gets full, the water is safely emptied into the next one below it without causing erosion.

1.2.4 Sand dams

Sand dams are water-harvesting structures constructed using stone masonry across seasonal sand streams. The reinforced masonry wall traps a lot of sand upstream, which holds subsurface, water within the sand. Once the sand dam is full of sand to the top, there is no effective further sand deposition or removal due to the rains. The dam wall prevents stream flow downstream. Water has always been obtained from sand rivers by digging pits in the seemingly dry riverbeds. The water then collects into these pits from where it is fetched. Construction of sand dams or subsurface dams enhances the performance of these rivers.

Subsurface dams are similar to sand dams except they are constructed with the dam wall having its top level with the sand. Another difference is that clay soil can be used to construct the walls instead of stone masonry (Peterson 2000). The best sites for constructing sand and subsurface dams consist of the following;

- Sand riverbed, which is ephemeral (seasonal) but is flooded during the rainy season.

- Presence of coarse sand in the catchment as these have bigger voids than fine sand

- Sites free of fractured or saline rocks

- Existing water holes that remain for at least a month after the rains

(Source Gould J and Peterson, 1999)

To obtain water from sand rivers, pits are dug in the sand where water collects. The water is then scooped and poured into containers that are then ferried by donkeys or donkey and oxen carts or women and children. In some cases, a shallow well is sank and lined with bricks except some few feet at the bottom where water percolates through from the sand into the well.

The particle size distribution of the stored solids in the dam affect the porosity, permeability and the rate of evaporation of water from the sand. On average around 40% of the volume of sand stored can be expected to be the water storage capacity of the sand dam while only about 35% of this can be extracted

The active evaporation zone is the first 50 cm below the sand surface.

Losses of water occur due to;

- Evaporation from the surface

- Evaporation from vegetation growing on the banks and dug holes

- Seepage losses

These losses can be reduced by;

- Clearing vegetation along sand dam to reduce evaporation. This is not likely to succeed as the river banks are usually grown with valuable fodder crops

- Proper construction of the dam wall foundation and sealing any fractures in the bedrock with thin cement mortar after thorough site investigation.

Once constructed, they require very little maintenance unless in cases where the walls break in which case they should be reconstructed.

1.2.5 Rock catchments

A rock catchment is a reservoir located on a bare rock surface, with sufficient catchment to capture enough rainwater during the rainy season for use during the dry season. The reservoirs are constructed using rock masonry walls. The rock surface is gutted at a gradient to direct the runoff to a reservoir.

The most suitable rocks include granite and granitoid gneisses because they have poor permeability and they are resistant to weathering. Most of the rock catchments in Kitui are located in places that have been subjected to intensive destruction of vegetation and subsequent soil erosion resulting in bare masses of rock. In southern Parts of Kitui, lack of water is extremely severe. Surface water sources are not available while ground water sources are saline and unsuitable for domestic and irrigation purposes. In these regions, rock catchments provide relatively clean water. They are however expensive to construct and maintain. For these reason the immense potential is far from exploited.

1.2.6 Earthdams

Earthdams consist of raised banks of compacted earth used to retain water. The dam wall is usually 2-5m high and has a clay core and spillways to discharge excess runoff. Earthdams should be constructed on public land to make them accessible to all community members unless they are individually owned. The catchment area should have soil conservation measures where the land is under cultivation. A natural depression or a gully is a suitable site as it enhances the storage capacity of the water. Highly porous soils are not suitable for earth dams construction as they result to high seepage losses. The following should be avoided; anthills, saline soils and pits.

1.2.7 Underground tanks and roof catchment systems

Underground tanks act as reservoirs for ground catchment systems. Ground catchment systems are cheaper than roof catchments and are normally employed where suitable roof

surfaces are not available e.g. in areas where houses are constructed with thatched roofs. Their main advantage is to be able to built a cheaper tank using less material due to the support by the surrounding soil. Another advantage is that they have bigger catchments compared to roof catchment systems. The big catchment makes it possible to harvest large water quantities in areas of low rainfall. Their disadvantage is in the sediments that are collected in the reservoir. Since the water is stored below the surface, withdrawing the water cannot be done using gravity. The tanks should be covered and a fence put to prevent children and animals from falling into the water and drowning. Cases of drowning of both livestock and children have been reported (Gould and Petersen, 1999).

To waterproof the tank, the tank can be lined with powdered anthills, mixed with a little cement, lime and sand followed by two coats of bitumen. This method is a cheaper alternative to cementing.

Once the tank starts leaking, locating the leak becomes difficult and this is their main obstacle preventing tank repair.

1.3 Objectives

The overall objective was to identify and evaluate the performance of water harvesting systems in Kitui district with the aim of promoting best practices in water management in order to enhance food security in the region

The specific objectives are:

a. Identifies a relevant study within the country in conjunction with the principal investigator and country association;
b. Identify different rainwater harvesting systems being used in the selected area;
c. Evaluate the performance of identified system(s) under the prevailing conditions;
d. Evaluate the social-cultural and gender perspectives under which different systems are being adopted;
e. Analyse environmental policy and governance issues affecting adoption and performance of RWH technologies;
f. Identify limitations and advantages of different RWH technologies in the area;
g. Identify appropriate rainwater harvesting options for improving food security in the area;
h. Document rainwater harvesting systems in the selected area;

2.0 METHODOLOGY

2.1 Terraces

Information on farmers practicing fanya juu was obtained from the Ministry of Agriculture office, Kitui district. The most successful farmers were the ones visited and interviewed to gather information on achievements in food security. Visual observation of the crop performance and comparison with crops in other farms not practicing terracing was also done. Those farmers who did not practice terracing also provided information on why they were not doing it. A discussion on what can be done was also carried out.
Rainfall analysis to estimate on water soil moisture adequacy for growing maize was done using monthly rainfall records for Tiva station. Crop water requirement records were obtained from Hai, 1998.

2.2 Pawpaw pits

The district soil and water conservation officer provided information on where the technology is carried out. The Yatta division soil and water conservation officer acted the guide to the farmers who were successful with the technology. The farmers were interviewed individually on the benefits of the technology and how it has helped to boast food availability for the families benefiting

2.3 Road runoff harvesting

The division soil and water conservation officers provided information as to where the farmers were to be found. Field visits were made to Mutonguni, Chuluni, Matinyani and Yatta divisions, which had successful farmers practicing the technology.
The farmers offered information on how they practice the technology and the benefits of road runoff in reducing food problems for their families. Visual observations provided a lot of information as in all the cases the contrast was very clear.

2.4 Sand dams

Sampling of the sand dams to be studied was done based on prior information obtained from the Ministry of Agriculture on community involvement and donor participation. The evaluation was carried out by visiting 5 sand dams. The water users at the site were interviewed to obtain more information on performance, their involvement in construction and maintenance, socio cultural and gender perspectives, water use, governance issues, limitations, advantages and disadvantages and their future plans.
Visual observation provided more information concerning the status of the structure, uses of the water and environmental impact. The volume of water contained in the dam while fully saturated was estimated using the equation;

$$\frac{Tb * max\ w * max\ d}{3*2} * 25/100$$

where tb= throw back

maxw =maximum width of sand in the riverbed

maxd = maximum depth of sand in the level of the sand

(Peterson, 2000)

The equation given by Peterson 2000 has been divided by 2. This was necessitated by the fact that, Peterson, 2000 considers a reservoir whose maximum depth is right at the middle of the reservoir and gets shallow towards both ends while the reservoir created by a sand dam has its maximum depth at the end i.e. at the dam wall and gets shallower one way i.e. upstream of the dam wall.

Water demand was calculated by estimating the population of human and livestock animals using the information gathered from the water users. The population obtained was multiplied by daily consumption of water for the following categories as given by (Hai, 1998) for ASAL regions.

User	Daily consumption
Human	10
Local cattle	17
Sheep/goats	4

2.5 Rock catchments

The available information during the preliminary visit was evaluated for possible similarities that would enable grouping. Two categories were identified and representatives studied in details. The dams visited included Kaseva, Ya Mutomo, Syonyaa Kinyoo and Kavili. The same committee manages Kaseva, Ya Mutomo, Syonyaa and Kinyoo. Kavili in Mutha division is managed by a different set of committee. The management at Kaseva was different from that at Mutha and because of these differences, the communities were gathered for a participatory discussion at Kaseva and Kavili. Both carry a lot of water for several months after the rains. Kaseva has strong community participation. Money collected is accounted for and there are plans for expansion. For Kavili, money collected was not accounted for.

The information gathered includes;

- Origin of rock catchments

- Effectiveness in providing water for food security
- Management of rock catchments
- Benefits realised
- Constraints if any
- Negative/positive impacts on environment
- Possibilities for expansion

Design rainfall of 67% probability was obtained to compute the possibility of reservoirs getting filled with water.

2.6 Earth dams

The study was carried out by picking a dam from each of the following regions;
1. From Mutonguni division representing the high potential/high population zone
2. From Chuluni division to represent medium potential zone
3. From Mutomo division to represent low potential zone

The beneficiaries were gathered for a participatory evaluation exercise and the following was discussed;
- Origin of the dam
- Construction
- Their involvement
- Benefits
- Advantages and disadvantages
- Management and maintenance
- Future plans

2.7 Underground tanks and roof catchment systems

The evaluation involved visiting the sites where these tanks are located. Five sites were visited which included;
- Two primary schools in Yatta division. Both schools had each an underground tank for ground runoff catchment and Ferro cement tank for roof catchment
- A home in Matinyani division belonging to Mr. Ndemange, also the division soil and water conservation officer which had an underground tank
- Itumbi farm in Mutomo division that had underground tanks
- Matinyani division dispensary that had an underground tank
- Jane Ndiko's home in Yatta division that had a Ferro cement tank for roof catchment system

Information gathered from those responsible included
- When the tank was constructed
- How it was constructed
- What the water was used for

- For how long the tank was functional (since it had been noted the tanks were no longer functional)
- Why the tank was not functional
- What use the tank has or can be put into

3.0 RESULTS AND DISCUSSION

3.1 ***Terraces****; fanya juu terraces and retention ditches*

A) Fanya juu

The first terraces in Kitui district were dug during the colonial days during the state of emergency. They were dug using forced labour and because of this the local people considered them as an oppression tool other than a measure to conserve soil and water. After independence, forced labour seemed to continue but this time it was through the chief's act. Presently, terracing is voluntary with individual farmers developing the interest and carrying out the excavation.

In Kitui district, Fanya juu terraces are laid by Agricultural staff and excavated by the farmers. In some cases the farmers dig without laying and this is hazardous as it cause soil erosion. The land in between terraces is planted with crops or could be pastureland though the main activity is crop growing. In a division like Matinyani and the others neighbouring the central district at least 80 % of the households practice fanya juu. Where possible, runoff from off farm e.g. road, homestead or grazing land is led into the channels. Where external catchment is not used, the Fanya juu terraces conserve rainfall falling on the land and the percentage conserved depends on rainfall intensity. Rainfall of less intensity is better conserved than rainfall occurring in heavy storms.

In the southern division, i.e. Mutomo, Ikutha and Mutha the adoption rate is low because the land tenure system is free hold and this hinders serious investment on land.

The Fanya juu terraces are common in the central division and those surrounding it, i.e. Matinyani, Mutonguni parts of Yatta, Chuluni and Mutitu. This is attributed to the fact that, these areas receive slightly more rainfall and efforts in rainwater harvesting have proved rewarding. Consequently, adoption rate by farmers is very high with about 80% of cultivated land having Fanya juu. These areas also benefit more from donor support as they are near Kitui town where donor organisations are located. The success of these terraces after construction is influenced by a number of factors. These are;

- Repair and maintenance, any section that is washed down by heavy floods need to be repaired.
- Stabilisation by planting grass on the embankment.
- Existence of Myethya groups whose attention is always easily drawn to other development activities like terracing.

- Some catchments have, active catchment committees that hold discussions on catchment maintenance and are also the link between the government officials and the community.

B) Retention ditches

The retention ditches are mainly below the homestead and are intended to harvest runoff from the home compound. They are laid by Agricultural staff and dug and maintained by individual farmer. The retention ditch is mainly combined with Fanya juu terraces at the lower side of the farm. The channel of the retention ditch is dug with a trapezoidal shape.

The retention ditches are maintained by planting Napier grass or makarikari grass on the embankment for stabilisation purposes. After sometime, the ditch gets silted up and this soil should be removed and heaped down slope. Most farmers also plant bananas in the channels after digging infiltration pits.

A depth of more than 2 feet is discouraged to avoid loosing the collected water to deep percolation.

CASE STUDY 3.1.1

A successful farmer practicing Fanya juu terraces to retention is David Kilanga who is from Kutha village, Kangii sub-location, and Kakeani location in Mutonguni division. He lives with his three children, wife and his mother. He is also a preacher. His land measures 2 1/2 acres and is sloping to the west with a slope of about 12%. The land is under individual ownership and he has a title deed. All the land is under cultivation with only a small section for the homestead. The type of soil is sandy loam with pockets of stone area. His water source is a borehole which is a half a kilometre away and he gets the water using a donkey, bicycle and sometimes manual.

He practices mixed subsistence farming system and the main crops include; maize, beans, pigeon peas and fruit trees, oranges, mangoes, bananas and paw paws. He uses farmyard manure from the livestock for adding soil fertility. Compost manure and fertilizers are used at low levels. The organic manure helps conserve the water in the soil, add fertility and reduce erosion. He has a store where he keeps the harvested grains.
He keeps one exotic dairy cow of the Ayrshire breed and local zebu cattle. The Ayrshire cow is under the zero grazing system. An ox is used for ploughing although he also does manual cultivation. The local breeds are kept under the tethering system during daytime and a shed at night. To feed the livestock animals are fodder crops planted on the embankment of the Fanya juu terraces.

(photo)

Fig 3.1.1 Fanya juu terraces that have developed into bench terraces in Mr. David Kilanga's farm.

The milk from the dairy cow is sold to the local community at Ksh.35 per litre. On average he sells about 5 litres per day, which is below the breeds potential. The cows' yield can be increased by use of dairy meal, which is commercially manufactured. He sells the crops at the local market or to people who come purchasing. Prices per kilogram range depending on the type and the season as shown;

	Soon after harvesting	2 months later
Cereals	10	15
Legumes	25	30

The food is most expensive towards the next harvest. At this time district depends on imports from outside the district most. He sells the fruits in the local market and the prices depends on the fruit type, and its size as shown

Pawpaw	Ksh.20 – 30
Oranges	Ksh.2
Mangoes	Ksh.2 –5

The maize is the food crop most grown in the area. During the long rains he plants katumani or Makueni composites. During the short rains, which have more rain that is more reliable than the long rains in ASAL, he plants 511 or 512 or 513 or 4141 hybrids. The stalk borer and the maize streak virus on the farm usually affect it. In the store there are rats and weevils that destroy the stored grains and he controls them using red cat and super actelic for rats and weevils respectively.

His Fanya juu terraces have been in use for about 10 years and have been highly effective. The terraces ensure no runoff leaves his farm. There is an additional water source on his farm, which is runoff that he harvests from the road. Runoff from the

homestead is also not wasted but instead is directed to the nearby piece of land. An estimated 20% of total rainfall is added to his land from external sources during seasons of average rainfall i.e. from road and home compound.

Before this water harvesting intervention, most of his income from preaching used to go to purchase of food and the farm yield was very little during some seasons. 20% of the seasons he suffered total crop failure while another 60% of the seasons the harvest was little due to moisture stress in the soil. It was only 20% of the seasons that he harvested enough. Now the situation has changed for the better. Presently the farm is a source of income, his family is better fed, clothed and he never have to worry whether the rains are going to be enough because since then, he has always harvested crops irrespective of the total rainfall. From the only available rainfall records at Tiva rainfall recording station by JICA, some seasons have had very little rainfall especially the long rains of March – May but this have not caused crop failure in his farm. The years 1992, 1993, 1994, 1995, 1996 had rainfall less than 120mm during the long rains. The long rains of year 2000 were unique as no single drop of rainfall was received and no crops germinated. Mr. Kilanga is at least 10 times ahead of his neighbours in terms of yield.
The only problem he has encountered with this intensive rainwater harvesting is periodic water logging which does not really affect the yield as maize is tolerant to water logging. This happens during the seasons of above average rainfall, which are expected once every five years according to the local people. The maize turns slightly yellow but he still harvests enough for his family and for sale.

The Fanya juu terracing demands a lot of labour. In this area every 10 metres of Fanya juu cost between Ksh.100 and 200 depending on the height. Mr. Kilanga used family labour and hired labour, which cost him Ksh.100 for every 10 metres.

(PHOTO)

Fig 3.1.2. In some cases the channel for fanya juu/ retention ditch is planted with bananas.

To plant the bananas, pits are dug and filled with a mixture of topsoil and organic manure. The dimensions for the pit vary with different farmers

CASE STUDY 3.1.2

Vitas Mutava with a family of 12 people is from Kakeani location of Kangii sub-location of Mitonguni division. He bought his land from a neighbour at a throw away price of Ksh.5000 per acre. The size of his land is one and a half acres. The land had been subjected to severe degradation to the extent it did not support any vegetation growth. He has now (April 2001) had it for slightly less than two years and has done the following through his own initiative;

1. Dug Fanya juu terraces and planted Napier grass and boma rhodes on the embankment. He is now self sufficient in fodder production. With the fodder, he now has an Ayrshire cow under zero grazing system, which gives him 4 litres of milk per day on average. He also keeps 2 oxen and two cows of the local breed zebu. The terracing in his farm is mainly for pasture production and had not started on any food crop planting. In between the terraces are natural species of grasses, which he uses to support his livestock animals.
2. Runoff harvesting from his neighbours farm. This is the runoff that had brought about the degradation the land had undergone in the past. The runoff is now directed onto the well-terraced farm and it is doing much better than before in terms of pasture production.
3. Healed a gully and dug a shallow well at the bottom of it. A gully had cut across his land on the eastern side. Stones lined with trash have been put along the gully at about 10 metres intervals to cut down on the speed of the flow so as to deposit the silt. The relatively clean water then empties into the shallow well where it is available for his livestock and domestic use for several weeks after the rains.

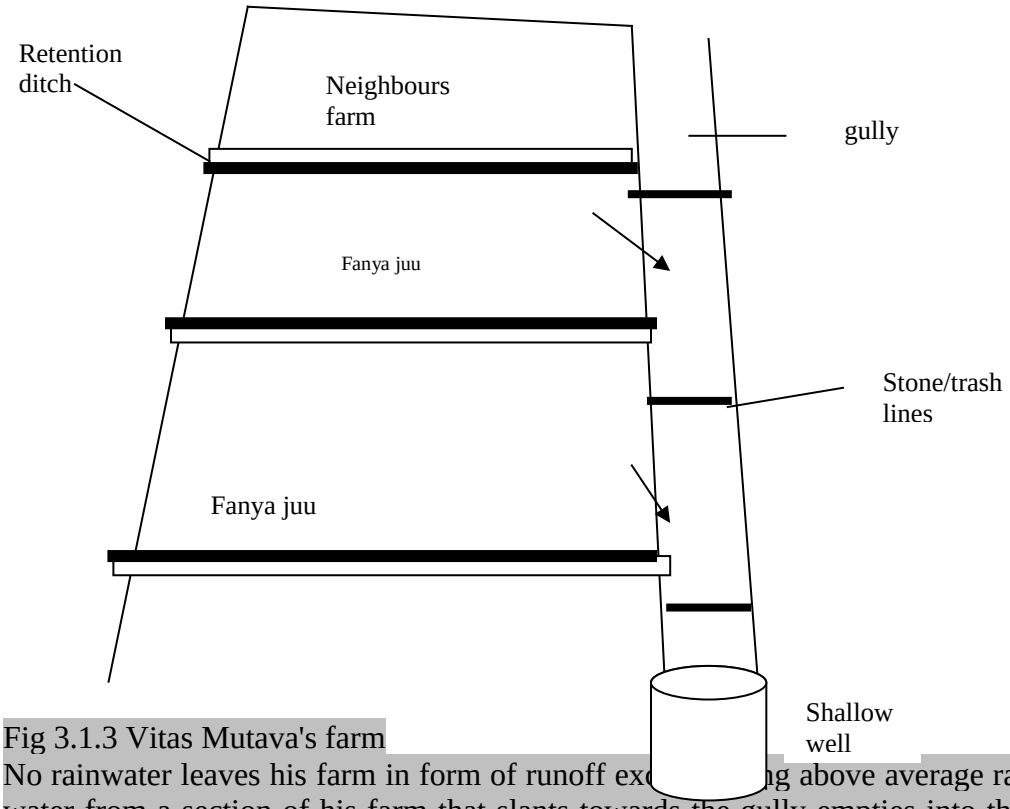

Fig 3.1.3 Vitas Mutava's farm

No rainwater leaves his farm in form of runoff exc[illegible]g above average rains. Some water from a section of his farm that slants towards the gully empties into the gully but this water finds its way into the shallow well where it is retained.

CASE STUDY 3.1.3

Kalile Musyoka initiative is very similar to David Kilanga. She is from Kangii sub-location and together with Vitas Mutava and other people form the catchment committee. The catchment committee form the link between the catchment and the government ministries. Collectively they offer advise to other members and intervene on behalf of the extension worker.

Mr. Musyoka is employed and leaves his land with the wife. She is free to make decisions and implement without seeking her husband's approval. She had dug Fanya juu terraces in her 3-acre land and no runoff leaves the farm. In addition, she has done road runoff harvesting since 1999, which she directs into the cropped land. Every season she harvests crops while her neighbours get a good harvest once every five years.

More intensified fodder crop growing still needs to be done, as some of the embankment did not have any.

CASE STUDY 3.1.4

Name of the farmer - Musyoka Lulu
Location of holding Kyeni village, Kauma location, Matinyani division.

He obtains his water from a spring, which is at the bottom of his farm. His land is 15 acres and is under individual owner operator tenure system. Out of the 15 acres, 9 are under cultivation.
He has done 3 rainwater-harvesting technologies.

1. Fanya juu
2. Banana pits
3. Spring protection

His main enterprises are bananas, onions, maize, sugarcane and avocado. He also has livestock animal's namely local zebu cattle and goats.
Since he dug the Fanya juu terraces in 1968, the harvests have been good in most seasons but before, the land used to yield little. When asked to give an estimate of increase in yield he gave an estimate of at least five times in maize. To maintain the fertility of the farm, he uses compost manure, he has a compost pit, where he makes compost manure, farm yard manure, fertilizers at low levels and crop rotation. Once harvested the grains are stored within the main house. A store outside the house attracts thieves of harvested crop.
Selling the surplus is easy for Mr. Musyoka as the traders come for produce from his home. It is then ferried to the nearest Kalundu market where it is sold.
Since he dug the Fanya juu terraces, a permanent spring developed at the bottom of his land. It is from this spring that he obtains all his water. There were signs of wetness prior to digging of the terraces but it was after the terracing that he spring became perennial. This is an indication that the terracing brought about a rise in the water table. As a result there is water logging that affects the quality of crop and a lot of mosquitoes.

3.1.1 Estimated crop water requirements for local conditions, water availability and deficit for maize crop

The dry land composite maize requires 240 – 430 mm (average 335mm) of well-distributed rainfall (Hai, 1998). In this assessment, the average 335 mm has been used. It should be noted that rainfall in the ASAL occur in heavy storms followed by long intra-seasonal droughts during the growing season and it is not possible for all the rainfall to end up in the crops root zone. Some of it will escape, as runoff while more will be lost through seepage. Terracing the land reduces the risk of water loss through surface runoff.

Table 3.1.1 Available rainfall and deficit for Tiva recording station

	long rains		Short rains	
Year	Rainfall Amount	Deficit(-)/excess	rainfall Amount	Deficit(-)/excess
1988	312	-23	603	268
1989	357	22	566.5	231.5
1990	515	180	595	260
1991	211.5	-123.5	416.8	81.8
1992	68.5	-266.5	570.5	235.5
1993	47.3	-287.7	356	21
1994	118	-217	462	127
1995	104	-231	294.5	-40.5
1996	112	-223	272.5	-62.5
1997	233	-102	748.5	413.5
1998	270.5	-64.5	166	-169
1999	145	-190	329.5	-5.5
2000	0	-335	286	-49
2001	131	-204		

From the table above, planting maize during the long rains is not a viable solution to food insecurity. Other crops should be planted to avoid wastage of resources. These crops include;

Crop	CWR	crop	CWR
Millet	(160 –320mm)	Pigeon peas	(370 –650mm)
Sorghum	(200 –500mm)	Cassava	(300 –1000mm)
Cowpeas	(190 –400mm)		
Green grams	(190 –400mm)		

(Hai, 1998)

This is for the following divisions; central, Matinyani, Mutonguni, Chuluni, and parts of Yatta that are near the central divisions. The situation is worse in the other divisions where rainfall is less than in the named divisions. The annual 67% probability rainfall for Mutomo in southern Kitui is 480mm. In these divisions, i.e. Mutomo Mutha and Ikutha, terracing for forage crops production should be encouraged. This is because the main economic activity in the drier areas is keeping of livestock. Also forage crops especially natural species of grasses grow very fast and there is never the danger of crop failure since the animals can feed on them at any stage. Forage conservation in form of hay in Kitui district need to be considered as a necessity if the battle of food insecurity is to be won. During the rainy season there is a lot of vegetation and a lot of it get wasted. If conserved the animals will have more to feed on during drought.

During the short rains, the situation is better and with proper terracing i.e. with minimal runoff, maize growing is possible in areas surrounding central division. In some years, rainfall deficit is expected and for this reason the crops named above which require less rainfall should not be left out. They should be grown alongside the maize. Establishing a perennial crop e.g. pawpaw, passion, and mangoes is necessary as the crops water needs can be met by exploring the water found deep in the soils. The named crops fetch good prices and are used by the few farmers who have them to offset the food deficit by buying food-using money obtained from sales of the fruits. A source of external catchment e.g. water obtained from a gully or road runoff can help offset the rainfall deficit especially during the short rains because the deficit is small. During the long rains, only some few farmers who have access to a lot of external water source are likely to offset the high rainfall deficits, e.g. from road runoff, gully water diversion.

3.1.2 *Benefits of terracing*

- Increase yield resulting from high moisture availability.
- Reduced soil erosion.
- Increase recharging of shallow wells.
- Easy planning of crop rotation and farm management.
- More trees and fruits are planted and survive. Farmers plant them above the terrace embankments.

2.2 Disadvantages of terraces

- It is a labour intensive exercise and therefore is expensive. For this reason some farmers especially the poor ones find it difficult to spare time for terracing, they are better of terracing for someone else for money to buy food as this is more urgent. Money for hired labour is also not available
- If poorly laid, they cause erosion.

2.3 modifications on fanya juu

- Some farmers leave crossties after a given length of the channel where there is an external source of runoff. This allows the water enough time to percolate into the soil before passing over to the next pit.
- Planting of bananas in the rectangular pits created by the crossties.

Most farmers in Kitui have a positive attitude towards Fanya juu terracing and they appreciate its importance especially on crop performance.

2.6 *Fanya juu terraces and the environment*

The terracing has an effect on the water table. The increased infiltration and reduced runoff has resulted to a raised water table. This has the benefit to crops because there is more water available in the soil. Survival of tree plants is higher in areas where a lot of people are carrying out terracing.

There are also higher yields of water in shallow wells. This is attributed to the higher infiltration that is encouraged by terracing. Seasonal rivers carry water for more days after the rains than they used to before the terracing was done.

Seasonal springs also yield more water e.g. Mr. Musyoka Lulu from Matinyani has a perennial spring that developed after terracing.

Losses of soil through erosion have been reduced and in some cases gullies have been healed to become productive. Siltation of existing earth dams is expected to reduce because the water carries less soil with it.

3.2 *Pawpaw pits/ semi circular bunds*

These are pits that are dug and filled with organic manure and topsoil after which pawpaw seedlings are planted. A diagonal line, which is 450 to the contour of the land, is drawn as shown on the diagram. A pit is marked every 4.2m and the pit dug 3ft by 3ft by 3ft. From these pits, lines are drawn along the contours that are parallel to one another and similar pits dug.

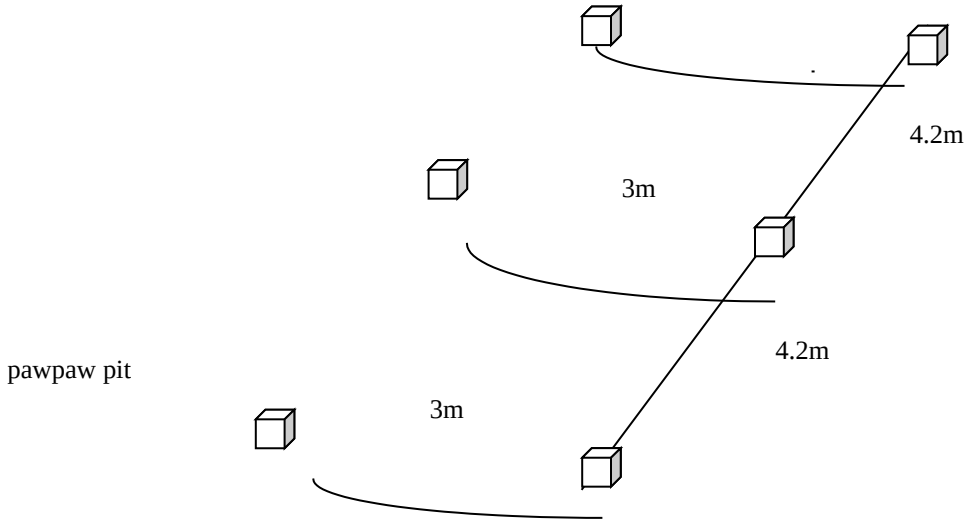

Fig 3.2.1 Dimensions used in making the pawpaw pits.

During digging the topsoil is put separated from the subsoil. The topsoil is then mixed with organic manure and used to refill the pit. In the middle of the pit the seedling (paw paw) is planted. From this plant a radius of 3ft is marked on the lower side and the subsoil used to make a hill on the lower side that forms an arc called a semi-circular bund. The semi-circular bund acts as a micro-catchment that harvest rainwater and retain it in the pit. The arrangement of the pit and the bud is as shown in fig.

The preferred pawpaw variety is solo because it is drought resistance. These pits harvest more water on flat or gently sloping land. To achieve the flat or gentle slope, fanya juu terraces are used. Planting fertilisers are not used and Agriculture officers discourage farmers from using any form of fertilisers apart from organic manure. Only 20 farmers practise this technology in Yatta division with the largest acreage being 0.5 ha. The reason why only Yatta division is doing this is because the technology is the initiative of the soil and water conservation officer. Kitui Agricultural project (KAP) helps the officers to implement what they have proposed to do in their areas.

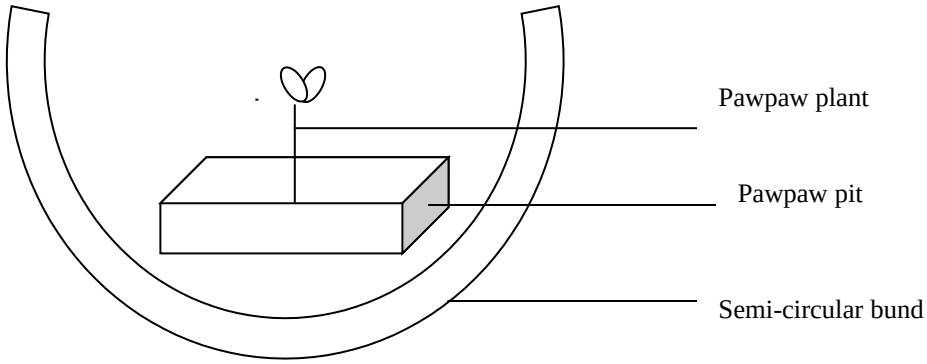

Fig 3.2.2. A pawpaw pit

This method of rainwater harvesting was introduced in 1998 and 1999 and the paw paw fruits were ready for harvesting for the first time after two years. For some farmers the technology has completely changed their lives as the harvest once sold gives an income which they had no idea would have came their way only 2 years ago.

The seedlings are supposed to be planted at the beginning of the short rains. This is because the short rainy season has more rain and is also better distributed. Another advantage of planting during the short rain is because the inter seasonal drought that comes after short rains and separate the short rains from the long rains is shorter and less severe. This increases the survival rate of the seedlings. Because of the rainwater harvested by the micro-catchment i.e. the semi-circular bund, there is water available to the roots of the plants and the water stays for sometimes after the rains because the organic manure, which increases the water retention capacity of the soil, assists it. Before the soil gets completely dry, the long rains that are expected in march starts and provide the necessary moisture. By the time the long rains ends, the roots of the paw paws are already deep and able to mine water from where the concentration of roots is low

meaning there is less competition for water. After the long rains, the paw paw plants survive well without irrigation. Weeding need to be done to reduce competition for the water and the nutrients between the pawpaw and the weeds.
The bunds need maintenance because they sometimes get broken and the micro-catchment gets destroyed. If broken they should be repaired

CASE STUDY 3.2.1

Among the most successful farmer is Muthanga Kavite from Mikuyuni sub-location, Kwa Vonza location, Yatta Division. His 4 ha land supports 8 family members and he has no other source of income i.e. any formal employment. He owns 2 zebu cows, a donkey and a few goats. The donkey is used for ferrying water from River Tiva, which is 6 km away. In 1998, he implemented intensive soil and water harvesting conservation and started harvesting any available runoff. Runoff harvesting was possible from the road and the pastureland that lies above the cropped land. No water in form of runoff leaves his shamba but instead gets some additional amount from pasture and road.

The land under cultivation is planted with paw paws, passion fruits, cereals i.e. maize and sorghum, pigeon peas, beans, dolicos and green grams. The last two crops dolicos lablab and green grams are for commercial purpose and soon after harvesting they are sold for income. Like most farmers in Kitui, he sells his crops after harvesting for income purposes but will later purchase the same at high prices some few weeks later.

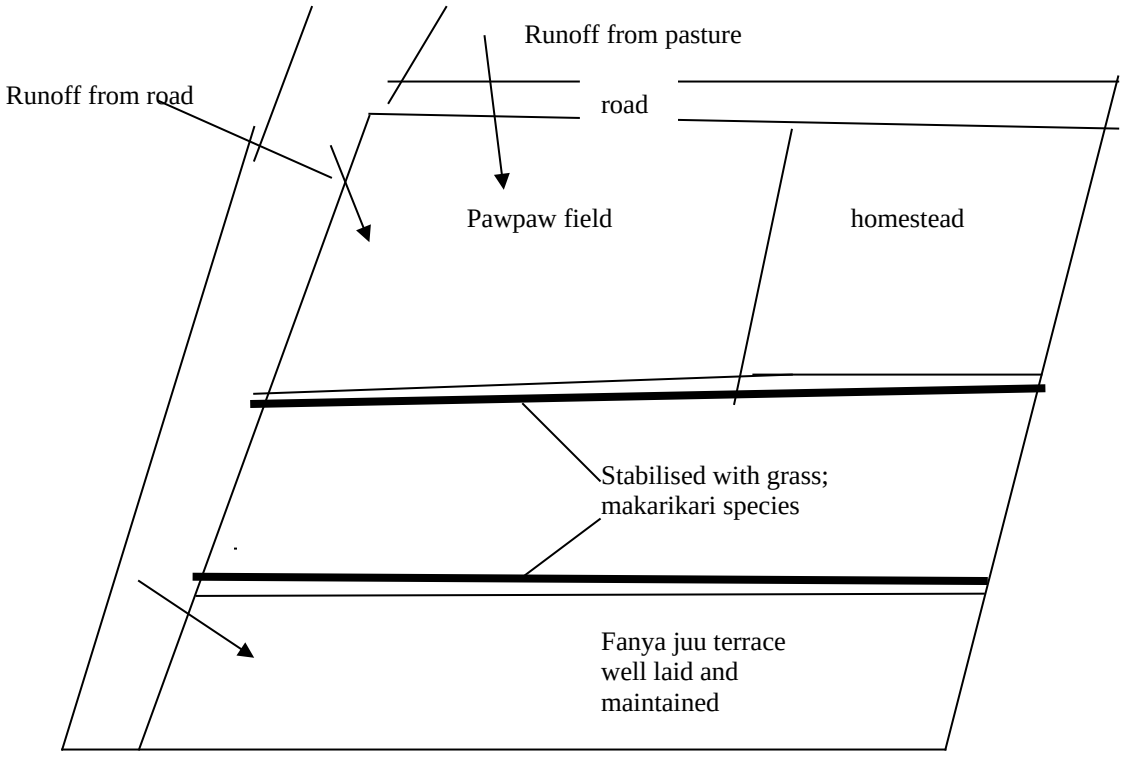

Fig 3.2.3 Mr. Muthanga Kivite farm in Yatta division

Asked to comment on the habit Mr. Munyithia the Yatta division soil and water conservation officer explained it as the people's way of life. They very much understand the implications of selling the food soon after harvesting but they nevertheless go ahead and do it. This is necessitated by lack of money. As the drought continues to bite and there is no more food in the stores, they turn to the livestock animals; sell to get money which they use to buy the food sold earlier on. Efforts to discourage sale of food after harvest have not been successful.

Mr. Kivite most successful project is paw paw farming which he planted in 1998. In July 2001, his income from the 270 paw paws plants was Ksh. 8,000. In addition to the money he has not had food problem in the last two seasons but before the intervention of Mr. Munyithia with laying out the fanya juu terraces and the pawpaw growing, crop failure was a common thing. His neighbours who have not done any soil and water conservation had gone for three years with no harvest.

Following this success, other farmers have tried to dig channels to direct road runoff into their land with little or disastrous effects. This is attributed to their poorly conserved land, which therefore cannot hold water but instead cause soil erosion. To harvest runoff from an external; source e.g. road, gully, homestead or pasture land, the land should be made ready to receive the water. This is mainly by terracing that increases the infiltration opportunity time for the water. The harvested water cause soil erosion during seasons of above average rains in Mr. Kavite's farm. Water logging also occurs during such seasons, which result, to a slight drop in yield. In Kitui district, above average rains occurs once every five years according to the farmers. Annual rainfall record by JICA in Tiva, which is within 20 km from his farm, were 816.5mm, 474.0mm, 237mm for year 1998, 1999, and 2000 respectively. The annual average for the same station is 673.5mm for records taken from 1988 to 2001. From the above figures, it is clear the rains are not much yet every season the farmer is able to harvest while his neighbours suffer crop failure.

CASE STUDY 3.2.2

Jedida Mutua also from the Yatta Division Masaani sub-location put aside land for paw paw production with the aid of the water and conservation officer for Yatta. The planting pit for the paw paw were prepared and fanya juu terraces dug. This was done in 1998/1999. The terracing was not the first he had done. In early 80's the government was determined to carry out soil conservation measure and area chiefs were put in charge of enforcing this. Mr. Mutua land had terraces dating back to those times but he never give them much attention because the chief forced him to do it.
In 1998/99 he was doing it once again out of his will to conserve his land and boast his food production. About 80% of his land is now fully conserved and his land now yields little runoff. His land takes up about 70-80% of total rainfall during seasons of average rainfall and he is now able to meet 50% of his food demands.

His land is 10 acres and 8 acres are under cultivation. He obtains water from Mwita Syano River, which is actually a furrow from R. Thika that was dug by forced labour

during colonial days. It is about 4km away. The water is ferried by use of a donkey. He has 4 cattle (zebu) and, 10 goats. He uses an ox-plough for cultivation. His cultivated land is grown with maize, beans, pigeon peas, and cowpeas. His cash crops are; paw paws, green grams and dolicos lablab. He also sells cowpeas and pigeon peas. To add fertility of the soil, he use farmyard manure gathered from his animal.

The paw paws germinated and grew properly with no external water source except rain falling on them. The paw paws produced flowers from year 2000 and he discovered about half of them were males and he had to uproot them. This was a big setback and he lost 44 paw paw plants to this. He had planted 100. It is difficult to tell apart sexes of the plant at transplanting age.

Mr. Mutua is employed in Nairobi and his wife, Jedida, manages his land. It is worthwhile to note that, women whose husbands allow them to make decisions concerning their land are also on the forefront in rainwater harvesting. Those who wait for their husbands to come home and make the decisions are lagging behind in food security issues. Mr. Mutua allows his wife to accept advice and implement them in his absence.

3.2.1 Benefit of paw paws pits.

The biggest benefits of paw paws pits are the fruits. Other than for family consumption, excess fruits are sold to earn some income, which the farmer can use to buy food and other necessities. They act as cash crops for the farmers.

3.3 *Road runoff harvesting*

The technology is relatively new and ministry of agriculture officials introduced it. It is quickly spreading from one farmer to another through visual observations of the benefits received namely increased crop yield. Among the farmers practicing road runoff harvesting, the following were visited;

Table 3.1.1. Some of the farmers practicing road runoff harvesting

NAME	DIVISION
Esther Kivava	Chuluni
Kalile Musyoka	Mutonguni
David Kilanga	Mutonguni
Jedida Mutua	Yatta
Muthanga Kavite	Yatta
Mrs. Mutinda	Matinyani

Table 3.1.2 Observable differences between the farms with road runoff harvesting and those without.

Farms with road runoff harvesting	*Farms without road runoff harvesting*
healthy crops	wilting small crops
more perennial crops e.g. fruit trees	no perennial crops except naturally occurring
healthy livestock animals	weak livestock animals

healthy looking children	malnourished children

There was a notable difference between terraced farms that carry out road runoff harvesting and those non-terraced farms. Gullies had developed in the not terraced farms. The farmers reported the main benefits as being the higher yields. Previously they suffered persistent crop failures but this is something that only occurs when there is total rain failure. In some cases farmers identified road runoff that was not accessible because the runoff need to be raised for a height that did not look attainable to the farmers. With a little technical support this runoff can however be raised and become available for use. One of the farmers was harvesting road runoff for pasture is seen in the photo below

(photo)

Fig 3.4.1. Road runoff harvesting

Left) Mr. Musyoka from Mutonguni div. Showing how he divert runoff from the road

Right) Mr Mutinda's farm from Matinyani division grown with forage crops using road runoff

Road runoff harvesting need to be encouraged and emphasis given to terracing of land. The farmers should be made to understand there could never be external runoff harvesting for non-terraced farm. To sensitise more farmers on the technology, visits need to be organised at a time within the season when the benefits of road runoff can

clearly be seen, e.g. during a season when the rainfall fails to meet crops water requirement and there is water stress in crops which is not being experienced where road runoff is being done. The capacity for road runoff harvesting to provide food security is immense for some farmers. It can be used by some farmers to offset rainfall deficit as tabulated in table 3.1.

It will however not be available for all the farmers as not all have access to it. When road runoff harvesting is used for pasture, it greatly increases the yield and gives the opportunity for forage conservation in form of hay. The hay can then be used during drought when the animals have very little to eat.

Gully development occurs on poorly terraced farms where road runoff is being carried out. This is because land that is not terraced cannot hold water for long enough to allow for infiltration. The water therefore runs on the surface causing severe erosion.

3.3.1 Conflicts over the sharing of the runoff

Any form of runoff was regarded a hazard as it always resulted to carrying away of soil where it concentrated. Runoff was always considered an enemy and where possible it was always diverted away from farms. This way of thinking has now changed and road runoff is being sought so as to add on the amount of rainfall being received. Unfortunately not everyone has easy access to road runoff and sharing is being sought. The water laws do not give support to runoff sharing as anyone is free to harvest as much runoff as possible without seeking permission from government authorities, Some farmers are not aware of this. In one instance i.e. Mitonguni division a farmer, Mrs Musyoka, whose farm had an advantage over the neighbours as far as road runoff availability is concerned harvested everything leaving nothing for the neighbour. When they saw how well Mrs. Musyoka's farm was performing the neighbour sought the intervention of the sub-chief. The sub-chief sought advice from the ministry of Agriculture. She was informed about the water rights, which he later advised to Mrs. Musyoka’s neighbour.

In most cases of road runoff harvesting there is an offended neighbour who now realises the crop on his/ her own farm could perform better with extra water input in form of road runoff. It is necessary for catchment members to discuss on sharing of the concentrated runoff with advice from soil and water conservation officers.

3.4 *Sand dams and subsurface dams*

Obtaining water from the seemingly dry sand rivers has been there since time immemorial. The Kamba people used to scoop out sand and water collected in a pool from where it was fetched. The first sand dams and sub-surface dams in Kitui district were constructed during the colonial era. There was no contribution from the local people. More sand dams were constructed during KIRD that was in operation in the 1980s. Once again there was no contribution from the community. These sand dams are

still in existence and have provided water for decades to the local community. It is the presence of the old sand dams that the community have learnt an important lesson i.e. with the existence of the dam wall, there is water availability long after the rains have subsided.

Recently, all donor agents will not move in and donate sand dams to the people. The communities gather and make their contribution then call upon a donor agency to assist with what they do not have especially in the area of skilled labour and industrial materials

Peterson, 2000 reports that more than a hundred sand dams were built by various projects in Machakos and Kitui. The most notable contributions being;

1. African land development ALDEV in 1950s
2. Machakos integrated development project (MIDP) in the 1980s funded by the European economic community
3. Kitui ASAL programme in the 1980s that also built subsurface dams.
4. The green valley project in the 1970s funded by DANIDA
5. Mutomo soil and water conservation project in the 1980s funded by DANIDA

They have the following advantages;

- They make it possible to store water under the sand surface in sandy riverbeds
- Construction of sand dams is simple and inexpensive
- Evaporation losses are minimum under the sand surface compared to water surface
- Water quality is good because of filtration through the sand
- There is less operational and maintenance cost as compared to boreholes and conventional dams.
- There is no occupation of valuable land by water inundation as in surface dams.
- Sand dams have little direct negative impact on the surrounding environment.

Disadvantages

- Not convenient everywhere. They require suitable geological and topographical formation, which is rich in sand, and gravel deposits.
- Being generally in the bottom of a valley and having relatively smaller quantities of water, it is not possible to develop larger water supply schemes
- Length of the period that the water stored in the sand can last may be reduced by inefficient extraction methods and also evapotranspiration losses by the vegetation along the sand dams.
- Holes dug to extract water expose water to evaporation, contamination and is risky as sand can carve in

- A little shower upstream may not reach the people downstream because the water get trapped by the dam wall

3.4.1 Sand dams and the environment

Sand dams and subsurface dams have resulted to rising of the water table in the riverbeds. This has resulted to vigorous growth of vegetation along the riverbanks. Although the growth of the plants provides forage for the livestock animals, they contribute to water loss from the sand dam through evaporation. The benefits of having the vegetation there greatly outweigh the water loss problem in that besides providing food for livestock animals they also;

- create an evergreen region that has some authentic value and also brings some cooling effect to the region.
- The vegetation protects the bank from erosion.
- The vegetation prevents catchment soil from being swept into the sand dam.
- The plants take up nutrients dissolved into the water therefore the water is less saline.

The other environmental benefits were obtained from the community members. Before the construction of the sand dam the water obtained used to be more saline but after the dam was constructed it is less saline. This could be attributed to the higher volumes of water trapped by the dam well that contributes to some dilution effect of the water.

Another environmental effect is gullies that have formed due to converging livestock animals as they come to drink water. The gullies keep advancing and consequently a lot of soil continues to get lost. The advancement of gullies can be prevented by constructing gabions on the floor of the gullies along the cattle truck. As new sand dams are constructed, it should be expected that gullies would soon form along the cattle trucks so measures should be taken and gabions constructed before they develop.

Where the dam wall is put, a vertical wall is established. On one side the sand is level with the wall while on the lower side i.e. down stream, the original level of the river remains. This is a potential site for accidents, especially the young boys who go to water the animals. At Ithi sand dam, two serious accidents have occurred and one victim died from drowning 10 years ago. In some of the sand dams the dam wall is made in steps and this minimises the risk of accidents. In some sand dams e.g. Ithi sand dam, there are faults in the dam wall and water leaks to the lower side and creates a pond. The pond is a very suitable site for watering livestock animals and a lot of them converge for that purpose. The steep wall and the water beneath can however be dangerous because it provides water for swimming and a diving board for the children. It was in this pond that the drowning accident occurred.

(photo)

Fig 3.4.1 Ithi sand dam. A lot of livestock converge every day to drink water from the pond downstream of the dam wall

The presence of sand dams has also been reported to create perennial rivers downstream of the dam wall from rivers that were seasonal. A good example is Wiitu sand dam in Mutha division.

3.4.2 Health aspects related to sand dams

Incidents of mosquitoes breeding, especially soon after the rains, are high because the water movements is prevented by the dam wall. The situation is made worse by the sand

scooping to obtain water because often the pits are left open. This is expected to contribute to incidences of malaria in the region.
The open holes from where water is obtained also contribute to water contamination. This is due to using dirty containers, animals drinking directly from the holes, people bathing, washing clothes and pouring water back into the sand. This has definitely contributed to incidences of water borne diseases especially diarrhoea.

The water users are careful to boil the water before drinking but this is mainly among the adults. Children and young men will directly drink water directly from these holes that are contaminated.

3.4.3 Technical problems related to sand dams

1. They are not convenient everywhere. They require suitable geological and topographical formation, which is rich in sand gravel deposit. Where proper side identification was not properly done, the dams filled with ordinary soil, which do not store water in an extractable form.
2. Being generally in the bottom of a valley and having relatively smaller quantities of water, it is not possible to develop water supply scheme by use of pumps that can deliver water close to the homestead.
3. Length of the period that the water stored in the sand can last is reduced by inefficient extraction methods of scooping sand and losses by the vegetation along the sand dams.
4. Holes dug to extract water expose water to evaporation, contamination and are risky as sand can carve in.
5. Poor maintenance among the sand dams/subsurface dams where the community was not involved. To overcome these problems, the following need to be done.

Problem one

It is very important to carry out proper site identification before deciding on constructing a sand dam. To achieve this it is important to work closely with organisation and individuals that have been involved in construction of successful sand dams in the region.

Problem two

Use of water from sand dams is concentrated at the site of the sand dam because this is an economical option. Pumping and piping cannot be done at the current economic status of the majority unless by use of simple inexpensive pumps that are community owned and used in rotation.

Problem three

Sinking shallow wells for extracting water can solve the problem. Some of the sand dams have shallow wells only at the dam walls. The situation can be improved by having

several wells along the river. The one shallow well drilled is always too far for the majority and they are forced to dig holes for water extraction.
To make use of sand/subsurface dams more viable, there is need to encourage more community participation. The community should be trained in site identification, maintenance and the construction itself.

3.4.4 sand dams and community/donor participation

Table 3.4.1. The sand dams and subsurface dams visited included;

Sand dam	Division	Donor	Stream
Ithui	Central	Catholic diocese	Mithima
Salukya tuthi	Central	Catholic diocese	River Nzeeu
Ngangani	Chuluni	Sasol	Mwiwe
Wiitu	Mutha		Wiitu
Mr & Mrs Mutinda dam	Matinyani	Individual	Vyanyu

sub-surface dams

Vyanyu	Matinyani	KIDP	Vyanyu
Vyanyu	Matinyani	KIDP	Vyanyu

Various donors with or without the community involvement constructed the sand dams and subsurface dams. Construction of the sand dam involved;
1. Site identification;
2. Construction; construction involved scooping out the sand to reach the rock. Sealing any cracks and building a wall to trap the sand.

The sand dams and subsurface dams were categorised according to community involvement during site identification.

Three main categories emerged;
1. Community owned; in this category, the community was fully involved in site identification and construction.
2. Dams benefiting the community but the community involvement were not there during construction and site identification.
3. Individual dams that was constructed by an individual to meet the agriculture needs of the family.

Table 3.4.2. The community owned sand dams included;

Name of the dam	Year constructed
Ithi	1987
Salukya	2000
Mbusyani village sand dam	Under construction
Ngangani	2000

The donor and community contribution is as shown below

Sasol Sponsored

Donor; contributed cement, reinforcement bars and skilled labour

Community; contributed locally available materials i.e. sand, stones and water, accommodation and maintenance of a qualified artisan from the donor, arranged the delivery, storage and recording of materials

Catholic church sponsored

Donor; 90% cost of cement, iron bars for reinforcement, skilled labour

Community; 10% cost of cement, unskilled labour, locally available materials

In the community owned sand dams men and women were involved as shown
Men;
Breaking stones, mixing and carrying concrete
NB; older men were assigned lighter work

Women;
Carrying sand, fetching water, measuring sand
NB; older women were assigned lighter work

An interesting scenario was encountered at Mbusyani village sand dam, which was under construction. Twenty-six people were expected at the site but only ten had turned up out of which seven were women. The women were the majority because the burden of providing water falls on women than men and therefore they welcome news of water availability with more enthusiasm.

Dam benefiting community but community involvement not there at construction and site identification was Wiitu constructed in 1984 in Mutha division
Mr & Mrs Mutinda owns individual sand dam. Mr. Mutinda is the district crop officer. The farmer facilitated all the identification, provision of materials for construction and the construction itself. Him and his wife are well educated and are therefore aware of the opportunities that exist in rainwater harvesting. They are on paid employment and purchase of materials or paying for hired labour is not a problem.

Sand dams and subsurface dams that benefited the community but the community was not involved in their construction were the first ever sand dams to be constructed in Kitui district. The community members were not consulted. The donor was responsible for everything from site identification, provision of materials and construction. Locally available materials were purchased from the community. The community members who

worked at the site were paid for it. After their completion, the donor left and the community members continued using the water. No maintenance has ever been done or repairs but the community members who are the beneficiaries are happy the water is available. Lack of involving the community contributed immensely towards donor dependency.

The community did not identify their resources or develop skills to be able to expand on what the donor had started. Fortunately, sand dams and subsurface dams require little or no maintenance and are therefore functional two decades after the donors have left. They are also highly acceptable by the community being an improvement of traditional water sources.

The increased availability of the water in the sand dam/subsurface dam has made the community aware there is potential of sand/subsurface dams in providing water. This is important because it has triggered interest in the community for developing more dams.

For the community owned sand dams, the community identified or were led to identify their need for water through participatory rural appraisal (PRA). They identified their resources and also their limitations and the donor stepped in to assist in what the community could not provide e.g. the expensive cement, reinforcement bars, and skilled manpower. The community provided what is locally available e.g. sand, ballast, water, unskilled labour and in some cases, little money. Today the community members are concerned about their structure. They believe it is theirs and some have drawn by-laws that regulate its use. They also restrict the number of people using the water to those who contributed, of course with little success. The little success is because it is difficult to draw dam boundaries and stop people from using water from a river that traverses their land and they have always depended on. This restriction could however propel other communities to desire construction of their own sand dams and this would reduce water problems in Kitui district.

It was noted that contribution in form of money is the most important. Where the donor demanded money contribution, the community is particularly vigilant in protecting their structure.

3.4.5 *Benefits of community owned sand dams*;

- Form the basis for construction of several more sand dams with little or no donor support.
- Transfer of skill to the community was achieved through their involvement.
- Desire to maintain and use properly the sand dam exist because the community regard it as his or her own.
- Has brought cohesiveness to the beneficiaries and this is easily diverted to other development activities e.g. irrigation farming.

For the individual owned sand dams, site identification, provision of materials for construction and construction was all the responsibility of the farmer. The water

available is for use by the farmer himself although the water extends beyond his farm and therefore other people benefit. There are several well-educated people with well paying jobs who do not see the need for settling in Kitui district due to the perennial water problem. Mr. and Mrs Mutinda prove them wrong because he has more water at his disposal than thousands of those who migrated to urban centres. The dam does not benefit himself alone but tens of people upstream have additional water because of the sand dam. Most people in Kitui district will however not afford to construct individual sand dams and can only manage donor supported community sand dams.

3.4.6 W*ater demand and water available*

CASE STUDY 3.3.1

For Ithi sand dam, the information obtained was as follows;
The dam was constructed in 1987 and filled with sand two years later. By then, 25 families were benefiting but today the number of families has quadrupled. Each family has 8 members on average and this gives a total of 25 x 4 x 8 = 800 people. The water is used for domestic, livestock and irrigation farming. The irrigated crops are mainly vegetables especially kales, tomatoes, spinach and onions. Each family has on average 5 cattle, 20 goats and one donkey. It was assumed the donkey's water demand is equivalent to the local cattle and this gives a total of 6. Similar information was gathered for the other sand dams.

For Ithi sand dam

user	*Total consumption per day (litres)*
Human	800x10=8000
Local cattle	17x6x100=10200
Sheep/goats	4x20x100=8000
TOTAL	26200

26200 litres = 26200 / 1000 l/m^3 = 26.2m^3.

Table 3.4.3. The average daily consumption for selected sand dams

Name of the dam	Number of beneficiaries	Daily livestock and human water demands	Amount of water available (m^3)	Number of days the water can be used
Ithi	800	26.2	17500	664
Salukya	300	9.9	6250	625
Mbusyani	200	6.6	Under construction	
Wiitu	At least 1000	32.8	Not sand filled	

It is not possible to quantify the exact number of people and livestock benefiting from a certain sand dam. This is because once complete; the sand storage may stretch upstream for several kilometres thus benefiting more people than were planned for. Another reason is because the number of beneficiaries fluctuates greatly with water availability or

lack of it from other sources e.g. shallow wells and sand rivers. However the information given by the beneficiaries was extrapolated to arrive at an acceptable figure, which very much agreed with the beneficiary's estimates. The amount of water available from the sand dam over looks losses that could occur due to seepage, evaporation from water holes, evapotranspiration. Another factor overlooked in calculating the water demand are the people outside the boundary of beneficiaries that will travel tens of kilometres to the sand dam in search of water during severe droughts.

3.4.7 *Effects of sand dams on the socio culture of the people*

Where sand dams do not exist, the pits dug to extract water go very deep. The men have to do the more difficult job of digging these pits that sometimes go up to 15 ft deep. They dig the pits while the women and children fetch the water. With the construction of the sand dams the very deep pits are not necessary because the quantity of water in the sand is more. With the construction of sand dams the men can concentrate on other development activities like terracing, construction work for houses and looking for paid employment in neighbouring farms.

The women have a lesser burden of going very far in search of water. Less time is spent looking for water and they are able to concentrate on other activities e.g. gardening, weaving, and looking after their children.

The children do not have to spend a lot of time looking for water because it is available nearby. Sometimes girls were required to stay away from school to go fetch water while the boys too had to stay away from school to take the livestock animals far away where water was available.

3.5 Rock Catchments

This method of water harvesting features highly in the rocky areas of the district. They are extensively utilised in the district within Mutomo division (now a sub-district), Mutha and Ikutha divisions. There are about 108 rock catchments in Kitui and Mwingi districts which have been constructed by different donors who include; African Land Development (ALDEV)
European Economic Community (EEC) Catholic Diocese, Danida, Sida. The majority of the rock catchments have been constructed by DANIDA in Mutomo, Mutha and Ikutha divisions. The rock surfaces are estimated to have catchments ranging from 15 m^2 to 3000m^2. This water is used for;

- Domestic purposes
- Drinking water for livestock animals
- Drinking water for bees
- Kitchen gardening

Rock catchments provide water for 75% of the population in Mutomo with 26 and Mutha with 24.

The first rock catchments were constructed during the colonial era to provide clean water during construction of the Kenya –Uganda railway. Some few reservoirs are naturally occurring e.g. Ya Mutomo has a natural depression that holds water. During construction, piped water draw points were incorporated but they are now not functional in 95% of them due to poor maintenance and vandalism of the pipes, consequently water is drawn directly from the reservoir using containers.

During construction works each party contributed as follows;

Donors; Industrial materials e.g. cement and reinforcement, skilled labour, working tools transport of local materials
Men; Building, ballast preparation, unskilled labour, uprooting trees
Women; Carrying the ballast, water, ballast preparation, unskilled labour, loading sand

During the evaluation, 5 rock catchments were considered. They are;

Table 3.5.1 Rock catchments evaluated.

Rock catchment	Division	Estimated capacity	No of beneficiaries
Kaseva	Mutomo	5000	10,000
Ya Mutomo	Mutomo	800	300
Syonyaa	Mutomo	700	700
Kinyoo	Mutomo	400	500
Kavili	Mutha	1000	8000

Table 3.5.2 other rock catchments in Kitui

Name	Division	Estimated capacity	No. of beneficiaries
Kaseva	Mutomo	5000	10,000
Kavili	Mutha	3000	8,000
Katothya	Mutomo	4500	8,000
Mbunyaka	Mutomo	5000	10.000
Ndue	Mutomo	2500	5,000
Syanduini	Mutha	2000	4,000
Nzonzweni	Mutha	1000	1000
Mulukya	Mutha	2000	1000
Kivili	Mutha	600	500
Yovwia	Mutha	500	200
Sikwata	Mutha	800	300
Ndilili	Mutha	2500	1000
Mweletu	Mutomo	900	500
Ya Mutomo	Mutomo	800	300
Syongaa	Mutomo	700	200
Kitambaasye	Mutomo	600	400
Kwakimweli	Ikutha	1000	600

Yanzati	Ikutha	1000	600
Kilamba	Chuluni	2000	1000
Ituki	Chuluni	1000	500

CASE STUDY 3.5 1

Kaseva rock catchment

Kaseva rock catchment is in Kyome village, Kawetu sub-location Kibwea division of Mutomo division, now a sub-district in Kitui district. The water harvested is utilised by people from Kibwea, Mutomo, Mathima, and Kanziko locations a total of between 10,000 – 15,000 persons depending on season. During the wet season, the number of people depending on it reduces as sand rivers; ponds and shallow wells get recharged. Different donors have constructed Kaseva rock catchment at different phases. The then colonial chief Mwanduka Kisemei together with the local leaders identified the site in 1957. The late Komu Mutua donated the area freely. The area has been surveyed as a public utility with an area estimated at 4 acres. It is still waiting for the title deed to be given to the committee.

Phase one was done in 1958 by ALDEV and involved the construction of a small reservoir that carries about a fifth of the total water. Phase two and three was done by DANIDA in 1993 and 1998 respectively. During phase two, another reservoir was added to the previous one of phase one. During phase three, the phase two reservoir was added to about double its previous capacity.

The catchment area potential is estimated at 2 ha and the reservoir capacity is estimated at $5000m^3$.

Management and Sustainability

There exists a water users committee with sixteen members, seven women and nine men. Beneficiaries pay money to the committee at the following rates; Ksh.50 per month per household, Ksh.200 per week for donkeys that ferry 100 litres at once, Ksh.400 per donkey carts that ferry several jerry cans at once. Donkeys and cart water is for sale hence the higher rates. Non-members pay Ksh. 1000 to register as members. The community through regular barazas monitors the collections. It is through these meetings the expenditure and collection reports are presented to the water users. The money is used for minor repairs and payment of the watchman.

An estimated 500 households and the whole of Mutomo town benefit from Kaseva rock catchment. Each family is allowed four jerry cans per day soon after the rains but after the nearby other water sources have dried up. These other sources include; Syonyaa, Kinyoo and Ya Mutomo rock catchments. The same committee manages the above three rock catchments. However, since they provide water during and soon after the rainy season, there are no restrictions on quantity of water fetched and there are no charges. The four jerry cans allowed when the reservoir contain a lot of water is constantly reviewed downwards as the drought advances. The water beneficiaries are guided by a set of by-laws as listed;

1. Members are not allowed to enter the rock catchment area with shoes. This has little effect on hygiene as most people fetching the water walk barefoot so their feet are as dirty as shoes.
2. Animals are not allowed to graze or browse within the catchment area. This helps to keep the dung and urine from falling to the catchment and it positively contributes towards proper hygiene.
3. Members who do not participate during working days are fined between Ksh.50 to a goat depending on the seriousness of the case at hand.
4. Members are not allowed to dip the whole jerrican into the reservoir. This ensures the possibly dirty jerrican will not dirtify the water.
5. Members are not allowed to go to the water followed by dogs. This is because the dog might defecate or urinate on the reservoir or catchment or drink water from the reservoir.

Alternative water sources are Tiva, 20 km away and Katumia River, which is 4 km away. For this reason, i.e. unavailability of other sources of water, the management at Kaseva is very keen on water quantities leaving the reservoir and this way they manage to have water however little all year round.

Future plans

The community plans to construct water kiosks to help reduce walking distance for the beneficiaries. Some piping was done to all the rock catchments but very few have the pipes and taps operational because they were vandalised. However, if the community put the same on their own the problem is not likely to happen because they know all possible loopholes and suspected thieves.

The community also plans to construct another reservoir below the main one in phase four. The catchment potential is immense and a lot of water has been going to waste. If this phase four is constructed the beneficiaries would be able to keep more animals and irrigate more crops as more water become available. Unfortunately, the money collected, might take a very long time before it is adequate. For this reason, identifying a donor to assist the beneficiaries can bring the water sooner other than later.

There is need for the beneficiaries of the reservoir to be trained on water use, sanitation, simple accounting, water use rights to ensure their water is not used badly and also to enable for expansion of the existing water uses. For instance, drip irrigation can be done using very little water but the farmers know very little about it. The water beneficiaries need to know the reasons why urine and dung from livestock and wild animals and dogs must never find its way to the water. If they know of the danger, they are likely to cooperate more and keep the animals away. For easy management of the money, there is need to train the committee members simple accounting techniques. This way, making plans for expansion will be easier.

The money collected is kept by the treasurer at post bank, Mutomo. It is used for paying a watchman who guards the water from 6.00am to 7.00pm. the money is also used to do

minor repairs. The bank account was opened in 1995 following misuse of money by the treasurer and demand for the money collected by the provincial administration (i.e. sub-chief chief, DO). Training the members on their rights over water is important. It will give the members courage to stop the provincial administration from demanding for this money, as it is not right. Without the money collected, there is no future for rock catchment as there will be no money to carry out repairs or expansion. Lack of money will make the people completely dependent on donors.

Problems encountered include;

1. Politicians who incite members during campaign by telling them the water should be free. Training should also be aimed at informing the members to be wary of such politicians as they are bringing confusion and misunderstanding.
2. Provincial administration demand for the money collected. Opening a bank account has solved this. Having a cheque signed for them is now very difficult.
3. Use of water by provincial administration during celebrations without paying for it. This is wrong since there is money assigned for the celebrations and they should pay for the water.
4. Members' late payments.
5. Stealing of water at night.
6. Too little water before the short rains onset

To reduce water problems in the area, Miyumbuni earth dam need to be rehabilitated for use by livestock. The earth dam water was drained away by digging a deep channel following a drowning accident and the channel has not been filled since. The dam is only three kilometres from Kaseva rock catchment.

3.5.1 Catchment reservoir and rainfall for Kaseva

The 67% probability rainfall for Mutomo was obtained from Hai, 1998 as 480 mm. About 40% of this rainfall occurs during the long rains while the rest is received during the short rains.
The catchment area is estimated at 2 ha = 20,000 m^2
The reservoir capacity is 5000 m^3

During the short rains about 288 mm of rainfall is received every 2 out of 3 years. This rainfall yields enough runoff of 5760 m^3
I.e. 60% of 480 = 288mm

20,000m^2 * 288 / 1000 = 5760 m^3

The rainfall in ASAL of Kenya occurs in heavy storms that cause a lot of runoff that probably spill over the gutters. It is also expected some water will seep through the rock and therefore not all rainfall ends up as runoff. An estimated 70% of the rainfall is estimated to be gutted into the reservoir.

i.e. 70 / 100*5760 = 4032m^3.

The local information gathered concerning the reservoir and the rainy season was that, the reservoir never fills during the short rains. The short rains of October to November often extend to December and January and there is only a short inter-seasonal dry spell between the short and the long rains. The water is preserved during this short drought and during the long rains of March and May; the reservoir fills to capacity and often overflows. This water is then used during the inter-seasonal drought from June to October, which is extensive and very severe. By the time the short rains start again in October, the reservoir is empty.

Fig 3.5.1 Kaseva rock catchment. Photo taken during the long rains of 2001 (April) to show the full reservoir

Fig 3.5.2. During the long inter-seasonal drought of May to October, all roads lead to search for water in Kitui district.

CASE STUDY 3.5.2

Kavili rock catchment

Kavili rock catchment is in Ngithi village, Kiimani sub-location, Mathima location of Mutha division, Kitui district. It serves Mathima, Kanziku and part of Mutomo locations. There are about 2000 – 4000 people depending on the facility. The number varies depending on season where during the dry season it serves the highest number. Different donors constructed it at three phases. Phase one involved scooping soil and uprooting a baobab tree. Phase two involved further scooping and was assisted by Catholic diocese with cement and ballast in 1971. Phase three involved ballast preparation and block making and was assisted by DANIDA in industrial materials, skilled labour, transportation of local materials and working tools in 1985. The late colonial assistant chief Nzamba Musuu and local leaders of the area, then Kanziku location in 1949, identified the site. Later on in 1971 local leaders requested Catholic diocese for assistance. In 1985 it was considered for expansion through the district focus for rural

development strategy. The land is a public trustee area and up to date it is no mans land still under public trustee. The local community here identified the project boundaries with an estimated area of 2 acres. The capacity of the three reservoirs is estimated to be $500m^3$. There is an existing water user committee with 16 members, 8 women and 8 men. It was trained and handed over the project by DANIDA in 1989. Similar by laws to those of Kaseva exist to govern the running of the facility. The chief and the local councillor are ex-officials. There is little or no accountability since monies collected are not banked. The water is used for the following purposes;

- Domestic purposes
- Making bricks by men to build houses and income generation
- Watering livestock
- Minor irrigation in kitchen gardens where vegetables and fruit trees are watered.

3.5.2 Benefits of rock catchments

- Less time is utilised in searching for water
- Water is generally clean compared to other sources egg sand rivers, wells
- There is more brick making for better houses and income generation
- There is more honey production for income generation
- Improved school attendance by children
- Less night movements by women
- Better diets because of kitchen gardening
- Less water borne diseases
- Fish farming help provide proteins in the diets
- Have encouraged farmers to keep more livestock animals

3.5.3 Maintenance and expansion activities required

- Expansion of the existing structures
- Fencing off to keep off intruders and thieves and wild animals
- Piping systems and water kiosks where water will be fetched and the taps locked at night
- Repair of leakages

3.5.4 Taboos

- No fighting or quarrelling at the water points among the water users. A fight or a quarrel results to a fine of a goat.
- No drawing water with cooking utensils e.g. sufuria and pots
- If anybody drowns by accident the water is drained away but if it is suicide draining away the water is debatable.

Fig 3.5.3a) Leaking walls of Kaseva rock catchment

(PHOTO) Kaseva walls

Fig 3.5.3b) Already repaired walls. December 2001. See fig a) above

3.5.5 *Constraints to rock catchments development*

- Not easy to expand because they require expensive materials and skilled manpower.
- The water is not covered and this result to pollution and high evaporation losses.
- Piping of water not functional resulting to pollution. This also exposes the people to drowning accidents.
- There is some donor dependency syndrome that hinder the community from expanding on the existing structures
- Low levels of income among the people is a hindrance to contribution of large sums of money for expansion
- Low donor support
- Unreliable rainfall. In very poor seasons even the existing rain water harvesting structures do not get full
- Poor management e.g. in case of Kavili where money is never accounted for.
-

3.5.6 *Health aspects related to rock catchments*

The rock catchments have brought water close to the people and this has resulted to improved hygiene standards. The burden of carrying water by women and children has been lessened for the beneficiaries and they reported less backache. The diets are better due to the vegetables grown in the kitchen garden and also the fish reared. They provide vitamins, minerals and proteins. For domestic water use, water is drawn directly from the source causing poor sanitation and introducing the risk of contacting water borne diseases.

3.5.7 *Environmental issues*

The runoff that is now dammed used to cause soil erosion and in some of the cases gullies had formed. The advancement of these gullies have been minimised. The farmers have put beehives around the rock catchment because of the water availability for the bees. The farmers understand bees will leave the hives if water is not available. They also understand they need flowers for nectar that can only come from plants. Consequently there is understanding for the need to conserve the vegetation around the rock catchments for more honey production.

3.6 Eathdams

Eathdams in Kitui provide water for livestock, domestic and irrigation. In some parts they are the only water resources. Some earth dams have committees that are charged with

enforcing a set of rules and regulation that govern the use of the water. These regulations ensure the water is only used for the intended purpose and pollution is controlled. In the well-maintained earth dams, animals cannot drink directly from the dam. Also bathing and swimming are prohibited. These rules help a lot in maintaining the structures and keeping the water clean.

Small earth dams are not viable in Kitui district because they are readily affected by drought and seepage losses and therefore dry up soon after the rains.
In the northern part of the district there is an earth dam for every location. However most Eathdams contain water for a short time after the rains. Those that have water, which assist people during the drought periods are few although water availability is also a factor of management.

CASE STUDY 3.6.1

Ug'ata earth dam

Ung'atu earth dam is in Ung'atu village, Mukameni sub-location, Mbusyani location, Chuluni division of Kitui district. It serves a population of 7000 people with the highest water users being during the dry season. It has a capacity of $1050M^3$ and it is served by Kalikulu stream with a length of 13 km.

Fig3.6.1Showing Ung'atu earth dam

The catchment area is 26000 ha and this area is partially conserved. i.e. there are some farmers doing cultivation with no soil measures. The soils within the catchment area are sandy loams with pockets areas of black cotton soils. The main vegetation cover is shrubs, and acacia trees species. It lies in eco-zone ILM4 – ILM5. The earth dam catchment area has crop farming and grazing land as the main economic activity. It was constructed in three phases

Phase 1; Was done in 1982/3. The local community and a local leader Mr Titus Mbathi, a parliament aspirant provided a crawler tractor.

Phase 2; Was done in 1993 by the local community and Kitui integrated development project (KIDP) which was funded by DANIDA undertook phase 2 that involved expansion of the reservoir. KIDP provided a crawler tractor.

Phase 3; was done in 1998. The local community and Kitui agricultural programme also funded by DANIDA undertook phase three. KAP provided a crawler tractor. Fish of the Tilapia species was introduced in the earth dam in 1998 by the fisheries department. The community paid Ksh.12, 480 as cost sharing during phase three. Each member contributed 25 shillings.

Site Identification

The local leaders and the then assistant chief identified the site for the dam in 1982. Mulei Munyika, a local community member, donated the land freely.

The area under the water reservoir is estimated at 3 acres and it was surveyed as a public utility with a title deed. There is no likelihood for future conflicts over water ownership because the reservoir is not in an individuals land.

Management and Sustainability

There is a water user committee with 13 members comprising of 9 men and 4 women. There are written by laws, which govern the running of the earth dam. There is a regular membership registration of Ksh.20 per year. Members usually work every week on Thursdays. The work done is fencing and minor repairs e.g. putting rafters at the drawing points. Absenteeism and lateness during the working days attract a fine depending on the case from Ksh. 100 to a goat.

Membership is open to everyone but with the consent of the committee members and contribution of an amount to be agreed upon by the committee. The money collected is used for the following purposes;

- fencing
- minor repairs
-

Earth dam construction

In 1982 when the first phase was done, the men from the area participated by;

- clearing the area, this was necessary to rid the area of the bushes and shrubs to make digging possible.
- Excavation of the reservoir using hand tools. The crawler tractor did most of the excavation.

In 1993 men were further involved in the phase two construction in the following activities;

- clearing the area
- fencing the dam and leaving one entrance, which is an environmental, as well as safety measure. Too many entrances leaves several drawing points which will lead to development of gullies that start as foot paths or track routes for livestock animals.
- removal of tree trunks and roots during tractor excavation.
- they paid cost sharing i.e. money amounting to 25 shillings per head
- watered the embankment for compaction.

In 1982, the women participated in weeding the area and feeding the men. In 1993 and 98, their involvement increased and they did more work. These included;

- weeding the area
- fencing together with the men
- drawing water from R. Nzeeu for compaction
- feeding the other workers. Food was cooked at the site by the women
- removing stubs and roots
- paid cost sharing amounting to 25 shillings per individual.

Donor participation

In 1982, the donor, Mr. Titus Mbathi provided 30 jembes, 30 shovels and a crawler tractor. The tools and the tractor were used for the excavation work. In 1993 and 1998, DANIDA provided the skilled labour that carried out the survey work and a crawler tractor for excavation. They offered training to the local community on water use and management.

Benefits of the earth dam to the community

Benefits for adult men include improved housing as there is water for bricks making. There is also improved personal hygiene. Men working in urban centres found it depressing on arriving home on weekends only to realise they couldn't take a bath because there was no water. Consequently, their inputs in agriculture used to be foregone as they avoided going home.

There is more income through vegetable growing and fruit trees. These vegetables, fruits and fish have also brought improved nutrition. Before the construction of the dam, the

men used to walk for long distances in search of water for livestock but this has greatly reduced for farmers. As a result there is more time for other activities in the farm like terracing and farming. The assurance that the water is there gives the water users confidence in keeping more animals. On average, each household keeps 2 zebu cattle, 5 goats and one donkey for the beneficiaries. Before it was 1 cattle and 3 goats.

The tree nurseries and fruit nurseries has brought about increased environmental conservation by checking soil erosion. The nursery was destroyed during phase 3 but plans are underway to restart again. For the young men the benefits are as follows;

- shortened distances to livestock watering points
- regular livestock watering. Previously the animals could not be offered water ad libitum and this lowered their production.
- early age improved housing as they too can make bricks.
- reduced tree felling due to use of bricks for housing.
- increased income from brick making water sales, and vegetable sales
- they enjoy improved personal hygiene
- improved school attendance

Better life has brought a reduction in rural urban migration and has actually although to a small extent brought the opposite i.e. urban rural migration.

For the women a reduction in water fetching distance has been a major benefit. Previously women used to trek to 30 kilometres to R. Nzeeu to find water. That also required then being on the road at night. The women reported less backache and chest diseases incidences. Other general benefits include improved personal hygiene; enjoy better housing and improved nutrition.

For the young women, they reported the following as their benefits;

- There is reduced water fetching distances
- More school attendance, as the young women are not desperately needed at home to fetch water.
- Others are improved nutrition, more leisure time and improved hygiene.

Problems with Ung'aatu earth dam

The community identified and ranked their problems as follows;

1. Gully that has been dug by spillway discharge when the reservoir is full the spillway water digs a gully down stream of the dam.
2. The water drawing methods cause pollution as it is drawn directly from the dam.
3. Encroachment into the water reservoir by vegetable growers. This is feared could result to conflicts over ownership of this land, which is publicly owned.
4. Waterborne diseases especially diarrhoea. The water is not clean and drinking it without boiling leads to sickness.
5. Need for a bathroom and latrine. Those coming to the dam spend several hours and some want to go back after a bath. To avoid taking bath from the dam a bathroom is necessary. A latrine will reduce chances of defecating on the dam vicinity.

6. The water user committee are ordinary people having no superior knowledge over the other water users. Consequently they have very little to offer to the other people.
7. Siltation. The dam is quickly getting silted up as some section of the catchment area cultivated with no erosion and water conservation measures.
8. Low income and poor education standards hinder maintenance levels, like the money collected is not banked and is kept by treasurer.
9. High donor dependency syndrome; e.g. the community insisted on awaiting a donor to donate a crawler tractor for disilting purposes other than attempting to do it on their own

Fig3.6.2 Gully that was dug by spillway discharge

Opportunities

The water users cited the following as opportunities that need to be exploited;

1. Good potential sites for seedlings production including pre-germinated maize. Under controlled community activities, plots can be set up for vegetable, agro forestry seedlings as well as pre-germinating maize for transplanting when the rainfall onset occurs.
2. There are local fencing materials that can be used for fencing the earth dam area.
3. There are able and willing men and women who can provide labour force for further development. Training to reduce dependency on donors is necessary.
4. There is a high potential for fishing. Currently the fishing is not controlled and is done by young boys. Traditionally the Kamba people have not depended on fish

because none has been available and training on low to incorporate fish into their diets is necessary.

Taboos

1. No drawing water with cooking utensils
2. No fighting or quarrelling at the water points.
3. If anyone drowns the water should be drained away unless it is suicide. If suicide the matter is discussed by the community and they decide on the measures to take.

The above 1 or 2 are contravened; the culprits produce a goat for a cleansing ceremony

(photo)

Fig3.6.3 Catching fish at Ungaatu earth dam is mainly done by young boys. This is because the Kamba people are traditionally not fish eaters. Training on incorporating fish into their diets is necessary.

CASE STUDY 3.6.2

Muthamo earth dam

Muthamo earth dam is in Muthale, Muthamo villages; Muthale to the west and Muthamo to the east of the earth dam. It is in Kangundo sub-location, Musenga location, Mutonguni division of Kitui district. It serves 5 locations namely; Musengo, part of Usiani, Mutonguni, Miwani and Kakaeni with an estimated population of 15000 – 20000 beneficiaries. About 25000 households. Each household has 3 cattle, 5 goats and one donkey on average.

The people drawing water from the dam are more during the dry season because of the drying up of other sources. Since it was constructed in 1975 it has never dried up. This is because of its big size. Also not much silt finds its way to the dam because the catchment is well conserved. It has a well-conserved catchment of about 20000 ha with a few patches un-conserved resulting to some siltation to the reservoir. The major soils within the water catchment area range from sandy loams to sandy clay loams with some pockets of black cotton soil. It has an estimated capacity of 150,000 m^3 and is served by Muthamo stream.

Ngundo Sila, Mwangi Wasua, Muturwa, Ithuku, Kimana, and John K.Kihungya donated the dam area. They were later compensated with money by the government. The area donated and compensated measured 15 acres and is fully fenced. The dam area is surveyed as a public utility with a title deed. The catchment area has a vegetative cover of bush thickets with major tree species being combretum spp. and acacia.

Fig 3.6.4 Muthamo earth dam. Since its construction, the dam has never dried up. Note the well-conserved catchment.

Management and sustainability

There is a water user committee, which is dormant. It has not formulated any by-laws and sustainability. It is only local leaders and provincial administration that monitor the utilisation of the facility.

Community participation

There was no community participation during the time of construction. This was because it was more of a political campaign tool in 1975. The area is densely populated and therefore a source of many votes. During construction the government provided the funds and constructed the national youth service that did all the work. They however view the earth dam as their resource. To say the community depend on it is an understatement as it is their livelihood. Muthamo earth dam has greatly improved their living standards.

Benefits of the dam

Livestock watering distance has been reduced for those near the dam. The men no longer walk long distances in search of water.

There is improved nutrition for all family members through vegetables, fruit farming and fish harvesting.

The time saved from searching for water is now used for other development activities especially terracing the farms.

There is income generation through water sales to the nearby centres, brick making for sale. Also those who catch the fish sometimes sell them.

`There is improved school attendance because of the higher income and also the children are not required to go looking for water for livestock and domestic consumption.

The women reported reduced back and chest pains. The 20 –25 litres jerry can they carry on their back result to such pains if they travel long distances.

There is improved tree survival rate of fruit tree seedlings. This has dietary, environmental and economic benefits. The trees conserve the environment, the fruits are eaten and provide vitamin c while, and others are sold to traders or to other people thus generating income.

The dam is the source of water for the following institutions;

- Muthale secondary school
- Muthamo secondary school
- Muthale mission hospital
- Kangondi primary school
- Muthale primary school
- Tulia market (biggest market in Mutonguni division)
- Muthamo shopping centre.

Problems of Muthamo earth dam

1. Substantial amount of siltation has reduced the dam's capacity over the years. With no active committee, disilting has never been discussed.
2. Waterborne diseases, this result from drinking water without boiling. Education on the dangers of drinking water without boiling needs to be carried out.
3. Poor water drawing methods. The water is scooped out directly from the dam with all types of containers resulting to water contamination.
4. Fencing; the fence need to be planted in areas where it has been damaged leaving unauthorised entrances through which the water can be accessed. Due to the large size of the dam, several entrances need to be identified and created.
5. Grazing within the dam site; this is because the dam has created an evergreen environment that attract livestock owners especially during the dry periods. This need to be discouraged to ensure siltation and contamination of the water is minimized.
6. Encroachment into the water reservoir by vegetable growers. To prevent this, water pumping is necessary. To take the water closer to peoples homes. This will make them grow the vegetables at their farms and not at the dam site
7. Deforestation; The evergreen dam site is under threat by man through tree cutting. This should be discouraged at all costs. To succeed, the dormant water user committee need to be activated
8. Vandalism of fence and pipes. This calls for a watchman to be hired and this can only be possible if the water user committee is functional.
9. Low income of the community contributes to the above problems because they cannot afford pumps and pipes. Also to obtain fuel wood, they sometimes steal the trees because they cannot afford to buy alternative fuel sources.

CASE STUDY 3.6.3

Mumbuni earth dam

It is located in Kyome village Kawela sub-location of Kibwea location Mutomo division of Kitui district. It was constructed in 1986 by Agricultural Mechanization services (AMS) funded by Mutomo soil and water conservation project. The community members were not involved and they contributed nothing towards its construction. It had an accident in 1989 where a boy drowned while swimming in the dam. The local community could not trace the body hence they opened the embankment to let the water drain. They found the body stuck in mud at the bottom. It was repaired by DANIDA in 1996 and the same thing happened in 1998 during El Nino and the scenario recurred. It has not been repaired since and the local people believe there are evil spirits camping in the water and so they are scared of it. The community would however welcome a donor who would be willing to repair the dam meaning there is a problem of donor dependency.

3.6.1 *Eathdams and the environment*

The availability of water has provided an opportunity for tree seedling nurseries including fruit trees. These trees once transported help in conserving the soil and making the area to be green. Aquatic animals and plants have habited the perennial earth dams. There is therefore more fauna and flora that have made up an ecosystem that was non-existent before. The availability of water for brick making has given an alternative for timber, which was and is still used for constructing houses. Presently there is less felling of the trees because of brick making.

In some cases e.g. Ungaatu earth dam, a gully has been developed by spillway water. A lot of soil has therefore been carried which is an environmental hazard.

The ministry of agriculture officials advice farmers on the lower side of earth dams to sink shallow wells because they believe there are seepage losses and this water is available else where from underground. This means earth dams do not provide water at the points they are located only but this dammed water is available elsewhere.

During construction of earth dams, the farmers are encouraged to intensify terracing of their farms to reduce silting up of the dams. Consequently, there is less soil lost through soil erosion than it would have been the case if the earth dams were not there.

There are paths that develop because of livestock going to the earth dams. Eventually these paths develop into gullies. There is need to take measures like construction of gabions to avoid the development of the gullies

3.6.2 Eathdams and health

Eathdams have contributed towards good health of the community in the following ways

1. Availability of water which can be used for domestic purposes, consequently there are better hygiene standards
2. Growing of vegetables using water for irrigation from the dam.
3. Fish provide proteins for the community

Numbers 2 and 3 have resulted to improved nutrition.

Negative influence on health from earth dams is due to the water, which is not clean. It should not be drunk without boiling as it contain harmful microorganisms which the community believe results to diarrhoea. Some people especially children drink this water directly without boiling which is harmful.

3.6.3 Conflicts emanating from earth dams

There was only one conflict noted at Kaiveti earth dam in Mutonguni division. One of the neighbours to the earth dam had sunk a shallow well, which the community believed could have been draining water from the earth dam. The dam water is community owned while an individual owns the shallow well water.

Fig 3.6.5.The controversial well at Kaiveti earth dam. The community believe it drain water from the earth dam.

3.6.4 Eathdams and politics

Communal water supplies are to a great extent the responsibility of the local leaders especially local politicians. It would be important to liase with local politicians in matters concerning community water supplies as their role in bringing people together cannot be overlooked. This is particularly true in earth dams. Construction of earth dams is an important political tool especially when looking for votes.

3.7 Under ground tanks. / Roof catchment systems.

Underground tanks were built to collect runoff from schools and home compounds while concrete tanks are for roof catchment systems. The water from underground tanks was to be used for; cleaning, watering livestock and tree nurseries for reforestation. The transplanted tree seedlings were also watered. The roof catchment systems are meant for domestic purposes. As a result, some schools have trees in their compounds, which were planted when the tanks were functional; -almost all the underground tanks are not operational. Concrete tanks for schools have suffered the same fate.

The targeted catchment for the underground tanks were the school compounds which mainly had compacted soil and is devoid of vegetation due to too many children playing in these compounds. The un-guttered roof water was also directed into these underground tanks using channels.

The site for the tank was excavated and lined with concrete. The ground to serve as catchment was cleared of vegetation to induce increased surface flow. Alternatively road runoff was diverted into underground tanks. Unicef funded their construction in 1988, which targeted 1,000 under ground tanks. Most of them functioned for only one year after which they developed cracks and the water leaked away.

The harvested water carried large quantities of silt, which lowered the tank capacity. The spillway yielded large quantities of water that resulted to gully erosion.

The blame is put on the high temperature fluctuation between night and day and between drought and rainy periods. Sometimes the temperature rises up to 33^0 c. Another possibility of poor workmanship as is evident in Itumbi farm in Mutomo division. The poor workmanship coupled with temperature fluctuation is probably the main cause of failure. Roots of plants especially trees could have caused cracks in some of the tanks.

The temperature theory could be true as two tanks found with little water had some temperature modifications. At the Masaani primary school in Yatta Division the tank has a life fence. In a dispensary in Matinyani Division, the tank has an iron sheet roof. The life fence and the roof provide shades on the tanks thus preventing extremes of temperatures. The tanks don’t hold a lot of water since the upper sides of the tank wall have developed cracks caused by roots of the life fence.

A better answer for the failure is available from Itumba farm in Mutomo division. The tank was lifted off its pit by runoff water in 1997. The exposed wall is thin and don’t have strong reinforcement to withstand pressure from the water.

Fig 3.7.1. An underground tank, which contained some little water, is fenced with a life fence.

[PHOTO].

Fig 3.7.2. A broken underground tank at Itumbi farm in Mutomo division

The tanks still lie empty in school and homes. Since the catchment still yields water they serve as infiltration pits. No one has put the tanks to any alternative use. They are dangerous sites for both human and livestock that could fall and get injured especially those in primary schools.
The main cause of their failure is poor workmanship. This is attributed to the fact that concrete tanks built for roof catchment systems suffered the same fate. Individuals who have put up tanks that are made of bricks and plastered with mortar have their tanks functional some for several years. These individual tanks are the main evidence that the tanks failed because of poor workmanship. Donor funded tanks were poorly constructed by the hired artisans while individual tanks are better constructed since failure to function would result to losses for an individual and therefore they are more careful with workmanship. The beneficiaries were not very keen on supervising because the tanks were donations and this resulted to massive losses of money that could have been put into better use.

8.1 These underground tanks can be put into the following uses.

1. Silage making for those who can afford extra fodder during the rainy season. These are for those in homes. Those who can afford extra fodder crops are very few.
2. Making compost manure for adding soil fertility.
3. Can be lined with polythene to continue serving in the purpose they were intended for. This option is good because polythene papers are readily available and they are also cheap. There is also need for harvested rainwater to be used for livestock drinking and supplementary irrigation. Unfortunately, polythene papers would have to be changed often because they are not durable.
4. The tank can be lined with powdered anthills, mixed with a little cement, lime and sand followed by two coats of bitumen. This method is a cheaper alternative to cementing.

Disadvantages.

- Spillway water causes erosion.
- The water carries large amount of silt and therefore requires frequent desilting.
- They are a site for drowning because most of them are not fenced. Those in primary school are particularly dangerous to the young children.

Table 3.7.1 Tanks visited

Name of the institution / farmer	Type of the tank
Kwa Vonza primary school; Yatta div.	Underground tank and roof catchment system
Masaani pry school; Yatta div.	Underground tank and roof catchment system
Mr. Ndamange; Matinyani div.	Underground tank
Jane Ndiko; Yatta div.	Roof catchment system. A tank 5000 litres capacity built in 1998. Catchment is about 80 m^2 . It should fill with water after a rainfall event of less than 100 ml but the tank has never filled with water probably because the water leaks at the bottom.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Terraces

Conclusions

Terracing is the single most important in situ rainwater harvesting technology in Kitui district. This is because it holds the rainfall on to the land and ensures adequate water availability for crops in the soil. The water stored in the soil is obtained by roots of plants and this way the plants continue to grow. Consequently, the family has enough to eat.

The embankment is planted with forage crops that are fed to livestock. The returns from the livestock and the crops often leave surplus for sale. The money collected is used to purchase foods not grown on the farm, clothes, build houses, pay school fees and pay for medical bills.

Terracing increases the survival rate of perennial plants like fruit trees. This ensures there is output from the farm even in seasons when the rains fail to come. Perennial plants have their roots deeper than the annual crops and benefit from moisture that is stored deep in the soil.

Recommended actions

To enhance replicability, successful farmers records should be kept as well as those of neighbouring farms. Then during a season when the differences in performance of terraced and non-terraced farms are very clear on the farm, groups of farmers to be trained can be taken to see for themselves. This is important because sometimes there is no visible differences in performance between terraced and non-terraced farms especially during above average rains and a field visit at such a time has very little impact on the farmers. Such a visit will make the farmers to see for themselves the benefits of using terraces in their own farms.

1. It is necessary that Fanya juu terraces be excavated with the assistance of technical staff to avoid causing erosion.
2. Planting grass on the embankment to be intensified.
3. Fanya juu for pastureland to be encouraged throughout the whole district but more so in the southern more drier zone.
4. Freehold tenure system to be replaced by individual tenure system to encourage investing in terracing.

4.2 Paw paw pits; Semicircular bunds

Conclusions;

Paw paws pits are very useful in harvesting water for individual crops. They however need to be used in conjunction with terraces, as is the case with some of the farmers. The water harvested help to reduce the rainfall deficit in meeting the crop water requirement.
Recommendations.

The use of the pits needs to be diversified to include other crops like the mangoes, oranges and other agro forestry trees.
Use of fertilisers for top dressing during the rainy season need to be considered. This is necessary because perennial crop farming is like mono cropping. The plants obtain nutrients with no chance of crop rotation. If fertilisers are not used there will be no source of replenishing the nutrients and the yield will continue to dwindle, over the years.
If available, organic manures can be used for top dressing but if not available inorganic fertilisers can to be used.
Marketing of the fruits need to be organised so as to encourage more farmers to get involved in paw paw as well as other fruit trees production. A ready market exists for paw paws but marketing that is better organised will give the farmers better organising power.

4.3 Road runoff harvesting

Conclusion

Road runoff harvesting can be an important measure of offsetting rainfall deficit. However care need to be taken to only do road runoff harvesting on well-terraced farms.
Available road runoff within various catchments needs to be identified for possible sharing by people who have access to it.
Road runoff considered unobtainable because it requires to be raised to high heights need to be gutted by qualified personnel to be made available to the farmers.

4.4 Sand dams

Conclusions

- Sand dams are cheap to construct because most of the required materials are locally available
- Sand dams store relatively clean water compared to other sources in Kitui district e.g. earth dams
- They are not likely to result to conflicts as they do not take anybody's land
- They can only be constructed at suitable sites and not everywhere
- They are socially acceptable being an improvement of traditional source of water
- They yield enough water to support domestic, livestock and minor irrigation needs but not enough to carry out pumping of water for large water supply schemes.

Recommendations

Since sand dams are highly suitable for water supply in the arid areas, surveyed sand dams should be constructed. A detailed survey for various potential water supply technologies exists at the water division office.

During construction the community should be involved as much as possible to empower them with knowledge that they can use to construct additional sand dams on their own without donor support.

During construction, donor agencies should liase with one another to avoid repeating the following mistakes;

- Sand dams filling with ordinary soil instead of coarse sand
- Water getting lost through floor and dam wall seepage.
- Walls breaking.

Organisations that have constructed successful sand dams e.g. the catholic diocese has or can identify suitable individuals who have been involved in sand dam identification and construction. These individuals are extremely useful because they have learnt many lessons from experience.
Mwethya groups' formation should be encouraged in areas where they don't exist because they are the gateway to community development in Kitui district.

4.5 Rock catchments

Conclusions

Rock catchments are an expensive source of water. They are nevertheless the only source of relatively clean water in the southern parts of the district. With good management the water can be made available for several days after the rains

Recommendations

- Opening a bank account for Kavili and other Rock catchments. The people at Kavili promised to do so.
- Provision of security by hiring a watchman to guide the water against for those without
- Repair of leakages in the existing rock catchments by the community but with no donor involvement. The community should repair on their own since donor support for repair work is not a viable option. This has already been done for Kaseva as seen in the photos below.
- Opening water kiosks below the reservoir to reduce walking distance.
- Phase four for Kaseva to be constructed

4.6 Eathdams

Conclusions

Eathdams can be an important source of water in Kitui districts especially those of perennial nature. There is need for community involvement during construction for the purposes of maintenance.

1. Opening of an account for water users revenue collection for the earth dams. Ung'atu community promised to be done by August 2001.
2. Fencing off properly the area with life fence e.g. cactus spp. The fence will help in reducing pollution, as only one entrance would be left.
3. Construction of pit latrine, bathroom and a cattle trough for sanitation purposes.
4. Training of water users committee on water management so as to improve on water catchment management.
5. Desiltation. The community need to be encouraged through training to use the available resources such as animal draughts power, spades, and carts to desilt the dam in September when the water is almost finished.
6. Buffer zone to be established between the reservoir and the vegetable growing area due to use of chemical, e.g. fertilisers. This will control pollution. Alternatively the vegetables to be grown with no fertilisers at all.
7. Farmers training on chemical use in the catchment to avoid further pollution with agrochemicals.
8. Formation of an active water user committee and training on their roles.
9. Distribution of water drawing points through pumping, piping and setting up of kiosks.
10. Construction of a good cattle trough
11. Organised fishing
12. Re-afforestation with dual purpose trees to be encouraged i.e. those trees that can be used for more than one purpose e.g. mangoes, papaws, gravillea e.t.c.
13. Surveyed earth dams need to be constructed to improve water availability.

4.7 Underground tanks

Conclusions and recommendations

Future tanks should be constructed by well-qualified personnel using stone masonry and the walls reinforced. A roof preferably iron sheet need to be erected to provide shade. The shade will prevent the tank from getting heated up by the sun. Life fence should not be planted too close to prevent the roots from causing cracks on the tanks walls.
To avoid the tank from lying idle polythene paper can be put so that they continue harvesting runoff for irrigation and watering livestock.

The tanks can be repaired using repair procedures as given by Nissen-Petersen 1992 d available from ASAL consultants, updated in 1998.
To waterproof the tank, the tank can be lined with powdered anthills, mixed with a little cement, lime and sand followed by two coats of bitumen. This method is a cheaper alternative to cementing (Gould and Schmidt 1999)

Tanks for roof catchments need to be constructed by the individuals. In cases where donor support is available, the farmer's contribution should be to the extent the farmers feel he/she fully owns the tank. This is due to the fact that individual owned tanks function for several years but donor funded have failed the test of time.