SURFACE WATER RESOURCES IN YATTA DIVISION: ACCESSIBILITY, VARIATIONS, UTILIZATION AND CONSERVATION ASPECTS.

BY

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DECLARATION

This Thesis is my own original work and has not been presented for a degree in any other university.

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ABSTRACT

The thesis highlights the problem of water scarcity in Yatta Division of Machakos District. The study intended to find out what the community does to conserve their limited surface water resources. Basically, the study was designed to identify the main surface water sources, the amount of water used in domestic and livestock sectors, the various conservation techniques used, how the community participates and the constraint that hinder their full participation.

In the study, several methods were used. First, a pilot study was conducted to test the research instruments. Data was then collected from both primary and secondary sources. A household survey was carried out, with the use of observation sheets, questionnaires and interview schedules. Systematic and random sampling techniques were used to sample the households. Data was analysed using averages, percentages, deviations ranking and trend analysis. The results were presented in form of tables, graphs, pictures, sketches and maps.

The findings show that the main water sources in the division are rainwater, rivers and other seasonal streams which are both annual and seasonal. The daily per capita consumption of water in the domestic sector is 6 litres while in the livestock sector cows consume 20 litres per head per day, goats and sheep consume 5 litres per head per day or less.The water conservation techniques practiced include terracing, roof and runoff harvesting. Afforestation is also practised although to a limited extent. The above techniques are however not widely practised mainly because of financial, religious, gender, labour, technical and institutional constraints. It was also observed that hardly any donor institution has effectively supported the community in their water conservation endeavours. There is therefore need for effective community involvement in water conservation activities in Yatta division of Machakos district.

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LIST OF ABBREVIATIONS

ASALS	Arid and Semi Arid Lands
CBS	Central Bureau of Statistics
CUMECS	Cubic Metres Per Second
DANIDA	Danish Development Agency
EEC	European Economic Community
IAG	Institute Of Applied Geosciences
IDA	International Development Agency
MPND	Ministry Of Planning and National Development
NAS	National Academy of Sciences
NGOs	Non Governmental Organizations
PPCSCA	Permanent Presidental Commission on Soil Conservation and Afforestation
TARDA	Tana and Athi Rivers Development Authority
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Scientific and Cultural Organisation
USADA	United States of America, Department of Agriculture.
USAID	United States Aid for international Development
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization

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DEDICATION

To my parents **Mr. William Ogola** and **Mrs. Felicitas Ogola**, my husband **Elisha Ochieng** and my daughter **Jill Barbara Onyando**. I know no other way of thanking you all for your unconditional love.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

Water has always been considered to be an essential component for human survival. Since the dawn of civilization, Man has harnessed water resources for agricultural, industrial, transportation and domestic uses. With continued population growth and the associated economic development activities, questions about availability, use, quality and sustainability of water resources have been raised by both researchers and policy makers. The continued increase in the world's population has had serious impact on water resources necessitating the use of appropriate water conservation techniques by the users with a view to optimizing the use of the existing limited water resources.

Besides human population growth, climate change (caused mainly by the use of fossil fuels and deforestation) has also affected the demand, supply and 'quality' of especially surface water resources globally causing water shortages which is a limiting factor in both social and economic development. The challenge that is now facing the world today is to device ways and means of satisfying the water needs of its increasing population. However, no matter how efficiently water resource planning and implementation is carried out, its long term impact will depend on public participation.

Most developing countries suffer from lack of enough water resources compared to developed countries. In the developing countries, the problem of water is more serious in the rural areas where the majority of the people

live. Moreover, most of the countries are in the arid and semi arid lands (ASALs) where rainfall is highly unreliable and persistent drought is a common phenomenon. Very few people have access to adequate water. Consequently, water scarcity is not only a constraint to social and economic development but also contribute to ill health through poor hygiene. The need to conserve the limited water resources in these areas should be emphasized.

More than three quarters of Kenya's total land surface area fall within the arid and semi arid lands. In these regions, rainfall is lost through evaporation and uncontrolled runoff. Most of the rivers in these regions are seasonal and yield water after the rainy season but remain dry for the rest of the dry seasons. The main sources of water are bore holes and a few perennial rivers which have low flows in the dry season (Ojany and Ogendo, 1988)

Besides the contribution of natural factors, Kenya's population has increased from 5.4 million in1948 to 25 million in 1989 (Ominde, 1978 and MNDP, 1989). This has led to intensified human activities like over-grazing, clear cutting of vegetation and unsuitable agricultural practices which have accelerated water scarcity. Most of the people living in these areas are also poor and tend to overexploit their immediate environments. Consequently, there has been reduction in vegetation cover and destruction of the soil structure through compaction which has led to accelerated runoff. As a result, women and young girls in these parts of Kenya have to walk up to ten kilometers to fetch water resulting in a very low per capita consumption (Timberlake, 1988).

Water resources in Yatta division of Machakos district are very limited. Most of the surface water sources are seasonal while ground water

sources are few and occur in deep aquifers. The potential of ground water is difficult to assess and therefore remains untapped. This calls for effective conservation of the limited surface water sources.

Efforts to improve rural water supply through conservation has become popular as a result of increasing interest in rural development. To meet the demand for water in the rural areas, national and international aid donors and voluntary agencies have been keen on providing water to the rural communities. However these water conservation programs do not realize their objectives because implementation is done in a hurry without initiating any water conservation publicity to the community in question. Consequently, government and the donor agencies involved have not fully integrated the local communities in their water conservation efforts (Danida, 1989).

In Kenya, the role of community participation in water conservation efforts has not been given the attention it deserves. The conservation, control apportionment and use of water resources in Kenya are constitutionally under the government. Water conservation efforts in Kenya have also been given a sectoral approach whereby most of the policy options governing supply and conservation are interministerial. These sectoral programs have failed to alleviate the water crisis in Kenya's drylands because of conflicting policies. For instance, water conservation policies emphasize on tree planting to protect the water catchment areas while the agricultural policies emphasize on the increase in agricultural production which has resulted in cutting down of vegetative cover thus threatening the water catchment base (MPND,1989). Consequently conservation efforts have failed to meet the expectations of the government, donor and the beneficiaries. It is therefore

necessary to promote community participation in the conservation of water resources for sustainable development.

1.2 Statement of the problem

The threats to water resources in arid and semi arid lands (ASALS) of Kenya is increasing with the increase in human and livestock population, poor farming methods, indiscriminate felling of trees and overgrazing. These activities have greatly reduced the quantity of water in ASAL areas where rainfall is highly unreliable and water sources are not near the users. As a result, pressure on the existing limited water resources has been increasing over the years. This has affected the availability and hence utilization of water resources in the domestic and agricultural sectors thus hindering development.

Water resources in Yatta division of Machakos district are limited. This is mainly attributed to climatic, geological, edaphic and demographic factors. Water scarcity in the division has been accelerated due to increasing demand in the domestic and agricultural sectors. Given these conditions conservation by the community at the grassroot level is a necessity. Ironically, information on water resources in the study area does not adequately address how accessible and reliable the resources are. Various conservation techniques and how the community participates in surface water conservation have also not been addressed despite increasing water scarcity in the area.

The problem of water scarcity in Yatta division is further aggravated by the rapidly growing population which puts an added strain on the available

water resources. It is out of the realization of the water problem at the community level that this study was designed to examine how the community participates in conserving water resources in the division.

The focus of this study therefore was to identify and examine various surface water sources, their uses in the domestic and livestock sectors; the various surface water conservation techniques used; the nature of community participation ; and, the various constraints that hinder water conservation efforts in Yatta division of Machakos district.

1.3 Research questions

The following research questions were used to guide the study.

a) Which water sources are used by the community?

b) How accessible and reliable are the various water sources?

c) How much water is used in the domestic and livestock sectors?

d) Which techniques are used to conserve water in the community, how adequate and how widely are they used ?

e) What is the nature of community participation in various water conservation project in the area?

f) What problems constrain water conservation practices in the area?

1.4 Objectives of the study

The objectives of the study were to:

a) identify main surface water sources, their accessibility, seasonal and annual variations in the area,

b) determine the amount of water used in the domestic and livestock sectors in the division,

c) examine various techniques used to conserve surface water in the division; and

d) examine the nature of community participation and the problems that hinder full participation in water conservation activities in the division.

1.5 Assumptions of the study

In this study assumptions were made that;

a) water availability is a major problem in the division,

b) water is mainly used in the domestic and livestock sectors,

c) various surface water conservation techniques are used in the division and

d) full community participation has not been realised due to various problems in the division.

1.6 Justification of the study

Water is necessary for the development of Yatta Division of Machakos district. Despite this, most water sources in the study area are seasonal and contain water only during the rainy season. The major perennial rivers (Thika and Athi) have highflows during the rainy season and low flows during the dry season while the ground water potential is low and has high fluoride

content (USAID, 1978 ; MPND, 1994). Thus water resources in the study area are limited and hence require to be conserved for continued development.

Some domestic water facilities in the division are also completely under utilized due to insufficient fuels and pumping engines. The analysis of water facilities in the division show that out of all the water projects initiated, only 50% are operational, 16% are partially implemented and 41% have not been completed (MPND, 1994). As a result of this, the water needs of the community have not been fully met. This is despite the fact that there are traditional self help groups ("Mwethya") consisting of 15-50 members who work on a communal basis on local projects and yet the area still faces water problems.

The problem has further been aggravated by the increasing human population (Table 1) which has exerted pressure on the fragile eco-system and increased demand for water in the domestic and agricultural sectors.

Table 1: Population density projection per square kilometer in Yatta division

Year	*Persons/square kilometers*
1979	56
1983	68
1988	82
1989	89
1993	153
1994	158
1996	168

Source: CBS, 1989

From 1979 to 1996, the population density was projected to have tripled. This is expected to decrease the productivity of land resulting in a decline in per capita income and poor health status. As a result, most people are now moving into the nearby rural centers and major towns. With this trend, there is need for effective water conservation to meet the growing demand from the above sectors.

The health status of the people in the study area is also deteriorating. For instance, between 1983 and 1987, disease incidence statistics show that diarrhoeal diseases were leading on the list of all diseases. This was attributed to poor water supply and sanitation (MPND, 1989). This calls for

improvement in the water situation through appropriate conservation measures.

1.7 Significance of the study

The study focuses on community participation in water conservation activities as a way of strengthening or making conservation projects more sustainable. The research findings will reflect sufficiently the wishes and experience of the people in conserving their water resources. With the improved water supply situation, educational, health and other economic benefits will be realized as well.

The information obtained from this study can be used by the government and relevant agencies in determining the inherent constraints to full community participation in water resource conservation with a view to identifying the potential solution to the existing water problems in the study area.

The findings of this study can also be used to address water conservation problems in other areas with 'similar' environmental settings. The findings will not only serve as guide for effective water planning in the area but also be applied in other areas in order to strengthen the existing water conservation activities.

Lastly, few studies that have been done on water conservation in the ASALS of Kenya have not addressed the role of the community in water resource conservation. Arising from this, the study has brought into focus the role of community participation as an integral component in water management.

1.8 Scope and limitations of the study

This study was based on the role of the community in water conservation activities in both donor-based and community-based, for proposed and existing surface water conservation projects in Yatta division. The study also addressed water use in the domestic and livestock sectors. This is because water for domestic use is a major basic need of the people in the study area while livestock rearing is the dominant economic activity with cattle, sheep and goats being the major livestock holdings. Hence the two sectors take priority as far as utilization of water in the division is concerned. In the livestock sector, water use for major livestock animals like cattle, sheep and goats was studied.

Extreme weather conditions was a limitation to the study. Very high temperatures in the dry season and wet conditions in the rainy season slowed down the research by slowing down the movement within the study area. Despite this, the research was successfully completed.

There was also lack of rainfall data for the thirty years required. Hence the analysis of the rainfall data was limited to the ten years records that were available.

1.9 The study area

1.9.1 Location

Yatta division is administratively located in Machakos District (Figure 1) which lies between latitudes 0° 45' and 1° 30' south of the equator and longitudes 36° 45' and 37 45' east of greenwich meridian. The division covers an area of 829 sq. km and lies at an altitude of between 1,000m - 1,300m above mean sea level (MPND, 1994). It has six administrative locations namely Kithimani, Matuu, Kinyatta, Ikombe,Ndalani and Katangi. This Division borders Masinga and Ndithini Divisions to the North , Kangundo and Mwala to the South, Kitui District to the East and Thika district to the West.

1.9.2 Climate

About 85% of Machakos district falls within the marginal range lands. Yatta division is located in the driest part of the district where rainfall is highly variable and unreliable with an average of 500 - 900mm and below per year (Figure 2 and Table 4). The division also lies in the rain shadow of Mua,lveti and Kangundo hills. The rainfall pattern is bimodal in nature (Figure 7). For instance between March and May winds bring heavy rainfall in the long rainy season while the months of June and August are mainly dry, and cool. The short rains fall between September and November brought by the easterly winds. The short rainy season is followed by dry conditions between December and February (MPND,1994).

The mean monthly temperatures in the region range between 16 degrees to 34 degrees.The mean daily solar radiation is 20.43 mj/sq.m while the mean daily pan evaporation is 6mm/day and the yearly pan evaporation ranging

Fig. 1 : LOCATION OF STUDY AREA IN MACHAKOS DISTRICT

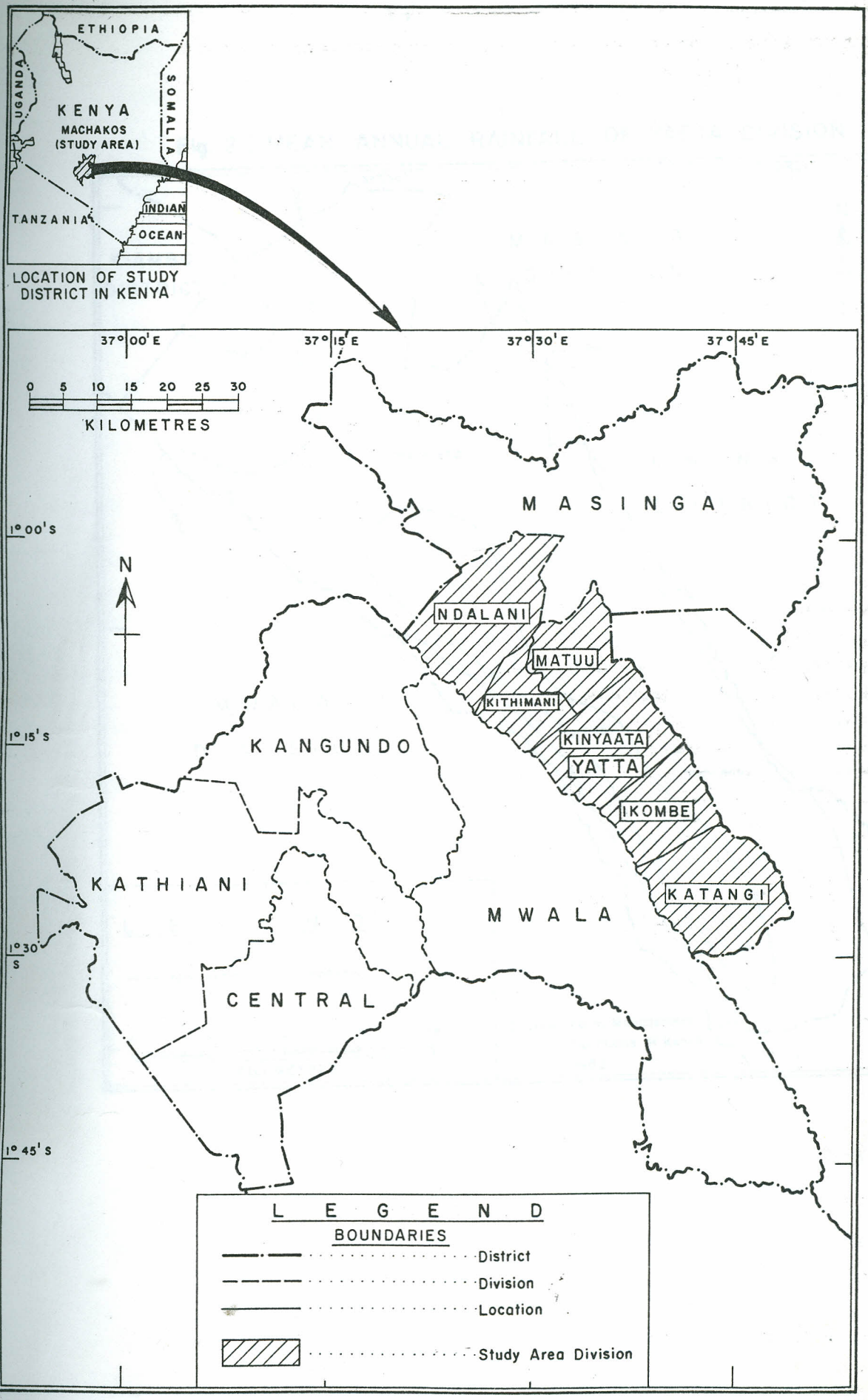
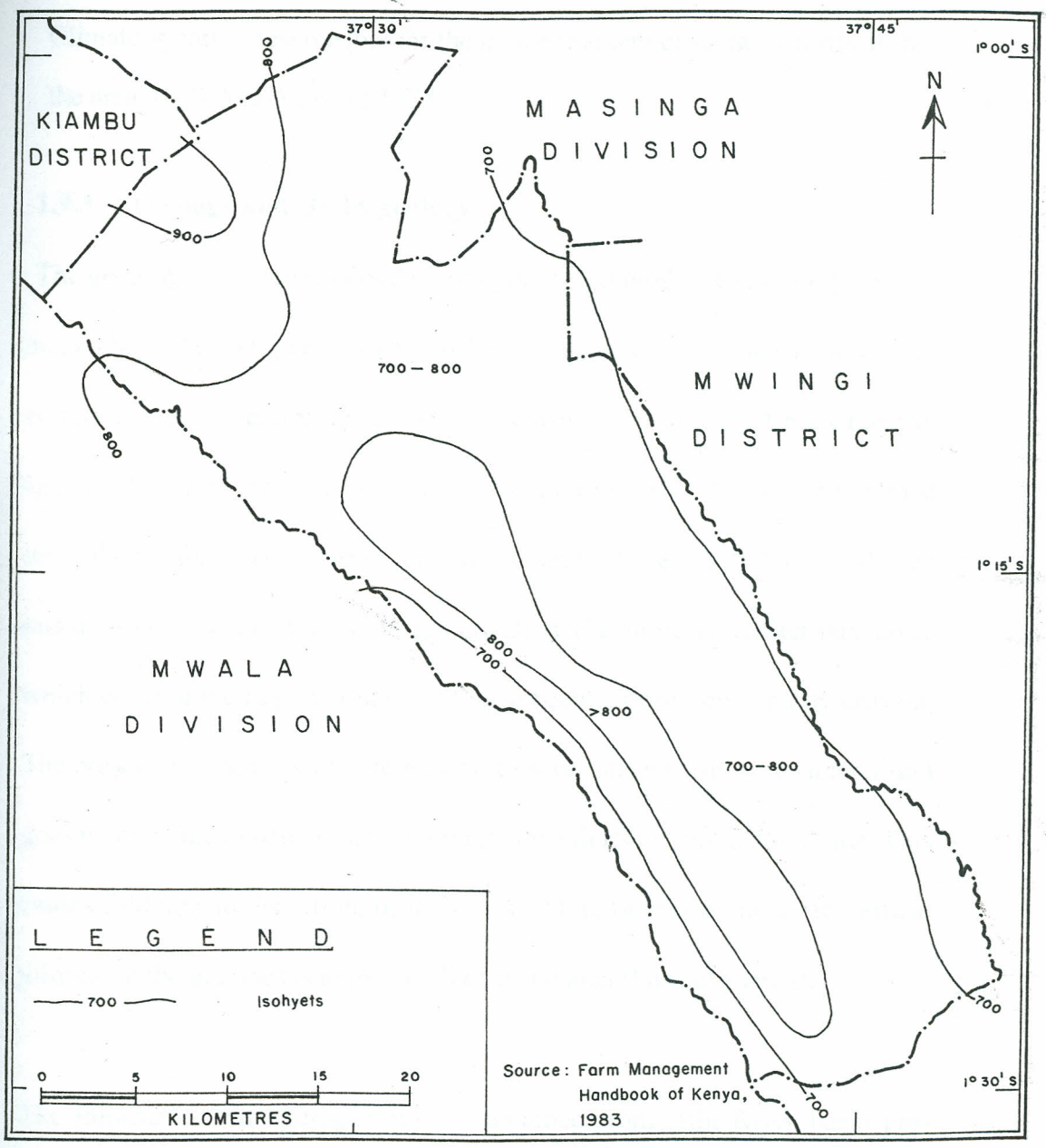


Fig. 2 : MEAN ANNUAL RAINFALL OF YATTA DIVISION



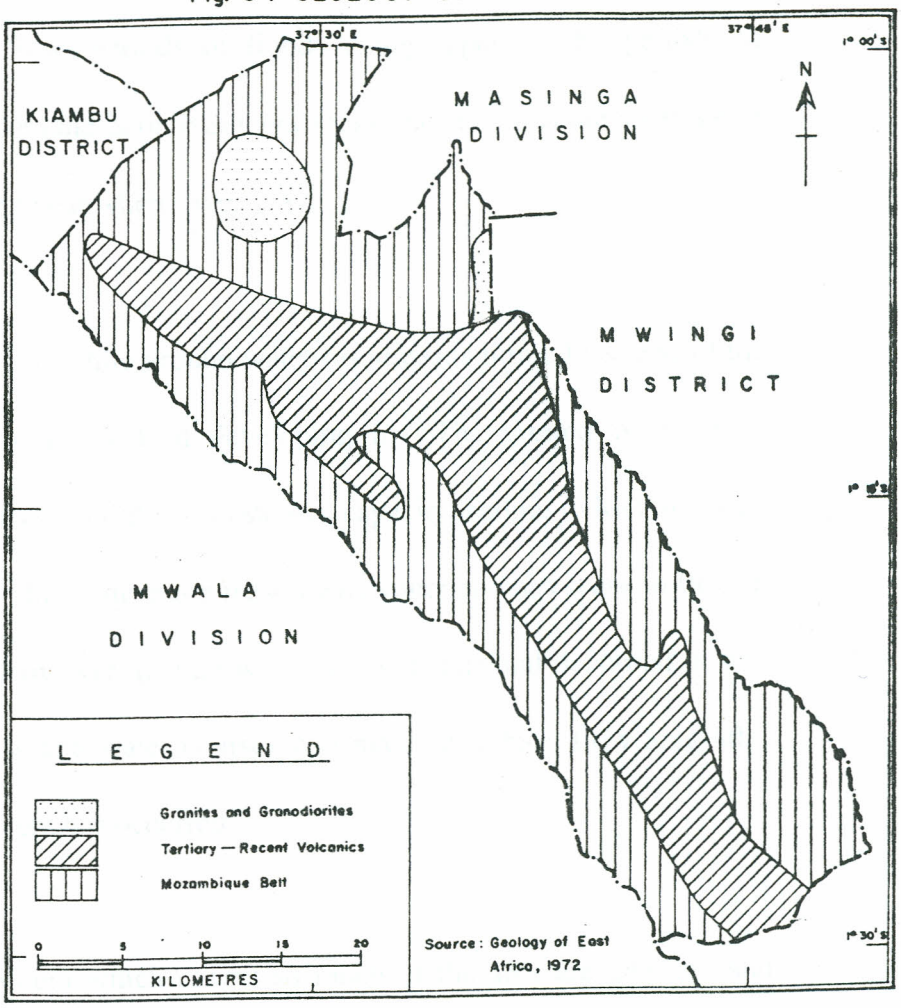
from between 2000-2200mm. The high evaporation has had a great influence on surface water resources reducing the amount that is available. Climate is partly responsible for the major frequent droughts that occur in the area. (U.S.A.D.A., et.al; 1978)

1.9.3 Geology and Hydrogeology

The geology of the area is divided into granites/granodiorites, tertiary and mozambque belt (Figure 3).The rocks in the study area are of basement system. They are mainly composed of schists and gneisses of pre-cambrian age which underwent several stages of metamorphosis. They can be divided into those that have been granitized and those that have suffered metamorphism with little or no granitization.The more recent tertiary lavas which covered the region at one time have been entirely removed by erosion. The present geological structure results from very heavy crushing stresses and granitization due to penetration by granite injections or granitising fluids. This causes folding and distortion, of the rocks. More or less pronounced vertical jointing in the gneisses is apparent all over the area (Fairburn,1963).

The information on hydrogeology is obtained from Athi River basin pre-investment study of 1981.The surface water and ground water supply is strictly related to the geology of the study area. Rivers and streams that do not receive supply of water from volcanic areas soon dry up after cessation of

Fig. 3 : GEOLOGY OF YATTA DIVISION



rains. The rivers deriving their supply of water from basement system rocks show intermittent flow, periods of floods being separated by periods of dryness. Most of the land is on basement rocks causing an acute shortage of water for most of the year when rivers are dry..

The potential for exploiting ground water resources is limited because of the geology and also the cost of developing it. The ground is made of impermeable rocks with little or no storage capacity leading to loss of water through run-off. This is the main reason why water courses cease to flow in the dry season. However, if rain water can percolate and be stored, it will be released slowly and water courses will maintain a base flow long after the last rainfall event has occurred.

The basement system which covers so much of the area are gneisses and schists which have very little pores and therefore cannot store water in significant amounts. Though it is evident that the system is heavily faulted and the weathered top zone has some pore volume which can hold water in limited quantities, the cover of weathered materials is in no way continuous and is generally shallow. It is therefore not possible for continuous development of ground water. Since ground water is stored in discontinuous aquifers its development depends on configuration of the weathered zone and the thickness of the soil cover. However, storage is impossible if the

weathered zone is denuded by erosion. The little water stored is responsible for the existence of seasonal springs in the study area (TARDA, 1981).

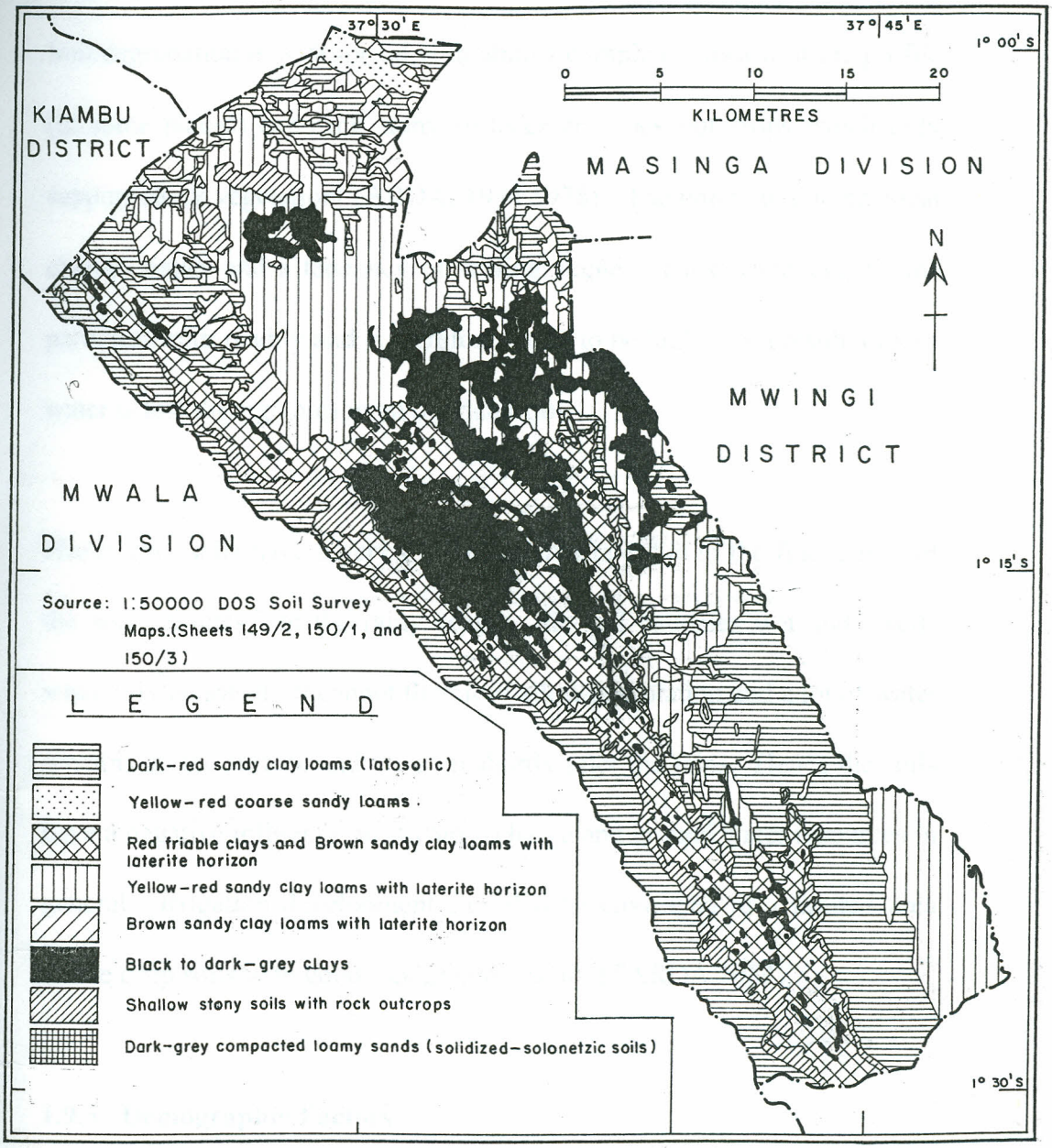
1.9.4 Soils

Soils in the study area are varied in nature. They range from dark-red sandy clay loams, yellow-red coarse sandy loams, red friable clays, brown sandy loam with laterite horizon,yellow-red sandy clay loams with latente horizon, black to dark grey clays, shallow stony soils with rock outcrops and dark grey sandy loams. The general profile is a course textured loamy sandy or sandy loam with A horizon 15 to 20cm deep overlying a some what finer B horizon of sandy clay loam. Heavy cracking clay soils also occur in some parts of the division as shown in Figure 4. The main soil types are ferralsols, acrisols and vertisols (TARDA, 1978).

The soil resources have different limitations. Soils with moderate limitations particularly heavy soils with low fertility count for 77 percent of the area. Soils with severe limitations occupy 19 percent of the area while very steep slopes cover 4 percent of the area. The Yatta plateau soils are limited in their use by numerous boulders which hamper mechanised agriculture (TARDA, 1988).

Soils are shallow (less than 1.0m) and have low organic matter. Surface capping of the soil is common particularly with the vertisols and is accompanied by high soil erodibility. Sandy loam has a weak structural

Fig. 4 : SOILS OF YATTA DIVISION



stability and is also prone to erosion. Deep gullies and rill erosion even under conditions of gentle slopes (<5%) show low infiltration capacity. Soil degradation is widespread with almost complete removal of the profile (in some places) exposing stony surfaces and rock out crops which only support stony vegetation(TARDA, 1984,1978). The unfavourable physical characteristics and a tendency of sealing suggest that detachment of fine particles occur readily and is therefore likely to be high. As a result,a lot of water is lost through hortonian overland flow.

Heavy clay soils have a very low infiltration rate due to the fine nature of the soil particles. In the rainy season, the soil becomes wet and swells when it is saturated. It cannot therefore allow percolation and a lot of water remains on the surface and dries up shortly after the rains. Hence the soils have a negative influence on stream recharge and ground water resources in general. Irrigation development can also be envisaged in a limited area where deep soils with good topography occur (TARDA,1984).

1.9.5 Demographic Factors

The population in the study area varies in terms of ethnic profiles. The majority of people in the area are Kambas followed Kikuyus (from the nearby high potential areas), Maasai (the original land owners) and Luos (who are mainly keen on fishing on permanent rivers).

According to the 1989 population census, it is evident that there is a sex imbalance in the division. For instance the male population was 53,273 while the female was 55,996. Giving a difference in the two sexes to be 2,723. The difference is attributed to out migration of the males in search of jobs outside the division.

Population increase in the study area is not only caused by immigration from the surrounding areas but also by natural increase within the division. The population density is projected to increase from 100 persons per sq. km in 1996 (Table 1) . This will obviously increase pressure on the existing water resources (MPND,1994).

1.9.6 Landuse characteristics

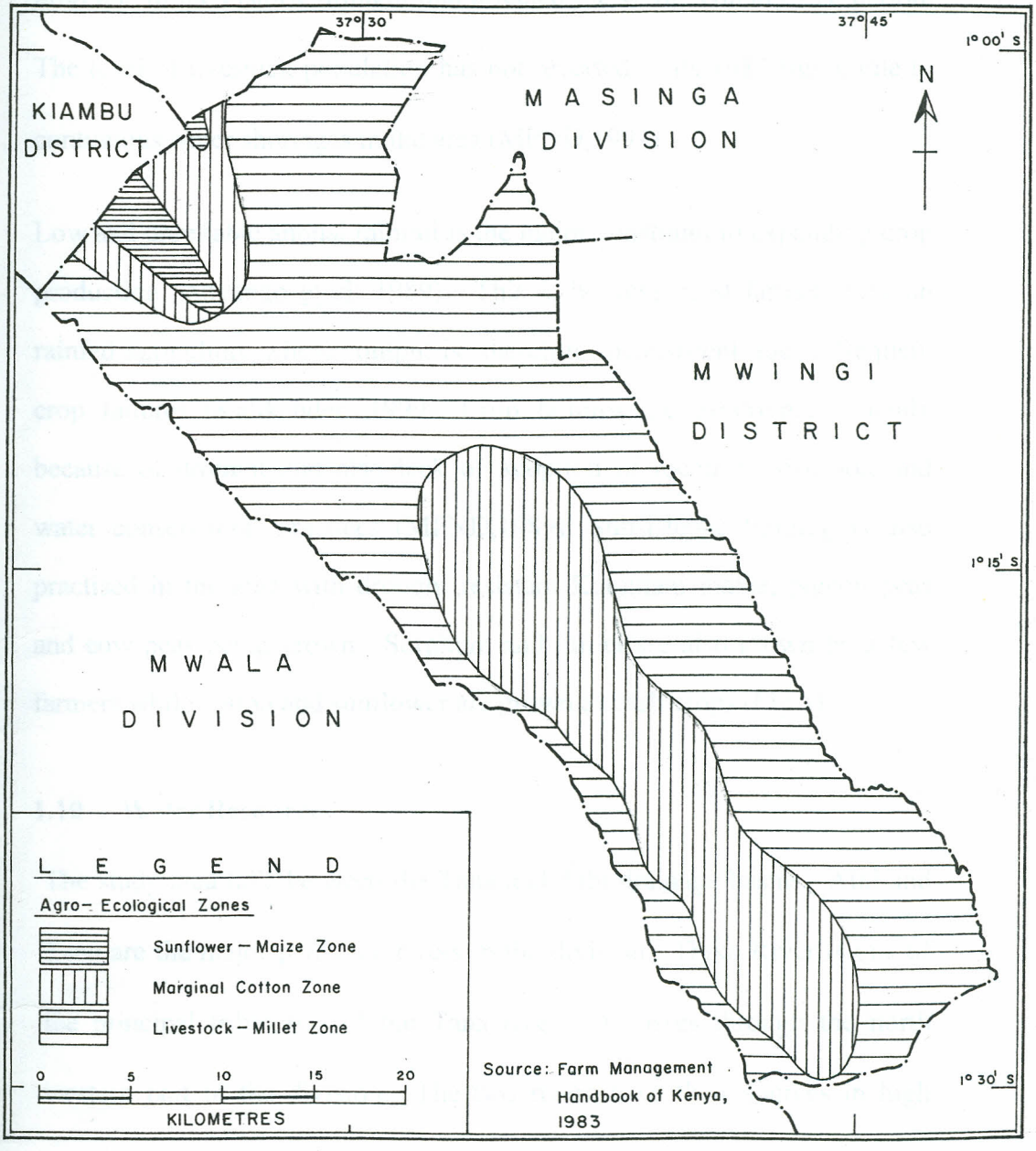
Livestock rearing is the dominant agricultural activity with the main species being the zebu and borana cattle. Sheep and goats, rabbits and poultry are also reared. Livestock density is beyond the carrying capacity of the soil and is considered to be a major contributing factor to reduction of soil cover by overgrazing and trampling (MPND,1984). Table 2 show livestock trends between 1980 to 1992 in the division while figure 5 shows the main agroecological zones in Yatta.:

Table 2: Livestock population density trend per sq. km.

Type	*1980*	*1982*	*1984*	*1986*	*1987*	*1989*	*1990*	*1991*	*1992*
Beef and dairy Cattle	29	32	24	25	24	22	23	20	18
Goats	31	39	17	15	16	18	19	19	18
Sheep	13	21	5	1	6	7	8	8	8

Source: CBS, 1979

Fig. 5: AGRO-ECOLOGICAL ZONES OF YATTA DIVISION



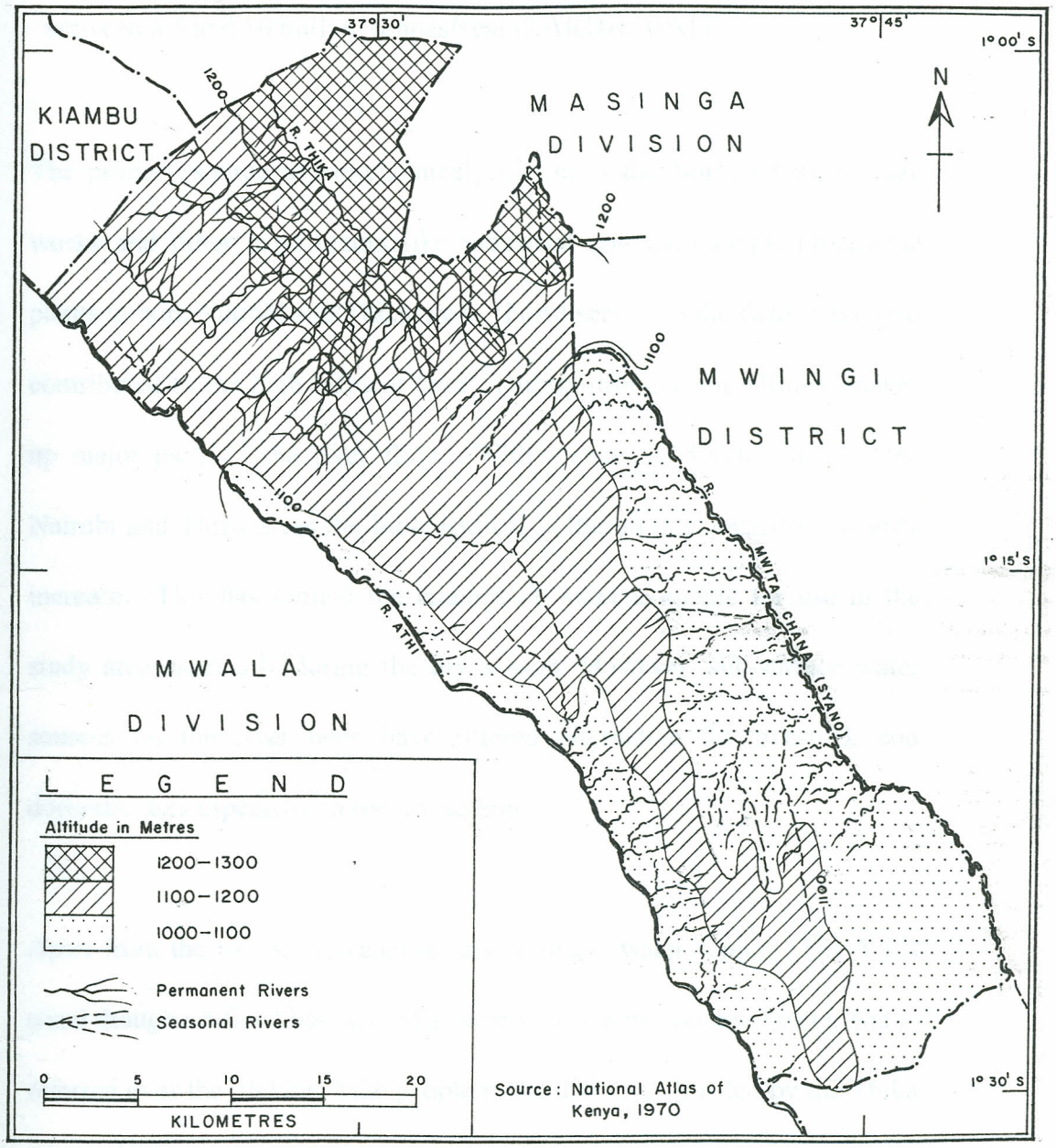
The livestock population has been increasing steadily in good weather and declining during drought. The years 1982-84 indicate a high population drop due to the historic drought that affected the whole country that period. The level of livestock population has not reverted to its 1982 figure due to continuous water shortages in the area (MPND,1994).

Low and unreliable annual rainfall is the major constraint to expanding crop production (Anyango et al; 1989). This is because most farmers rely on rainfed agriculture whose output is therefore inconsistent due to frequent crop failures (Kalikander ,1990). Crop failures are experienced mainly because of drought and also lack of adoption of recommended soil and water conservation practices (MPND,1989). Subsistence farming is also practised in the area with drought resistant Katumani maize, pigeon peas and cow peas being grown. Sorghum and millet are also grown by a few farmers while cotton and sunflower are grown as cash crops (Fig.5).

1.10 Water Resources

The study area falls between the Tana and Athi drainage basins. Athi and Tana are the major perennial rivers in the division. Thika River is one of the principal tributaries of the Tana river. It passes through the north western part of the division. The two rivers have their sources in high potential areas. However, the flow of these rivers vary considerably during the dry season. These rivers have high flows in April/May (long rainy season) and November/December (the short rainy season) and extreme low flows in the two intervening dry seasons. Most streams are seasonal and only flow after a rainy season and completely dry up during the dry season (Figure 6).

Fig. 6 : PHYSICAL FEATURES OF YATTA DIVISION



The Athi River is heavily polluted and has high levels of sediments and increasing effluent loads. The sediment load has been estimated to be between 8.5 and 10 million tonnes/year (TARDA, 1981).

The primary source of bio-chemical effluent is the Nairobi City sewage works and other contributors like industrial and agricultural processing plants in both Nairobi and Thika areas. Fertilisers from the fields have also contributed to the high effluent load. During drought, the effluent makes up major parts of the river flow. With increasing development in the Nairobi and Thika areas the bio-chemical pollution is expected to steadily increase. This has limited the amount of water available for use in the study area especially during the dry season. However, sub-surface water sources on the river beds have offered alternative for livestock and domestic uses especially in the dry season.

Apart from the rivers, the canal is also a major water source. The Yatta canal though artificial has served as a very important source of water and is referred to as the lifeline of the people in the division. It is fed by the Thika river which passes through the north-western part of the division. The 60km open canal drains back into the Tana river through seasonal river courses like Mwita-Syano and to a certain extent Mathuata.

The canal is connected with Kenya's political history. It was constructed in 1953 by Mau Mau detainees during the emergency to provide penal employment and to supply water to the Yatta grazing lands thus permitting rotational grazing. The canal was also to permit irrigation whose extent was then not yet determined. The canal is now used to supply water to the local population and livestock, irrigation and provision of domestic and livestock water needs outside the study area by discharging into Mwita Syano River.

Besides surface water resources, limited ground water resources occur in deep aquifers. Boreholes sank in the area have not been very successful. Some of the boreholes either yield as little as 90 gallons/hour or are completely dry (Faviburn, 1963). The ground water potential is therefore difficult to assess and remains untapped. The total the fluoride content of borehole water is high and ranges from 0.0 to 16.2mg/l. This exceeds the WHO limit of 1.5 mg/l. Total dissolved solids (TDS) content varies from 230 mg/1 to 7,040 mg/1 which exceed the WHO standard of 500 mg/1(IAG, 1986).

1.11 Definition of operational terms

Community: These are people living in a particular place or area characterised by common interests.

Community participation: This refers to the involvement of the local inhabitants at the household and the communal level in both donor based and community based water conservation activities.

Water conservation: These are activities that are undertaken by the community and the various institutions to increase water supply by accumulating water using various methods or reduce unnecessary losses for intended purpose.

Accessibility: This is the physical distance, time taken to and from the water sources and to draw water and the financial costs incurred at the various water sources.

Appropriate techniques: These are techniques which are financially affordable and socially acceptable to the community.

Arid and Semi Arid Lands: These are dry lands where the difference between rainfall amount and evapotranspiration varies considerably throughout the year. Most of these areas experience the problem of recurrent food and water shortages.

Drought: This is prolonged and unanticipated periods of long dry seasons when precipitation is not sufficient to allow even the basic human activities to take place. It is usually reflected by acute water shortages and reduced vegetation cover.

Nature of community participation: This will refer to the involvement of the community in the conception, planning, financing, construction and management of water conservation activities.

Rain water harvesting: This is the tapping of rain water from roof surfaces into storage tanks and from hill slopes into artificial ground storage devices.

Reliability: This is the seasonalities of various sources of water during the dry and rainy season and also water supply systems which are working or not working.

Runoff: This is divided into two categories, that is surface run off and channel runoff. Surface runoff is water that moves on the ground surface after/during the rainy season due to low infiltration rates while channel runoff is water that flows in the rivers and streams.

Water sources: This will include the natural water sources, rain water sources and diversion from the main sources like canals, cut-off drains and furrow.

In the next chapter, literature is reviewed on water sources in the arid and semi-arid lands, water conservation and community participation.

CHAPTER TWO:- LITERATURE REVIEW

The literature review in this chapter is divided into various sections, dealing with water sources in arid and semi arid lands, water conservation and community participation in water conservation activities.

2.1 Water sources in arid and semi arid lands

Most parts of Africa exist within the arid and semi arid lands (ASALS). These areas suffer from water scarcity due to eratic rainfall which also comes in violent sporadic down pours with a lot of it being lost through runoff (Ominde,1979). Infact two thirds of the African population are said to live in severely water stressed countries. This severe water stress is largely due to rising population growth (Danida,1989).

Rainfall is unreliable in most parts of Kenya especially in the low potential areas of Northern and Eastern parts. These areas receive less than 750mm of rainfall per year and cover three quarters of the country and because of this, most water sources in these regions are limited. USAID (1978) show that besides the rising population and unreliable rainfall geology, soils, topography and vegetation influence the distribution of water sources.

Despite the above problems, no dry land is completely without water. The various water sources in these regions include both surface and ground water sources. However most of the surface water sources are not in close proximity to water users and are unreliable hence

women and children have to walk long distances for water. In line with this observation, it has been observed that;

> The availability of household drinking water varies enormously. In well watered highland areas, few households have to go more than half a kilometer to get water. By contrast during the dry season in drier areas a woman might have to trudge up to five or ten kilometers, using most of the day and a lot of energy to provide a family with one or four gallon container (Raikes,1986:22)

Most rivers are seasonal due to unfavourable climatic conditions while the few perennial ones have their sources in high potential highlands. A lot of pressure has also been mounted on these water sources due to increasing human and livestock population (Akonga, 1981). As a result, surface runoff has been accelerated through human activities like deforestation, overgrazing and poor methods of farming which have led to surface compaction thus reducing infiltration and percolation. This has reduced the amount of ground water. For example studies done in Machakos by USAID (1978) show that the water table is fifty meters deep making drilling and pumping of boreholes costly.

Other sources of water during the rainy season include small ponds, earth dams and rock catchments. These structures are suitable because they are traditional and therefore are easy to manage. However, they constantly get silted up and are easily destroyed by floods and the amount of water reduced by high evaporation rates. Sub-surface water sources are therefore preferable. World Bank (1989) observes that water kiosks, communal water taps and water vendors are other outlets of water in arid and semi arid lands.

Owing to the scarcity of water in the arid and semi arid lands water conservation should be encouraged for proper water management.

2.2 Water Conservation

> "Access to water is considered a basic human right.But there is simply not enough to go round"(UNEP,1995:1).

Water resources are not equally distributed globally. A recent global survey by World Health Organisation (WHO) shows that 86 percent of the rural population do not have access to safe water (WHO, 1990). This situation can be rectified if appropriate water conservation techniques are practised. Table 3 shows world wide stastistics of countries without access to safe water.

Table 3: Numbers and percentages of regions without reasonable access to safe water.

Region	*Population without safe water (in millions)*	*Percentage %*
Africa	136.0	89
Americas	92.1	76
Eastern Mediterranean	139.5	82
Europe	23.3	56
South East Asia	661.7	91
West Pacific	59.0	79
All Regions	1111.6	86

Source: WHO,1990.

Gleick (1993) also observed that in 1990, 1.2 billion people lacked access to clean drinking water. In view of the statistics in Table 3 there is need for developing rural water through effective conservation methods. The doubling of the world's population within the last fifty years is directly responsible for the diminishing water resources. Demand on the resource is increasing as societies attain higher standards of living (Young et al,1994). The ralative scarcity of water resources due to growing demand requires rational and sustainable management approaches to this limited resource.

In Africa, Timberlake (1988) notes that 90 people out of every 100 are without water as compared to Europe where 95 out of every 100 have piped water. He further elaborates the situation and says that;

> "In Ethiopia only 1% of the population has good water, in Sierra Leone 2%, Zaire 5%, Mozambique 7%, Congo 8%, Angola10% Zimbabwe 10%, Lesotho 11% and Kenya 15%"(Timberlake,1988:38)

The above observation clearly shows the magnitude of the water problem in Africa and hence the need to conserve water. However, the problem of water scarcity has been accelerated by increase in human and livestock population, increased development in both urban and rural areas and other human activities like overgrazing, excessive cutting of trees and poor methods of cultivation (Akonga,1981; Darkoh, 1989; Kilwe, 1989; Liniger, 1989; Gleik, 1993). These have posed threats to water resources and the situation is likely to worsen in future unless remedial measures are taken. Juma (1991) observes that already the demand for water in Kenya

was expected to increase from 600 cubic meters per year in 1989 to 5,900 million cubic meters per year by the year 2000. Despite this, the government's effort to make safe water available is concentrated in urban areas. For instance in 1980 about 85% of urban population had access to safe drinking water while the share of rural population was only 15% (Danida,1989).

Inspite of the rising demand for water, very little is being done to conserve water resources especially in the dry lands. This crisis has manifested itself in resource depletion, decline in productivity and recurrent droughts. Most of these problems have been solved by giving the local people relief food instead of developing their water sources (Bake,1989). There is need to adapt various water conservation techniques taking into consideration the most important needs of the community. Bake (1989) and Ogendo (1989) note that the first priority is clean drinking water, followed by water for livestock, then water for crop production and finally water for other activities like brick-making, pottery and other commercial activities.

In Machakos district, pressure is exerted on water resources due to high human and animal population. Under these conditions water conservation is a great necessity(Edwards, 1977). Kalikander et al (1990) notes the need for water conservation and improving rural water supply in Machakos district because this will help in achieving sustainable development of the region as population increases so that they are not prove to famine relief in times of rainfall deficiencies.

Mutiso (1989) observes that the problems associated with the demand and supply of water in the district is due to inadequate conservation techniques and therefore recommends that problems constraining efficient exploitation and supply of water in Machakos district be studied.

2.2.1 Water conservation techniques

Various water conservation techniques have been used to harvest rain water, protect water sources and minimise misuse in both domestic and livestock sectors in the rural arid and semi arid land. Water conservation for livestock production is mainly evident amongst the pastoral communities.

Jones (1948) notes how the Maasai protected their water sources by placing their encampment approximately 8 kilometers from water supplies and gave their herds water from the same source once in two days. This way they protected their river banks and riverine vegetation.

Association amongst pastoralists were formed in Nigeria in early 1980s, whereby they managed the water collection system on a household co-operative basis of 20 pastoralists. The strategy behind this management of water on a co-operative basis was to minimise misuse and overuse of the water resources so as to conserve enough for the dry season. This technique also minimised the pressure exerted on a particular water source because it was only used by members of the co- operative society.

In most livestock areas excavated runoff harvesting techniques have been used to conserve rainwater. These include the use of cisterns, small dams, rock catchment, subsurface dams and weirs. Such execavations are filled with runoff from hill sides and provide water for large herds of animals. In Niger, its been observed that natural rainfilled pools are the ones first used by pastroralists after a rainy season while water is saved in the artificial pools (Pacey and Adrian 1986). This strategy of conserving water has helped in sustaining the pastroral way of life.

In the Sudan where the population is dependent on Iivestock, "hafirs" are dug so that livestock are watered via a well using suitable drinking troughs. The inflow of water is usually via a silt trap. During drought the amount of water given to livestock is controlled (Cloudsley,1978). However, Kassas (1970) notes that construction of "hafirs" and dams is not the best way of conserving water because of high evaporation and infiltration rates involved. He therefore suggests subsurface storage of water resources as effective means of collecting and storing water.

Irons (1968) reports on his study of the Turksmen nomads, that they owned and dug private wells which were seen as personal property and could be used by the owners. Timberlake (1988) and Jacobs (1965) noted that this technique also protected the area around the wells from degradation by many animals as compared to the communal wells. Most of the above techniques are not expensive and can be adopted in alleviating water problems in Yatta division of Machakos district.

Rainwater harvesting is a technique used to collect water from roofs mainly for domestic purposes. This technique is widely practised throughout the

tropical world. Corrugated galvanised iron roofs are used to harvest rainwater in many countries. In rural areas in most developing countries thatched roofs are common and can also be used to intercept water in small quantities when gutters are installed. However, the water collected is coloured, unattractive and contaminated. Collection of rain water from roofs when satisfactorily done can effectively supplement other water supplies (UNEP,1983).

Inspite of its potential, rainwater harvesting has not received adequate interest among policy makers, planners and water project managers in Kenya. However, some donor communities and non governmental organisations based in Kenya have supported small scale water supply systems based on rain water harvested both at the community and household level (Mbugua and Petersen,1995).

Most of the techniques highlighted above vary in their suitability depending on environmental conditions of an area, although some of the traditional techniques which have long been neglected should be reconsidered as a solution to water problems. Moreover for these techniques to be successful and sustainable, there is need to integrate environmental considerations in conception, planning and implementation of the conservation projects.

2.3 Community Participation

Local communities are usually ignored by government and experts because they are thought to be technologically less knowledgeable and could slow down the development of any project within the country (Makokha,1985).

WHO and UNEP (1991) further observe that development programmes are conceptualized, planned and implemented by governments and agencies involved. Most communities are thus treated as recipients of benefits. Moreover, the technical staff were foreign to the communities and are therefore easily mistaken about local needs, customs, values and aspirations of the recipient communities. There is need to promote water conservation techniques which are familiar to the local people and the aim to meet them needs should be a first priority.

Community participation is not just a spontaneous and automatic process but requires initiative to launch it and good management skills to organise it (Oyugi,1981). The most effective method of conserving water should begin at the grass root level. This is because local communities being the main users of such a resource have a capacity of either destroying or conserving it. Rogers (1985) and Habitat (1986, 1989) note that in order to achieve effective community participation, there should be motivation, education and training of the people. The communities should also be involved in the planning and management of the water conservation activities.

WHO (1990) sees community participation as a key to long term sustainability of water supply. This is because communities can conserve water through modifying their personal habits and use of water saving appliances in line with this. Petersen (1982) has observed that water for cooking can be reduced by the use of pressure cookers, hay boxes, keeping a close fitting lid on a cooking pot, pre-soaking of hard food substances and water re-use. These can be achieved by changing personal habits.

However, World Bank (1976) argues that the most important issue in conservation of rural water is the willingness of the local people to contribute to construction costs and pay

an adequate fee once the water system is in operation, while Mbithi(1974); Akonga (1981) and Makokha (1985) show how community participation in construction of water supplies can be achieved through the knowledge gained from the local people.

World Bank(1989) further argues that women have been ignored in decision making concerning water conservation activities and yet they are the main users of these projects. There is therefore need to promote women's involvement in conception, decision making, planning, implementation, construction and general management of water resources if sustainable rural water supply is to be achieved.

In Malawi, successful community participation has been realised because the programme had well defined community and government responsibilities. For example the community is responsible for identifying sites, electing water committees, organising digging, electing repair teams, raising funds for replacement parts and enforcing community water use rules, while the government provides funds, sets standards and adopts technical responsibilities (World Bank,1989).

Baker(1979) in his study in western parts of Machakos noted that wherever rural water supply was introduced, self-help schemes were springing up to satisfy the needs of small communities. These projects however face financial and technical problems due to lack of skilled manpower.
Mutiso (1991) has shown the success of the Utooni Community of Kalama Location in Machakos District through self help movement in the construction of sub-surface dams and Galla tanks both as sources of water and conservation techniques. Kalikander (1990) also noted that water

conservation in Machakos District can be achieved through traditional self help groups ('Mwethya').

PPCSCA (1983) and Liniger (1989) note that there has been community participation in Machakos district in conservation of soil resources through terracing, mulching, agroforestry, gully rehabilitation and planting of trees. Some of these techniques have also helped in conserving water resources.

2.3.1. Constraints to community participation

The state of underdevelopment in most developing countries has made community participation unobtainable. Ghai et al ; (1979) and Habitat (1987) have observed that most rural people are poor and spend their time working in low income employment and hence do not have time to attend to community projects. Poverty has also hampered participation because most people are not able to finance water projects. Oyugi (1973) argues that grassroot participation is hampered by political leaders. In cases where the government feels threatened, community roles have been confined to activities and priorities of the government, which sometimes lead to lack of community participation.

Habitat (1987) WHO/UNEP(1991) and Gleick (1993) note that institutional framework through which the community is expected to participate is usually weak. The community dynamics are often ignored and planners' contribution only tend to be focused on the physical and financial aspects. In addition, traditional knowledge is ignored by concerned agencies thus making participation difficult and impossible. This means that most of the conservation projects are initiated without due consideration of economic and socio-cultural environment of the communities meant to benefit from these projects.

Bradley(1991); Ghai et al.; (1979); World bank (1989) and Langley (1986) reiterate the role of culture as a constraint to community participation in resource conservation. It is also noted that women who are the main users of water resources are often ignored in decision making or prohibited by cultural taboos to engage themselves in water conservation practices.

From the literature cited in this chapter, it is clear that:

(a) No appropriate measures have been taken to alleviate the growing pressure that is being exerted on water sources in ASALS especially in Yatta division of Machakos District.

(b) Water conservation has not been given the attention it deserves in Machakos district and especially in the dry areas of the district like Yatta division despite the fact that water is the major constraint to development.

(c) No studies have been done on community participation in water conservation in the area.

(d) No evaluative studies have been done on water conservation techniques and how appropriate they are in the light of increasing demand for water in Yatta division of Machakos District.

In the next chapter methods used to collect and analyse data in the study are discussed.

CHAPTER THREE: RESEARCH METHODOLOGY

In this study, different research instruments were used to collect both quantitative and qualitative information necessary for the study. Various methods of analysis were also adopted as discussed in the various sections that follow.

3.1 Research design

A household survey was carried out using questionnaires, interview schedules and observation sheets to obtain the required data. A pilot study was conducted to test the research instruments before the actual data collection. The study area was visited in the dry and wet seasons. All the three research instruments were administered in the wet season while further observations and a few interviews were conducted in the dry season. Data was then collected from both primary and secondary sources.

3.2 The sample and sampling procedures

The sample was derived from the population studied. This included heads of households (either mother, father or guadian) from the selected households and at least one water engineer from various ministries, non-governmental organisations and churches.

Out of the six locations in the study area three were randomly chosen. The chosen locations were Kithimani, Matuu and Ndalani. From each location, one sub location was randomly selected using balloting technique. In each location, the chief's camp was used as the research starting point. This was

inevitable because permission to commence research each day had to be obtained from the chief. From the chief's camps the researcher moved into six different directions (North, South, East, West and any other two significant direction).

Systematic sampling procedures were used and at least every fourth household selected (the sample interval was chosen owing to the scattered nature of the households in the study area) until a total of thirty households were obtained from each sub location. A total of ninety households were therefore interviewed. In places were the household members were absent, substitution was done by going to the next household.

3.3 Nature and sources of data

The nature of data depended on the two categories studied that is, household and various institutions. The data collected from the households broadly included information on the water sources and their adequacy; water use and conservation practices; nature of community participation; and the various constraints that hinder full community participation. The nature of data collected from the various institutions reflected their role in conception and implementation of various water sources; promoting water conservation; involving the community in water project designs and the constraints they face in water conservation activities.

3.3.1 Primary data

This data was obtained directly from the various resource persons visited such as heads of households, ministry officials (District water engineer and livestock officer), officers from the non governmental organizations such as Danida, Udungu Society, WFP, and World Neighbours and Water Engineers for the (Catholic and Anglican churches dealing with water conservation in the division). The instruments used to obtain primary data included oral interview schedules, questionnaires and observation sheets. Primary data was also obtained from the field by tape recording and photography.

3.3.2 Secondary of data

Secondary data was obtained using literature from the various institutions visited such as the relevant government ministries, non governmental organizations and churches. The information obtained included both published and unpublished information from journals, books, magazines and other relevant periodicals.

3.4 Research instruments and administration

The research instruments used to obtain data included observation sheets, questionnaire schedules and oral interview schedules. These instruments were administered by the researcher and the research assistant.

Non-participant observation method was used to collect information on various water conservation techniques at the household level and the types and condition of water sources in the sampled area (Appendices C and D). This is because observation increases range of relevance and reliability of data (Piel,1982). This information was used to verify information from the respondents.

Questionnaire schedules were used to collect information from household heads because a great deal of information can be obtained from the respondents directly through questionnaires in a short time(Kerlinger, 1973). The information included accessibility to water sources, conservation techniques used and how the community participates in conservation activities. Questionnaire schedules were used to collect information on the role of institutions in construction of various water sources and conservation techniques used to conserve water in the study area (Appendices A and B).

Oral interview guidelines were also used to collect information from the heads of households and various institutional officials to verify the information from the questionnaires (Appendices E and F). Kerlinger (1973) observes that interviews are advantageous because of face to face interpersonal interaction.

3.5 Data analysis and presentation

The data collected from the field was analysed and presented by use of descriptive statistics and other quantitative methods. These include the use of averages, percentages, deviations, variance and ranking. The averages were used to analyse the per-capita consumption of water; the physical

distance to and from the water sources; the time taken to queue at the various water sources; the number of livestock kept per household, the amount of money paid for water and the average income of the local people. Percentages were used to analyse the number of water uses while ranking was used to analyse the water sources, conservation techniques practiced and uses preferred for various activities and the constraints that hinder full community participation.

Trend analysis was used to analyse the reliability of various water sources in the division. Results were presented using tables, graphs, charts, pictures, sketches and maps.

Details of the results are presented in the next chapter.

CHAPTER FOUR : RESULTS AND DISCUSSION

This chapter presents the results of the water situation, water uses, conservation techniques, community participation and the problems related to conservation and participation in the division.

4.1 Water Sources

The division is endowed with different types of surface water sources. These are mainly rain water, river or stream water and the Yatta canal which has greatly contributed in provision of water to the local residents despite the fact that it is artificial.

4.1.1 Rainfall

Rainfall as a source of water is highly depended upon by residents of Yatta division. However, rainfall is highly unreliable and inadequate and cannot meet demands of the community. The monthly and annual rainfall data for this study were obtained from the Kenya Meteorological Department at Dagoretti corner. The data was collected at Masinga Station which falls in the same climatic region as Yatta.

4.1.1.1 Average annual rainfall

The analysis of rainfall data during the period 1983 - 1992 shows that average annual rainfall ranges between 490 - 954 mm (Table 4). The variation in annual rainfall could mainly be attributed to drought in the years with lowest amount of rainfall (1983 and 1987). However, the 1983 drought is the one which struck the whole country.

A comparison of the year with the least amount of rainfall (1983) and the most amount of rainfall (1990) is shown in Figure 7. It is clear from the figures that in 1983 the monthly average rainfall was 40 mm. In 1990 the monthly average rainfall was 79.5 mm. The difference between the good and the worst year is 39.5mm. From the annual average totals in Table 4 it is also evident that there was a steady increase between 1983 and 1986 while from 1987-1992 there was a fluctuation. The 10 year annual average is 672.2 mm. This clearly indicates that four out of ten years receive rainfall below the average (Table 4).

4.1.1.2 Average seasonal rainfall

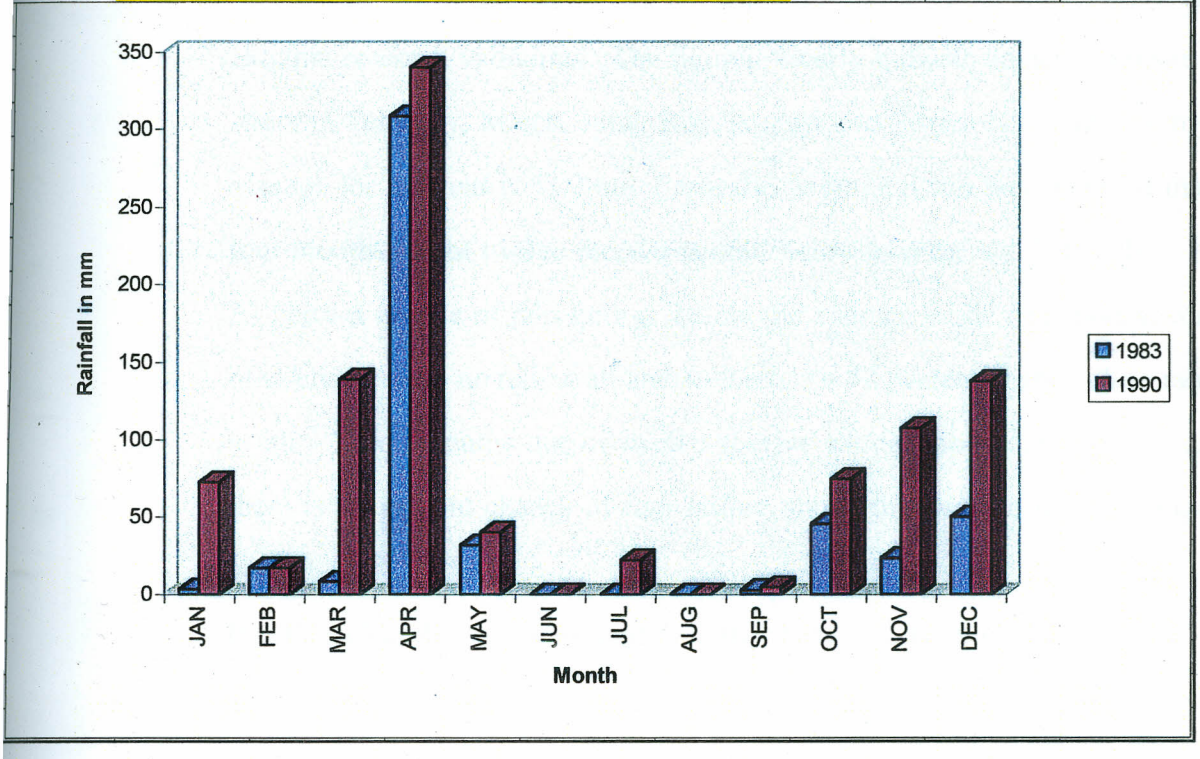
In the study area, rainfall is not equally distributed throughout the year. The dry season (October - December) and the wet seasons are pronounced. The rainfall is bimodal in nature. The short rains begin in mid October to December with an average of 100 - 250 mm. The highest amounts in this season is recorded in November. The long rains come in mid-March to mid - May with an average of 300 - 400 mm. During these two seasons the average potential evaporation ranges between 450 - 550 mm. The average rainfall is higher in the long rains than in the short rains.

Table 4. Annual and monthly rainfall average of Yatta Division.

Year	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*	*Total*
1983	3.4	17.0	8.2	308.3	31.9	0.0	0.0	0.0	2.7	45.6	23.4	50.0	**490.5**
1984	20.9	6.2	75.7	142.3	0.0	0.0	0.0	0.0	5.7	127.4	138.6	37.5	**554.3**
1985	10.3	74.8	98.4	323.4	28.6	0.0	3.4	0.0	0.0	39.9	78.3	34.6	**691.7**
1986	3.7	0.0	21.8	364.0	70.3	2.3	0.0	0.0	0.3	18.6	300.2	49.6	**830.8**
1987	45.5	0.0	14.1	149.3	68.9	77.5	0.0	13.8	0.0	0.4	124.4	75.5	**499.4**
1988	34.6	0.0	88.3	302.8	51.1	8.4	0.0	0.0	0.6	53.3	177.8	148.0	**909.9**
1989	65.8	2.7	78.4	237.0	44.6	2.7	1.0	0.0	4.7	64.2	188.8	--	**692.5**
1990	72.2	17.0	139.1	340.0	40.0	0.0	22.0	0.0	4.7	74.0	107.5	137.8	**954.8**
1991	12.6	1.8	83.6	123.6	47.6	0.0	0.0	16.0	0.0	46.3	112.6	72.2	**516.3**
1992	17.6	0.0	1.2	144.9	49.8	0.0	0.0	0.0	0.0	43.9	192.6	223.8	**683.8**

Source: Kenya Meteorological department.

Figure 7 : A comparison of the year with the minimum amount (1983) and the maximum amount (1990) of rainfall in the decade 1983 - 1992

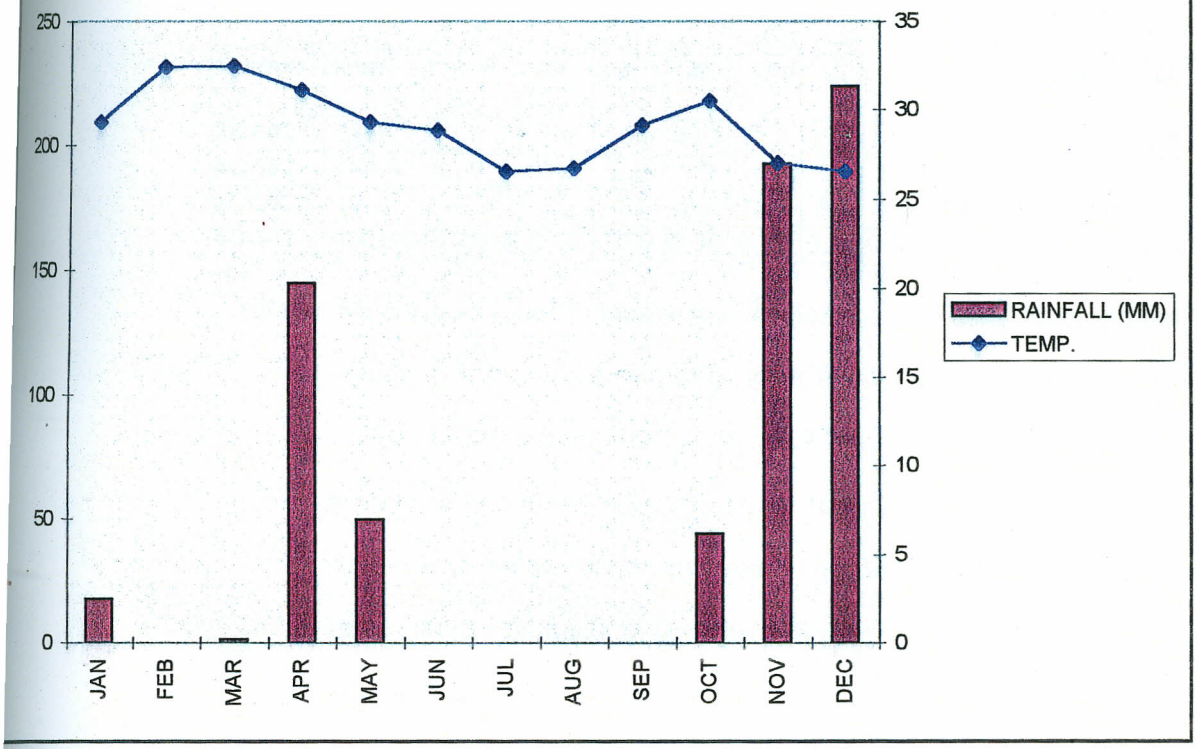


The area experiences two dry seasons. The short dry season starts in January to mid-March with the driest month being February (Figure8). During this season the average seasonal rainfall is 50 - 100 mm. The long dry season starts in June to mid-October with an average seasonal rainfall of 0 - 20 mm. From Table 4 it is evident that the average rainfall is higher in the short dry season than in the long dry seasons.

From the rainfall figures shown on Table 4 it is also evident that the division is not only plagued by inadequate rainfall but is also subject to extreme seasonal variations. The figures clearly indicate an acute moisture stress in February, March, June, July, August and September. The monthly average for the year is 53.2mm. From this average it can be concluded that four months out of twelve receive rainfall below average and hence there is 33 percent chance of rain falling below the average while five months out of twelve receive no rain at all and so there is a 42 percent chance of no rain at all. Three months out of twelve receive rainfall above average hence there is 25 percent chance of rain falling above the average in an average year.

It is thus clear that seasonal rainfall in the study area is unreliable.

Figure 8 : 1992 Monthly Rainfall Variations and Mean Maximum Temperatures



4.1.2 Rivers and canal discharge

The river discharges are greatly influenced by the amount and duration of rainfall. Just like rainfall the discharges also show strong seasonal patterns. The temperatures also influence amount of discharges by affecting precipitation type and the rate of evaporation (USADA, 1978).

Table 5: Monthly river discharges in cumecs for four stations

Station	Year	J	F	M	A	M	J	J	A	S	O	N	D	Monthly Average
3DA02	1988	2	1.2	1.4	10.9	40.1	21.8	13.8	10.9	7.8	10.9	7	1.8	10.8
4CC03	1990	0.8	0.1	0.8	0.8	0.8	1.1	1.3	1.3	1.3	0.9	0.7	0.6	0.9
4CC03A	1994	0	0	0	0.1	89	11.4	3.9	1.6	0.4	0	0.4	2.6	12
4CC06	1982	0.08	0.08	0.08	0.09	0.08	0.16	0.16	0.01	0.05	0.08	0.19	0.08	0.09

Source: Ministry of Land Reclamation, Regional and Water Development.

Table 5 summarises monthly river/furrow discharges for stations 3DA02 (Athi River), 4CC03 (Yatta Canal), 4CC3A (Thika River) before the canal and 4CC06 (Thika River) after the canal. All the stations fall within the study area. The flow rates of the rivers and canal were obtained from the Ministry of Land Reclamation, Regional and Water Development.

4.1.2.1 Seasonal and annual river and canal variations

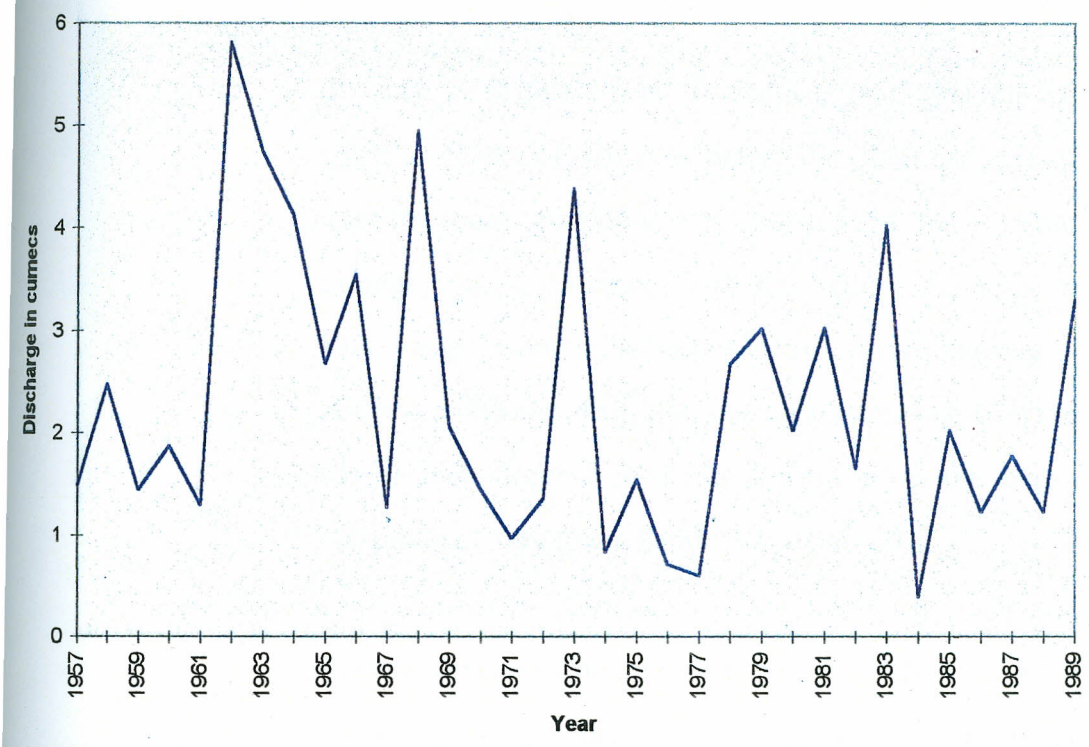
The Athi River has strong seasonal variations in flows. The river has high flows in April/May/June during the long rainy season and in October/November during the short rainy season. In the year 1988, minimum monthly average was 10.8 cumecs (Table 5). In that year

Table 6 Annual discharge for the Athi river at station 3DA02

Year	*Discharge in cumecs*	*Year*	*Discharge in cumecs*
1957	1.49	1958	2.462
1959	1.451	1960	1.872
1961	1.301	1962	5.816
1963	4.757	1964	4.127
1965	2.672	1966	3.546
1967	1.28	1968	4.948
1969	2.064	1970	1.454
1971	0.971	1972	1.365
1973	4.388	1974	0.836
1975	1.547	1976	0.713
1977	0.602	1978	2.676
1979	3.025	1980	2.025
1981	3.026	1982	1.659
1983	4.025	1984	0.39
1985	2.025	1986	1.231
1987	1.777	1988	1.231
1989	3.303		

Source: Ministry of Land Reclamation, Regional and Water Development

ure 9 : Annual Discharge for Station 3DA02 (Athi River)



six months out of twelve had flows below the monthly average with the lowest being 1.2 cumecs in February . Five out of ten months fall below the average and therefore there is 50% chance of water flowing above the minimum monthly average discharge.

The annual variation of Athi River from 1958 t0 1988 show very high fluctuations (Figure 9). Inspite of that, only five years recorded minimum flow below one cumec. There is a general decrease in flow over the years.

To analyse Thika River discharges, two ganging station were chosen. Station 4CC03A is before the canal and station 4CC06 is after the canal. At station 4CC03A in 1994, the minimum monthly average was 12.0 cumecs with the highest discharge recorded in May while lowest in January/February/March causing acute water stress with the minimum flows being zero cumecs (Table 5). In that year, eleven months out of twelve were below the average, a clear indication of very low reliability of about 92%.

The average annual discharge of the same station from 1973 - 1995 show very high fluctuations. The annual minimum discharge graph (Figure 10) shows extreme water deficit in the years 1984, 1986, 1987, 1988, 1992, 1993 and 1994. This is attributed to low rainfall and abstraction for domestic industrial and agricultural uses (T A R D A, 1978) .

Figure 10 : Annual Discharge for Station 4CC03A (Thika River)

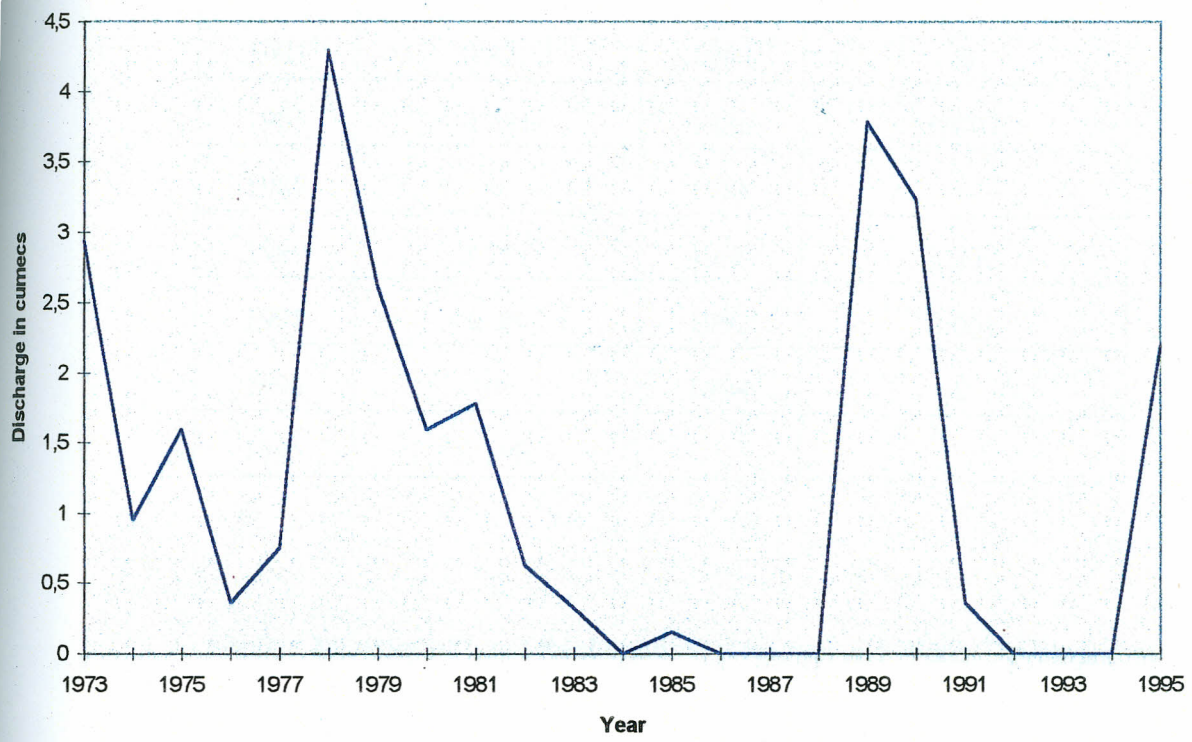


Table 7: Annual discharge for the Thika river at station 4CC03A

Year	*Discharge in cumecs*	*Year*	*Discharge in cumecs*
1973	2.937	1974	0.953
1975	1.595	1976	0.357
1977	0.755	1978	4.292
1979	2.623	1980	1.595
1981	1.781	1982	0.63
1983	0.321	1984	0
1985	0.151	1986	0.007
1987	0	1988	0
1989	3.781	1990	3.232
1991	0.36	1992	0.001
1993	0	1994	0
1995	2.192		

Source: Ministry of Land Reclamation, Regional and Water Development

From station 4CC03A, the river feeds the Yatta canal whose gauging station is 4CC03. The analysis of minimum monthly discharge (Table 5 and Figure 11) shows the available water resource as low as 0.1 cumecs. The mean monthly minimum discharge in 1990 was 0.9 cumecs. In that year, seven months out of twelve had minimum discharges below the average. Hence there is 58% chance discharge falling below the average in the year.

The annual minimum discharge for the canal from the year 1963 to 1994 has not reached 1.0 cumecs. The years which the canal experienced alot of stress were 1967,1968,1974,1980 and 1981 with 1980 being with the least discharge of 0.017 cumecs. Ther was then a steady increase until 1992 when it went down due to drought. Generally the fluctuation of the canal water can also be attributed to various reasons search as withdrawal upstream of canal water, temporary closure (especially during the dry season) for dredging, losses through seepage, unreliability of rainfall in the area through which canal passes and the increasing demand for both livestock and domestic uses.

The canal makes a substantial demand on Thika River. The station 4CC06 after the canal does not even record a minimum flow of 1.0 cumecs. (Table 5) For example in 1982 the highest minimum flow recorded was 0.19 cumecs in November with the lowest of 0.05 cumecs recorded in September. The monthly minimum average for

Table 8: Annual discharge for the Yatta canal at station 4CC03

Year	*Discharge in cumecs*	*Year*	*Discharge in cumecs*
1963	0.201	1964	0.453
1965	0.34	1966	0.34
1967	0.147	1968	0.147
1969	0.24	1970	0.21
1971	0.34	1972	0.35
1973	0.672	1974	0.182
1975	0.441	1976	0.625
1977	0.637	1978	0.424
1979	0.429	1980	0.017
1981	0.139	1982	0.274
1983	0.274	1984	0.26
1985	0.429	1986	0.379
1987	0.424	1988	0.247
1989	0.564	1990	0.685
1991	0.712	1992	0.487
1993	0.364	1994	0.26

Source: Ministry of Land Reclamation, Regional and Water Development

ure 11: Annual Discharge of the Yatta Canal at Station 4CC03

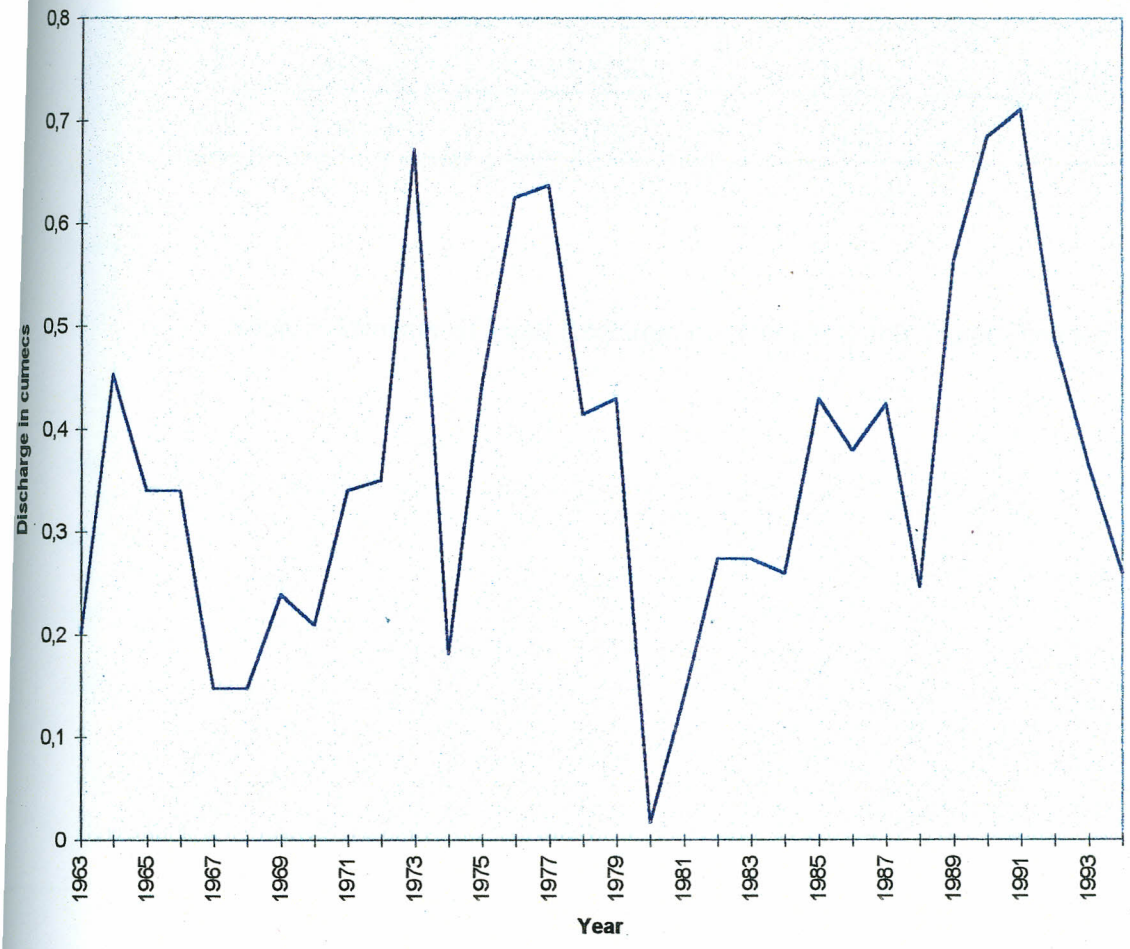
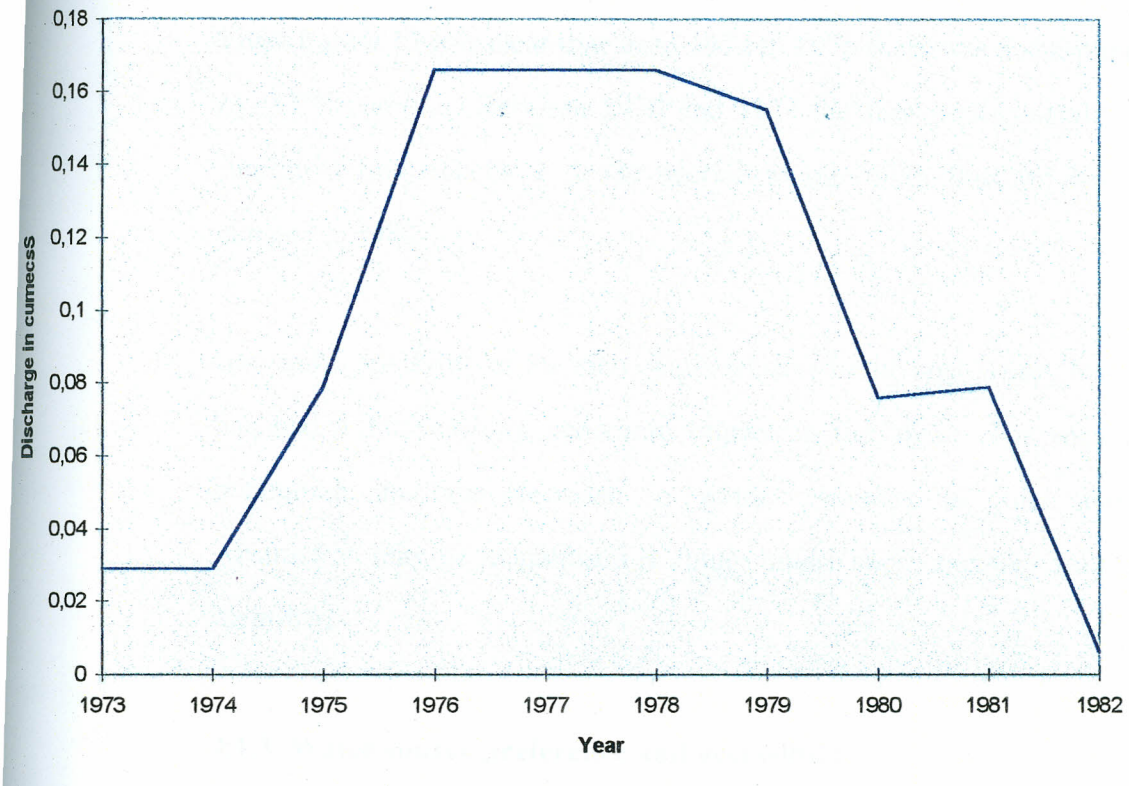


Table 9: Annual discharge for the Thika River at station 4CC06

Year	*Discharge in cumecs*	*Year*	*Discharge in cumecs*
1973	0.029	1974	0.029
1975	0.079	1976	0.166
1977	0.166	1978	0.166
1979	0.155	1980	0.076
1981	0.079	1982	0.006

Source: Ministry of Land Reclamation, Regional and Water Development

ure12 : Annual Discharge for Station 4CC06 (Thika River)



that year was 0.09 cumecs. Eight months recorded minimum discharge below the average thus indicating that there is 66% chance of discharge not falling above the average in a normal year. Compared to station 4CC03A (upstream), the downstream experiences alot of water stress not only because of the canal but due to domestic, livestock and agricultural uses. Also, most of the tributaries of this river are seasonal and discharge very little water into the river even in the rainy season.

For station 4CC06 data was only available from 1973 to 1982 (Table 9). From Figure 12 it is clear that from 1974 to 1976 there was a sharp increase by 0.137 cumecs. Between 1976 and 1979 the flow was generally stable (uniform) followed by a steady decline to minimum flow of about 0.06 cumecs in 1982.

Generally, reliability of the main water sources in the area is very low. This has had a far reaching economic impact in the area. The increase in population and the decrease in water resources is quite alarming. Abstraction may be jeopardised in future unless supplementary sources are identified.

4.1.3 Water source preference and accessibility

Accessibility in this study has been determined by physical distance to and from the source, and time taken at the source. It was observed that most residents got their water from surface water sources. However, a few others got it from water distribution outlets like taps, water kiosks and boreholes especially for the people living near a church or dispensary.

4.1.3.1 Sources preferred for domestic uses

Various water sources are preferred for different uses for different reasons. All the 90 respondents interviewed use more than one water source for domestic purposes. The choice of the source vary with the seasons. However, it was clear that some water sources are more prefered than others. Tables 10 (a) & (b) ranks the water sources in order of their preferences and also shows the number of times sources were mentioned.

Table 10(a): Sources for domestic use:

Water Sources	*Number of times mentioned*	*Percentages of mentions*
Furrow	66	38.4
Rain water	58	33.7
River/Stream	38	22.0
Subsurface	8	4.7
Springs	2	1.2
Total	172	100

Table 10 (b): Distribution outlets

Water distribution outlets	*Number of times mentioned*	*Percentages of mentions*
Water kiosk	10	62.5
Stand pipes	4	25
Bore holes	2	12.5
Total	16	100

The furrow is the main water source in the study area and that is why it is highly preferred. This is due to the fact that it is reliable and to most people it is nearly permanent. Besides, there is no alternative especially during the dry season.

Rainwater ranks second in preference despite its seasonality because it is clean. Cleanliness here applies to water collected from roofs or directly from the rain into a container while river water is used because of its abundance in the rainy season. Sub surface sources are used in the dry season. This is mostly common especially on seasonal rivers. Very few people use spring water because of its salinity, sparse distribution and seasonality. The water distribution outlets are only used where available mainly because of its cleanliness and proximity. However, water from the kiosk is determined by affordability.

4.1.3.2 Sources preferred for livestock use

Livestock rearing is a dominant economic activity in the study area. It is against this background that their water needs should be met. Table 11 shows the sources preferred for livestock use in order of preference and the number of times the sources were mentioned. The animals are watered in more than one source depending on distance and water availability. The data in the table was obtained from 90 respondents.

Table 11: Sources pefered for livestock use

Water Sources	*Number of times mentioned*	*Percentages of mentions*
Furrow	84	64.4
River/Stream	36	27.7
Small dams	8	6.2
Springs	2	1.5
Total	130	100

The Yatta furrow is leading in preference because, in the region there is high demand for near sources, livestock can get enough water from it, there is no alternative source especially in the dry season and it is reliable.

The furrow is an important source both in the dry and wet season. During the rainy season animals are mostly taken to nearby small dams, seasonal ponds and streams. However those who do not have dams or have large herds of livestock use the furrow and perennial rivers to water their livestock. The animals are also taken to the main sources to ease the problem of collecting water because they can drink directly from the source. Seasonal springs which emerge during the rainy season are preferred for livestock use because the water is salty.

When the dry season sets in, water in the dams, seasonal ponds and streams dry up. The dry season in Yatta is elaborate hence people have to search for water in far places. During this season the animals are mainly taken to the furrow and permanent rivers for water.

4.13.3 Water collection / distance and time taken

Water collection is mostly done in the morning between 5.00 - 9.00 a.m and in the evening between 4.00 - 7.00 p.m although it is also collected throughout the day. The largest percentage of water carriers in the division are women and children. To some extent men also go for water by using bicycles, bull/donkey carts or wheel burrows. They thus bring larger quantities of 100 to 200 litres (Plate 1) than the 14 to 20 litres carried by women (Plate 2) on one journey. In addition, financially able members of the community sometimes pay off a neighbour with a cart to fetch water for them. Different types of containers are used for water collection (Table12).

Table 12: Types of containers used for water collection .

Container type	*Size in Litres*
Large buckets	10-20
Small buckets	<10
Jericans	5, 10, 20 & 25
Oil drums and other drums	100-200
Gourds	5-20
Plastic bottles	<5

The number of round trips made to the source is determined by physical distance and time taken. The trip made to the source ranges from once to thrice a day.

.ate 1: A mode of water transportation mostly used by men in the division.

.ate 2: A woman drawing water from a seasonal spring with a jerican. The eye of this spring should be protected with slabs and the water pumped into the tank where it can be drawn from a tap.

Table 13 shows the distance to the main water sources. It is important to note that the main water sources according to different respondents were furrow and the rivers.

Table 13 : Distance to the Source

Distance (kms)	*Frequency*	*Percentage*
Less than 1 km	8	8.9
1.0 - 3.9 km	38	42.2
4.0 - 6.9 km	32	35.5
7.0 - 9.9 km	10	11.1
More than 10	2	2.2
Total	90	100

From Table 13, the mean distance to the main water source is at least 4 km with the minimum distance being 0.00 km in the wet season and the maximum being 14km in the dry season. Such a distance to water sources are not easily reached and this greatly lowers consumption and general development in the division. In times of drought, the distance does not only increase but the quantity fetched reduces. About 77.8 percent walk between 1 and 6 kilometres to fetch water. Because of such long distances, alot of time is taken fetching water. Table 14 shows average time taken to and from the source and also during fetching.

Table 14: Time taken to and from the water sources

Time (hrs)	*Frequency*	*Percentage*
Less than 1 hour	8	8.9
1-3	44	4.8
4-6	36	40.0
7-9	2	2.2
Total	90	100

From the Table 14, it is evident that the mean time taken is 3 1/4hours . The distance travelled is one of the factors which determines the time taken with the majority of the respondents spending between 1 - 6 hours a day fetching water.The time taken is also determined by availability of water at the source. In some instances people have to queue at the source especially in the dry season where water is drawn from the sand on the river bed.

About 40 percent of the the people interviewed queued at the source especially in the dry season. Due to this, a lot of precious time is wasted. About 3 to 8 hours is spent on queueing depending on the season and the number of people at the source because people tend to go for water at the same time. The problem is further worsened by the fact that water is fetched at one common place by the people. The implication of distance and time taken to fetch water are rather obvious in the division. Generally speaking, the people and especially women have failed to find extra time for shouldering other domestic and farm work. The overall impact of this has been low yields and incomes leading to poor health and general poverty.

4.2 Water use and consumption

In this section, results of water consumption patterns and habits in the domestic and livestock sectors are presented and discussed. The supply of water for humans and animals must be satisfied at all times without which life cannot be sustained.

4.2.1 Water use and consumption in the domestic sectors

The water use in this sector can be divided into four broad categories. These include direct consumption (drinking and cooking), indirect consumption (cleaning, dish washing and laundry), family consumption (house plastering) and gardening (home, vegetable garden watering).

The first two categories are the most popular in water consumption habits with water for cooking and drinking being the most basic need. Water use for house plastering is occassional while vegetable watering is mainly determined by nearness of the source although it is not very common in the study area. The daily water consumption per household ranges between 10 and 120 litres with a mean average of 60.6 litres. Daily general per capita consumption is estimated to be 6.6 litres.

The analysis of water consumption using cummulative frequency clearly shows that 50% of the households sampled consume 60 litres and below per household per day, 25% consume 40 litres and below while 75% consume 70 litres and below. The difference between the highest and the lowest water consumption is great (Table 15 and Figure 13).

According to the WHO the daily per capita water consumption of the people living in semi arid lands should be 25 litres/ day out of which 6 litres are for

cooking and drinking (WHO,1990). The per capita consumption of 6.6 litres per day in the study area is far much below the expected WHO standards. A study by Timberlake (1988) also reveal that in some dry parts of Kenya, the general per capita consumption is as low as 2.5 litres per day which is the absolute miminum for drinking and cooking according to WHO standards.

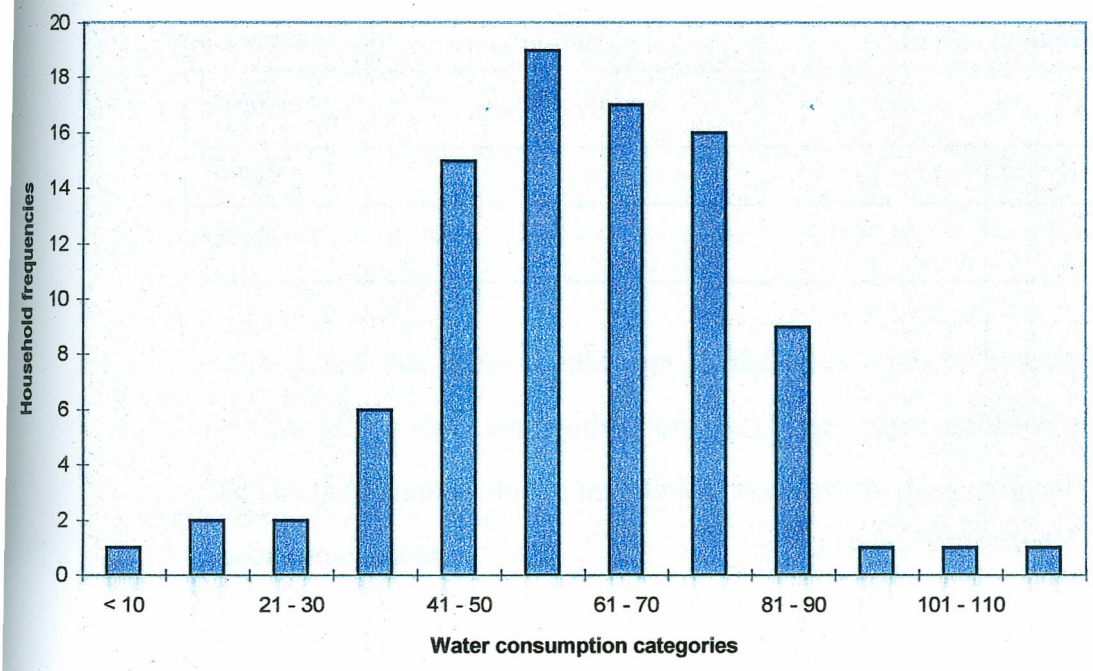
From the research it was clear that distance to the sources was the main determinant of water consumption. However, in some instances some domestic chores like washing clothes (Plate 11) and bathing are done at the sources. Clothes are washed once or twice a week while bathing takes place almost daily by women and occassionally for men and children especially when water has to be carried home.

The household size and water availabilty also determine the amount of water used because this will determine the amount of food cooked, dishes washed, clothes washed and the number of people bathing.

TABLE 15: Water consumption categories and household frequencies

Water consumption categories	*Household frequencies*	*Percentage*
LESS THAN 10	1	1.1
10 - 20	2	2.2
21 - 30	2	2.2
31 - 40	6	6.7
41 - 50	15	16.7
51 - 60	19	21.1
61 - 70	17	18.9
71 - 80	16	17.8
81 - 90	9	10.0
91 - 100	1	1.1
101 - 110	1	1.1
over 111	1	1.1
Total	90	100

ure 13 : Water consumption categories and household frequencies



4.2.2 Water Consumption in the livestock sector

The leading land use is livestock rearing with cows, sheep and goats being the main livestock animals. The number of livestock kept varied from one household to another. Table 16 shows the livestock types kept by the various households.

Table 16: Range of livestock kept

Livestock type	*Range in numbers*
Cows	1 - 20
Sheep	1 - 5
Goats	1 - 15

It was noted that some people kept all the three types of livestock, some kept two of the three while others only kept one. Some of the respondents had lost their animals due to insufficient water in the dry season and due to water borne diseases.

Water for livestock use ranks second after water for domestic use. Water consumption in this sector can be divided into two broad categories namely, direct consumption (direct drinking) and indirect consumption from natural pastures.

During the dry season, pastures are usually dry and hence have low water content of upto less than 10 percent. In the rainy season pastures are green and contain upto 80 percent of water. This reduces the amount required for animal use. During the wet season, animals are either watered once a day or

once in two days depending on availability of water in the nearby seasonal sources.

In the dry season due to the distance travelled, sometimes the animals are only watered once in three days. Where animals are few or are sick water is fetched from the source and the animals are watered at home.

Analysis of the water consumption per livestock unit was done. Most of the respondents estimated the amount consumed using jericans. For instance, a cow consumes water from a full 20 litres jerican or half of it in a day. Results are presented in Table 17.

Table 17: Estimates of water consumed in litres per head per day in the livestock sector.

Livestock type	*Average amount consumed per day (litres)*
Cows	10-20
Sheep	4-9
Goats	1-9

Despite the water consumption ranges in Table 17, the majority of people confirmed that a cow consumes at least 20 litres/day, a goat 5 litres/day and sheep 5 litres/day. However, when the water situation is very bad, the consumption is lower. Similar results were found by Mutiso (1989) in his study on regional problems and potentials in agricultural and domestic water use in Machakos District.

4.3 Water Conservation Techniques

Owing to the scarcity of water in Yatta division, the resident have been forced to adopt various water conservation techniques. From the study it was evident that at least 84 percent of the 90 people interviewed practiced various water conservation techniques. However, the type and the extent of conservation methods is highly varied. Table 18 shows different types of water conservation methods practiced and the number of times each conservation type was mentioned. Most of the people interviewed practiced more than one conservation method.

4.3.1 Rainwater harvesting

Rainwater harvesting is the leading technique in the study area. Rainwater harvesting for domestic and livestock uses have been shown in general. Different types of rainwater harvesting include roof harvesting and runoff harvesting. Due to the unreliability of rainfall in the study area, rainwater cannot provide a permanent source. However rainwater when satisfactorily collected can supplement other water supplies effectively.

Table 18: Conservation techniques practiced in Yatta division

Conservation type	*Number of times mentioned*	*Percentage of mentions*
Rainwater harvesting (Domestic use)	80	43
Rain water harvesting(Livestock use)	30	16
Terracing	18	10
Planting Trees	41	22
Mulching	12	6
No method	5	3
Total	186	100

4.3.1.1 Roof harvesting

The results in this study showed that rain water is harvested from roof tops which are corrugated. However, the harvesting is done using different methods. Rainwater is harvested directly from roof tops by use of short gutters made out of folded iron sheets. The water is channelled into a closed container or open containers like cooking pots, basins, buckets, drums and tanks where available (rainwater tanks are rare in the area due to lack of certain skills, tools and the cost of material needed for its construction).

Rainwater is also harvested from corrugated roofs by use of folded iron sheet gutters and a rope . This technique is mainly used to harvest water

into a container with a small mouth like a jerican. In this technique, the rope is placed horizontally on the gutter so that when it rains the rope gets soaked by water from the roof which is rolling into the gutter. The rope then directs the water into the mouth of the container where the water drips into the container (plate 3). The method is slow and is mainly used by those who do not have oil drums and large open containers.

Rainwater is also harvested directly from the eaves of the roofs without the use of gutters although people who use this technique cannot afford to buy gutters. When the rains come, the open containers are placed directly under the eaves to collect water. This method does not collect enough water because the water is not channelled by a gutter and therefore a lot is lost to the ground. The method is quite inadequate because the short duration of rain does not allow maximum harvesting.

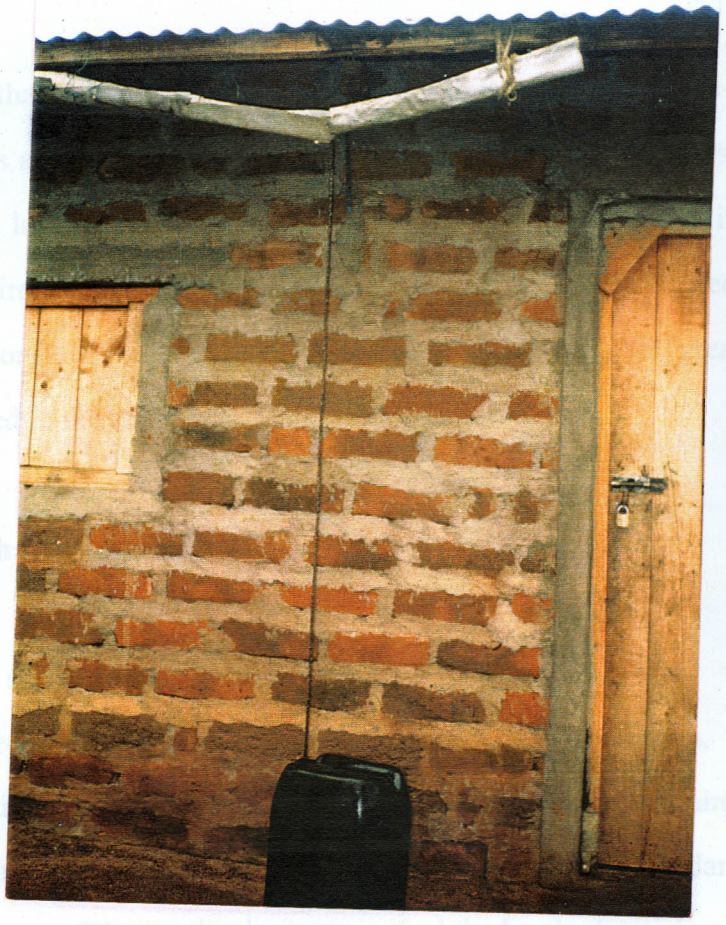
Those who do not have corrugated roofs harvest rainwater by placing the containers out in the open. However, this method is not efficient as enough water cannot be harvested by its use. Table 19 shows the type of containers used for storing rainwater and the number of times they are mentioned by the respondents. It is important to note that most respondents use more than one type of containers for storing water for domestic use.

Table 19: Rain water storage containers for domestic use

Container	*Number of times mentioned*	*percentage of mentions*
Tank	2	2
Jericans	4	3
Drums	50	43
Open containers	60	52
Total	166	100

Rainwater tanks are scarce in the area because of the high costs of buying the materials and tools needed for their construction. The majority of the people are low income earners who are generally poor. Infact, 95.5 percent of the respondents interviewed quoted lack of finances as the major constraint to the use of rainwater tanks. Most corrugated roofs are also small and measure about 3x3 meters.

Only 3 percent of the people use jericans to harvest rainwater from the roof because it is a slow method of water harvesting and can only be used by people who have gutters. 43 percent use oil drums because it can be easily obtained than a tank. Those who use oil drums complained about contamination of water caused by the poisonous substances that were initially in the drums and rustiness of the drums. Open containers are commonly used because of their availability. The open containers used include pans, basins, jugs and buckets.



e 3: A roof harvesting technique using short gutters, a rope and closed container (jerican).

e 4: A common type of roofing in the study area. such roofs are not adequate for rainwater harvesting.

Despite the fact that rainwater harvesting is the leading technique, there are various problems associated with it. These include lack of long gutters or gutters that leak, lack of adequate storage facilities, lack of corrugated iron roofs or small iron roofs (plate 4)and lack of finances to buy needed equipment for conservation. Thus roof harvesting technology has greatly been underutilised in the study area.

4.3.1.2 Runoff harvesting

During the rainy season, a lot of water is lost through runoffs. This is because when trees are cut down for charcoal burning in the dry season, there is overgrazing and thus the land is left bare to the impact of the rains. The water running off is harvested by different methods and stored in dams. In the study area, runoff harvesting has not reached the level where harvested water is stored in tanks for use. But rather, the dams have been left open and exposed to both humans and livestock.

One of the most commonly used technique in the area is earth damming. The earth dam is constructed on an undulating landscape where excavation is done on the lower side of the landscape and water from the upper side is channelled into the excavated dam. Excavation is done using hoes. Once the excavation is done, the soil from the excavated land is scooped to one side of the dam forming an arc (plate 5 (a)). The scooped soil is used for making a bund that hold rain water. At the end of the construction, the earth dam is in the shape of half moon. Water is collected in the area above the bund. The height of the bund ranges between 0.1 m to 0.5 m depending on the construction needs while the radius varies from 5 m to 30 m.

te 5 (a): A family owned earth dam. The dam forms a half moon shape.

te 5 (b): The same earth dam (5a). The drinking point is eroded by animals.

Most of the earth dams are individually owned. The water from the dam is mainly used for livestock watering. However, some families also use it for domestic purposes such as washing clothes and utensils, bathing, boiled for drinking and cooking. Construction of earth dams on family basis is time consuming and tiresome and hence need a lot of manual labour which can not be provided for by a family unit. The construction is usually done in the dry season.

Most of the family dams are dug at the edge of cultivated land. There is considerable erosion due to inappropriate farming methods resulting in heavy sedimentation of the dams.

Animals also cause erosion at the drinking point (plate 5 (b)). The suspended sediments in water increase opacity which results in absorption of solar radiation in surface levels of water. This results in increase in water temperatures and hence in high evaporation rates. The volumes of water is thus reduced tremendously. Such losses are additional to those caused by animals through splashing and spreading on the surrounding dry surface. The water in the dam can thus only last for at most two months depending on the amount of rainfall and the number of users. However, some earth dams are protected with trees planted around them and hence there is little sedimentation taking place (plate 6). Such dams have cleaner water than the unprotected ones and can hold water for at least three months.

In areas where soils cannot hold water and the ground is rocky, rock catchments are constructed. This is usually done on an undulating land with rocks where rain water is chanelled to a dam at the bottom of the undulating landscape where a barrier is built to hold water (plate 7).

6 (a): A well protected earth dam in the rainy season with vegetation around it.

e 6 (b): The earth dam in the dry season. All dams in the study area completely dry up in the dry season.

The soil removed was used to construct the bund to hold water. Rocks are also used to reinforce the bund, whose height range between 0.5 m to 0.25 m with a radii of 20 to 40 m. The rock catchment is proctected using local materials like thorns, branches and euphorbia which are used for fencing. The rock catchments are owned by groups and do not easily get silted like earth dams. The rock catchment dams are used for both domestic and livestock purposes.

Dredging of the dams and the rock catchment dams is done in the dry season. The community members lack proper tools for digging and dredging of these dams. In some places the ground has boulder and is rocky hence dam construction is a problem while in some places the land is plateau like making harvesting of runoff impossible. In area of clay soils digging is a problem because the soils are heavy.

Check dams, although few, have also been constructed in the study area through consultative efforts of the villagers or groups, their chiefs, Ministry of Public Works and Ministry of Land Reclamation, Regional and Water Development. Check dams are small dams which impound storm run off (Plate 8). They have been constructed across small seasonal water courses with impervious rock or soil strata. The area chosen for construction is also gently sloping. The width of the dam varies from 5 m to 20 m at the damming point while the length is between 10 - 15 m with a depth of 0.5m to 1.5m. The construction of check dams involve excavation which widens and slightly deepens the valley to create room for impounded water. Then a concrete weir constructed across the valley as shown on Plate 8.

Plate 7: A rock catchment dam. On the background is the rock catchment dam while on the foreground is a seasonal spring. These dams are built near seasonal springs for replenishment.

Plate 8: A check dam with concrete weir in the dry season. The dam is heavily silted (as can be seen on the middle ground) and will soon be rendered useless if not dredged.

Generally, the dam is triangular in shape. The check dams in the study area are properly designed and constructed but their general maintenance is very poor. They get silted up because there is no regular dredging. They are also seasonal and the quantity of water impounded is determined by the amount and intensity of rainfall. As the dry season approaches only a puddle is left on the dam bed and when the dry season finally sets in, the water in the dam completely dries up. They thus provide unreliable and discontinous supply of water. They are mainly used for livestock purposes (with livestock drinking directly from the source) but can also be used for domestic purposes like bathing and cleaning when need arises.

4.3.1.3 Condition of existing water sources

The water sources in the study area have not been protected as they should be. It was evident that most rivers, streams and water canals are not protected in some places. The poor management of these sources have greatly contributed to the diminishing amounts of water available in the study area.

For instance, in some places, river banks are heavily eroded because of human and livestock impact and because of deforestation around the rivers which is mainly done to pave way for farming. These have caused gullies running into the rivers and roots of trees being exposed (Plate 9). Erosion has led to heavy siltation of the rivers and stream beds and their eventual degradation.

Some parts of the rivers and canals are proctected (Plate 10). These have vegetation growing on the banks since cows are prohibited from drinking directly at the sources. It was also evident that in some places, the Yatta and Ndalani canals have their banks worn down by people and animals gaining access to the water. This problem is worse because animals are watered directly from these canals (plate 11). It is also evident from the plate that animal dung is found in the water along with other dirt like tree branches, tins and waste papers especially from soap covers (plate 12). This is because some people bathe and wash at the canals just like in the rivers and streams (Plate13).

Terracing is also practised in some areas. About 10 percent of the people interviewed practice terracing. The most common types of terraces are ridges and furrows and the "Fanya Juu" type. These techniques do not only hold water in the farms but prevent soil loss during the rainy season. Prevention of soil erosion on the farm is important because it reduces the amount of soil deposited on the river bed.

Although terracing is practised there are constraints which the community members face. For example, the terraces get swept away by heavy rains, rocky ground also prohibit construction of terraces and lack of facilities for terrace construction such as fork" jembes", spades, wheel burrows and manual labour. These problems have a far reaching impact on water conservation since soil erosion from farms is one of the leading causes of sedimentation of surface water sources in the area.

9: The banks of river Yanguni are heavily eroded and tree roots exposed. The river has vegatation growing on its bed thus reducing it to a puddle.

10: A well protected section of the Yatta canal.

Plate 11: A cow drinking directly from the Ndalani canal. The slabs on the left side of the canal are loose due to erosion caused by animals gaining access to water. On the same side of the canal animal dung can be seen.

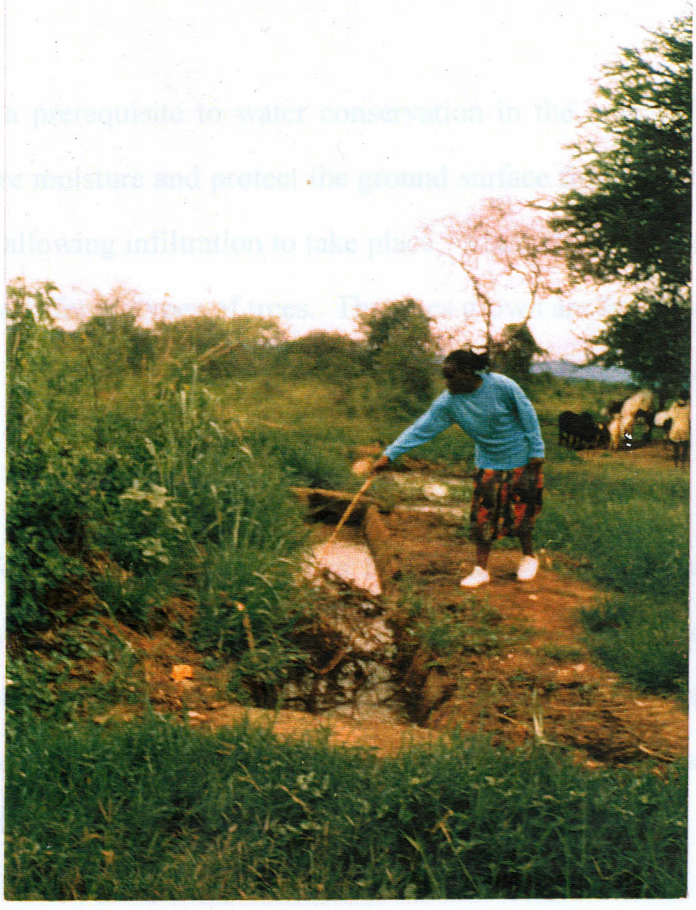


Plate 12: A section of the Ndalani canal with tree branches and waste paper.

Plate 13: A woman washing directly from Muthuata River.

Tree planting is a prerequisite to water conservation in the area. This is because trees store moisture and protect the ground surface from the impact of rain drop thus allowing infiltration to take place. About 22 percent of the respondents grow different types of trees. The trees grown are fruit and non fruit types which are mainly used for fodder and for charcoal burning in the dry season.

Despite their efforts, community members face serious problems such as lack of seedlings for planting (seedlings are expensive), pests which attack seedlings, lack of water for the seedlings especially in the dry season and lack of plastic papers for planting. Afforestation as a water conservation strategy has not really taken off in the study area as it should.

4.4 Community Participation

Since water scarcity has been the main barrier to development in the study area, the community has been forced to participate in various surface water conservation projects. It was evident in the study that men, women and children were all involved in water conservation activities although their roles differ a lot. Participation is mainly done on family basis or through self help groups.

4.4.1 The nature of community participation

The community members participate in various ways in planning/decision making, financing, construction/implementation and operation and maintenance. This depends on the type of conservation, and the needs, values and aspiration of the people.

4.4.1.1 Planning / decision making

In this stage, each stage of the proposed project is conceptualised. This is where, the role of each individual in the community group and the resources needed is decided. The resources required mainly include funds, manpower, user rules and management process. It was noted that 17 percent of the respondents interviewed participated in the process of planning and decision making.

Most people who participated in this stage were owners of small private dams mainly used by households and those owned by self help groups. On the family basis, the owners of small dams are charged with identifying the appropriate location for the dams based on past experience. They also decide on type of labour, water use rules and general management aspects of the small dams. In communal dams, community members identify their needs and liaise with administrators such as chiefs and extension officers who inturn consult with the surveyors on the location of the dam. The extension officers from the Ministry of Environment and Natural Resources and the Ministry of Land Reclamation, Regional and Water Development decide on afforestation programmes and canal extension respectively.

Once the appropriate locations have been demarcated, the community members then proceed with the construction/implementation. However, some of the factors considered before implementation include the number of members/users, proximity to the local community, and to water source. Most dams are therefore built near seasonal springs for replenishment and mostly public land is chosen by surveyors for construction/implementation of

communal self help projects although in some instances, individuals offer their land.

Despite the fact that women are the prime water collectors and users, they are hardly involved in the decision making processes especially where dam construction is concerned.

4.4.1.2 Implementation and construction stage

About 36 percent of the people interviewed agreed to participate in the implementation and construction of various surface water conservation projects through provisions of voluntary labour. Other than voluntary labour, there are people who are non members of the group who are hired to offer paid labour. This is mostly common in family dams where labour shortage can be a main obstacle to participation. At this point, construction activity mainly involve digging and collecting materials for construction. It was evident that women were the majority at this stage. This does not mean that men do not completely participate but few do. Participation through voluntary labour not only reduces the financial cost of the project but also contributes to a sense of ownership of the project by the community.

Women also belong to self help groups which are concerned with buying and selling seedlings and implementing tree planting and also contributing money for buying corrugated iron sheet roofing materials. However, these two projects have not really taken off as they should due to lack of sufficient funding . To some extent, it is also practised in communal dams.

During drought, the various donor agencies start up a food for work programme. At this time, the community members are not encouraged to participate in dam construction in order to be given relief food since the food for work project is abandoned immediately the food donors and distributors leave, hence this programme is not sustainable as far as construction for water conservation projects is concerned.

4.4.1.3 Financing Stage

In order for water project to succeed, the community need to contribute as much as possible toward financial costs. Financing of the project is done from planning stage to operation and maintenance. Table 20 shows different stages of the project and the percentage of people who indicated their willingness to contribute towards surface water conservation projects. Some of the people contibuted in more than one stage while others contributed in all.

Table 20: The project stages and percentage of the people willing to offer financial contribution towards water conservation project

Project stage	*Number of times mentioned*	*Percentage mentions*
Planning	30	20
Construction	22	15
Fetching point	48	33
Operation and maintenance	30	20
None participation	18	12
Total	148	100

From Table 20, it is evident that the financing of water projects in the study area is done at all stages. This can be attributed to the low income of the residents. During the planning stage, 20 percent of the people contribute in order to identify with the water project especially if it is a communal dam. In some places the community is forced by the administrators to contribute towards the forthcoming water projects. At this stage, contribution is given out by the members of the self help group. For instance, the members of Kwamutaki self help dam give Kshs.100/= for registration which is payable in instalments per year with an annual subscription fee of Kshs.20/= , while in Ndalani members of the Mawe Tatu Women group decided to pay Kshs.300/= each for the construction of the water tank. Few members are however able to contribute to these projects due to financial constraints.

Sometimes community members are forced to pay for construction money during planning stage. In Ndalani the community members are forced to Kshs.600/= per household by the chief for construction of a dam and storage tank. However, some members cannot afford to pay while others do not trust the administration. Those who refuse to pay are forced to pay by having their livestock taken or are locked up in the Chiefs camp until the funds are raised by household members. Unfortunately most of the projects in the study area do not take off from planning stage because of the above problems.

Of the people interviewed, about 15 percent contribute funds during construction of various water conservation projects. This money is used to purchase or hire construction equipment such as hoes, spades and

wheelbarrows. Labourers who are non members are also paid. Some of the money is also used to purchase food for the labourers.

About 33 percent pay for water at the fetching point since they do not belong to any water conservation project. Usually the fee payment range between Kshs.1 and 5 depending on the size of the container. A watchman collects the funds before the water is collected to avoid possibilities of non-payment once the water has been collected. This is mostly common on communal dams and to some extent private dams. The funds collected are usually kept by the treasurer of the group.

During operation and maintenance stages, about 20 percent pay Kshs.10-15 depending on the need of the group. The funds are put together with those that are collected during fetching and are mostly used to pay the watchman, hire labourers and for other miscellaneous activities of the project.

From the study in general it was apparent that only about 28 percent of the respondents agreed to contributed in financing water conservation projects in various ways. For the project to succeed , proper accounting is essential because users must be convinced that their money is being used in the intended way.

4.4.1.4 Operation and maintenance

Once construction and necessary financial contribution has been done, the members are charged with proper maintenance of the projects. The type of maintenance is part of the decision taken during planning. Some of the decisions taken during planning include deployment of a watchman to collect relevant funds during fetching and to ensure there is no abuse and conflicts

between users. Unfortunately only 18 percent of the respondents participate in operation and maintenance of various of water sources and projects.

Technically the most common type of operation and maintenance in the study area is dredging. For instance the people participate in the dredging of the furrow, communal and private dam. The furrow which is currently under the Ministry of Land Reclamation, Regional and Water Development has been abandoned due to lack of funds for operation and maintenance. The community under the supervision of their chief is now charged with clearing the banks and disilting the canal or the furrow. During this exercise, each household is given their portion for clearing and disilting. However, some community members are not co-operative and do not participate during this exercise in the dry season. Some parts of the canals are worn out by animals and people. Maintenance of the canal is thus very poor despite the fact that it is the lifeline of the local people.

It was also evident that some dams and rock catchments are well maintained than others. For instance, the Kwamutaki dam in Kithimani which is a communal rock catchment dam is better maintained than others. The dam is protected by a thorn fences to bar animals from drinking directly from it. The members have also employed a watchman to look over the dam and protect it from people and animals making it dirty and from non members who want to fetch water. The animals are watered in a different section of the dam. During the dry season , the dam is desilted by members despite the fact that tools used are rudimentary. This makes the work tedious.

In the case of small earth dams (owned on family basis) there is poor maintenance. Some of these dams are not fenced and animals drink directly from them. The edges of the dams where animals drink from are usually eroded. The water also has a lot of silt deposits due to poor maintenance. The maintenance of this dam is usually very difficult because of labour shortage during desilting .

The river banks in the study area are not also properly maintained by the local residents. Farming is done right to the river bank. Some small streams have dried up due to siltation from the farms. Poor farming methods have greatly contributed to the sediments on the river banks. Farming on steep slopes has not just eroded the land but has also caused deep gullies running into the river. However, the people have not done anything to protect the banks from erosion. The high sediment load has reduced the amount of water available in the river and water conservation projects for use in the domestic and livestock sectors in the study area.

4.5 Major constraints to full participation

Despite efforts by the community to improve their water problems they are faced with a range of constraints . These include financial, lack of technical knowhow, labour shortage, gender bias, weak institutional framework, corruption of local leaders, religious discrimination and physical contraints.

Financial constraint is one of the leading factors hindering full community participation. This is because the income of the residents is low (Table 21).

Table 21: Yearly income of the respondents

Income (Kshs)	*Frequencies*	*Percentage*
Under 500	20	2.2
500-1000	14	15.6
1001-1500	14	15.6
1501-2000	4	4.4
2001-2500	8	8.9
2501-3000	28	31.1
Over 3000	2	2.2
Total	90	100

Data was collected on yearly income because most people earned their income after a harvest without which there is no income. About 71% of the people interviewed are farmers. From Table 21, it is evident that the income cannot afford to buy them various water conservation facilities. Most people can not afford to buy rainwater tanks, spades, wheelbarrows, fork jembes, pipes and taps to enable them harvest rainwater.

Lack of technical assistance is another major constraint. Despite the fact that people are willing to participate, there is hardly any technical assistance. For example, in dam and rock catchment construction, the people can improve their water quantity and 'quality' by use of storage tanks and pipes. Storage tanks can be constructed using local materials like sand, rubble and stones. However lack of technical assistance has completely hindered the adoption of such techniques. There is therefore need for various institutions to train the people on how to use and construct these facilities to conserve water in the area.

Labour shortage is also a common constraint in water conservation activities. For example digging and dredging a family dam on private basis is a tiring exercise and so is construction of terraces on the farms to curb soil erosion. Labour shortage during communal work is also evident because most young men are looking for jobs in towns thus leaving women, children and the old who are not able to cope with all the domestic , agricultural and water conservation activities. This has greatly slowed down progress as far as water conservation in the study area is concerned. Some people have therefore completely given up on the dams.

There is also gender bias as far as as the decision making is concerned. Women are the traditional water carriers and they spend long hours in search of it. Inspite of this, they are not given a chance to fully participate in the decision making or planning process, or even when they are given an opportunity they shy off because they believe that this is the responsibility of the men. They have taken a surbodinate role as far as planning for water conservation is concerned. Their role is mainly providing labour and financial support where possible. It was also noted that women self help groups did better than mixed self help groups. This could be attributed to the fact that as women alone in their groups, know their needs and demands as far as water conservation is concerned. They should therefore be provided with a legitimate basis for participation in the decision making process.

Corruption of local leaders and political interference have not allowed implementation of water conservation projects to take place. This is because the money donated or contributed by the community is greatly

misappropriated. For example the funds collected for a dam and a tank in Ndalani has neither been used nor accounted for. There is also political in interference as far as planning and financing of projects are concerned. For instance, some politicians influence the location of these water projects, They start construction and abandon the work when defeated in elections like in the case of the extension of Ndalani canal. Inspite of this, the community members do not complain for fear of being victimised. Lack of trust from the community has therefore hindered full participation especially in planning and financing stages. The administration at the village level is also centralised such that it retains control over decision making hence leaving out the majority.

There is also weak institutional framework within some self help groups. This has led to poor distribution of responsibility, poor understanding of each other, poor budgeting and spending and lack of effective enforcement of laid down user regulations. This has discouraged other members of the community from joining various groups.

There is also lack of co-operation from some community members. This is a big problem especially in dredging the canal, watering animals directly from the sources and washing at the sources. These have discouraged committed members from protecting their sources fully and participating in various activities related to water conservation in the division.

Religious discrimination is also common in water conservation projects. Efforts to promote water conservation through churches have become segregative. Only a certain group of people in the church are assisted and

helped to construct water tanks and instal gutters. The churches only give such services to the faithful of their churches and not outsiders. However, there were hardly any rain water tank in all the households interviewed.

Lastly, physical constraints like soils, topography and boulders have also played a part in hindering full participation . For instance in places where clay soils are found, the members are discouraged from building dams because clay soil is too heavy to scoop especially with rudimentary tools like hoes. In areas where land is too flat, harvesting runoff has been a problem whereas in places with boulders, terracing has been hindered.

The above problems have greatly influenced the extent of participation in water conservation, activities in the Yatta division. .

4.6 The role of Institutions

Various institutions involved in water conservation activities in the district as a whole include government ministries, churches and non - governmental organisations. However, most of these institutions are not as actively involved in water conservation activities in the division as they are in other divisions of the district.

4.6.1 Churches

These include Catholic and Anglican churches. They are mainly involved in voluntary activities such as construction of water tanks and dissemination of appropriate technology to the community. It was noted that most church activities were limited in the area due to lack of cohesiveness of the local community in the area. This has resulted in the churches helping

individuals instead of groups which should be their targets. The churches are mainly funded by the international donor agencies.

4.6.2 Government Ministries

The government ministries involved in water related activities in the division are Ministry of Land Reclamation, Regional and Water Development, Ministry of Environment and Natural Resources, Ministry of Culture and Social Services, Ministry of Public Works and the Ministry of Agriculture, Livestock Development and Marketing.

The Ministry of Land Reclamation, Regional and Water Development is charged with planning, conserving and operating water supplies with a view to providing safe and clean water to all households within a reasonable distance. The Ministry is also charged with canal desilting, regulation of intake as well as overall management of water abstractions. These objective has not been achieved by the Ministry due to lack of funds. Most water conservation projects planned by the ministry have not been implemented due to lack of funds. However, the Ministry gives technical support where possible especially where water distribution outlets like water kiosks, and stand pipes are concerned.

The Ministry of Environment and Natural Resources initiates rural afforestation programmes, extension services and other aspects dealing with tree growing (Plate 14). Agroforestry has been introduced and the community is trained on the right species to grow on the farms. Afforestion programmes are initiated in areas that are neither suited for agriculture nor grazing for the purposes of supplying firewood for domestic use.

e 14: A tree nursery run by the Ministry of Natural Resources in Kithimani location of Yatta division.

The people cannot, however afford seedlings making their response towards afforestation rather slow.

The Ministry of Culture and Social Services mobilises local communities for self reliance in basic needs and involvement in the development planning process. This is done by the District Social Development Committee. The Ministry also promotes the status of women by involving women groups in decision making in various activities in the division. The Ministry also registers self help groups.

The livestock division of the ministry is charged with rendering advisory services with respect to improvement of ranching activities mainly through rotational grazing made possible by pipe water supply, fodder/grass establishment, range pitting and range re-seeding. However, most of the above objectives have not been achieved in the study area because of inadequate funds.

4.6.3 Donor and charitable organizations.

The donor agencies which have or are planning to undertake water conservation projects in the area are World Neighbour, Undugu Society, EEC and WFP. The donor agencies are mostly concerned with piping and distribution of water from boreholes and rivers. They have not fully undertaken any surface water conservation project in the division. A project (a dam) taken by WFP was soon abandoned when the donors left because it was a 'food for work' project. It was also evident that most donor funded distribution outlets are expensive to the community and thus their contribution is limited to manual labour.

4.6.4 Tana and Athi River Development Authority.

It is involved in regional planning and is mainly concerned with developing the potential of Athi River. This include identifying dam sites for irrigation and electricity production.

Generally the institutions have not come in strongly to support the community in their water conservation endeavours. This can be attributed to the fact that the area is considered remote and so some places are inaccessible, because of inadequate publicity given about the water situation in the area and lack of cohesiveness on the part of community members because most of the members are immigrants.

CHAPTER FIVE: RESEARCH SUMMARY , CONCLUSIONS AND RECOMMENDATIONS

5.1 Research summary

The aim of this study was to identify water sources in terms of their reliability and accessibility, determine the amount of water used in the domestic and livestock sectors, examine various conservation techniques and describe how the community participates in these conservation techniques with a view to identifying inherent problems that hinder full participation.

From the literature reviewed, it was apparent that water conservation has not been given the attention it deserves and no evaluative studies have been done on community participation in water conservation in the light of the increasing demand of the resource in Yatta division of Machakos district.

To achieve this, a household survey was carried out in which a total of 90 households were interviewed. These were selected through random and systematic sampling techniques. Charitable organizations, churches and government ministries were also interviewed. The research instruments used were questionnaires, observation sheets and interview schedules. Data was analysed using simple and descriptive statistics such as percentages, averages, ranking and deviations. Time series analysis technique was also used.

From the study , it was evident that water availability is one of the necessary conditions for development of Yatta division of Machakos district. Results of the study indicate that surface water sources are mainly rainfall, rivers,

streams and the Yatta/Ndalani canals. Rainwater is harvested for both domestic and livestock purpose. Its unreliability has been responsible for seasonality of other surface water sources.

The perennial rivers (Athi and Thika) have both high efficient load and are over abstracted especially in their upper catchments. Most of the streams are also seasonal and heavy laden with silt from the high potential areas and within the division. The streams have not been very useful sources of water for domestic and livestock use especially during the dry season because of their seasonality.

Analysis of the most used domestic water sources in the division revealed that the furrow is the most utilized water source followed by rainwater, river/stream, sub surface and springs respectively. A few others got their water from water distribution outlets like taps, water kiosks and boreholes especially for those near a church, or a dispensary. In the livestock sector, the furrow was the most prefered followed by river/stream, small dams and springs respectively.

Water collection is done in the morning between 5.00 - 9.00 a.m and in the evening between 4.00 - 7.00 p.m. It is collected using jericans, buckets, drums, gourds and bottles. The mean distance to and from the water source is aproximately 4 kilometres with 0.00 minimum distance and a maximum of 14 kilometers. Because of such long distances, alot of time and energy is consumed in search of water.

Due to scarcity of water, its use has been very low in both the domestic and livestock sectors. In the domestic sector, daily water use has only been

limited to cooking and washing utensils. Other activities like washing clothes and bathing are done occasionally. The per capita water consumption of 6 litres in the domestic sector is way below the expected WHO standards of 25 litres per day in the arid and semi arid lands.The average water consumption in the livestock sector is 20 litres per head for cows and 5 litres per head for sheep and goats. In this sector animals are watered once in three days especially during drought.

Results also indicates that most of the water conservation techniques adopted are either unsustainable or are under utilised. This is due to lack of sufficient funding and technical know-how. Consequently most water conservation techniques have not been fully adopted.

In an effort to conserve water, some community members have organized themselves into self help groups through which communal work is done. Generally participation in water conservation activities is low on family basis due to insufficient labour force. It was however observed that most of the self help groups are not involved in water conservation projects despite the fact that water is crucial resources in the study area.

Some projects planned by the government have not been implemented due to the lack of funds while a few projects started by donor agencies have been abandoned. It is important to note that there is hardly any donor involvement in water conservation in the study area.

Most of the problems hindering full participation (such as financial, political, religious gender and institutional) are major and need to be addressed. The problems have adversely affected water conservation activities in the area.

This is because without effective community involvement in water conservation activities, the water situation is likely to worsen causing an increase in disease incidences and a general decline in productivity and in per capita income. Efforts to improve water distribution through pipes is futile because most people cannot afford pipes and taps. The ground water potential is also low (Fairburn, 1963) and hence the only cheap way to improve on the community water supply is through effective conservation of surface water sources. It is through these groups that finances should be chanelled.

5.2 Conclusion

It was quite clear from the study that water problem in the study area is serious. The availability of water in sufficient quantities has been a major draw back to economic development. This has led to extreme poverty. Unfortunately the community members do not relate their poverty to water scarcity. Most of the people are living in absolute poverty without sufficient water, food, good clothing and school fees.

Besides inadequate water, poor water quality has also contributed to the blight of the people living in the study area. Most of the sources are polluted causing water borne diseases to both animals and human beings because the sources are not protected. They are used for washing clothes, bathing, watering animals as well as for drinking purposes. These diseases have not only caused deaths but have also costed them alot of money interms of treatment.

And in regard to water conservation, other than the financial and technical factors, physical conditions have greatly hampered conservation practices especially on rocky grounds with boulders and flat terrain. Generally the sources are not protected. The banks are eroded and their beds filled with silt thus reducing the amount of water avialable at the source.

The area relies on rainfed agriculture. Due to insufficient rainfall, crops fail and the farms are left to the mercy of rain water and wind because they are bear. Alot of water is thus lost through surface and channel run off. Despite this, rain water harvesting has not taken off the way it should. Rainwater should therefore be considered as a potential supply in the study area.

Most of the community group activities found in the area are not water related. They mostly deal with issues relating to house building, dowery payment, digging, crop harvesting and for solving other social problems. If the community can concentrate more in water related activities, their water problems would be minimised.

The institutions involved in the study area include the government ministries,

non-government organizations and churches. These institutions are partially involved in water conservation activities in the study area. The government ministries lack sufficient funds to start off projects despite their plans. Their roles should be encouraged through sufficient funding.

The churches have only helped a few faithfulls who are actively involved in the church with rain water tanks and gutters while the non-governmental organizations only assist during drought through food for work programmes which they abandon soon after the food shortage is under control.

Otherwise, most of them have plans to start serious water projects in the area. Without joint efforts by the community, government ministries non-governmental organizations and churches, the water problem will worsen.

5.3 Recomendations

As human and animal population continues to grow the water demand continues to increase. This calls for urgent solutions from the community affected, the government and aid donor agencies. They should identify ways of survival and the necessary support needed by the community. Since finances have been a major barrier to water conservation practices, water projects should be implemented in relation to the needs, values, habits and aspirations of the people. However, before any of the above is done, reduction in population growth rate should be encouraged by the use of effective family planning methods. This would reduce the pressure exerted on water resources in the study area and improve the economic and health status of the people.

Since water sources in Yatta division have been overused and misused, there is need to promote proper management of water sources. This can be done through soil conservation and afforestation programmes both upstream and within the study area and pollution control upstream of the perennial rivers especially the Athi. This can be achieved by imposing pollution control rules within the industrial areas which release their wastes into the Nairobi river. Despite the treatment of water at the Dandora treatment works, water is still polluted because some of the water from the river does not pass through the treatment works. This has greatly limited the amount of water available in the river in the dry season. It is also a health hazard and hence the need for proper treatment.

Given the expansion in rural water supply upstream of the Thika/Chania confluence as well as growth by Nairobi and Thika urban centres, it is obvious that there is little chance of increasing the Yatta abstractions despite the increasing demand. There is need therefore to regulate the river use upstream and to draw and implement plans that will permit use of available canal water to be maximised.

There is also need to reduce sediment generation in the catchment areas and surrounding areas through formulation of suitable programmes, restricting farming along river banks and limiting the number of animals getting access to the source by construction of various cattle troughs near the source. In relation to the eroded sides of the canal, local materials such as rubble and locally produced fire bricks or clay should be used for lining and strengthening of the canal.

Lastly, there is need to develop small water points for both domestic and livestock use. This is because small water points are environmentally sustainable, will limit pressure on a single water point and reduce the distance travelled and time taken on round trip to and from the water point (World Bank, 1989).

On water conservation, the potential of rainwater harvesting should be taken seriously by policy makers, water planners and managers since rain water is a major source of water in all sectors in the study area. There is need to integrate both modern and traditional technologies where rain water tanks can be made with polythene sheets using mud, sand (which are readily available) and a little cement to form the tank lining and internal structure

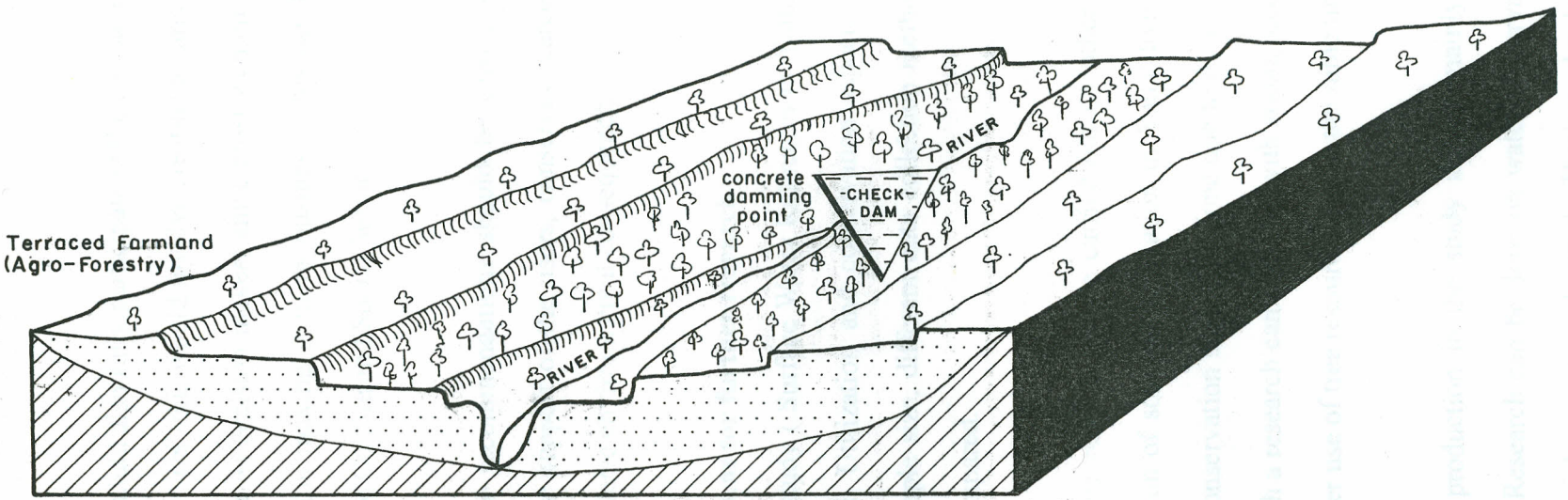
(Pacey and Adrian, 1986). This is important because most of the respondents wanted information on simple tank construction technology.

Polythene sheets can also be used on grass thatched roofs where heavy polythene sheets are put on top of the roof to ease the flow of water into the gutter or containers. This method has been used successfully in Makueni. However, the use of this method is subject to availability of polythene sheets. Where there are no gutters, bamboo gutters can be made. The gutter may be tied to the roof structure with a wire.

For better dams and continuous supply of water there is need for the construction of storage tanks where by the water collected is channelled into a tank. This will reduce direct abstraction because a tap would be installed. Water from the tank can also be pumped to other areas thus minimising the work load on women and time spent in fetching water. Water in the tanks can also be treated to improve its quality.

The amount, availability and reliability of the supply systems need also to be improved. Tanks can be made using stones, rubble and sand (found in the area) with a little cement. The dams also need better and stronger fences like barbed wires instead of thorns to prevent animals from gaining direct access to the source, also cattle troughs should be constructed near the dams. The embarkment used for holding water should also be reinforced by use of stones or bricks which are readily available to prevent collapsing. On the check dams, there is need for planting trees on either sides of these dams and also appropriate soil conservation methods practised (Figure 14).

Fig. 14 : A WELL PROTECTED CHECK DAM



LEGEND

Trees

Not drawn to Scale

Women should also fully participate in the decision making process just like men. However this would involve creating awareness especially relating to their rights as decision makers since most women in the study area believe that decision making is mens business. This can be achieved through the Ministry of Culture and Social Services.

The above recommendations should be carried out in a manner which secures the support of the users, conserves scarce financial resource and avoids adverse environmental consequences.

5.3.1 Areas for further research

(a) This study (Surface Water Resources in Yatta Division: Accessibility, Variations, Utilization and conservation aspects) can be redone using a larger sample size, different data collection methods and analysis and the results compared.

(b) Further reseach can be carried out on other resources especially the conservation of soil and vegetation in Yatta division. Research on energy use and conservation should be done due to excessive felling of trees in the area. Such a research can come up with strong recommendations which can reduce over use of tree resources and at the same time prevent soil erosion.

(c) Crop production in the study area is mainly rainfed by small scale farmers. Research can be done on water conservation techniques for crop water use and crop water demand. This can also be extended to large farms where irrigation is done like the National Youth Service irrigation plots,

privately owned large scale irrigation or patch work of small scale irrigation farming.

(d) Water use in other commercial rural sectors especially brick making and its implication on water resources should also be studied.

(e) Most of the respondents in the study area were complaining of water pollution and other water related diseases affecting both human and livestock. There is need therefore for research on the analysis of surface water quality if the health of the people and their livestock is to improve.

(f) Research can be carried out on surface water conservation with emphasis on traditional / indigenous modes of community participation.

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APPENDICES

APPENDIX A :HOUSEHOLD QUESTIONNAIRE

KENYATTA UNIVERSITY

FACULTY OF ENVIRONMENTAL STUDIES

P.O. BOX 43844

NAIROBI

Dear Sir/Madam,

The aim of carrying out this research is to enable us to identify the role played by your community in water conservation activities. This information will be important in making recommendations and giving constructive suggestions on how community participation in water conservation activities can be improved in order to increase the amount of water available through conservation. Your opinions/views on the current water situation and how the community participation in water conservation activities will be highly appreciated. The information will be treated as confidential.

COMMUNITY PARTICIPATION IN WATER CONSERVATION ACTIVITIES IN YATTA DIVISION

Household Number_____

Location_____

Sublocation_____

A PERSONAL INFORMATION

1. Sex_____ (Male/Female)

2. Level of education (Tick one)

No formal schooling	
Primary	
Secondary	
College/University	
Post - secondary	

3. Occupation_____

4. What is your monthly income?

Under 500/-	
500-1000/-	
1001-1500/-	
1501-2000/-	
2001-2500/-	
Over 2500/-	

5. What is the size of your family (Children and Adults)?

Total_____

6. Which types of animals do you keep?

Type	Number
a)_____	_____
b)_____	_____
c)_____	_____

d)_____ _____

B WATER SOURCES

7. a) Which type of water sources do you have?

(Tick the ones you have)

Rivers/Streams	
Sub-surface water (on river-beds)	
wells	
Rainwater	
Small dams	
Springs	
Others	

b) Other than the natural water sources which water outlets do you have?

Bore holes	
Stand pipes	
Water kiosks	
Water vendors	

c) Which sources do you utilize for

Domestic use_____

Livestock use_____

d) Why do you prefer the particular sources for the above sectors mentioned in (b)

Domestic use_____

_____

Livestock use_____

_____

_____

8. a) What is the distance of the sources from your home?

For domestic use_____ (km)

For livestock use_____(km)

b) How long do you take to and from the main water source?

1-3 hours ☐
4-6 hours ☐
7-8 hours ☐
More than 8 hours ☐

c) Do you queue to get the water?

Yes ☐
No ☐

If yes how long do you take queueing _____ (hrs) and why do you have to queue_____

_____

_____

9. a) Do you pay for water at the various sources/outlets?

Yes ☐
No ☐

b) If yes whom do you pay?_____

c) How much do you pay?_____

d) At which sources do you pay for water?_____

10 How reliable are the water sources in your area?

Not reliable ☐
Reliable ☐
Very reliable ☐

11. Are there alternative sources of water during the drought season?

Yes ☐
No ☐

If yes, which ones?_____

12. a)What problems do you encounter at the water sources?

_____

b) What do you do to protect the water sources?_____

_____

_____

13. In your opinion, what should the government and donor agencies do to protect the water sources?

_____

_____

C WATER USES AND CONSERVATION PRACTICES

14. What are some of your domestic water uses

(Tick all the relevant ones)

Cooking	
Washing	
Bathing	
Others	

15. How much water do you use at the domestic sector per day in litres?_____

16. How long does the water fetched last

1 - 2 days	
3 - 4 days	
4 - 5 days	
over 5 days	

17. How much water is consumed per

cow_____

goat_____

sheep_____

18. What other water conservation techniques do you practice? (Tick the ones you practice)

Planting trees	
Protecting water sources	
Mulching	
Terracing	
rainwater harvesting	

19. Do you harvest rainwater for

Domestic_use_____(Yes/No)

Livestock_use _____(Yes/No)

20. How do you store the water harvested for

a) domestic use?

Tank	
Pot	
Plastic containers	
Others	

b) Livestock use?

Dams	
Troughs	
Rock catchments	
Ponds	
Others	

21. a) What problems do you face in practicing the above conservation methods?

_____

_____

b) How serious are those problems?

Very serious	
Not serious	
Just serious	

22. How do you solve the above problems?

23. In your opinion what should be done to solve the above mentioned problems?_____

_____

_____

D COMMUNITY PARTICIPATION

24. Is there a community based self help group in your area?

Yes	
No	

25. a) What does the community group do to improve the water situation in your area?
(Tick all activities undertaken)

Construction of water sources	
Financing of the water sources	
Protecting the water sources	
Planning for the water sources	

b) How much do you contribute per month for the operation and maintenance of the community based water Sources?_____

_____

26. Are there agencies involved with the improvement of water facilities in the area?

Yes	
No	

If yes, please specify

27. Do you participate in any of water conservation activities?

Yes	
No	

If yes what is the routine of your participation?

Planning Stage	
Financing	
Construction/Implementation	
Management (Operation & Maintenance)	

And if you do not participate please explain why_____

28. Do you participate in deciding the location of the water conservation projects?

Yes	
No	

If yes, how do you decide on the appropriate location?

29 Do you participate in the construction of water conservation projects?

Yes	
No	

If yes, how do you participate?

Voluntary	
Paid labour	
Paying cash for construction	

30 a) At what stage do you finance the water consevation projects in your area? (Tick the appropriate answers)

Construction Stage		
Fetching		
Operation and maintenance		
Others		

b) How is the payment done

Individual basis	
Collective basis	
Community based organization	
Others	

c) How much do you pay?_____

Is the amount you pay for the water high, low, sufficient?

d) Are there penalties for non-payment?

Yes	
No	

If yes, please specify_____

31. Have you received any training on how to conserve water?

Yes	
No	

b) If yes what kind of training have you received?

Technical (as local care taken
Administrative (eg. in Payment & Collection

(Please tick one or both)

c) What kind of water conservation methods have you been trained to manage_____

_____

32. a) Do you experience any technological constraints during the operation and maintenance?

Yes	
No	

b) If yes, why do you experience these constriants?

Because of the (please tick the problems experienced)

Type of technology	
Availability of construction materials	
Affordability	
Operation of technology	

c) What happens if you cannot handle a particular technological problem?

Call for technical assistance	
Abandon	

33. What kind of cultural constraints do you experience in adoption of water conservation techniques?

Attitude towards a technology ☐

Denominational differences (eg. if the project is started by a church to which you do not belong)

34. Other than technological, financial cultural constraints, what other constraints do you experience?_____

_____

35. What do you do to solve the above problems?_____

36. In your opinion, what should the government, non-governmental organizations and churches involved do to promote community participation in water conservation in your area.

APPENDIX B: INSTITUTIONAL QUESTIONNAIRE

Name of institution:_____

Location_____

A. WATER SOURCES

1. What type of water supply system does your institution construct?_____

_____

2. What criteria do you use in choosing the location of these water facilities?_____

_____

3. Do villagers help in deciding water points and formation of users groups.

Yes	
No	

If yes, how do you reach the villagers? through

community leaders	
Existing village committees	
Schools	
Household surveys	
Church	
Others	
Please specify	

4. How effective have these institutions been in nobilizing the community to participate in water conservation activities?

Very effective	
Effective	
Less effective	

b) Please explain your answer in 4 (a) above_____

c) If they have been less effective what does your institution do to solve the problem?

_____

5. What are some of the factors you consider before giving a range of technologies and service level? (Please tick all the appropriate answers).

Needs and expectations of the local people	
Payment capabilities of the local people	
Maintenance capabilities of users and	
Organizational capacity of users	
Others	

If others please specify_____

b) What do you do when the community differ in their willingness and capacity to contribute the capital of a water source?_____

_____

6. As principal water collectors, users and managers how have the women been involved in decision making or large scale programming for water supply/sources?

B. WATER CONSERVATION

7. What is your institution doing to promote water conservation activities in the study area?

8. a) What types of water conservation techniques do you promote for domestic and livestock production

b) How sustainable have these techniques been?

Very sustainable	
Sustainable	
Not sustainable	

Please explain your answer_____

9. Does your institution educate and train the local people on water conservation activities?

Yes	
No	

b) If yes what kind of training do you offer

Technical	
Administration	
Others	

c) If No please explain why_____

_____

d) What is the ideal time for training the community? During

Planning	
Implementation/construction	
Management	
Maintenance	

e) Why do you think that the chosen training time is ideal_____

10. How do the government assist in promoting water conservation in the area?_____

11. What are some of the problems you encounter in promoting water conservation activities?

Institutional weakness	
Financial problems	
Communication problems	
Political problems	
Others (Please specify)	

12. In your opinion what can be done to solve these problems?_____

C. COMMUNITY PARTICIPATION

13. What has been the background of community participation in Machakos district especially Yatta Division?_____

14. Does your institution involve the community in all the water conservation activities you undertake?

Yes	
No	

b) If yes, at what stages do you involve them?

Conception	
Planning	
Financing	
Construction/implement ation	
Management (Operation & Maintenance)	
Others (please specify)	

_____

15. Who assists in the preliminary design of community participation?_____

16. How does the community participate in construction of water facilities?

Voluntary labour	
Paid labour	
No labour	

17. What activities are needed to reach those who may be inhibited from participating?

Use of communication channel to promote attendance
Discussing with local leaders
Holding meetings at a time convinient for all
Others (please specify)

18. What is the major source of your finances?

Community
Donor agencies
Government
Church
Others (please specify)

19. Does the community pay for the water supply facilities?

Yes
No

If yes, at what stages do they pay?

Planning
Implementation/construction
Operation and maintenance
At the water sources

20. How is the payment done? On

Voluntary contribution
Individual basis (Regular user payment)
Collective basis (community based org.)
Others (please specify)

b) What are the set rates for payment?

Flat rates (all pay the same)	
Weighted (according to benefit /payment capacity)	

c) Approximately how much is paid in each of the above

Flat rates Ksh	
Weighted rates Ksh	

21. Who collects the money?

Village commitee	
Water user group	
Community leaders	
Donor agent	

22. Are there community based maintenance groups?

Yes	
No	

23. Do you assist the community in the maintenance of the water facilities

Yes	
No	

b) If yes, how often do you assist them

Daily	
Weekly	
Monthly	
Half yearly	
Yearly	

c) What kind of assistance do you provide?

Technical support	
Spare parts supply	
Routine serving	
Provide area mechanics	
Others (please specify)	

24. How does technology influence the level of acceptance and community participation?_____

25. Do you experience any cultural constraint in your efforts, to promote various conservation techniques?

Yes	
No	

b) If yes which ones

Gender bias	
Local attitude	
Others (specify)	

c) How have these constraints affected community participation and water conservation activities in the area?_____

26. In your opinion what can be done to alleviate the above constraints?_____

_____

27. What are your achievements in promoting community in water conservation activities?_____

_____

_____

APPENDIX C

A CHECK LIST FOR THE AVAILABLE WATER SOURCES

WATER SOURCES	AVAILABLE YES/NO	FUNCTIONAL YES/NO	PHYSICAL CONDITION	MANAGEMENT (PROTECTION)	SEASONALITY	MAIN USES	GENERAL REMARKS
Boreholes							
Dams							
Ponds							
Rain water Tanks							
Rivers/stream							
Springs							
Stand Pipes							
Subsurface Dams							
Water Kiosks							
Wells							

APPENDIX D: OBERSERVATION SHEET 2: HOUSEHOLD WATER CONSERVATION ACTIVITIES

LOCATION----------

NAME----------

SUBLOCATION----------

NUMBER

HOUSEHOLD (HH)	TYPE OF ROOF (CORRRUGATED/GRASS THATCHED)	OBSERVED WATER USES	WATER CONSERVATION
H H 1			
H H 2			
H H 3			
H H 4			
H H 5			
H H 6			
H H 7			
H H 8			
H H 9			
H H 10			
H H 11			
H H 12			
H H 13			
H H 14			
H H 15			
H H 16			
H H 17			
H H 18			
H H 19			
H H 20			

APPENDIX E: HOUSEHOLD INTERVIEW SCHEDULED

Location

This was mainly used in the dry season to obtain additional information

1. Where do you get your water for domestic and livestock use in the dry season?
2. How accessible are these water sources?
3. How much water do you use in the domestic and livestock sectors in the dry season?
4. Is the amount consumed in the above sectors sufficient?
5. What do you do to offset the deficit?
6. Do you have any other water related problems?
7. What do you do to alleviate the problems mentioned above?
8. Which water related activities do you practice in the dry season?