Socio-economic Impacts of the Construction of Sand Dams on Communities in Kitui District, Kenya

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Summary

It is expected that climate change will threat food security and water availability in large parts of Africa. In order to secure these basic needs for livelihood, various adaptation strategies that cope with these possible impacts of climate change are tested by policy makers on efficiency and sustainability. This report is part of an integrated and long-term research program (ADAPTS) concerning the adaptive capacities of developing countries with respect to climate change and local water policies. The potential adaptation strategy described in this report is the construction of sand dams in seasonal rivers in Kitui District, Kenya. The majority of the population in Kitui District depend on the rivers for their water supply. Most of these rivers are seasonal and only hold water during the wet season. Especially during prolonged dry periods the local people are forced to walk long distances to bigger rivers still containing sub-surface water. A local NGO 'The Sahelian Solutions Foundation', also known as SASOL, assists local communities with the construction of small-scale sand dams. The sand dams are built in the seasonal rivers, increasing the local storage capacity of the sandy aquifer and so retaining water in the dry periods. The water can be retrieved from the riverbed by digging wells or holes (scoopholes). Hydrologic research on sand dams measured an increase from 500 m^3 to 2.800 m^3 of stored water as a result of the construction of the sand dams. During the last 10 years SASOL has helped with the construction of sand dams in large parts of district, providing ca. 65.000 people with better access to water. The material costs per dam are about U$ 5.000 and one dam offers water to about 150 people, adding up to a total investment of U$ 35 per capita.

The main aim of this study is to evaluate the social and economic impacts of the sand dams exerted on the communities. This was done by a number of household interviews held in two catchments: Kiindu catchment with sand dams and Koma catchment without sand dams. The effects of the sand dams were quantified in two ways. First of all, to make a comparison between the situation before and after dam construction, the questionnaire used in Kiindu catchment contained questions on the current situation (2005) and on the situation before dam construction (1995). Secondly, to rule out changes in the socio-economic standing of the community not inflicted by the sand dams, the questionnaire used in Koma catchment compared the current situation (2005) to the situation in 2000.

The results of the socio-economic research show clear evidence that the construction of the sand dams has led to a variety of benefits for the communities in Kiindu catchment. It also shows that the socio-economic situation in Koma catchment stayed the same over the last five years.
The main aspect of the sand dams is the retention of water within the riverbed. This retention has led to an increase in water availability throughout the year. For the community, the two most important benefits of this aspect are 1) an increased quantity of water available for various activities (like irrigated agriculture, tree nurseries and brick making), and 2) a shorter distance to the water source. Because of this decreased distance, the households save on average about 150 minutes per day with fetching water. The majority of households (43 percent) spent this time for new, non-agricultural activities.

The economic benefits are a result of the increased water availability and the extra time household save from fetching water. There are several agricultural and non-agricultural changes noticeable, most of the time these changes generate extra income and lead to an improved standard of living. A striking change is the increase in households growing irrigated crops; this increased from 37 to 68 percent of the households. Another important change is the percentage of households planting new (fruit)-trees. Brick

making, bee keeping, basket weaving and tree nurseries are some examples of non-agricultural activities initiated by the households.

On average, all these agricultural and non-agricultural activities add up to an extra income of 9000KSH the households earn per year. This comes down to approximately 17U$ per capita. This increase in the standard of living in Kiindu catchment can be seen when the household inventories of both catchments are compared: the increase in both practical assets and assets for leisure in Kiindu catchment is impressive, whereas in Koma catchment there is only a small increase. The social benefits for the community are mostly in the form of an increased health-standard and a more structured community-organization in groups

1 Introduction

Climate change is expected to worsen food security and water availability in large parts of Africa, mainly through increased extremes (i.e. droughts and floods) and temporal and spatial shifts in climate [IPCC, 2001]. Policy makers face the task of ensuring water availability and food security, while taking into account the possible impacts of climate change. It is therefore important to evaluate potential adaptation strategies on efficiency and sustainability. This study is a case study on one of these potential adaptation strategies to climate change: the construction of sand dams in seasonal rivers in Kitui District, Kenya.

Large parts of Kenya suffer from water shortage. Although the annual amount of rainfall (500 to 1100mm/y) is adequate, it falls in two rainy seasons (October – December and April – May). Between these rainy seasons drought is a serious problem for the people in the rural areas. The rain, which falls in short events, hardly infiltrates the ground and disappears as runoff into the river that stands dry for the remaining of the year. Climate change is expected to increase variability and reliability of the rainy seasons [IPCC, 2001], making local storage of water increasingly important.

This research paper is part of an integrated and long-term research program (ADAPTS) concerning adaptive capacities of developing countries with respect to climate change and local water policies. The main research-subject of this report is the Sand Dam Project in Kitui District in Kenya: an evaluation of the social and economic impacts the sand dams exert on the community.

1.1 Background

1.1.1 ADAPTS

The ADAPTS program is an initiative of the IVM (Institute for Environmental Studies). The main aim of the program is ‘increasing developing countries’ adaptive capacities by including climate change and adaptation considerations in water policies at the local scale’. The program first identifies successful local water management activities and evaluates the robustness of these activities under current and future conditions. The program will stimulate additional adaptations to make these local actions more sustainable and less vulnerable to climate change impacts.

The Kitui Sand Dam Project and the involved NGO (Sahelian Solutions Foundation, also known as SASOL) in Kenya is selected as one of the pilot areas for the ADAPTS program.

1.1.2 Sahelian Solution Foundation

The Sahelian Solutions Foundation (SASOL), a local NGO in Kitui, helps local communities with the construction of small-scale sand dams to increase the water-storing capacity of seasonal rivers. The main goal of SASOL is to reduce the distance to water sources for the entire Kitui District to less than 2 km and improve the overall water availability.

During the last 10 years, SASOL has developed around 450 dams within the Kitui District and succeeded to reach their goal for large parts of the District. On average, the material costs per dam are U$ 5.000. Besides this the community provides raw materials such as stones, water and sand and labour.
In the dry season these dams offer water to an average of 150 people per dam. This adds up to a total of 65.000 people that have access to water during the dry season, with an investment of U$ 35 per capita [Aerts & Lasage, 2005].

1.1.3 Sand dams

In Kitui District most of the population depend on the rivers for water supply. As most rivers in the district are ephemeral, water is not available throughout the year [Mutiso, 2002]. In the dry periods the water level is very low and water can only be found if holes are dug in the riverbed (also known as scoopholes). During prolonged dry periods, however, in some catchments (like Kiindu and Koma) there is no water left in the river at all, forcing the local people to walk long distances to bigger rivers that still contain sub-surface water.

In order to retain water in dry periods, dams can be built, behind which surface water is stored. Arising problems with storing water as surface water include high evaporation rates and contamination. However, water that is stored in subsurface aquifers does not suffer from these problems. Enlarging the sub-surface aquifer in a riverbed can be realised by building a sand dam (Figure 1.1). A dam is built in the riverbed all the way to the underlying bedrock. Behind this dam, providing local conditions are suitable, sand will accumulate. The dam obstructs the flow of groundwater and the water is stored in the pores of the sand. The water can be retrieved, as was done before, using scoopholes or wells [Borst & De Haas, 2006].

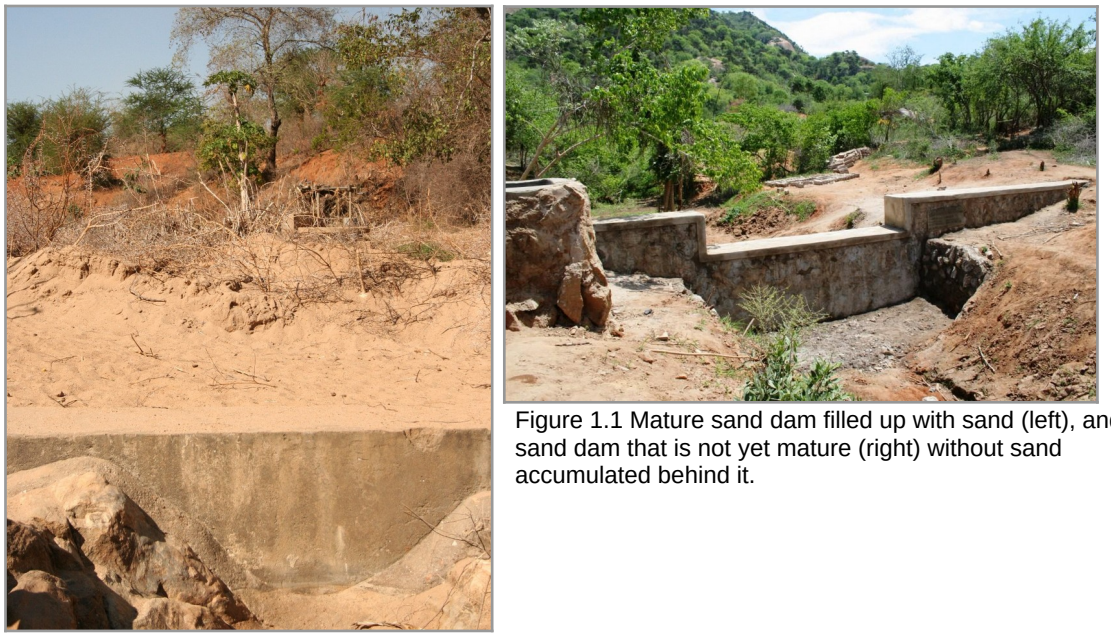

Figure 1.1 Mature sand dam filled up with sand (left), and a sand dam that is not yet mature (right) without sand accumulated behind it.

It is expected that sand dams have a positive effect on the involved communities. Small streams, which previously did not contain water throughout the year, should contain more water after the construction of sand dams, which can be used by the community. The amount of water in one specific dam in the Kiindu Catchment now contains 2800m^3 of water at the end of the wet season, where the river had only 500m^3 of water available in the dry season without the sand dams.
Because of this the distance to a water source becomes significantly shorter and the communities have access to (more) water throughout the year.

This increased accessibility of water should have an indirect positive impact on economic activities. The time and energy that is saved, is, for example, spent on agricultural improvements and activities, and on other economic activities, which generate extra income. Eventually this could lead to an increased land-output, more income, a more diverse and better food-pattern, and to an overall increased standard of living.

1.2 Research project

1.2.1 Context

The general benefits for the local communities seem to be obvious to all stakeholders. Both research on the hydrological consequences of the Sand Dam Project, as well as the socio-economic impact exerted by the sand dams on the communities is needed for possible expansion of the program to other parts of Kenya and eventually to other countries worldwide. For this expansion, insight into the structure of the project and of the institutional framework around it is also required.

The focus of this research paper is on the social and economic impact of sand dams. In addition, research will be done on the institutional framework around the Kitui Sand Dam Project and on community involvement in the project. The results of this research will be used in a best practice handbook on the Sand dam technique. This book will contain a description on how to organize the community involvement, the construction of the dams and the follow-up training. The aim of this book is to support the implementation of the sand dam technique in other areas.

The hydrological aspects are examined by Borst and De Haas [2006], as part of the project “Recharge techniques and water conservation in East Africa”. In this research a set of measurements is carried out to determine the working and effectiveness of the sand storage dams in the Kiindu River in the Kitui District.

1.2.2 Aim

The main aim of this study is to evaluate the social and economic impacts of the sand dams on the involved communities. These socio-economic impacts can be divided into five categories:

1. Changes in utilization of water;
2. Changes in time budget;
3. Changes in agricultural output;
4. Changes in non-agricultural output;
5. Social changes.

First of all, it is expected that the increased availability of water captured in front of the sand dam [Borst & De Haas, 2006], will result in a two-folded impact: 1) a change in the utilization of water by the nearby households, and 2) change in the time that is spent on fetching water. These impacts are the first two categories mentioned above, referring to the direct impacts of constructing a sand dam.
The third and fourth impacts are indirect consequences of the sand dam construction and have an economic base. With these two impacts, it is assumed that the households will use the changes in water availability and time for economic purposes. The economic impacts are either agricultural or non-agricultural.
The last impact mentioned above is social change. These social changes include health and community organization

1.2.3 Research Questions

The main aim will be investigated with help of the following research questions:

1. Changes in utilization of water:
   - Has the construction of sand dams changed the utilization of water?

2. Changes in time budget:
   - Is there a change in time that is spent on fetching water after construction of the sand dams?
   - Has the construction of sand dams influenced the use of time for the households in the community?

3. Changes in agricultural output;
   - What are the main subsistence crops and cash crops? Has the harvest of these crops changed after dam construction?
   - Is there a shift in planting of crops?
   - Has the construction of the dam led to changes in livestock keeping?
   - Is there a trade-off between agriculture and livestock as a result of the construction of sand dams?

4. Changes in non-agricultural output:
   - Has the number and the type of non-agricultural activities changed?
   - Is there a notable change in the inventory of households and the type of housing as a result of dam construction?

5. Social changes:
   - Is there a change in the health situation of the community?
   - Does the construction of sand dams have an impact on drought-coping mechanisms used by the community?
   - In what way has the construction of the sand dam changed the organization of the community in active groups?
   - Is there a notable, overall change in the average standard of living before and after the construction of the sand dam?

2 Study Area

Kitui District is one of the 13 districts in the Eastern province in Kenya. It is located in the southern part of Kenya (Figure 2.1). The District shares borders with Machakos and Makueni Districts to the West, Mwingi District to the North, Tana River District to the East and Taita Taveta District to the South.

Kitui District is located between latitudes 0º 3.7' and 3º 0' South and longitudes 37º 45' and 39º 0' East. The total surface area is approximately 20,400 km^2, of which more than one-fifth is part of the uninhabited Tsavo National Park. The District is divided into 10 administrative divisions. The capital of the District is Kitui Town, located in the North of the District, about 150 km East of Nairobi.
The District has approximately 550,000 inhabitants according to the 2002 population consensus. The average population density is 80 persons/km^2, ranging from 6 persons/km^2 in the division including the Tsavo National Park, to 153 persons/km^2 in the Central Division (including Kitui Town and the research area). The population growth rate was 2.2% a year in 2002 [Kitui DDP, 2002].

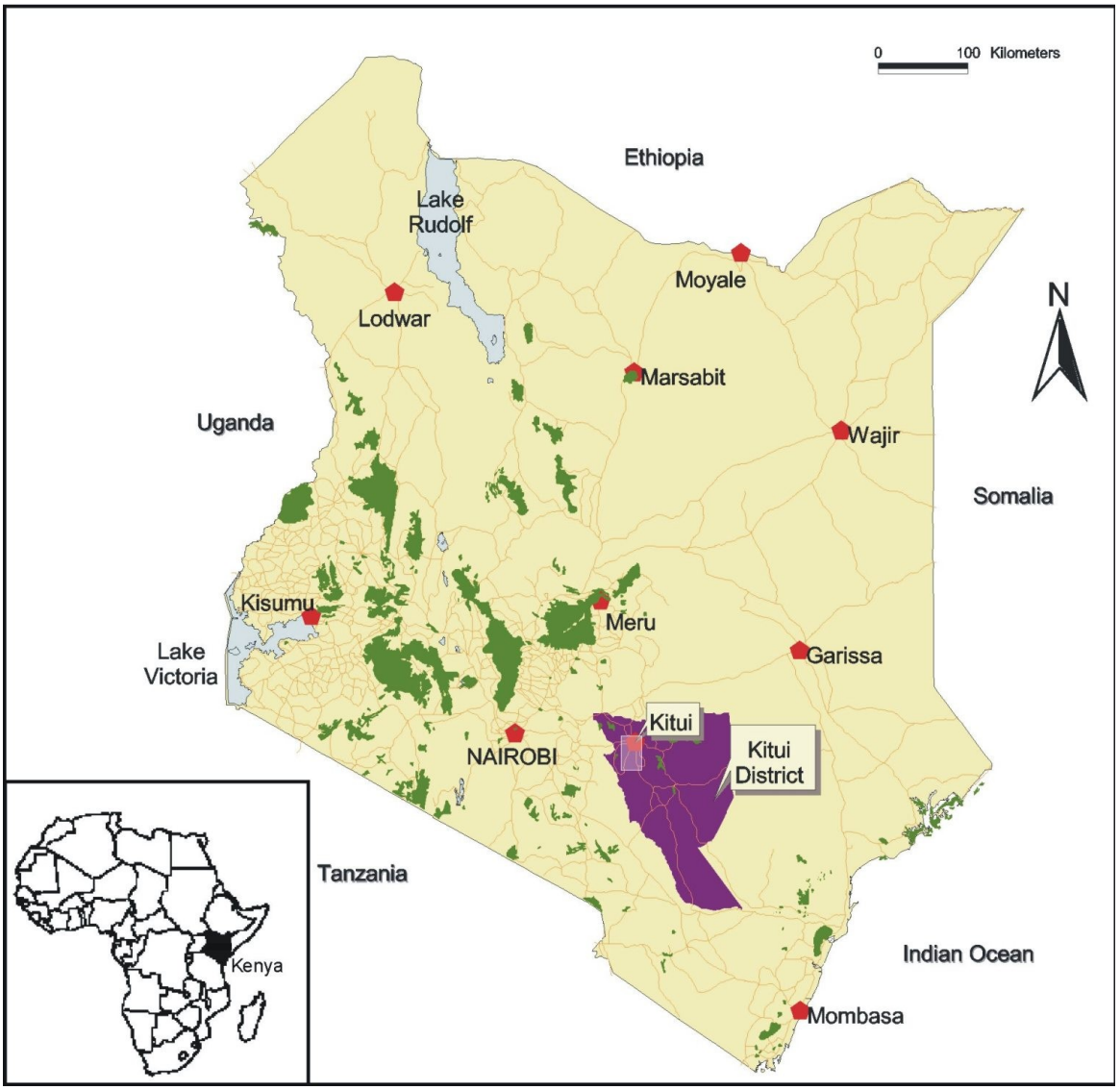

Figure 2.1 The Kitui District situated in the Southern part of Kenya. The light purple rectangle near Kitui Town indicates the research area (Fig 2.2).

2.1 Kiindu Catchment

The socio-economic research was carried out around the Kiindu River; a seasonal river situated about 10 km South of Kitui Town in the sublocation Mulango (Figure 2.2). The research area is located between the towns Wikililye in the North, Mulango and Kyangunga in the East and Yakalia and Kangula in the West. The Kiindu River is a relatively small river, with a total length of 16 km, flowing downstream to the South into the Nzeeu River. The Kiindu River catchment is about 37 km^2 and varies in elevation between 950 and 1140 m above sea level.

Within the Kiindu catchment SASOL has constructed 20 sand dams to increase water availability in the area. These dams were built around 1995, which means the sand dams are all matured and filled up with sand. Furthermore, the communities have had enough time to adjust their water usage to the increased amount of water available.

2.2 Koma Catchment

Koma River is the second catchment area selected for the socio-economic research. This seasonal river is located about 16 km South of Kitui Town in the sublocation Mulango, approximately 6 km South-West of the Kiindu catchment (Figure 2.2). The Koma River has a total length of 20 km, and flows southwards into the Nzeeu River. The total area of the catchment is roughly 50 km^2, with an elevation varying between 1000 and 800 m above sea level.

The soil of the Koma catchment has a higher clay-content compared to the Kiindu catchment, and also the bedrock is situated deeper under the surface. These two features make the catchment unfit for the construction of sand dams. The high clay-content of the soil means porosity and water storage capacity are low. The depth of the bedrock means that it is more difficult and expensive to build a dam.

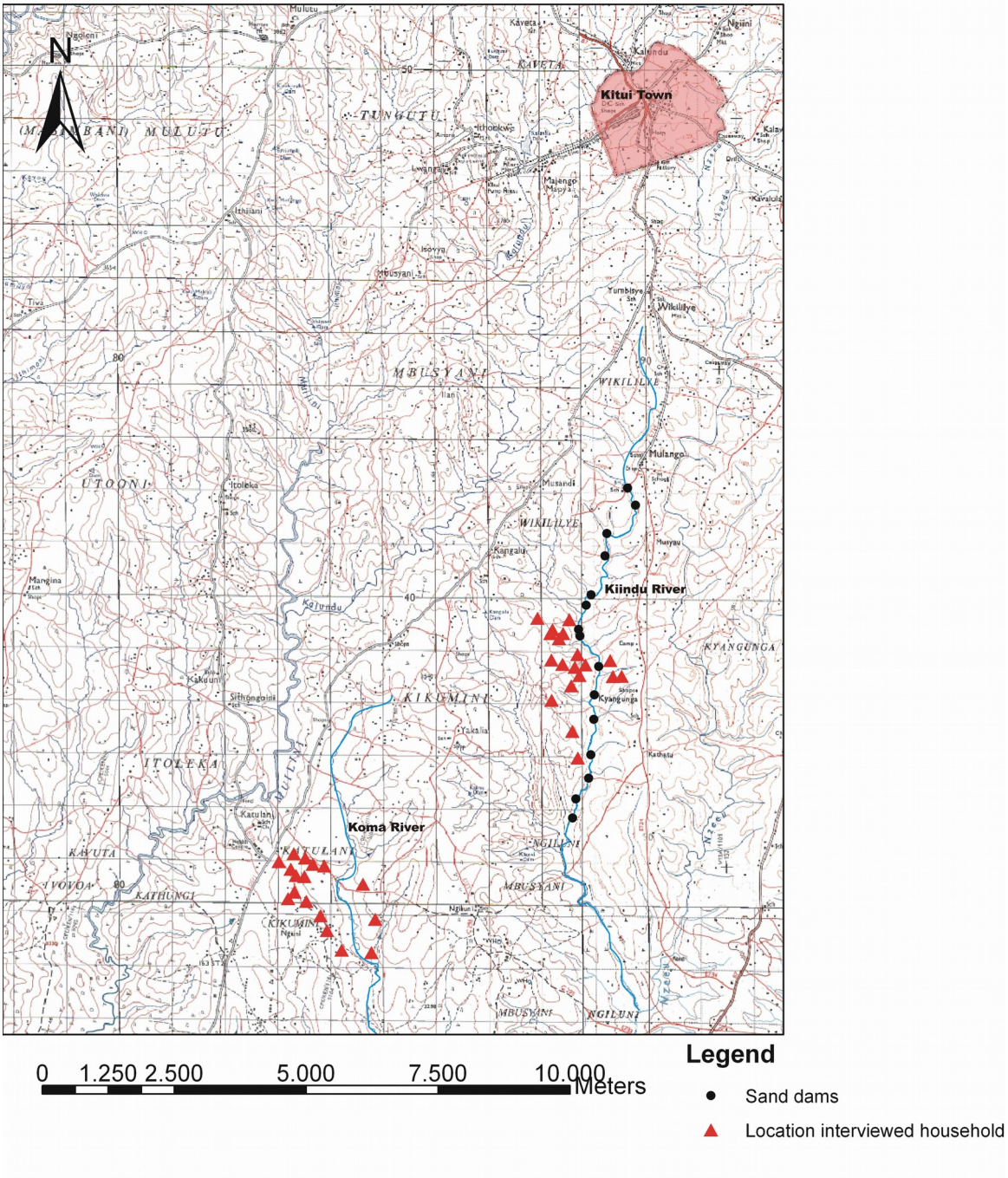

Figure 2.2 Locations of Kitui Town, Kiindu catchment and Koma catchment. The dams in this figure are not all the dams in Kiindu catchment.

2.3 Topography and Climate

The Kitui District is situated in a semi-arid area with a gently eastward-facing slope. The higher, upland area in the West covers the Yatta plateau with elevations varying between 600m and 1800m above sea level. The central part of the District, which includes the research area, is made up of hilly ridges separated by wide low-lying areas with altitudes between 600m and 900m. The lower area consists of an Eastward sloping plain, with some isolated Inselbergs. The elevation in these lowlands varies between 400m to 600m above sea level [Kasperson et al, 1995].

Because of the difference in altitude, the climate can be divided into two climatic zones [Louis Berger International Inc., 1983]. There is a semi-arid climate in the Western part of the District, where the rainfall is higher and the temperature lower. The Eastern and Southern parts of the District have lower average rainfall and higher temperatures; and therefore fall within the arid climatic zone.

The rainfall pattern is bimodal, ranging from 500 to 1050 mm/yr, and is highly erratic and unreliable. The long rains last from April to May and the short rains from October to December, with the last being more reliable. The driest periods are from June to September and from January to March.
Elevation and topographical features of the landscape strongly influence the amount of rainfall at a regional scale (Figure 2.3): the higher areas and hill masses in the West receive most rainfall (between 700 and 1050 mm/yr), these amounts decline to the South and East where the annual rainfall is less than 500 mm [Kitui DDP, 2002].

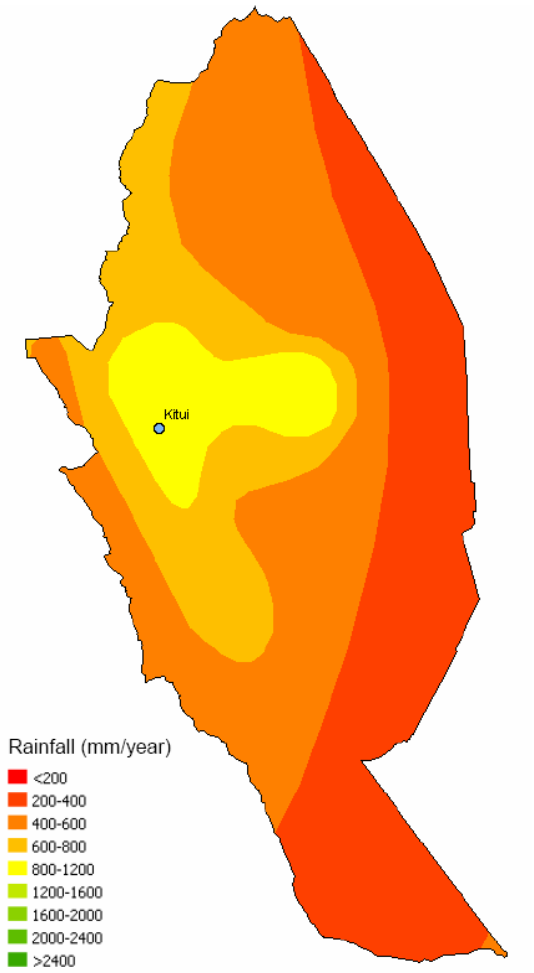

Figure 2.3 Annual rainfall distribution within the Kitui District. [Borst & De Haas, 2006]

The seasonal and annual variations within the District are very high and rainfall is strongly influenced by the topography, making the rainfall received in Kitui District unreliable in amount and in both spatial and temporal distribution. This explains why it is not uncommon for rains to fail, causing long periods of drought, which often result in crop failure and food shortage. Local lore states that rains completely fail at least one year in four [Thomas, 1999]

Temperatures in the Kitui District are high throughout the year, ranging from 16 °C and 34 °C [Kitui DDP, 2002]. The warmest periods are between June and September and January and February. The mean annual temperatures in the southern and eastern parts of the District are generally ca. 4 degrees Celsius higher compared to the temperatures in the western parts.
These overall high temperatures in combination with the low and erratic rainfall, result in high rates of evaporation estimated around 1800 mm/yr [Kitui DDP, 2002].

2.4 Geology and Soil types

2.4.1 Regional Setting

Like the whole of Eastern Kenya, metamorphic and igneous rocks, also known as the basement complex system, mainly characterize the geology of the Kitui District. This basement system consists of various types of Precambrian sediments metamorphosed into gneisses, schists, quartzites and marbles. The Inselbergs found in the District comprise of alkaline rocks and other intrusive rocks, which are more resistant to erosion than the surrounding deposits. The Southern side of the District is primarily composed of Permian deposits, while in the Western part tertiary volcanic rocks are dominant, extending into the Machakos District.

Continuous processes of erosion have eroded and shaped the landscape, creating the hills, ridges and Inselbergs. These morphological features have a considerable influence on the distribution of deposits. The Tertiary and Quaternary deposits can be found on top of the hard rock, especially on the hill slopes and in the riverbed. [Munyoki, 2003]

2.4.2 Local Setting

The geology of the Kiindu catchment consists mainly of gneisses (granitoid gneisses and biotite gneisses), intersected with pegmatite veins and locally some quartzites. The bandwidth of the gneisses differs from half a meter to tens of meters, with a general structural trend of 0° to 35° [Borst & De Haas, 2006].

The riverbed is filled with coarse sand (ca. 600 µm), an erosion product of the different local lithological units. The sand forms a phreatic aquifer with a thickness varying from several centimeters to over 2 meters. This sand accumulates behind the sand dams. This coarseness means that there is a lot of pore space, which can hold large quantities of water.

The geology of Koma catchment is very similar to that of Kiindu. The main difference being that the riverbed is not filled with coarse sand, but with more clayey material. This makes the river unfit for the construction of sand dams.

2.4.3 Soil types

The red soils (Lixisols) are the most common soils in the District. They are derived from metamorphic rocks of the basement complex system (predominantly gneisses). Red sandy loams cover the Eastern and Central parts of the District. The red soils in the East are relatively low in natural fertility, but rich in sodium, making them highly suitable for grazing. The soils in the Central parts of the District are usually high in fertility, but are not intensively used for agricultural production due to the lack of water [Munyoki, 2003].

Alluvial deposits (Fluvisols) generally occur in isolated patches along rivers and on hill slopes. These so called black cotton soils consist mainly of clays (from silty loams to silty clays loam). The black cotton soils are found in the Western part of the District. In the South shallow stony soils exist, with rock outcrops alternated with the black cotton soils and light brown sandy loams.

The drainage of all these soils is very poor, and many are highly erodible; resulting in high overland run-off and erosion. Therefore big parts of the soils are highly degraded and eroded, with gullies through the soils to the bedrock. This also results in low infiltration of rainwater on the valley sides and the banks of rivers. [Borst & De Haas, 2006].

2.5 Hydrology

The erratic rainfall pattern in combination with the storage capacity of the system in the Kitui District, results in scarce surface water sources and groundwater resources. There are two perennial rivers, the Athi and the Tana. The latter being the largest river in Kenya, draining most of the Kitui land area. The Athi River, forming the Western boundary of the district, flows along the border with Machakos District and drains only a narrow strip of Kitui District. Both rivers discharge to the Indian Ocean [Kitui DDP, 2002].
For the majority of the population in the Kitui District the seasonal rivers are more important. These seasonal rivers only contain water during the rainy seasons and slowly dry up after the rainfall due to evaporation and infiltration. Most of the seasonal rivers are generally dried up within a month after the rainy season [Borst & De Haas, 2006]. Some dry riverbeds still contain sub surface water throughout the year. Water is abstracted by digging scooping holes in the sand (Figure 2.4).

Figure 2.4 People using scoopholes to extract water from the riverbed in Athi River in the South of Kitui District.

The discharge of the rivers in the district is characterized with high flows in April-May and November-December, and with extremely low or no discharge in the dry periods. This strong seasonal character, in combination with immediate run-off from the hills caused by lack of terraces and lack of vegetation, often results in flash floods, which transport large amounts of sand and silt [Munyoki, 2003].

Metamorphosed Precambrian rocks underlie most of the Kitui District. These rocks form poor aquifers. The Quarternary superficial deposits on top of this consist of alluvium and Quarternary deposits. Both form very good aquifers as they consist of usually coarse material overlying the bedrock. The aquifers are only recharged by rainfall.

The underground water sources supplement the scarce surface water sources through drilling boreholes.

2.6 Vegetation

The vegetation in the District is drought resistant, consisting predominantly of semi-arid deciduous thicket and bushland. In the driest areas (below 900 mm/year) the thorn bushes grade into semi-desert vegetation. The vegetation consists mainly of Acacia's and other thorny bushes (for example Acacia spp., Terminalia combretum and Commiphora spp.) in grassland [Borst & De Haas, 2006]. These trees and bushes are also the main vegetation in the study area. Close to the river more types of vegetation occur.

Most of the hills were once forested, but have been cleared for agricultural purposes, leaving only patches and corridors of forest as well as dry forest in vast grazing lands. Forestland covers little less than 18.000 ha, serving mainly as water catchment areas [Kitui DDP, 2002].
At present, the local people are still cutting down trees and shrubs for firewood and building material. This results in large areas of bare land, which are more vulnerable to erosion.

2.7 Agricultural Potential and Poverty

The biophysical agricultural potential is mainly a function of soil characteristics and moisture availability, both being largely controlled by elevation and topography [Kasperson et al, 1995]. Within the Kitui District only 2% of the land has a high agricultural potential, and 32% is of medium potential [PRSP, 2001].

The District is one of the poorest regions in Kenya, with the income of 65% of the inhabitants lying beneath the poverty line of 2 dollars a day [Kitui DDP, 2002]. A study in 1992 found that the average yearly income in Kitui District was around 15000 Kenyan Shillings (190USD) [International Development Studies Roskilde, 1992]. Agriculture is the main economic source of income for 80% of the population. These agricultural activities are strongly dependent on rainfall, because most agriculture is rain fed. The major food crops are maize, beans, sorghum, pigeon peas, cowpeas, cassava, green grams and millet. Maize and beans are mostly grown in the higher and central parts of the District, with relatively high rainfall. In the lower areas, millet and cowpeas are the major food crops.

Due to the low availability of water sources, the production of irrigated (cash) crops within the District is relatively low. This activity is mostly done on small isolated plots along the river. Irrigated crops are tomatoes, kale, cabbage, spinach and onions. Some of this production is sold on the local markets, while the rest is grown to supplement the diet of maize and beans. Other cash crops are cotton, mangoes, pawpaws, bananas and citrus fruits.

Another form of agriculture is a tree nursery, in which tree seedlings are grown on an irrigated plot until they are large enough to be able to cope with drought without being irrigated (Figure 2.5). After reaching this point, the seedlings are planted higher up in the valley, or sold. These tree nurseries are usually kept near the riverbanks and are often a group activity. The group, (usually women) irrigate the seedlings together and, when they are large enough and the young trees are sold, the money is divided between them. Besides the economic benefits for the households involved, the planting of trees in the area is also beneficial to the environment. The trees are used for fuel (firewood), construction, windbreaks, shade on the homesteads and for the fruits, which can be sold or consumed to supplement the diet. The leaves of the trees can also be used as fodder for livestock.

Because of the arid climate, keeping livestock is the second major economic activity. The majority of the households in the Kitui District keep cattle, goats and donkeys. Cattle and goats are mainly kept to be sold in the dry period, rather than for consumption. Milk production is generally minimal, but can be consumed or sold at the local market. The latter is mainly kept for transport of goods and for fetching water in the dry season. Bee keeping, basket weaving and charcoal burning are other important economic activities practiced in the area. [PRSP, 2001]

Figure 2.5 A tree nursery at Kiindu river.

Due to the recurring drought in vast parts of the District, it experiences food deficit and food poverty most of the year. During the dry periods the harvest of the farmers is supplemented through relief food from government and donor agencies.

3 Methodology

This chapter describes the methodology used in this research project. In the survey a number of household interviews were held in two catchments. As the aim of the research is to quantify the socio-economic effects of the construction of sand dams in a catchment; two catchments, one with sand dams and one without, were selected. The effects of the sand dams are distilled from the results of the questionnaires in the two catchments in two ways.
The questionnaire in the Kiindu catchment contains questions on the current situation and on the situation before the construction of the dams, respectively the year 2005 and 1995. By comparing these two, the effects of the construction of sand dams become visible.
The questionnaire in the Koma catchment, where no dams were built, contains the same questions, but these compare the situation at the time of the interview to the situation five years ago, the years 2005 and 2000 respectively. This information can be used to rule out changes in the socio-economic status of the community, which are not due to the construction of sand dams.

3.1 Indicators

The first step in making the questionnaire was to formulate a set of indicators that could be used to test the socio-economic status of the communities with and without sand dams. In addition to this, for the catchment with dams, indicators should be able to test the influence of these dams on the community.
To make the list, earlier studies were consulted to find the indicators, which can supply information about the socio-economic status of a household. The book '*Designing Household Survey Questionnaires for Developing Countries'* from the World Bank Group contains questionnaires used to measure and monitor poverty, employment and unemployment, school enrolment, health and nutritional status, housing conditions, and other dimensions of living standards [International Bank for Reconstruction and Development / The World Bank Group, 2000].

Indicators that would apply to the aim of this study were taken from these questionnaires and changed to fit the specific situation in Kitui. The indicators are organized as shown in figure 3.1.

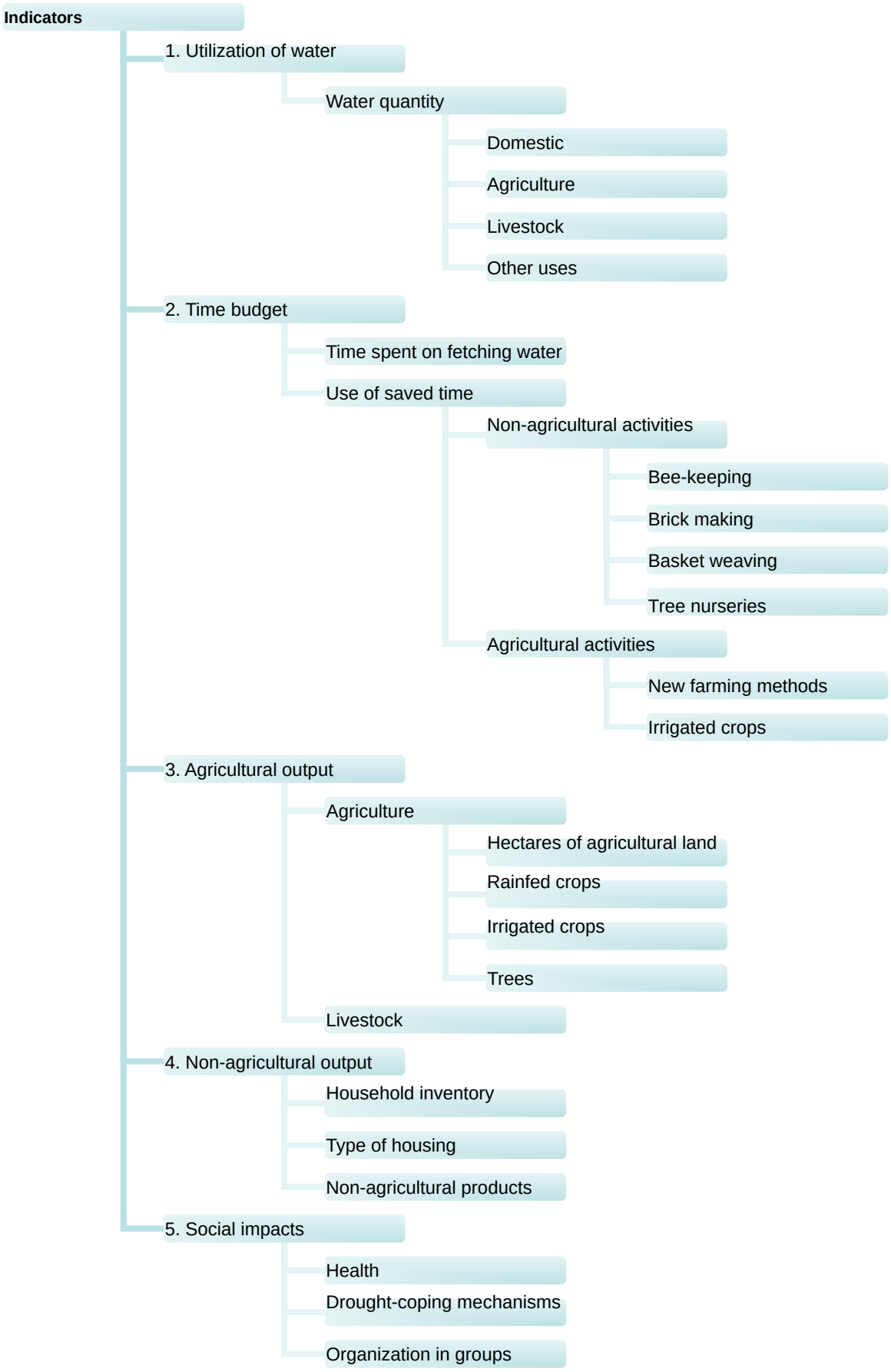

Figure 3.1 Flowchart of the different categories of indicators.

3.2 Selection of catchments

For a representative study on the impact of sand dams, the selection of a catchment is crucial. There are a few criteria a catchment and the dams in it need to satisfy:
The catchments that are to be compared need to have similar external drivers. These include: equal access to markets, population density and natural resource endowments. This is needed to minimize the difference in the economic potential of an area, in order to be able to filter out the effects that are not due to the construction of sand dams. When one community is next to an important road, for example, it will have a greater potential for trade than one that is far from any roads.
Secondly, the dams in the catchment have to be mature, as the dam needs time to become fully operational. Furthermore most of the possible benefits (such as more irrigated crops and non-agricultural activities) need time to be set up and running.
Some practical requirements, like accessibility, travel times and language also influenced the selection of the catchment.

For this study the catchment with sand dams, Kiindu River, did not only fit these criteria, but was also being used for the hydrological study of Borst and De Haas [2006]. Because of the need to be able to link the results of this study with the results of the hydrological study, using this catchment had many advantages.

In selecting a catchment without sand dams more difficulties were encountered. As SASOL has been building 400 sand dams in the district, it was hard to find a catchment which was very similar to the Kiindu catchment, but without sand dams. The catchment that was selected, Koma catchment, was the only option near Kitui town. The reason why no dams were built in this catchment is that the soil (clay) does not have the right properties for a sand dam to have effect. Besides this the bedrock is too deep, so that building the dam on bedrock is difficult.

3.3 Questionnaire

For this study a multi-topic questionnaire was set up. The questionnaire contains questions that provide information on all the indicators. The questions were formulated in such a way that it would be easy for the translator to ask the questions in Kikamba (local language). Any questions that were thought to be inappropriate, or difficult to get an honest answer to, were changed.

Annex 2 shows the different questionnaires that were used. The questionnaires used in Kiindu and Koma only differ in the fact that the questions about the situation before the dams in the Kiindu catchment are changed in the Koma catchment to ascertain the situation of five years ago. All the questions, aimed at investigating the economic status of a household have two parts. One assesses the situation at the time of the interviews (October 2005), while the second part aims at gathering information on the situation before the dams in Kiindu (1995) and five years ago (2000) in Koma. The reason for choosing five years ago as a basis for comparison in Koma is that it was thought to be hard to get reliable information on years too long ago. People in Kiindu are expected to remember the situation from before the dams, as the construction of the dams was a big event and they had been told that the dams would be beneficial for the community. Because of this the community has been using the situation of before the dams as a reference point.

The next paragraphs give a short explanation of the questionnaire. The items are organized in the same order as in the questionnaire; this is somewhat different than the order of the indicators (Fig. 3.1) and the order used to explain the results.

3.3.1 Household

The first part of the questionnaire is aimed at determining the household size and composition, as well as the occupation and level of schooling of the household members. This is important for the socio-economic status, as higher schooling can lead to better jobs and higher income from activities not related effects of the sand dam. A secondary effect of the dams could be that children go to school more often as time spent on fetching water is decreased.

3.3.2 Agriculture

The questionnaire continues with questions about the harvest of the last season and of the season before this. By not only informing about the last harvest but also the previous one and also asking qualitative questions about the harvest, it is possible to get an idea about how this harvest compares to a normal harvest. To get a good view on the effect of the sand dams on agricultural production, the variability encountered is an aspect that needs to be considered. Also included are questions about income from the sale agricultural produce and the stockpile.

The questions on trees that have been planted supply information on income from the sale of fruits and the reasons for planting the trees. This is important, as vegetation coverage could also be an indicator for effects of the construction of the dams.

Irrigation of crops can only take place if abundant water is available; therefore the amount of irrigated crops is an important indicator on the effects of the sand dams.

The last questions related to agriculture address the implementation of improved farming methods. As many of these methods need a considerable amount of labor, any differences could relate to changes in use of time in the household.

The next issue that is discussed is livestock. Here the amount of livestock held, the amount sold and the income from by-products is determined. Again the current situation is compared to the situation of either before the dams (in Kiindu) or of five years ago (in Koma). The answers on the way the livestock is watered are used in calculations on water-use by the household and more general information on water-usage in the community.

3.3.3 Income, assets and standard of living

To evaluate the standard of living and the income of the household, the questionnaire continues with questions on the amount of items present in the household, which represent a certain standard of living. Items like bicycles and motorcycles are only purchased when not all the income of the household is needed for survival and therefore represent a higher standard of living.
Another indicator of the standard of living is the source of energy used in the household. Firewood is collected by the household itself and is therefore free. Charcoal and kerosene is usually bought; therefore the use of these fuels usually indicates a higher income.

To be able to ascribe the income to the correct sources a question on any other sources of income (besides agriculture, livestock) is included in the questionnaire. This allows us to separate income that could be related to the construction of the sand dams from income that is not related and should not be used in the results.

Finally the personal view on the change in income is asked, to get an idea on how the people themselves consider their situation to have changed after the construction of the sand dams.

3.3.4 Water

This part of the questionnaire inquires about the source of the water used by the household and the amounts. As there is a difference in which sources are available in the dry and the wet season, the first question deals with which sources are used to fetch water from in the dry and wet seasons, before and after the construction of the dams.

The reason for also inquiring about the amount of water used is that if these amounts have changed, this is probably the result of changing amounts of available water in the catchment. These figures are also important for the hydrological survey, because the total water usage of the community can be estimated by multiplying the average water use per household with the number of households.
The need to use a donkey or a bicycle when fetching water can be an indication of large travel distances to the water source.

The next question on the time needed to supply the household with water aims at finding out how far the water source is and whether there are any queues, which could mean that water is very scarce in the area and only very few sources still provide water. Changes in these figures are under direct influence from changes in the water table.

If there have been changes in the time used for fetching water, inquiring on what type of activities are unfolded using the extra free time, can supply information on which indicators are influenced by the changes in availability of water.

The question on what drought-coping mechanism the household uses is included to provide data on the adaptability of the community to climate change.

3.3.5 Health

As the construction of sand dams is supposed to be beneficial to the overall health of the community, by means of increased water quality, a question on which diseases are most common is included in the questionnaire. Information on the health of the community was also collected at the clinic serving the communities.

3.3.6 Dams

The questionnaire for the community in Kiindu catchment contains additional questions on the dams and dam construction. This information is not included in the results of this report, but will be included in a later report. The answers to these questions can be used to get insight into the involvement of the community in the process of construction and maintenance. Another result of the questions is information on the opinion of the community with regard to the benefits they realize from the sand dams and any improvements they think should be incorporated.

3.4 Field procedure

As most of the people in the community do not speak sufficient English to be able to understand and complete the questionnaire, a translator asked the questions in the local language, Kikamba. Hilda Mwanza comes from Kitui Town and has a BSc. degree in Agriculture. She speaks fluent Kikamba, as well as English, which is necessary to avoid wrong results as a result of miscommunication.

3.5 Selection of households

In the field households were randomly selected. The sampling area contained all the households that were dependant on the selected sand dams for their water supply. About one-third (twenty four households) of the total households in each community (around 60) were interviewed. The total number of households was established in an interview with the village elder.

With the help of GPS and a topographical map, the households, which had been interviewed, were drawn in on the map. Through this way ample geographical dispersion of the households could be obtained (Figure 2.2).

4 Results and Discussion

This chapter discusses the results of the socio-economic survey in the Kiindu catchment and the Koma catchment. The results are organized in five categories according to the indicator categories (Paragraph 1.2.2).
Kiindu catchment represents a catchment with mature dams. The results represent the socio-economic impacts of the construction of sand dams. The households, which were interviewed, are all part of one village that constructed three sand dams in cooperation with SASOL. The three dams are Syonganga, Kwa Kangesa and Kwa Ndunda. These are the same dams on which Borst and De Haas [2006] have done a hydrological survey. The questionnaire included questions about the situation before (1995) and after (2005) the construction of the sand dams. Besides demonstrating the results of this study, the results of earlier studies will also be incorporated and compared.
The Koma catchment represents a similar catchment, but without sand dams. In this questionnaire information was gathered on the present situation (2005) and the situation five years earlier (2000). The results are used to check the results of the Kiindu catchment questionnaire. Any progress, which is not related to the building of sand dams, can be identified through this questionnaire.

4.1 Impact of Sand Dams on Utilization of Water

4.1.1 Water quantity

The community uses the water, which is extracted from the river, for many different purposes. These can be divided into four different categories:

- domestic use
- agriculture
- livestock
- other uses

The people in the communities can accurately estimate water quantities for domestic and agricultural purposes as the water is collected in containers of twenty liters.
The water that is used for the livestock is harder to estimate. This is because some of the households go to the river with the livestock and are therefore not certain how much water is extracted from the river. The quantities stated for livestock in this paragraph are based on a calculation in which the average water use for the different kinds of livestock given by people who do bring the water for their livestock to the homestead is used as the average for all the households. This could result in an underestimation of the water use as livestock that is taken to the river is likely to drink more water as there is no limit to the amount available to them.
In the category ‘other uses’ brick making constitutes the main part. Brick making is only done for a few months of the year, at the start of the dry season. In the process large quantities of water are used (up to 6000 liters) at once. The red soil is wetted with water and made into bricks at the beginning of the process after which no more water is used. In the graph the value is changed to an average value per day, but it must be noted that the water is extracted in one week and not throughout the dry season.

The quantities of water used for different purposes show some large differences between Kiindu before and after dam construction and Koma now and five years ago (see figure 4.1). Water for domestic use is higher in Koma catchment than in Kiindu, which is remarkable, as the water in Koma catchment has to be collected much further away. This might be explained by the fact that in Koma catchment the livestock is watered at the river, so all the water that is brought to the household can be used for domestic purposes.
Water use for agriculture has significantly increased in Kiindu catchment since dam construction. With more water available, more people have irrigated plots. In Koma catchment the usage for agriculture has slightly decreased. This slight decrease can be explained by the fact that in Koma catchment less people are currently involved in irrigated agriculture as the labor involved proved to be too high in comparison to the harvest.
In Kiindu catchment the water usage for livestock has increased slightly as well. Reasons for this could be the increased amount of livestock and that people give their livestock more water as more is available. Water quantities used for livestock did not change in Koma catchment.
Overall, the average increase in total water use per household adds up to 290 l/day (from 300l in 1995 to 590l in 2005), which is an increase of 49%.

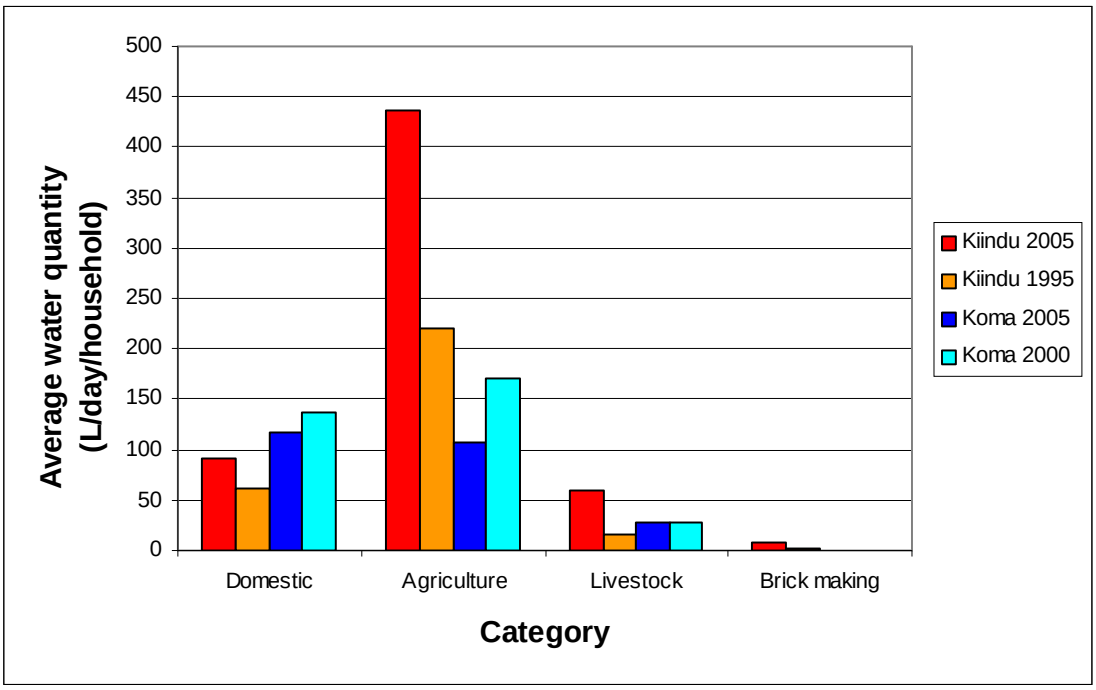

Figure 4.1 Average water use for domestic, agricultural and livestock use

The results of the study of Rempel et al. (2005) show similar trends. This study concludes that the quantity of water collected increased with an average of 47 percent in communities where sand dams had been built.

4.2 Impact of Sand Dams on Time Budget

4.2.1 Time spent on fetching water

The task of collecting water is an important part of daily work in both the catchments. In Kiindu the time used per day to get domestic water has decreased from an average of 140 minutes per day to 90 minutes per day. This decrease in time is partly because water is now available in this river throughout the year, whereas is the past Kiindu river used to be completely dry at the end of the dry season, forcing people to go to a different catchment for their water. Furthermore the queues at the limited water points have decreased, as the number of water points has increased.
In the Koma catchment the time needed to get water for domestic use has stayed the same over the last five years. On average the households spent 180 minutes per day.

Irrigated agriculture is another activity that consumes a lot of time. The irrigated plots are and always have been very close to the river, as large quantities of water are needed. Due to this fact, the time used for irrigation has not decreased much since the construction of the dam. The difference lies in the fact that much more people are now active in growing irrigated crops. The time needed to irrigate the plots was 290 minutes before the sand dams were built, and has decreased to 250 minutes now. It must be noted however that the households that were irrigating plots before dam construction have not decreased the time spent on irrigation after dam construction. The amount of time spent depends mostly on the area of the plot.
In Koma catchment the amount of time spent on irrigated agriculture has not changed in the last five years, at around 170 minutes. This being less than the time spent in Kiindu is probably due to the fact that people have to rent land close to the river, which is expensive and people therefore have smaller plots.

The time needed to water the livestock (either in the river or at home) shows a similar trend. In Kiindu catchment average time used per day decreased from 110 minutes to 50 minutes, which is less time than people use to get domestic water. The reason for this is that the livestock is watered only once a day, while people mostly make more than one trip per day to get water for domestic use. In Kiindu, the livestock is mostly watered at the river, as the river is not far.
In Koma catchment time used to water the livestock is stable at 90mins per day. As the river is further away, in Koma catchment most of the livestock is watered at home so as not to wear out the animals.

Table 4.1 Time spent on fetching water for the various purposes

Purpose	Time Spent (minutes per day)			
	Kiindu, 1995	Kiindu, 2005	Koma, 2000	Koma, 2005
Domestic use	140	90	180	180
Agriculture	290	250	170	170
Livestock	110	50	90	90
Total	540	390	440	440

The total time that is saved from collecting water each day is 150 minutes. In the study of Rempel [2005] the time saved was found to be 90 minutes over a number of catchments with sand dams. This number includes catchments where the sand dams had dried up. In catchments where water was available in the river, as was the case in Kiindu catchment at the time of this study, the time saved was 140 minutes, which is comparable to the results in this study.

4.2.2 Use of Saved Time

As seen in the previous paragraph, a lot of time has been saved in the Kiindu catchment because less time is spent on fetching water. This saved time can be put to use in other activities. Some households use this time for more than one activity. In Kiindu catchment, 43 percent of the interviewees state that the time is spent on income generating activities. Income generating activities can be brick making, basket weaving, beekeeping and more. This is discussed in detail in the next paragraph. Of the households interviewed in Kiindu catchment 33 percent uses this time for agricultural activities, including terracing, irrigated vegetable growing and preparing the land in time for the rains (Figure 4.2). The result of spending more time on agricultural activities is discussed in detail in paragraph 4.2.4 'New Farming Methods' and chapter 4.3 'Impact of Sand Dams on Land-Output'. Of the interviewed people, 29 percent use this time for domestic use, generally improving hygienic conditions in the household. Other uses mentioned for the saved time were: leisure and joining a corporation.
In Koma catchment there was nobody who had saved time compared to five years ago.

Figure 4.2 Time saved from fetching water can be used for agricultural activities, in order to increase the harvest.

Table 4.2 Activities undertaken as a result of saved time from fetching water in this study and the study of Rempel et al. (2005)

Activity increased due to time saved	Percentage of households	Percentage of households in Rempel et al. 2005
Income generating activities	43%	34%
Agriculture	33%	55%
Domestic	29%	Not available
Joining a cooperation	10%	22%
Leisure	5%	Not available

Comparing the results of this study to the study of Rempel et al. (Table 4.2), there are a few discrepancies. The reasons for these differences could be that the study of Rempel [2005] covered nine catchments. It is to be expected that different communities will use their time for different purposes, as agricultural potential of the area could differ and people might have been more active traditionally in other activities such as beekeeping and basket weaving. Although the numbers differ, all the activities are in some way beneficial for the household, this being for increasing income, food security and/or health.

4.2.3 Non-agricultural Activities

The non-agricultural activities in Kiindu and Koma catchments differ significantly (see figure 4.3). Casual labor, small businesses and regular employment haven't changed significantly over the years in both catchments. This is probably due to the fact that these activities are not linked to the availability of water. Livestock keeping is more popular in Koma catchment. A reason for this could be found in the fact that, traditionally, the people of Koma catchment were more reliant on livestock than on agriculture. In Kiindu catchment, livestock keeping has increased. The availability of water could have some influence on this, but there have been some programs for grade goat keeping in the area, which could have increased the importance of livestock keeping as a source of income. The largest differences can be seen in basket weaving, brick making, bee keeping (figure 4.4) and tree nurseries. All of these were not very important in Kiindu catchment before dam construction. However, after dam construction these are the most important activities after casual labor and regular employment. The reasons given for these changes were that time saved from getting water and the increased availability of water made these activities possible.

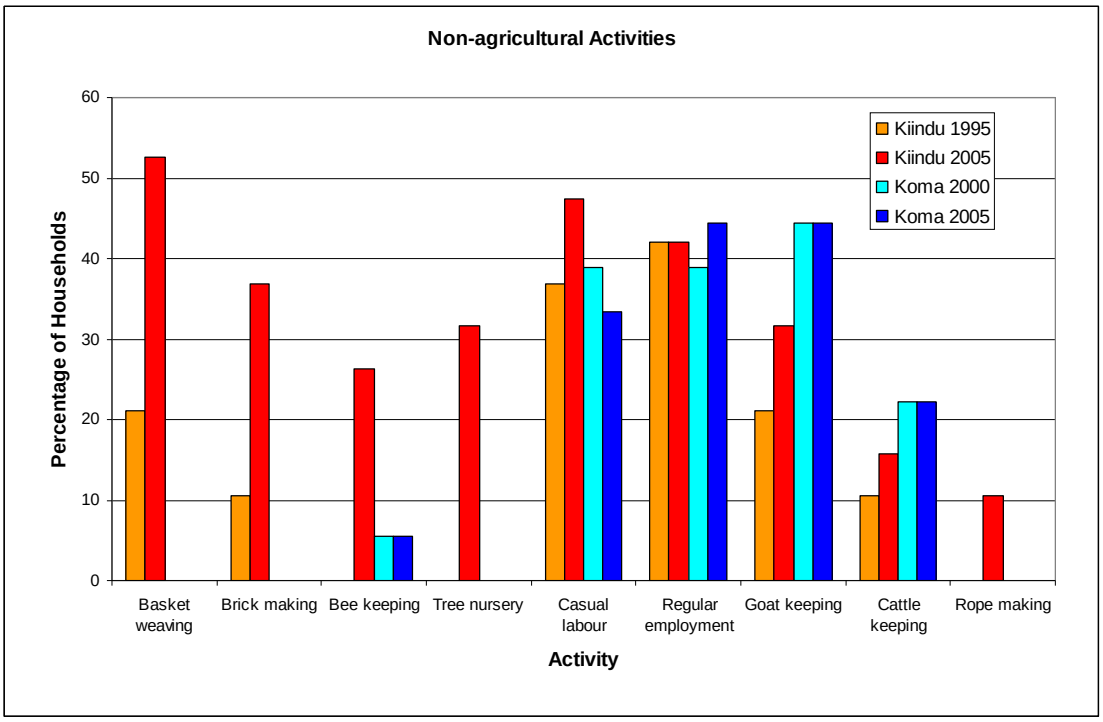

Figure 4.3 Percentage of households involved in non-agricultural activities in Kiindu and Koma catchment

Figure 4.4 Beekeeping and brick making as a result of time saved from fetching water

4.2.4 New Farming Methods

One third of the households in Kiindu catchment stated that the time saved from fetching water is utilized for agricultural activities. These agricultural activities can include the normal preparation of the fields before the rainy season as well as weeding and aerating the soil. Figure 4.5 shows that more new farming methods are used now than before the dams. An increased number of households uses terracing, fertilizers and new crops and trees on their farms after the construction of sand dams. The increase in people planting new trees is especially large. The reasons and results of this are discussed in detail in paragraph 4.3.4 'Trees'. In Koma there is also a slight increase in these practices, with the exception of new/more trees.

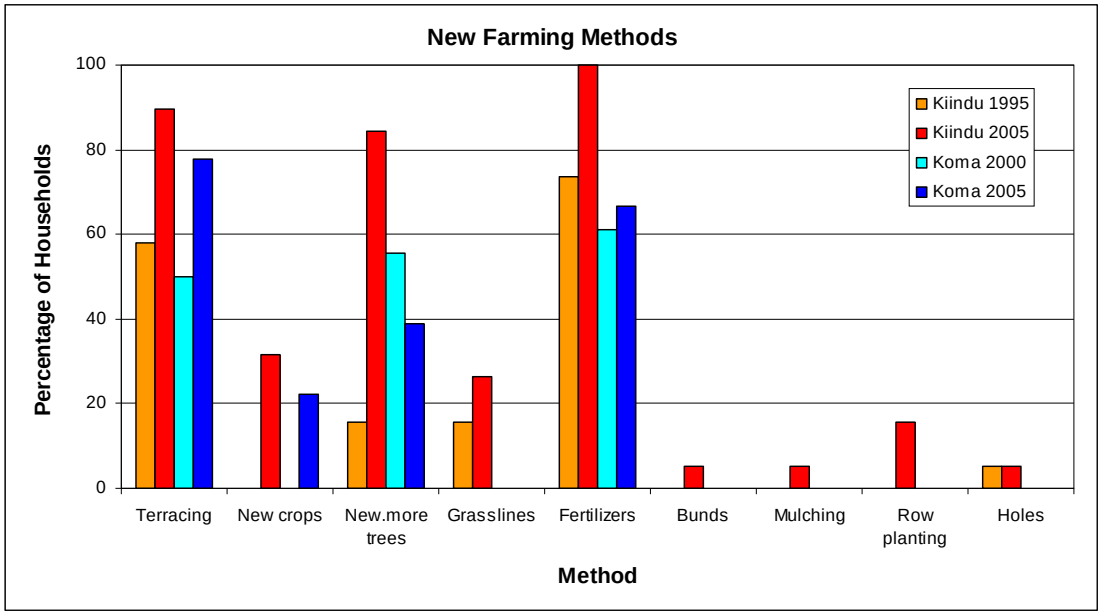

Figure 4.5 Percentage of households practicing new farming methods

There are two reasons for this change. One is that people have to learn these practices before they can use them. This could be, for example, through extension workers from the Ministry of Agriculture or by the Farmers Field Schools. The second reason for the change can be through spending the time, saved from fetching water, on agricultural practices. This last one could be the most important factor in Kiindu catchment.

Data from another study in 1992, states that 34 percent of the households that do not implement new farming methods because there is not sufficient labor available to do this [International Development Studies Roskilde University Centre, Department of Sociology University of Nairobi, 1992]. While the study was not done in the Mulango sub-location, but in neighboring sub-locations and other sub-locations scattered over the Kitui District, it still provides an indication that insufficient time is one of the reasons for not implementing new farming methods.

The study of Rempel [2005], shows that 55% of the households in communities with sand dams invest part of the saved time in agricultural activities, but further distinction in which activities is not made. This means time for harvesting and soil preparation, which are not new farming methods, is also included.

4.3 Impact of Sand Dams on Agricultural Output

4.3.1 Hectares of Agricultural Land

The average size of agricultural land owned and rented by the households in the two catchments is 2.6 hectares for Kiindu and 2.0 hectares for the Koma catchment. In Kiindu, however, the number of households that have increased their land since dam construction is 6 out of 19. The average increase is 1 hectare. Most of this added land is rented. It is not clear whether this increase in land size is connected to the construction of the sand dams. It could be that people increase their agricultural land as a result of having more time available for agricultural activities. Only one household in Koma has increased its agricultural land since five years ago.

4.3.2 Rainfed Crops

The most common rainfall dependant crops, for both catchments are maize, beans, cowpeas and pigeon peas. Other fairly common crops in the Kiindu catchment are cassava, sweet potatoes, millet, pumpkins, sunflower and green grams, grown by 4 to 12 households. Sorghum and sojabeans are rare crops, grown only in one household.
In Koma millet and green grams are reasonable common crops (grown in 6 to 4 households); and cassava, sorghum and sojabeans are rare crops. In table 4.3 the different crops are shown. The percentage of crop failure is the percentage of households that had no harvest of a specific crop last season.

Table 4.3 Number of households that planted certain crops with the number and percentage that failed (no harvest) for Kiindu and Koma catchments

	Kiindu			Koma		
	No. of HH	No. failed	Failure (%)	No. of HH	No. failed	Failure (%)
Maize	19	0	0	18	1	6
Beans	19	1	5	16	1	6
Cowpeas	18	5	28	18	2	11
Pigeonpeas	17	9	53	17	17	100
Pumpkins	6	0	0			
Cassava	12	8	67	1	0	0
Millet	8	1	13	6	1	17
Sorghum	1	1	100	1	0	0
Sweet potatoes	9	2	22			
Green grams	4	1	25	4	1	25
Sunflower	5	1	20			
Sojabeans	1	0	0	1	0	0

The yield of the different crops is calculated per hectare. Because the precise area used for the different crops is unknown, the assumption is made that the crops are grown over the whole agricultural area. In this way, the estimated crop-yield per hectare is probably less than the actual yield per hectare. Furthermore, the average of the estimated yield is calculated over all households who planted the specific crop, regardless if the harvest failed.

The average yield of the different crops is shown in figure 4.6. Of the common crops only cowpeas and pigeon peas show some distinctions between the two catchments: with a complete failure of harvest of the later one. Of the fairly common crops only green grams and millet are comparable. The yields of both these crops are much better in the Koma catchment.

All these crops are rainfall dependant. The sand dams could possibly have caused an increase in the groundwater level, which in turn could cause an increase in yields. However, there is no evidence for this in the results.
Although there is no clear trend in production per hectare, one clear difference is that in Kiindu the diversity of grown crops has increased from 7 to 8 rainfed crops per household. In the Koma catchment this number has not changed over the last five years, it remained at five crops per household.

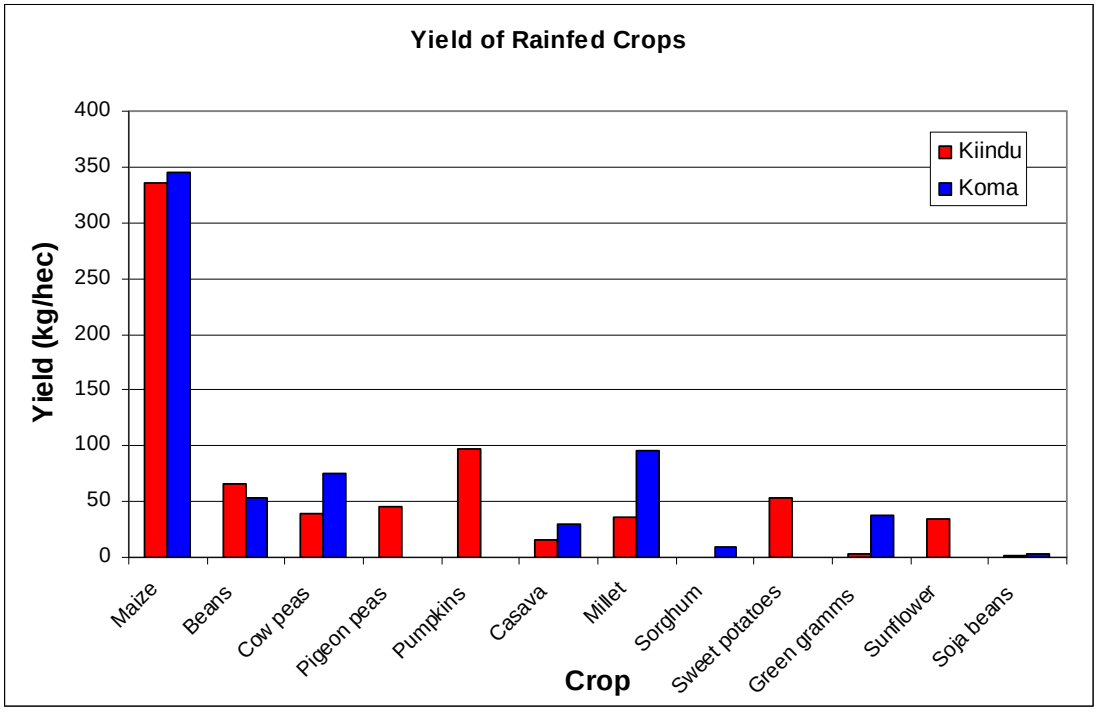

Figure 4.6 Yield of rainfed crops in kilograms per hectare in Kiindu and Koma catchment

4.3.3 Irrigated Crops

The construction of the sand dams has increased the amount of water available in the Kiindu catchment [Borst & De Haas, 2006]. This water can be utilized for growing irrigated crops. From figure 4.8 it is clear that in Kiindu catchment the number of households growing irrigated crops has almost doubled after the construction of the dams, from 37% to 68%. The plots used for irrigated crops are small (around 0.1 hectares) and usually close to the river (Figure 4.7). Most of the harvest is used to supplement the diet of the household, while 50% of the households sell some of the harvest. The income from growing vegetables amounts to an average of 6000KSH (80 U$), varying from 800KSH to 13000KSH per year.
In the study of Rempel [2005], 21% of the households were found to have started growing vegetables after dam construction

Figure 4.7 Irrigated Sukuma Wiki in Kiindu Catchment

In Koma there has been no notable change in the last five years, with around 40% of the households growing irrigated crops. Of the people growing irrigated crops only one sells the harvest.

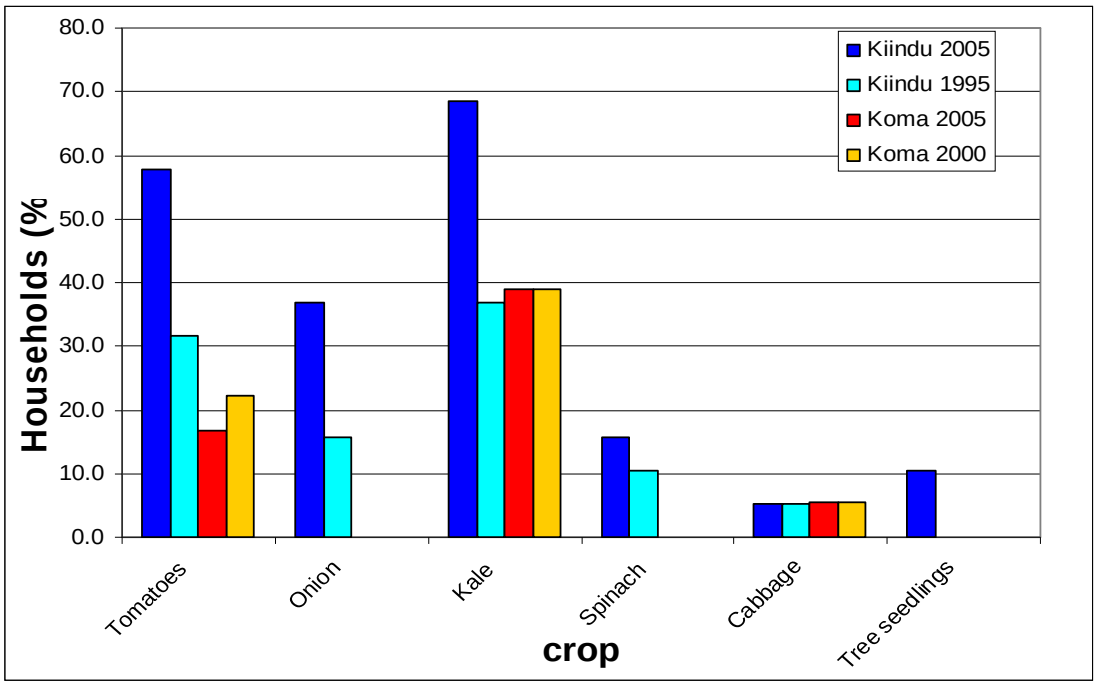

Figure 4.8 Percentage of households growing different irrigated crops in Kiindu catchment and Koma catchment in 2005 and before dam construction.

4.3.4 Trees

The possibility of planting new trees is reliant upon the availability of water. The young seedlings need to be irrigated in the first year, as the rains are not sufficient for them to survive. In Kiindu catchment a number of tree nurseries were set up after dam construction (See Figure 2.6). These tree nurseries are often on small plots of land near the river, so that irrigation with buckets is easier. After one year the young trees are large enough to cope with drier soil and they can be planted higher in the catchment along fields or on the homesteads (Figure 4.9). The fruits from the trees supplement the diet of the household and are often sold on local markets to generate some extra income. Trees are also used for firewood and construction. Added benefits are: shade provided by the trees on the homestead, trees along fields act as windbreaks and the ornamental value.

In the Kiindu catchment 84% of the interviewed people said they planted new trees since dam construction. These are mostly fruit trees (mangoes, pawpaw, banana, orange and lemon), planted for consumption and for sale. Some other trees are planted for fuel, windbreaks and construction. Five households had sold fruits in the past season, earning an average of about KSH3000.
In Koma catchment 65% of the interviewed households had planted trees in the last five years and 40% of these said these trees had dried up. The reason given for planting was: for own consumption only and none of the households had sold any fruits last season.

Figure 4.9 Fruit trees (pawpaw, mango and banana) planted after construction of sand dams

4.3.5 Livestock

For livestock there are no significant differences between the situation before and after the dams, as well as between Kiindu and Koma catchments. One remarkable difference is that the number of donkeys is higher in the Koma catchment. This can be explained by the fact that the people in the Koma catchment have to travel greater distances to find water. Donkeys are the most important means of transport for this water. Another difference is that in Kiindu more people say they have increased their number of goats and cows since dam construction than in Koma catchment.
Compared to the results of the 1992 study, the numbers of poultry and cattle are slightly lower compared to other sub-locations in the district, while the number of goats and donkeys is slightly higher in Kiindu and Koma catchments [International Development Studies Roskilde University Centre, Department of Sociology University of Nairobi. April 1992]. Overall, there seems to be no clear correlation between the construction of the sand dam and changes in numbers of livestock.

4.4 Impact of Sand Dams Non-agricultural Output

4.4.1 Household Inventory

To assess the general prosperity of the households in the community after the construction of the sand dams, an inventory was made of a number of assets present. As people have more money to spend they will start investing in more valuable assets. These assets can be divided into two categories: practical assets (bicycles, wheelbarrows or agricultural tools), and assets for leisure (radio, television).
In the Kiindu catchment it is clear that people have invested in practical assets in the past 15 years (Table 4.4). The number of bicycles and wheelbarrows owned by people in the community has increased dramatically. The number of agricultural implements has also increased slightly. When people have even more money to spend, they will start buying items that are representative of a higher standard of living. These items (radios, television, couches) also show an increase in the community around the Kiindu River.

Table 4.4 Number of household assets in Kiindu catchment

Assets	Number per household (in 2005)	Difference (with 1995)	Percentage change
Bicycles	0.9	+0.6	+240%
Wheelbarrows	0.6	+0.3	+120%
Agricultural implements	6.5	+0.9	+16%
Radios	1.5	+0.8	+107%
Television Sets	0.2	0	0%
Couches	1.3	+0.2	+14%

In Koma catchment the number of household assets shows only a small increase in some cases (Table 4.5). Overall the increase is much smaller than in Kiindu catchment.

Table 4.5 Number of household assets in Koma catchment

Assets	Number per household (in 2005)	Difference (with 2000)	Percentage change
Bicycles	1.2	+0.1	+10%
Wheelbarrows	0.4	0	0%
Agricultural implements	7.3	+0.3	+4%
Radios	1.3	+0.2	+26%
Television Sets	0.1	0	0%
Couches	0.7	0	0%

4.4.2 Type of Housing

The type of housing present on the homestead is also an indicator of the economic situation of the household. The type of roof can be either thatched of iron sheeted. Iron sheets are more expensive, but generate better conditions for living (Figure 4.10). People who can afford it will rather make their roof out of iron sheeting than thatch. The results of counting how many people had iron sheets on the houses show no large differences between Kiindu and Koma catchments. In Kiindu 90% of the households owns at least one house with an iron roof, while in Koma catchment 95% of the people have at least one house with an iron roof. As the question did not include a part about the situation before the building of the dams, it is not known whether the construction of the sand dams lead to better housing in the Kiindu catchment.

Figure 4.10 House with iron sheeting in Kiindu catchment

4.4.3 Extra Income after Sand Dam Construction:

In Kiindu catchment income has increased after construction of the sand dams, through various extra activities made possible because of increased water availability and time saved (Table 4.6). The approximate extra income from these activities per household and the percentage of households involved in them are:

Table 4.6 Extra incomes made possible because of increased water availability

Activity	Average income per year	Percentage households involved
Vegetable growing	6000KSH	35%
Tree nursery	4000KSH	32%
Brick making	5000KSH	37%
Fruit trees	3000KSH	24%

All the above activities are dependant on a water supply in the near vicinity, as large quantities of water are needed and transport of this water is mostly done by manual labor and the use of donkeys. This means that it is important that the water supply from the sand dams needs to be used with care, so that it doesn't run out in the dry season. If these activities were to be employed on a large scale or by too many households, the water supply from the sand dams would not suffice. For this reason it is important that people in the community find other ways of earning extra income without using large quantities of water. Since sand dam construction the community has started making rope and baskets and keeping bees (Table 4.7). This was made possible because the people have more time now that the time spent on collecting water has decreased.

Table 4.7 Extra incomes made possible because of increased time availability

Activity	Average income per year	Percentage households involved
Basket weaving	5000KSH	53%
Bee keeping	3000KSH	26%

This means that an average household in Kiindu catchment earns around 9000KSH extra per year (sum of income multiplied by the percentage of households involved) after the construction of the sand dam. This amounts to approximately 17U$ per capita.

4.5 Social Impacts of Sand Dams

4.5.1 Health

In Kiindu catchment 44% of the households interviewed stated that there was a decrease in water-related disease. 22% stated that there was an increase in the cases of water-related disease. Another illness influenced by the construction of the sand dam is Kwashiorkor, which is caused by malnutrition. This disease is reported to have been present before the sand dam was there, but now there are no cases reported anymore. Malaria is said to have increased since the construction of the dams in 83% of the households, the reason the people give for this change is climate change, but in reality it could be related to the sand dams, although this is not supported by clear evidence.

4.5.2 Drought-coping Mechanisms

In the past there have been many problems with rains failing which has resulted in famines. Climate Change is expected to increase extremes such as drought in future. One question in the questionnaire was focused on drought-coping mechanisms people use to survive these dry years and if they have changed since dam construction. In Koma catchment the most frequent answer was selling livestock. Relying on off-farm income and casual labor were also mentioned often. In Kiindu catchment people rely mostly on off-farm income and this number has increased since sand dam construction. This includes income, which was made possible by the sand dams, like bee keeping, basket weaving and brick making. Selling livestock is also used as a drought-coping mechanism, now more than before the dam construction. Overall it is clear that the people in Kiindu catchment have diversified their ways of coping with drought. It is to be expected that the community in the Kiindu catchment will be able to cope with drought better than before, not only because there is more water available for longer, but also because of the different methods of generating income.

4.5.3 Organization in Groups

In the Kiindu catchment around 70% of the households is active in one or more groups. These groups only consist of women, with the exception of grade-goat keeping. These groups are active in a wide range of activities. The most popular group-activity in the Kiindu catchment is the money-go-round. In this acitivity each member of the group contributes a small amount of money each week. In turns the members of the group receive the money from the other members, so they receive a larger sum of money at once, which they can use to pay school fees, or start a small business. Basket weaving is also said to be a group activity. In fact the baskets are made and sold individually, but they are taken to the market all at once by one member of the group, who sells them collectively and then returns the earnings to the makers of the baskets. Another group activity in Kiindu catchment is the tree nursery. The seedlings are taken care of by the group and the young trees are divided among the group. The trees that are not used by members of the group are sold and the income is divided between the members of the group. The only group activity in which men are active is grade-goat keeping. The different households involved take turns in taking care of the goats.
In Koma catchment, the only group activity that was mentioned were the farmers field schools, in which a group of women comes together to learn improved farming techniques from a representative of the ministry of agriculture.

4.5.4 Opinion of the Community on Benefits

People in Kiindu catchment were asked what the greatest benefits of the sand dams are in their opinion. 60% of the interviewed households stated that the increased availability of water was the greatest benefit. Because of this availability they realized many other benefits, namely, in order of most importance: a shorter distance to the water source, increased domestic food availability, increased cash crop production, increased livestock and better health. These benefits can also be identified in the results of the rest of the questionnaire. This shows that people are aware of the benefits they realized as a result of the sand dams and that there are no benefits found through the questionnaire that are not experienced as such by the community.

5 Conclusions

The results of the socio-economic survey show clear evidence that the building of sand dams in the Kiindu catchment has led to a large number of benefits for the involved communties. In Koma catchment the socio-economic situation has stayed the same over the last five years.

The most important aspect of the sand dams is the retention of water within the riverbed, which leads to an increase in the water availability throughout the year [Borst & De Haas, 2006]. The direct benefits of this aspect for the community are: a higher quantity of water available for various activities and a decreased distance to the water (especially in the dry periods). The increased availability of water leads to a general higher utilization of the water. The largest increase in the use of water is seen in the agricultural category, this has increased from 220 liters a day to 440 liters per day after dam construction. The added amount of water can be used for extra income generating activities such as irrigated crops, tree nurseries and brick making.
The decreased distance to the water source results in an amount of time that is saved compared to the time spent on fetching water before dam construction. On average, the households save about 150 minutes a day because of the shorter distance. Most of the households (43 percent) use this time for new, non-agricultural income generating activities, and 33 percent of the households spent the time on improving or expanding agricultural activities.

The indirect benefits can be subdivided into agricultural and non-agricultural economic benefits. In Kiindu catchment there is an increase in agricultural land after dam construction. This is possibly a result of the saved time, invested in expanding crop-land. An important change is the increase in households growing irrigated crops; this has increased from 37 percent of the households to 68 percent. Most of the harvest is used for own consumption; a part of it is sold, generating an extra income of around 6000KSH per year. Another change is the percentage of households planting new trees. Most of the trees are fruit trees to supplement the diet, and to generate extra income. In Koma catchment 65 percent of the households have planted new trees, 40 percent of these have dried up. In Kiindu catchment 84 percent has planted new trees since dam construction; the average extra income from the trees is approximately 3000KSH per year. There are no significant changes in livestock since the construction of the sand dams.
The non-agricultural activities initiated include brick making, basket weaving and tree nurseries. Basket weaving, bee-keeping, tree nurseries and brick making show the largest increases in this sector, around 30 percent of the households have started these activities after dam construction, each generating around 4000KSH extra per year.
All the extra activities taken into account, the average household in the Kiindu catchment earns around 9000KSH extra per year as a result of the construction of sand dams. An indicator of the changes in the standard of living since dam construction is the comparison of household inventories in Kiindu and Koma catchments. In Kiindu the increase in both practical assets and assets for leisure is dramatically, especially the investments in bicycles and wheelbarrows (an increase of 240 and 120% respectively). In Koma catchment there is only a small increase in these assets (around 10%).

The construction of sand dams has also led to some social changes in Kiindu catchment. Overall health has increased as there are less water-borne and

malnutrition related diseases. Furthermore, the people in Kiindu catchment have started organizing themselves into groups. Seventy percent of the women are involved in some form of group activity. These include: doing farm work as a group, setting up tree nurseries, basket weaving and money-go-round. The increased income as well as the increased number of methods for generating income, mean that the people of Kiindu catchment are now better equipped to cope with extreme drought.

Although the benefits of the sand dams are clear, care has to be taken in order not to overexploit the water source. Too many individuals starting irrigated farming and brick making on a larger scale will prove to be unsustainable in the long run, causing the river to dry up before the dry season is over. Therefore the alternative ways of earning extra income, which mostly depend on the availability of time, are very important and need to be stimulated by organizations and ministries.

6 Recommendations

The conclusions of this study clearly indicate that the construction of sand dams is beneficial for the community in Kiindu Catchment. Both the availability of water and food has increased and substantial economic benefits have been realized. Given these facts, it has to be taken into account that the number of interviews, which forms the base for these conclusions, is too small to extrapolate these to the entire district and other parts of the country.

It is recommended that more research be done in more communities with sand dams over a larger area. Within this research more detailed information on harvest and economic benefits should be gathered. With more interviews in different communities, statistically supported conclusions can be drawn. These conclusions would be valid for the entire sand dam project, as apposed to one case study, as seen in this report.

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ISBN: 9966-9642-0-7 Questionnaire

Household No.: Village:

GPS Location: 37M Location:
UTM

Member No.	Sex	Marital Status	Age	Education	Occupation
1 respondent					
2					
3 No. of children				Primary:	
4				High:	
5				Not in school:	

Agriculture

How much land do you […]?	for domestic use	for agricultural use	Did you […] more, less or the same land before the dams existed?
Own			
Rent			

What crops do you grow on you farm?

How much [...] have you harvested in the last wet season?		How much […]			To whom did you sell […]?	Did you grow […] before the dams existed?	Did you harvest more, less or the same amount of […] before the dams existed	What is the reason for the change in harvest?
		is still in storage?	did you use?	did you sell?				
Maize								water-related
Beans								imp. Farm prac.
Cow peas								increased land
Pigeon peas								enough time
Pumpkins								inadequate rain
Cassava								
Millet								
sorghum								
sw potatoes								
….								
….								
….								

Would you say this is a […] year? good normal bad

Have you planted any trees since dam construction?

What type of trees?	Reasons for planting		If sale, how much did you sell?
mangoes		1 food	
papaya		2 sale	
banana		3 agriculture	
oranges		4 availability of water	
lemons		5 ornamental	
other		6 fuel	

Do you grow any irrigated crops?			What do you do with the harvest?	If sale, how much did you sell?	Is the harvest more, less or the same as before?	Reason for change in harvest
	before	after				
Tomatoes						water related
Onion						imp farm meth
Kale						incr land
…						time
…						

How do you irrigate your plots?

How did you irrigate your plots before the dams existed?

Which new farming methods do you apply?

Do you apply any of these or other new farming methods on your plots?		Did you also apply these methods before the dams existed?	Where did you learn these methods?
Terraces			
New crops			
New/more trees			
Grasslines			
Fertilizers			
Bunds			
Mulching			
….			
….			

Livestock

Which livestock do you own?

How many […] does your household own?		Is this more, less or the same as before the dams?	How many […] did you		In what way do you water your […]?	What do you do with the byproducts? (eggs, dairy)	
			eat last season?	sell last season?		use	sell
Chickens							
Ducks							
Goats							
Sheep							
Cows							
Donkeys							
….							
….							

Assets, implements and income

How many […] does your household own?		How many […] did your household own before the dams existed?	Did you buy [..] in cooperation with others? If yes, with whom?
Bed			
Couch			
Bicycles			
Carts/wheelbarrows			
Spades			
Ploughs			
Motor vehicles			
Transistor radio			
Television set			
….			

What are your sources of energy?	main	secondary
Firewood		
Charcoal		
Kerosene		

Does your household have other sources of income?		Is this activity in cooperation with others? If yes, with whom?	Did this activity also take place before the dams existed?	What is the reason for the change?
Goat/sheep keeping				
Cattle keeping				
Brick making				
Tree nursery				
Bee keeping				
Basket weaving				
Regular employment				
Casual labour				
….				

Are you involved in any cooperative activity?

Has the total income of your household […] compared to before the dams existed?
Increased Decreased Stayed the same

Water

	What sources of water do you use?				How much of this water did you use for […] before and after dam construction?							
	before		after		Domestic		Agriculture		Livestock		Other	
Season	Dry	Wet	Dry	Wet	before	after	before	after	before	after	before	after
Scoophole												
Open Well												
Pump												
Roof catchment												
Piped												
Scoophole other catchment												
….												

What factors do you consider when choosing a water source for:-	Dry season		Wet season	
	first	second	first	second
Domestic use				
Agricultural use				
livestock				

Choose from: 1availability,2 distance,3 quality,4 reliability,5 quantity,6 price

How do you store your water on your homes?

What means do you use to transport your water? Donkeys
Human labour (Who) + Donkeys
Human labour
Others,

How much time does your household spend for getting water for […] use per day?					How often do you fetch water?-(Daily/once in two days,….)	
	How much time?		Who?			
	before	after	before	after	before	after
Domestic						
Agriculture						
Livestock						
Others						

What do you do with the time saved from fetching water?
Agriculture Domestic Income generating Cooperative Leisure

What do you do when the rains fail?		Are these the same methods you used before the dams were built?
Selling livestock		
Sell trees		
Sell household assets		
Reduce food consumption		
Purchase cheap foods		
Rely on off-farm income		
Borrow money		
Other		
….		

Health

What kind of common diseases does your household suffer from?					Are they more or less or The same as before?	Reasons for change?
	Before		After			
	Adults	Children	Adults	Children		
Malaria						
Cholera						
Typhoid						
Amoebic dysentry						
Skin diseases						
Kwashiorkor						
Marasmus						
others						
….						

Dams

Who does this dam belong to?

community members	
government	
individuals	
Political party	
SASOL	
Schools	
…	
….	

Did you participate in construction of the dam?

In what way?

How did your household become involved?

Is there any care/maintenance taken on the dam?

If yes, by whom?

How was the site for the construction of the dam selected?

What benefits have you realised from the sand dams?

What are the three main benefits for your household?			
	first	second	third
increased water availability			
increased cash crop production			
increased domestic food availability			
increased livestock			
increased sand for construction			
increased income/ std of living			
increased land value			
better health			
higher brick production			
shorter distance			
….			

Do you think the energy you spent in constructing the sand dam is worth the benefits you get from it?

Do you think every member of the sand dam community benefits equally from the sand dam?

Can you think of anything you didn't like about the approach used in the construction of the sand dam?

Do you think there could be any improvement in the way the sand dam was constructed?

Questionnaire

Household No.: Village:

GPS Location: 37M Location:
UTM

Member No.	Sex	Marital Status	Age	Education	Occupation
1 respondent					
2					
3 No. of children				Primary:	
4				High:	
5				Not in school:	

Agriculture

How much land do you […]?	for domestic use	for agricultural use	Do you […] more, less or the same land as five years ago?
Own			
Rent			

What crops do you grow on you farm?

How much [...] have you harvested in the last wet season?		How much […]			To whom did you sell […]?	Did you grow […] five years ago?	Did you harvest more, less or the same amount of […] five years ago?	What is the reason for the change in harvest?
		is still in storage?	did you use?	did you sell?				
Maize								water-related
Beans								imp. Farm prac.
Cow peas								increased land
Pigeon peas								enough time
Pumpkins								inadequate rain
casava								
millet								
sorghum								
sw potatoes								
….								
….								
….								
….								

Would you say this is a […] year? good normal bad

Have you planted any trees since five years ago?

What type of trees?	Reasons for planting		If sale, how much did you sell?
mangoes		1 food	
papaya		2 sale	
banana		3 agriculture	
oranges		4 availability of water	
lemons		5 ornamental	
other		6 fuel	

Do you grow any irrigated crops?			What do you do with the harvest?	If sale, how much did you sell?	Is the harvest more, less or the same as five years ago?	Reason for change in harvest
	Now	5 years ago				
Tomatoes						water related
Onion						imp farm meth
Kale						incr land
…						time
…						

How do you irrigate your plots?

Which new farming methods do you apply?

Do you apply any of these or other new farming methods on your plots?		Did you also apply these methods five years ago?	Where did you learn these methods?
Terraces			
New crops			
New/more trees			
Grasslines			
Fertilizers			
Bunds			
Mulching			
….			
….			

Livestock

Which livestock do you own?

How many […] does your household own?		Is this more, less or the same as five years ago?	How many […] did you		In what way do you water your […]?	What do you do with the byproducts? (eggs, dairy)	
			eat last season?	sell last season?		use	sell
Chickens							
Ducks							
Goats							
Sheep							
Cows							
Donkeys							
….							
….							

Assets, implements and income

How many […] does your household own?		How many […] did your household own five years ago?	Did you buy [..] in cooperation with others? If yes, with whom?
Bed			
Couch			
Bicycles			
Carts/wheelbarrows			
Spades			
Ploughs			
Motor vehicles			
Transistor radio			
Television set			
….			

What are your sources of energy?	main	secondary
Firewood		
Charcoal		
Kerosene		

Does your household have other sources of income?		Is this activity in cooperation with others? If yes, with whom?	Did this activity also take place five years ago?	What is the reason for the change?
Goat/sheep keeping				
Cattle keeping				
Brick making				
Tree nursery				
Bee keeping				
Basket weaving				
Regular employment				
Casual labour				
….				

Are you involved in any cooperative activity?

Has the total income of your household […] compared to five years ago?
Increased decreased stayed the same

Water

season	What sources of water do you use?		How much of this water did you use for […] before and after dam construction? (per day)			
	wet	dry	Domestic	Agriculture	Livestock	Other
Scoophole						
Open Well						
Pump						
Roof catchment						
Piped						
Scoophole other catchment						

What factors do you consider when choosing a water source for:-	Dry season		Wet season	
	first	second	first	second
Domestic use				
Agricultural use				
Livestock				
Others				

Choose from: 1availability,2 distance,3 quality,4 reliability,5 quantity,6 price

How do you store your water on your homes?

What means do you use to transport your water? Donkeys
Human labour (who) + Donkeys
Human labour
Others

	How much time does your household spend for getting water for […] use per day? (min)				How often do you fetch water?-(Daily/once in two days,….)	
	How much time?		Who?			
	Now	5 years ago	Now	5 years ago	Now	5 years ago
Domestic						
Agriculture						
Livestock						
Others						

What do you do when the rains fail?		Are these the same methods you used five years ago?
Selling livestock		
Sell trees		
Sell household assets		
Reduce food consumption		
Purchase cheap foods		
Rely on off-farm income		
Borrow money		
Other		
….		

Health

What kind of common diseases does your household suffer from?					Are they more or less or the same as five years ago?	Reasons for change?
	5 years ago		After			
	Adults	Children	Adults	Children		
Malaria						
Cholera						
Typhoid						
Amoebic dysentry						
Skin diseases						
Kwashiorkor						
Marasmus						
others						
….						

Observations