Potential for community based adaptation to droughts: Sand dams in Kitui, Kenya

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Summary

The research aims at finding local level adaptation strategies that, apart from alleviating impacts from climate change, also assure food production, sustain people's livelihoods and ultimately contribute to rural and urban poverty alleviation. These strategies are thought to be cost effective and relatively simple to implement, because they connect to local knowledge. This paper evaluates a local project in Kenya concerning the construction of small scale dams by communities. The sand dams are evaluated on physical and socio economic effects. Out of research appeared the sand dams are a success. In 10 years time, 65.000 people have better access to water through low cost measure at an investment of about 35 USD per capita. The increased water availability results in higher farm yields, as well for irrigated and non irrigated crops. The average income of farmers living near dams rose with 9.000 KSh. (USD 120).

1. Introduction

Currently 800 million people suffer from hunger, among them 200 million children under five years of age. It is estimated that by 2025 cereal production has to be increased by 38% in order to meet world food demands (FAO, 2003). Climate change is expected to increase the severity, duration and frequency of extreme events such as floods and drought IPCC (2001), thereby threatening water availability and food security for millions of poor people (Aerts and Droogers, 2004; Dialogue on Water, Food and Environment, 2003). It is therefore important for policy makers, planners and managers

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who are involved in ensuring water availability and food security to take into account the possible impacts of climate change. Consequently, this implies that potential impacts should be outlined and appropriate options for adaptation to the impacts should be tested.

However most development agencies and national governments have only recently started to consider and discuss adaptation to climate change. As a consequence, discussions have remained on a conceptual level. Yet, given the growing interest in the subject of adaptation, there is a need to start identifying and implementing potential adaptation measures and to integrate adaptation into ongoing policy discussions. Policy makers, planners and water managers play a key role in the development of adequate adaptation strategies –especially at the local level where adaptation measures should be implemented (Seckler et al, 1999). The challenge lies in finding local level adaptation strategies that, apart from alleviating impacts from climate change, also assure food production, sustain people’s livelihoods and ultimately contribute to rural and urban poverty alleviation (Kashyap, 2004).

The goal of this research is to evaluate, and if possible improve, local adaptations in water resources management to climate variability and climate change in Kenya, with the focus on small-scale water storage. This goal is achieved by:

- Evaluating the potential for developing so called ‘Sand dams’ as a local adaptation to cope with climate events such as droughts
- Identifying vulnerabilities to Climate change in the Kitui water sector by performing a socio economic assessment of the effects of sand dams and link these to physical characteristics of the water resources system.
- Assessing institutional requirements for monitoring and maintenance of sand dams and search for opportunities for up-scaling local knowledge to the national level

2. Community based adaptation in the water sector

2.1 Issues and challenges

With the expected increase of extreme events -such as droughts and floods- under climate change (IPCC 2001), local storage of water is increasingly seen as an adaptation for ensuring water availability and food security to rural and urban populations. This is particular the case in semi-arid and arid regions outside the reach of perennial rivers and where there is no (or little) groundwater available. The need for increased storage capacity (and thereby an increase in water security) is underpinned by the Millennium Development Goals that specifically address storage needs to adapt to global changes such as sharply growing populations, climate change and catchment degradation.

Ensuring water storage capacities under climate change is a complex issue. Water storage for urban water schemes may include options such as construction of dams, long distance conveyance of water or desalination. However, for rural water security such solutions are generally too costly and complicated. Provisions for rural water supply require low cost systems with easy maintenance that can be constructed and operated with a high degree of community involvement. This perception is supported by the Copenhagen Consensus (2004), which regards small-scale water technology for livelihoods as likely to be highly cost effective.

Examples of such low cost methods are found within water conservation (or water harvesting) methods. They have been applied and used since ancient times in arid and semi arid regions, such as in the Middle East, for example (ACSAD, 1998). Since local communities are traditionally familiar with such methods, development and maintenance need relatively little training and investments. Therefore, they are increasingly seen as robust adaptations to climate change. In the development of adaptation strategies these and other local activities should be taken into account.

2.2. ADAPTS programme

The goal of the ADAPTS programme is to increase developing countries' adaptive capacities by achieving the inclusion of climate change and adaptation considerations in water policies and to stimulate local based knowledge in water management. This is achieved through establishing policy dialogues and taking local action. These dialogues should take place between local and national stakeholders on the issues of sustainable water management and climate change and adaptation. The ADAPTS programme aims t first identifying successful local water management activities and next seeks to evaluate these activities under climate change scenarios and stimulate additional adaptations to make local actions 'climate proof'. The research on drought management activities in the so-called Kitui sand dam project is part of the ADAPTS programme.

2. Case study: Kitui Kenya

2.1 Geographical characteristics

The Kitui District in the Easter Province is a semi-arid region situated 150 km eastern of Nairobi (Figure 1). The total land area is approximately 20.000 km² including 6.400 km² of the uninhabited Tsavo National Park. The elevation of the district is between 400 and 1800 metres. The central part of the district is characterised by hilly ridges, separated by low lying areas between 600 and 900 metres above sea level. Approximately 555.000 people inhabit the district and the growth rate is 2.2 percent a year (DDP,2002).

In 1997 the income of 58 percent of the eastern districts was beneath the poverty line of 2 dollars a day (PRSP, 2001). This is one of the poorest regions of Kenya. The main economic activity is rainfed agriculture (Census,1999). Irrigated agriculture only takes place on small plots on the river banks. During prolonged dry periods the farmers are dependent on relief food from donors. In 2004 and spring 2005 up to 50 percent of the inhabitants of Kitui received food aid (FEWS-NET). Besides farming the main economic activities are charcoal burning, brick making and basket breading.

The area is characterised by rainy periods that are highly erratic and unreliable. It usually falls in a few intensive storms (Nissen-Petersen, 1982). There are two rainy seasons, one from April to June, these are the so-called 'long rains' and one from October to December, these are the 'short rains'. On average the precipitation in the Kitui District is around 900 mm a year, but there are large local differences in amount of precipitation due to topography and other influences. The potential evaporation is high, 1800 to 2000 millimetre a year.

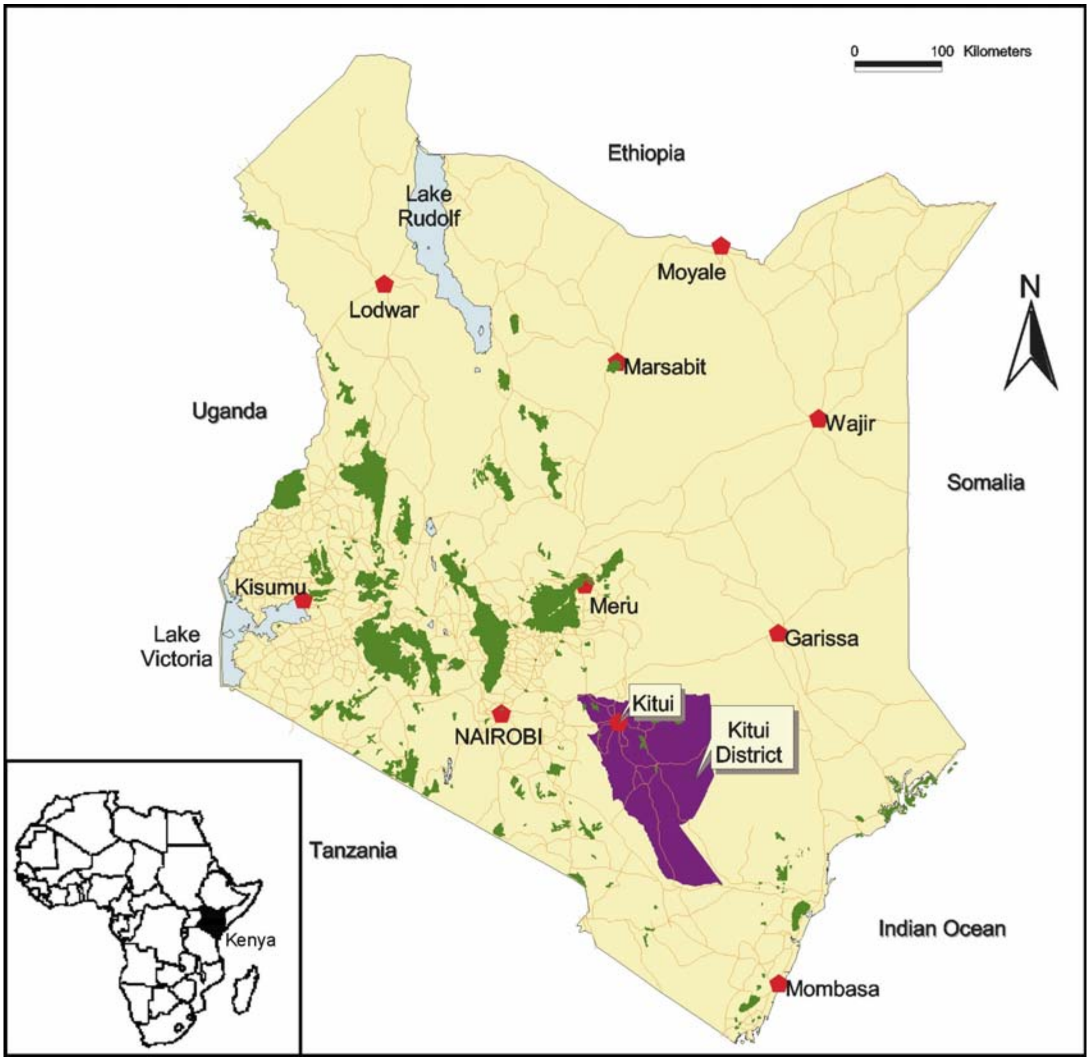

Figure 1. Location of the region of Kitui in Kenya.

Only 45 percent of Kenyans have access to clean water for domestic use and even fewer have access to water that is fit to drink. In the Kitui district these numbers are even lower only 6 percent of the inhabitants has access to potable water (DDP, 2002). Water is the most essential development commodity in this area, the major sources are the ephemeral rivers. Water scarcity forces women and girls to walk up 20 kilometres in dry periods to water sources such as springs and scoop holes.

Historical analysis of metrological data shows that Climate (change) is already an issue in the Kitui district. For example, figure 2 shows the relative frequency of yearly precipitation of one meteorological station for the period 1904-1954 together with the relative frequency of yearly precipitation of 7 meteorological stations for the period 1954 to 2004. The frequency of years with low annual precipitation has increased in the period 1954-2004 compared to 1904-1954. Mean yearly precipitation for the first period is 1000 mm and decreased to 800 mm a year. The district has become drier in the last 50 years. These historical time series of precipitation were provided by the meteorological department of Kenya.

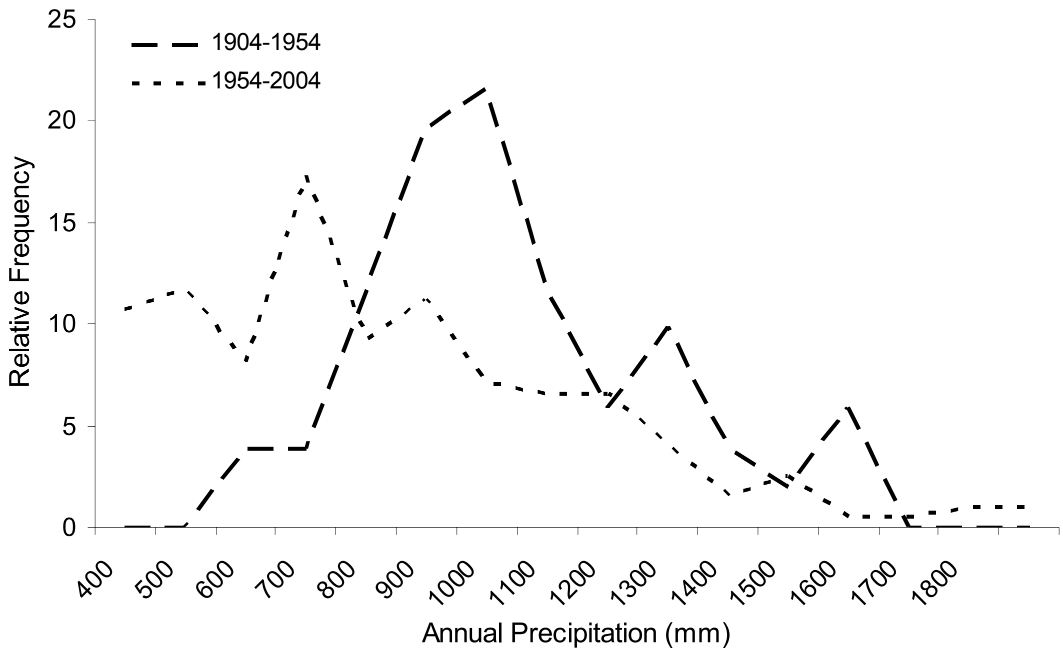

Figure 2: Occurrence of annual precipitation in Kutui for two periods. The Figure shows that in the second half of the past century, the annual precipitation decreased as compared to the first half.

Climate change and climate variability are expected to affect water resources in the Kitui district through changes in precipitation and evaporation. Temperature will roughly rise 2 to 4 degrees Celsius in the coming century, see figure 3. Precipitation will rise 10 percent in the second half of the century, but the first 50 years it remains nearly constant. The data is from the Hadley model under scenario A2 en B2. It is expected that the increase in evapotranspiration caused by temperature increase will cause a net negative trend in water availability despite precipitation number might increase.

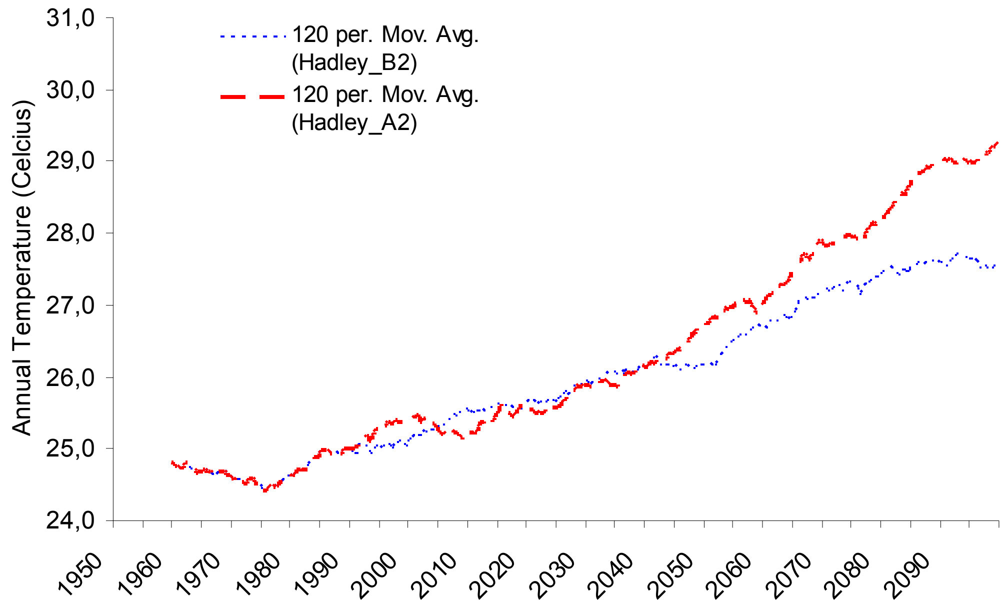

Figure.3: Modelled annual temperature (HadCM3) for Kenya under the A2 and B2 climate change scenarios.

2.2 Sand dams as local adaptation

A local NGO in Kitui (Sahelian Solution foundation, SASOL) assists local communities in building small scale sand dams to store water in sandy aquifers in ephemeral rivers. This technique improves the availability of water. SASOL's strategy is to reduce the distance to water sources to less then 2 kilometres and make water available for irrigation. Over the past ten years they succeeded to reach these goals in a large part of the district. Some 65.000 people have better access to water and are less vulnerable to droughts.

The sand dams differ from traditional dams by not only storing water in upstream reservoirs, but also storing water within the sand and gravel particles accumulating against the dam (Figure 4). Coarse gravel and sand can store and retain up to 35 percent of its total volume as water. This water is captured for use through an ordinary well or tube well that is dug into this storage material. In this way, the stored water is protected against high evaporation losses and against contamination. At certain locations where a soil of black volcanic ashes is present, replenishment of groundwater uphill is recorded. This type of soil has a high potential for holding water.

The construction of a dam is fully dependent on the inputs and commitments of local farmers. SASOL only facilitates fund raising for the dam materials, the site selection for the dams and the engineering of construction works. After choosing the location the construction starts with digging a ditch in the river bed to reach the bedrock. The work is done by a group of circa 15 persons, which is changing over time. On average 20 families are involved in building a dam. The construction normally takes 2 months and the material costs lay around U$ 5000.- . The number of dams constructed by a user group depends on the length of the river, the number of suitable locations and the availability of funding. The user groups are responsible for the maintenance of the dam and are usually committed, as they have built the dams themselves.

Figure 4. Example of a Sand Dam. The word 'sand' refers to storing water within the sand that accumulated behind the dam. A 'mature' dam is a dam where sand is accumulated to the highest level of the dam, hence generating the highest potential for water storage

The user group also builds a hand pump well besides the dam for extracting drinking water. These wells are constructed by the FAO guidelines. The use of the wells vary between the user groups, when drinking water is available during most part of the year near their homes they only use the well during the dry period. When there is no easy access to water, the well is used throughout the year, saving especially the women daily walking time. The water is also used for irrigation, both through simple scoping holes and the placing of water pumps. The availability of water during the whole year leads to cultivation of tomatoes, unions, mango, citrus, sugar cane, banana's and so on. During the dry period the water is also used for the production of bricks, an activity that is widespread in the district.

2.3 Institutional aspects

From a policy perspective there are two developments that are of importance for the sand dam project. First of all the Kenyan government translated the UN Millennium goals (UN,2002) to region specific goals. The Ministry of Planning and National Development supervises the realisation of these goals and the dams contribute to this. Besides the Millennium goals the government is in the middle of the process of changing the organisation of the water sector (Water Act, 2002). In the new constellation water user groups are an important entity on local level, through which the water resources are managed. These water user groups might be shaped like community groups that are formed for building the dams.

3. Research Approach

The Kitui project aims at first exploring physical possibilities for improvement of the structure and organisation of sand dam construction. This especially refers to the hydrological effects of the dams, such as the percentage of water stored as part of the total available water. Also, a cost benefit analysis is carried out and the socio economic effect of investing in this local knowledge and activities is assessed. Finally, institutional aspects are being explored in order to assess how the dams can be maintained and how the local knowledge can possibly be up scaled to other regions

3.1 Physical assessment

The physical assessment of the sand dams aims at identifying technical improvements of the dams and quantifying the amount of water that is stored by the sand dams. This was initiated by questions raised by engineers who claimed that the sand dams would store too much water, leading to less water availability in downstream parts.

During a field survey gauging tubes were placed on a section perpendicular on the riverbed, to monitor the groundwater levels over the year. Groundwater tubes were also placed along a section in a creek, passing several dams. During the rains, groundwater levels rise and the aquifer in the sand body besides the dam fills up. The river level during the rain events are estimated instead of measured, because runoff is too turbulent.

The hydrological measurements make clear what percentage of total runoff is harvested by the sand dams. It also points to whether downstream regions are affected by a decrease in runoff through upstream dam storage. For this, meteorological data is collected and will be used in combination with the runoff data to make a hydrological model of the region. This model will be used to estimate the effects of up scaling sand dam construction to the whole district and to simulate climate change impacts on water availability. This will finally provide an indication of vulnerability of the measure to climate variability and climate change. The meteorological department provided the historical time series of temperature and precipitation.

3.2 Socio economic assessment

The goal of the socio economic research is to quantify the effect of the sand dams on the vulnerabilities to climate variability and climate change of the local communities. Also, an indication of costs and benefits are made. The research starts with collecting data through interviewing farmers in two comparable communities, one with and one without sand dams. We followed this approach to exclude effects of external (economic) developments besides the construction of sand dams. Another reason is that the first dams were built some years ago and the farmers might not remember what their situation and production was before. Many of the interviewed farmers have finished primary school, but still 40% of the people in the Kitui District are illiterate. The interviews provide information on differences between the communities in time spend for collecting water and what activities are deployed in the time saved (basket breading, terracing, etc.). The interviews also provide insights in how the additional amount of water is used and whether there are changes in crop production after dam construction. If so, are there changes in household income. All the information will be combined in a cost benefit analysis.

3.3 Institutional assessment and up scaling

An important goal of this assessment is to identify the important factors influencing development and spreading of small-scale water retaining structures. Identification of the important stakeholders, their roles, goals and responsibilities are essential for the assessment. Therefore, an important part of the interviews is to assess how farmers experienced the way they were involved in the process of dam construction and what improvements they would like to see. Also current drought coping mechanisms are identified during the interviews. This information can be used to develop a generic methodology that can be applied to other regions (up-scaling)

Besides the historic development over the last 10 years, the impact of the reorganisation of the water sector and how community driven measures fit in is also subject of research.

4. Results

A quick scan of the case study produced some preliminary results. These form the base for further, in depth, research. The physical assessment mainly took place in the Kiindu catchment, where dams were constructed between 1994 and 1996. The socio-economic and institutional assessment was carried out in both the Kiindu and Koma catchment, the latter has no sand dams.

Physical

Groundwater levels were monitored over a stretch of river containing three sand dams, during the period September 2005 to November 2005. During this gauging period the short rains passed by. In combination with the size of the aquifer and peak levels in runoff the percentage of total runoff harvested by the sand dams is estimated. It is estimated that the dams store only about 5% of the total runoff.

Socio-economic

This section describes the preliminary outcomes of the socio-economic survey in the Kiindu and Koma catchment. After dam construction in the Kiindu catchment, farmers shifted to grow water demanding crops such as pumpkins, cassava, sweet potatoes, and sunflower. There is also less crop failure as compared to the Koma catchment over the same period. Farmers in the Koma catchment remain cropping rain dependent crops

Vulnerability categories	Vulnerability indicators	Before Dam construction	After dam construction
Agriculture	# of cash crops	1.5	2.8
	% crop failures	---	24.4
	% irrigated crops	37	68
Social aspects	Water collection domestic [minutes]	140	90
	Water collection livestock [minutes]	110	50
Gender	Average walking distance to water [kms]	3.0	1.0
Economic	Income [U$ / year]	230	350
	Value of New economic activities [U$ / year]		
Health	% households suffering from malnutrition	31.6	0
	% households indicating that malaria has increased	---	78.9

Table 1: Changes in vulnerability after dam construction for a numbe rof vulnerability indicators

Table 1 shows the results of the socio economic assessment. The table presents several vulnerability classes and vulnerability indicators and shows how the values of the indictors have changed through the construction of the dams.

In the Kiindu catchment the percentage of households growing irrigated crops rose from 37% before dam construction to 68% after dam construction. On average 20 households use one sand dam. From these households 50% sell their harvest, earning between 1000 and 13000 Kenyan Shilling (Ksh.) per year (USD 13 to 175). In the Koma catchment, there has not been any notable change over the last 5 years in terms of both cropping or income change. The growing of tomato, union and kale almost doubled in Kiindu whilst the production in Koma remained the same (Figure 5).

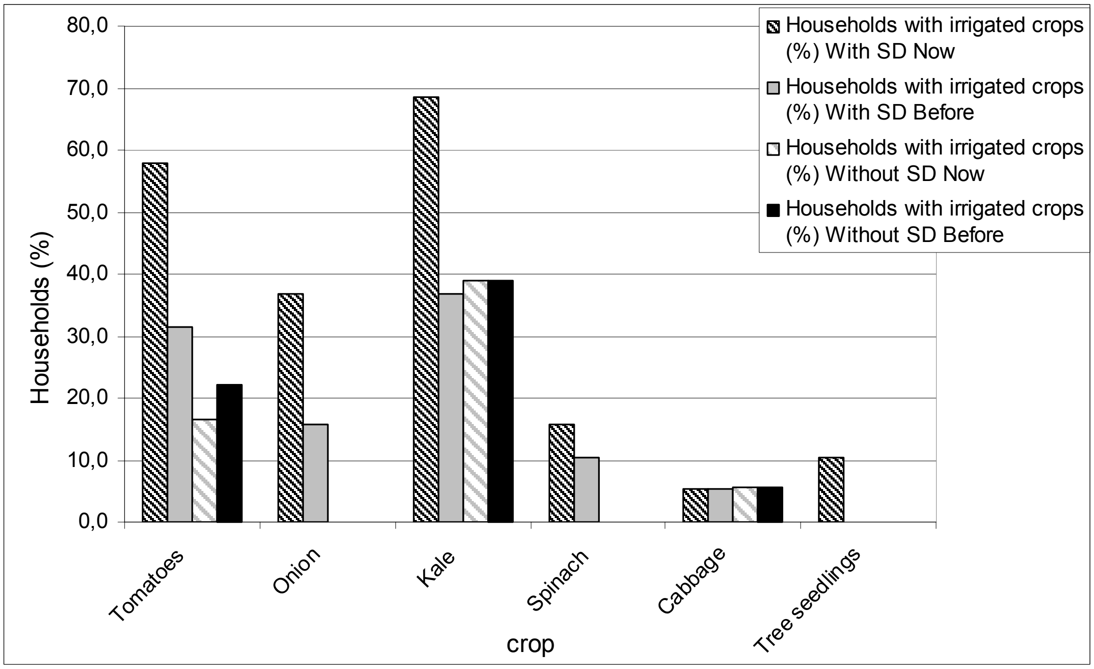

Figure 5: Number of household growing irrigated crops. *Before* are values from before sand dams (SD) construction in both catchments. *Now* is after dam construction in Kiindu catchment only. The Koma catchment still does not have dams.

The time spent on collecting water for domestic use decreased from 140 minutes per day to 90 minutes per day after dam construction. The decrease is due to the fact that water is available throughout the year, whereas scoop holes in the river go dry between the rainy seasons before dam construction. The women used to go to other catchments further away during the dry period. This is no longer necessary. Also the number of water points increased after dam construction, decreasing the queues and thus waiting time. In Koma the time spent on collecting water for domestic use stayed the same over the past five years. A household spends on average 180 minutes a day. Time spent on watering the livestock also shows a decrease, from 110 minutes to 50 minutes, interesting to see is the number of livestock that has risen since the construction of sand dams. The irrigated area per farmer is larger at Kiindu, this is due to higher rent for land near the river at Koma, where irrigation is also possible.

Because water is available at nearer distances through the development of dams, farmers can spend their time saved on other activities. 33% percent of the households answered that they could spend more time on farming (terracing, irrigate, prepare the land before the rains), 29% responded that domestic tasks were further developed (increase hygiene, cook meals) and in 43% of the responses it appeared that they shifted to other income generating activities. The time is also spent on joining corporations and leisure. Figure6 shows the percentage of households carrying out non-agricultural activities in both catchments. For the no sand dam Koma catchment, there is almost no change in non agricultural activities. In the catchment with sand dams there is a large increase in basket weaving, bee keeping and rope making generating extra income. Casual labour and goat and sheep keeping increased slightly.

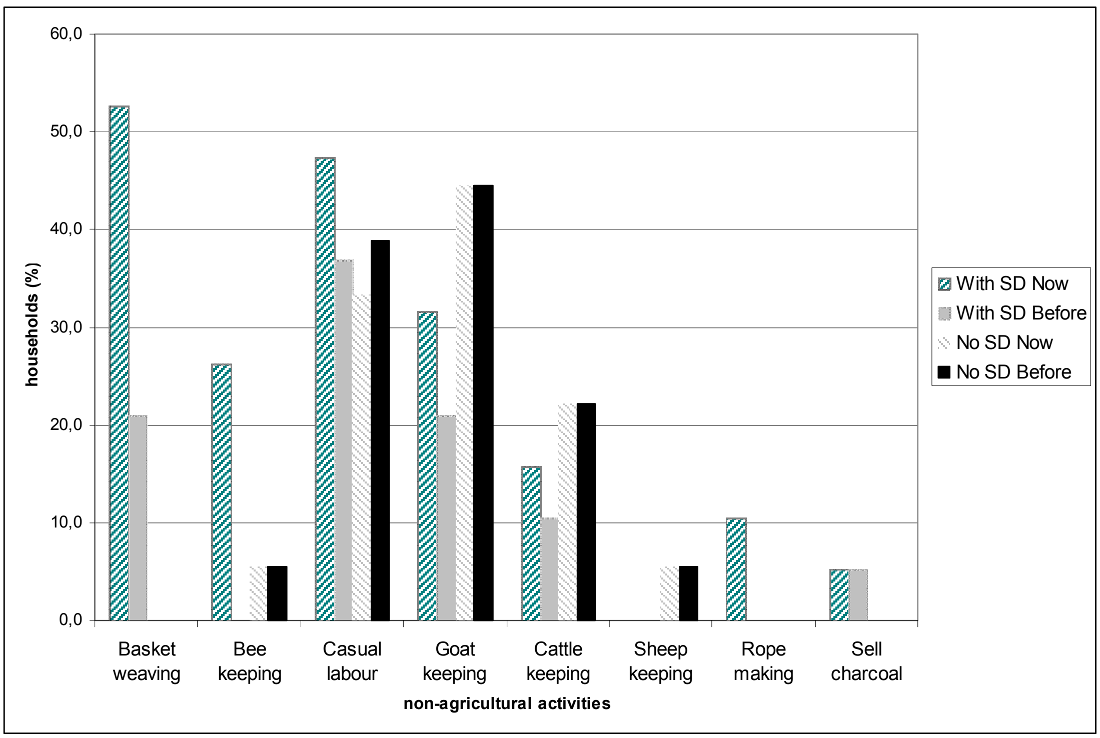

Figure 6: Changes in non agricultural activities before and after sand dam construction.

The average household generates an extra income from non agricultural activities around 8500 KSh (USD 115) per year after dam construction, before dam construction this was around 4000 (USD 50).

The construction of the dam costs USD 5000 and labour time. The benefits to the community (20 households) of a mature sand dam with irrigation is around 180.000 KSh per year (USD 2400). In a few years the initial investments are earned by higher profits.

Policy/ institutional

During the field study more catchments and sand dams were visited. In most cases, farmers were enthusiastic about the dams. When a dam breaks down the community contacts SASOL and together they repair the dam. According to the interviews this success is dependent on good community organisation and cooperation within the community.

In some cases, the institutional setting caused problems. It appeared that some of the dams did not function properly or were even broke. The interviewed farmers told some communities did not really believe in the sand dams and carried on with the same practices as before dam construction. Others were disappointed when something went wrong with the dam and did not feel responsible for the maintenance of dams.

There is also still a large gap between the local activities and the National water policies of the Kenyan government. For example, the implications of the new water act are not clear; the report on reorganisation of water resources is not finished yet.

5. Conclusions and future research

The sand dams are a success. In 10 years time, 65.000 people have better access to water through low cost measure at an investment of about 35 USD per capita. The increased water availability results in higher farm yields, as well for irrigated and non irrigated crops. The average income of farmers living near dams rose with 9.000 KSh. (USD 120).

The success of the dam is mainly dependent on the commitment of the community. This depends on community organisation and the presence of a good community elder. In the process of building sand dams even more attention should be paid to this aspect, even after finishing the building process.

The dams store only a small part of the flash floods in the river, around 5%. There is enough water available for the construction of more sand dams.

There are points for further study such as:

- Are the current dams climate proof and are they suitable to help to adapt to climate change? What are the effects of successive dry years and how will the dams help to overcome such situation? Through a participatory approach with farmers and stakeholders projected climate change effects on Kitui District out of climate change scenarios will be discussed, when falls the extra precipitation, during the growing season or outside the growing season. How can they improve the dams and / or their management?
- How to increase the success rate of dam construction further? The key element is expected to lie in community organisation and involvement.
- Institutional aspects: What is the potential for up scaling and dissemination of the good practices the Sand dam method to other regions. What are the institutional implications for up scaling? Future research will also go into the effects of implementation of the new water act on sand dams and sand dam community groups.

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