Soil and Water Conservation in Thika-Chania catchment, Kenya

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Soil and Water Conservation in Thika-Chania catchment, Kenya

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Abstract
Soil and water conservation measures are widely practiced in Kenya to tackle the degradation of the ecosystems and to improve land productivity. Local government and NGOs have developed programs and campaigns about soil and water conservation measures. The aim of this study is to assess the need for soil and water conservation measures in Thika-Chania catchment by conducting a household survey using QuickTap Survey software. A total of 200 respondents were successfully interviewed and results analyzed in SPSS program. GIS tools were also used to do a classification of slopes in the study area. Results indicate that more than 90% of the people in the catchment area are farmers. In the recent years, 50% of the respondents have noted a decline in the vegetation. During the rain seasons, the intensity of color in the local rivers due to sediments have been observed to increase by 75% of the respondent while 9% said there was no change. More than 70% of the respondents indicated that the water levels have been on the declining trend especially during the low flows. Terraces and grass strips were the common soil and water conservation measures although some of them were severely degraded. We concluded that there is an immediate need to implement soil and water conservation measures in the catchment to enhance and restore the optimum functioning of the ecosystems. Capacity building and frequent extension services are needed to increase awareness on the impacts of the respective conservation methods. Incentives programs need to be established to encourage more farmers to participate in conserving and protecting their lands from degradation.

Keywords: Baseline survey, soil and water conservation, capacity building, degradation.

1. Introduction

1.1. Background information

Studies done in Africa have shown that most small holder farmers have inadequate soil and water conservation measures and lack of diversification in the farming methods [1]. Land degradation leads to the deterioration of ecosystem services thus endangering their sustainability. Soil and water conservation methods have been evaluated for their effectiveness and have been shown to significantly reduce sediments and nutrients loss from the agricultural fields [2,3,4]. However, inadequate farmers' perception to practice or maintain those measures has been attributed to be the major cause of increasing soil erosion [5]. According to [1], if soil and water conservation measures are not taken into account, the cost of mitigating the degradation of ecosystems get higher while the crop yields persistently decline.

Approximately 5t/ha of top soil is washed to the water bodies in Africa thus deteriorating water quality [6]. Degradation of water resources costs Kenya at least 33M USD annually which is approximately 0.5 percent of the GDP [7]. These costs emanate from the degradation of water catchments, sedimentation of reservoirs and pollution of surface and groundwater.

Research has shown that Thika-Chania catchment contributes to the sedimentation of reservoirs downstream of the catchment. Masinga and Kamburu reservoir have an annual average sedimentation rate of 8.03 and 1.1 Mton of sediments respectively [8]. This can be attributed to the inadequate soil and water conservation measures and degradation of the existing ones. There exists a gap in conducting baseline surveys to evaluate the existing conservation methods prior to advocating and campaigning for the implementation of soil and water conservation measures. Studies have shown that governance performance could be improved if the local farmers are involved at all stages of decision making [9]. The aim of this study was to evaluate the need for soil and water conservation measures in the Thika-Chania by conducting a household survey on soil erosion, water and land use and climate variability.

1.2. Study Area

Thika catchment, Figure 1, lies in the central province of Kenya between latitude 36.58^0 and 37.58^0 E and 0.58^0 and 1.17^0 S. The catchment lies in three counties and covers a total area of 839 km^2. The area is drained mainly by Thika and Chania rivers that later join at the outlet of the catchment and drain into Masinga reservoir. Forests cover 36% of the total catchment area while 28% and 20% are for coffee and general agriculture cultivation, respectively. Rainfall distribution in the catchment is bimodal and varies from 800 mm in low altitude areas to 2200mm in high altitude areas. Dominant soils in the study area include Andosols, Nitisols and Cambisols.

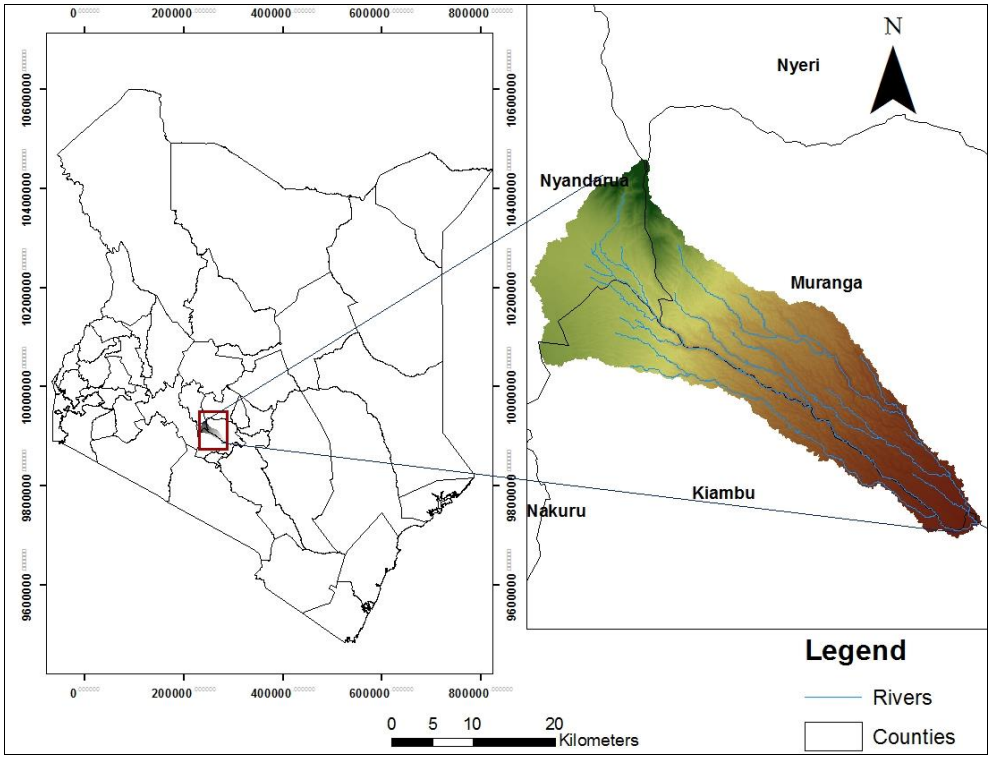

Figure 1. Thika-Chania catchment

2. Methods

A total of 200 respondents were interviewed between March and April, 2017. The household survey was designed to assess the current land and water use, soil erosion and degradation of water resources. The draft questionnaire was finalized after deliberations with several stakeholders including the water resources users' association (WRUA), academic experts and the local administration officers.

QuickTapSurvey software version 5.4 (www.quicktapsurvey.com) is used to collect data in the field. The software allows for creation of questionnaires with skip and branching logic that ensures that only appropriate questions are asked. Once the survey has been uploaded to the tablets, the exercise is then done offline in the field. The collected data is then uploaded to the software provider's server at the end of each day.

Cluster sampling of household within the randomly selected administrative wards were selected. These included those households along the Thika and Chania rivers and their respective tributaries where soil and water degradation would be monitored. The survey also targeted the respondents who had stayed in the respective areas for more than one year since it was assumed that they had good know-how on the hydrological processes in the catchment. A pilot study was conducted in the neighboring town of Thika to rule out the possibility of errors or complexity in the questionnaire setup.

To ensure internal reliability of the survey, questions on land use and water use were asked in two different ways at the beginning and end section of the survey. The survey was also programed such that no out of range answer could be entered. However, enumerator had the option to comment on a question if the answer entered is the correct one e.g. when the land size is more than 20 acres. ArcGIS tool (version 10.3) was also used to analyze the slopes of the catchment. A design effect of 0.9 was assumed for the sample size given the cluster sample and high inter-cluster correlation among the villages in the wards. A 5% margin of error was targeted and a 95% confidence interval. The data was then analyzed in SPSS program to evaluate the farmers' responses on land and water use, climate variability and water degradation.

3. Results and discussion

3.1. Respondents characteristics

A total of 200 valid interviews were completed. However, the incomplete interviews were deleted and replacement households were selected. The sample size provided an overall of 5.0% margin of error with a 95% confidence interval. Most of the respondents were male (56%) with more than half (70%) of them being the head of the household. The average age of the respondents was found to be 40 years.

3.2. Land use/cover

Most of the inhabitants in the catchment derive their main source of livelihood from farming as shown in Figure 2.

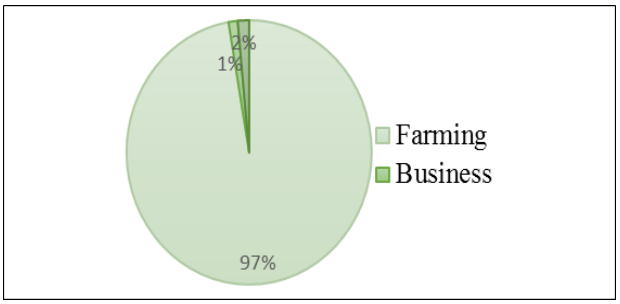

Figure 2. Main activity of the respondents in Thika-Chania catchment (n=200)

The crops grown include tea, coffee, maize, potatoes and cabbages. Cabbages and potatoes were mostly grown in the upper regions of the catchments while coffee was common the in middle parts. The average land holding under cultivation in the catchment was found to be 2 acres. Only 1% of the respondent indicated that they had leased out their lands. Long term soil and water conservation methods could therefore be encouraged in this region because most people have secure land tenure.

Studies show that farm size and land use types are key factor that determine the adoption of management practices and also increase water use efficiency [10]. Land tenure arrangement and lack of information by farmers have been attributed to the low adoption rate of soil and water conservation measures [11]. Most people (74%) depend on rainfed agriculture while 26% irrigate their crops during dry seasons.

Vegetation cover on the farms was observed to have decreased by 50% of the respondents.

Table ***1*** shows the response of farmers on the trends in vegetation cover compared to the past five years.

Table 1: Comparison of vegetation cover on the land to past five years

Subcatchment/Ward	Decreased	Increased	Same	n
Gituamba	53%	41%	8%	47
Thika Valley	50%	41%	7%	81
Gatura	47%	45%	8%	72
Thika-Chania Average	50%	42%	8%	200

The decline in vegetation cover could be attributed to the inadequate rainfall to support plant growth. Some respondents have indicated that they are now cultivate crops that could not do well in those areas due to changing weather conditions.

Seventy percent of the respondents in the catchment were observed to have their lands adjacent to a river or a stream. The farmers in conjunction with the water resources users' association could be better targets for riparian conservation. From the respondents who have their land neighboring a river or stream, 80% indicated that they do cultivation along the riparian region. Riparian conservation as outlined in the national land use guidelines [13] could effectively be implemented in these areas through participatory approach involving all the stakeholders.

3.3. Water use and change in quality during rainy season

During and after rain events the color intensity of the local rivers have been observed to be high by most of the residents as shown in Table ***2***.

Table 2: Change in color intensity of local river after rains

Subcatchment/Ward	Higher intensity	Lower intensity	Same	Not sure	n
Gituamba	73%	9%	2%	16%	47
Thika Valley	78%	13%	5%	4%	81
Gatura	75%	3%	20%	2%	72
Thika-Chania Average	75%	9%	9%	7	200

The change in river color implies an increase in the amount of sediments carried in surface runoff during rainfall events. It also means that soil is carried from the uplands and therefore conservation efforts need to be prioritized to control the amount of sediments reaching the waterbodies from the farm lands. The high amounts of sediments lead to deterioration of water quality especially for the communities that rely on river water for their domestic use. The river water takes more than 3 weeks to get clear again as it has been observed by 60% of the respondents. These exposes the community to contaminants that are washed from the agricultural lands and urban centers.

Soil and water conservation methods would slow down the rate of flow of surface runoff thus enhancing infiltration and also retaining the sediments on the farms [2,4,12].

Conservation techniques have also the capability to increase the baseflow that contributes to stream flow during low flows [14].

The dry season water levels have been observed to be lower compared to 10 years ago, as shown in Figure 3.

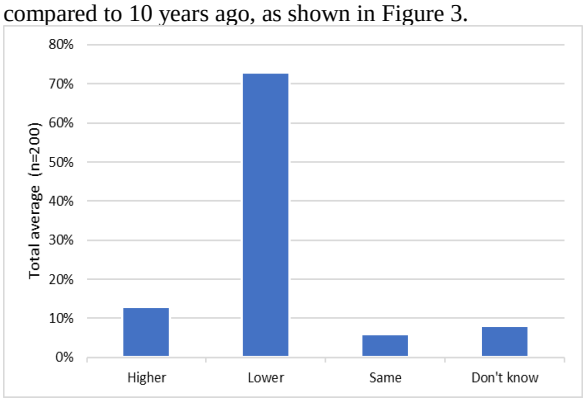

Figure 3. Water level in rivers and streams during dry seasons.

During dry seasons, communities that rely on rivers for their domestic use (30%) should walk long distances in such of water or dig shallow wells along the riparian regions. This ends up in loosening the soils in these areas that are then washed into the rivers during rain seasons. In a community where 3 out of 10 people should go to the rivers to fetch water for drinking and cooking, surface water protection and conservation is paramount.

Most people indicated that they dispose domestic wastewater within 25 meters from the household and only a few used it to irrigate kitchen gardens. Re-use of water should be encouraged especially in water scarce areas. Rainwater harvesting is practiced by majority of the respondents (85%) in rain water tanks and small containers. Those who don't do rain water harvesting had either tapped water from water services providers or have their own water wells.

3.4. Slopes characteristics

The slopes in the catchment varies from steep to very steep with only 4% of the respondents indicating that their lands are flat while 40% and 13% said that their lands are steep and very steep respectively. Although these results were verified with a slope that was produced using GIS tools as shown in Figure . Analysis of the slopes indicates that 69.3% of the catchment have slopes between 0 -20% and 21.30% have slopes between 20-30%. These areas are majorly on tea, coffee, corn and other agricultural crops. In some tea zones and in the forests, the slopes were observed to be more than 30%. Although in the latter zones, soil erosion might not be as high due to minimized manipulation of the soil and extensive ground cover, conservation methods in agricultural lands should be emphasized.

Reports have shown that coffee and maize growing zones have high soil erosion rate compared to tea zones in the catchment [12,15]. If slopes, Figure 4, are considered as a contributing factor to soil erosion, then the middle part of the catchment should be prioritized for implementation of soil and water conservation methods.

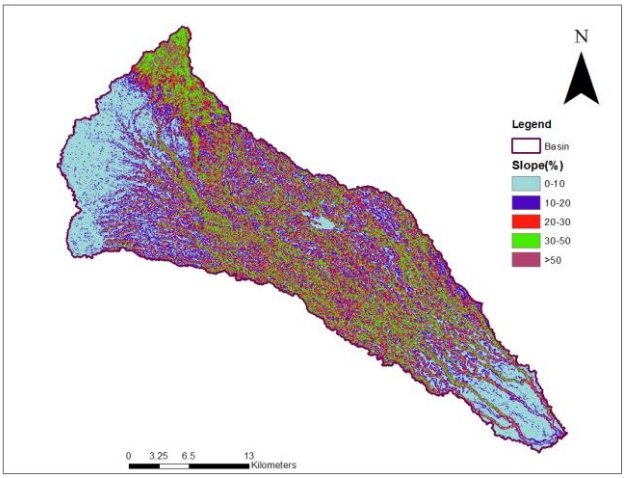

Figure 4. Slopes in Thika-Chania Catchment.

3.5. Soil erosion and existing soil conservation methods

More than three quarters of the respondents indicated that soil erosion occurs on their lands. A physiographic survey that was done in 2011 in Upper Tana catchment indicated that from the catchment contributes 36% of the total sediments inflow into the downstream Masinga reservoir [16]. Terraces and grass strips are the main conservation methods used by farmers in the study area as shown in Figure 5.

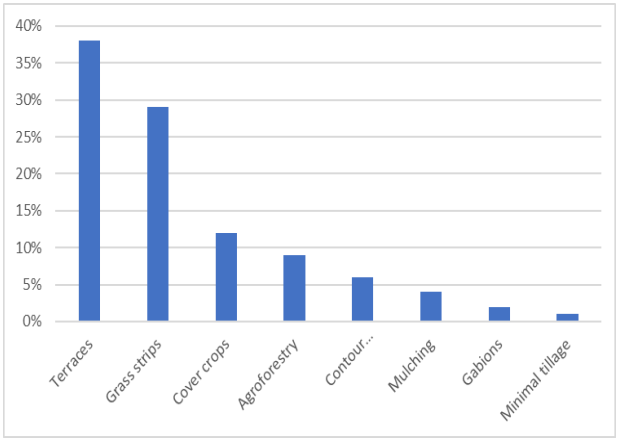

Figure 5. Common soil and water conservation measures in the catchment.

Terraces were commonly found in the coffee growing zones. The terraces are however not managed properly leading to their collapse and the soils washed away by surface runoff as shown in Figures 6 and 7.

Figure 6. Collapsed terraces in Gatura village.

Figure 7. Degraded grass terrace in Gatura village.

For their optimal operation, terraces need to rehabilitated and encourage construction of new ones in areas where none exists. Based on a study done in Ethiopia, the lack of short term benefits from conservation measures could be attributed to the lack of maintenance of terraces [11]. This is evident in areas where grass strips are well maintained because they are a source of fodder for livestock.

Research shows that when soil and water conservation measures are improved, they can reduce moisture stress and improve crop yields associated with rain-fed agriculture [17]. Surface erosion was evident in sloping areas where gullies have already developed Figure & 7. From the baseline survey, it was observed that more than half of the respondents (51%) had less than a quarter of their lands with soil conservation measures.

The absence of adequate conservation measures implies that soil loss will carry along the applied fertilizers and pesticides to the water bodies. This will not only lead to deterioration of water quality but also lead to poor soil structure and decreased crop yields. Research has shown that farmers has the tendency to adopt soil and water conservation measures if only they can realize in increase in their profitability and have access to government incentives [18,19]. The degraded existing conservation methods could demotivate farmers to implement new ones. A study was done to determine the adoption behavior of soil conservation measures in Tanzania and found that participation of farmers in promotional activities of the conservation programs influences their adoption decision [20].

3.6. Trends in fertilizer use

Farmers were asked on the current usage of fertilizers compared to the past five years. Most people indicated that they mostly use farm yard manure and chemical fertilizers on their lands. More than half of the respondents (52%) indicated that they apply more fertilizers on their lands while 24% indicated that fertilizer use has been declining and 23% has been the same. Those whose fertilizer use has not changed indicated lack of resources while others said that declining yields discourages them from applying more fertilizers. Declining soil fertility and low crop yields are some of the factors that were attributed to the increase in the amount of fertilizers applied. Declining soil fertility could also be attributed to the high erosion rates in the catchment [12]. To address the declining productivity of farm lands, soils need to be protected from erosion by installing conservation methods to reduce surface flow velocity. Ecosystem services provided by nature will continue to degrade if intervention measures are not implemented. These measures include the soil and water conservation measures with involvement of all stakeholders. A study done in Tanzania showed that effort by the government on soil and water conservation activities through collaboration of different institutions, socioeconomic support to farmers and persistent participation of the local community in restoring the degraded ecosystems were successful in ensuring environmental and socioeconomic sustainability

3.7. Climate variability/change

Most respondents indicated that they were unfamiliar with the term climate change. However, they said that they have observed changing weather patterns since they were young. This indicated that farmers have observed climate change but have not been capacity built on what climate change is about. A Similar study in Iran found that farmers rarely use communicative media and information sources [21]. The authors recommended improving farmers' access to communicative channels and others useful sources of information to strengthen their interactions among themselves, service providers and increase awareness and knowledge of modern technologies. Those that have heard of climate change said they learnt from electronic media like radio and television. Rainfall variation has been observed to majorly decrease in the recent years Figure 8.

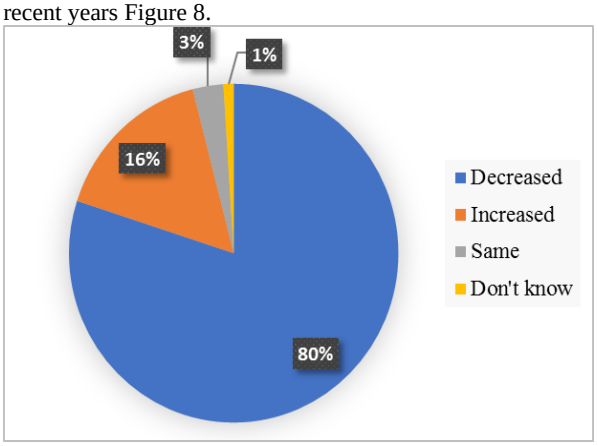

Figure 8. Rainfall trends in the catchment (n=200).

Those who noted that rainfall have increased said that in the recent years there is a high rainfall intensity of a short duration compared to 10 years ago, others indicated that in their young days, rainfall used to be of longer duration, low intensity and was adequate for crop growth. They added that they had traditional methods of predicting rainfall that were also useful to inform on the timing for different farming activities.

Firewood and timber for construction was observed as the man reason why people cut down trees in the catchment. Seventy percent said they cut down trees on their farms as a source of firewood while 15% used it as source of building materials.

4. Conclusion

A total of 200 interviews were successfully completed and analyzed. Results showed that majority of the inhabitants are small -holder farmers with an average land size of 2 acres. Fifty of the respondents indicated a decrease in vegetation cover over the past five years. The color intensity of the local rivers has been observed to increase during rain seasons and it takes more than a fortnight to clear. More than three quarters of the respondents indicated that soil erosion occurs in their fields. The slopes in the catchment were observed to vary between steep and very steep. The existing soil and water conservation measures were damaged and in some places, they did not exist at all. Rainfall trends have been observed to decrease with time hence the need to conserve water for dry season.

These results indicate that soil and water conservation measures should be implemented and rehabilitate the existing ones in the catchment to prevent soil loss due water erosion. These measures will also enhance infiltration of water during rain seasons hence recharging the shallow aquifers that supplement water to the rivers during low flows and also reduce the deterioration of water quality. These measures will also ensure that crop yields are increased since fertilizers will not be washed away in surface runoff. Institutional strengthening and capacity building is key ensure protection of riparian areas should be enhance adoption of soil and water conservation measures.

All stakeholders should be incorporated from the decision making to the implementation of such measures that will improve the ecosystem processes. Programs such as payment for ecosystem services should be established to provide incentives to farmers that implement and maintain soil and water conservation methods. Farmers interaction with the extension agents and frequent capacity building are significant to increase adoption of soil and water conservation measures and to increase awareness of their impacts of the ecosystem.

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