Effects of Soil Erosion on Sediment Dynamics, Food Security and Rural Poverty in Makueni District, Eastern Kenya.

WAMBUA, Boniface Nzuve[1] & KITHIIA, Shadrack Mulei[2]
[1]Department of Geography & Environmental Studies
University of Nairobi, Nairobi, Kenya.
[2] Department of Geography & Environmental Studies,
University of Nairobi, Nairobi, Kenya.

Abstract

Makueni District has experienced low crop production per unit area despite increased hectarage under crop production. The district relies heavily on farming for food and income generating activities for the households. However, poverty level has been on the increase due to poor crop production and limited diversity in sources of income. Analysis of field survey carried in the district shows high variability of soil nutrients (Nitrogen, Phosphorous, and potassium), Cation Exchange Capacity (CEC) and soil pH due to various land use systems which have been in use for a long time. These land use systems have contributed to land degradation and increased sediment fluxes from farmlands. Subsequently, food production has declined by 50% due to soil fertility decline leading to increased household poverty levels. This is based on a survey study carried in the district between the year 2005 and 2008. The district has also experienced increased sediment influxes problem in water supply systems. These have affected immensely water sources in the district namely, earth dams, water pans, traditional river wells among others. Continued sedimentation of these water sources has compromised the quality and quantity of water supply in the district and therefore, changing the socio-economic characteristics of many households. Increased sediment load is attributed to poor methods of farming and grazing such as lack of contours, cut off drains, terraces and overgrazing. This paper examines soil erosion incidences, intensity of land degradation and sediment influxes on water resources, farm productivity and poverty status at household level.

Keywords: soil erosion, sediment influx, land degradation, food security, rural poverty.

Introduction:

Kenya has a varied ecological environment, which is characterized by differences in agricultural potential and in patterns of food production. The country has faced increasing food deficits, and high rural poverty levels, a fact attributed to high population growth (2.8%) per annum, environmental degradation and limited sources of livelihoods. In the past few years the country has witnessed increasing levels of rural – rural migration from densely arable agricultural areas (12% of the total land area) which receive annual rainfall of more than 1400mm to areas of marginal agricultural potential with less than 700mm of rainfall per annum (Kagutha, 1995; Republic of Kenya, 2001). The expansion of cropping activities into such fragile ecosystems and settlement of people on the same areas has increased land degradation, sediment influxes into water points leading to regular food shortages and inadequate water supplies.

Land is the main asset in agricultural production and generally, limited availability of productive land is a major constraint to increased agricultural production (Kinyua, 2004). Soils in Kenya and in particular marginal areas have over the years been subjected to serious erosion and low organic matter due to low density of plant life, particularly on steep slopes. Much of the natural covering for the rangelands has been degraded and indigenous vegetation depleted (through charcoal burning and firewood harvesting) thus leaving ground cover in some areas badly depleted (Tiffen, *et al*., 1994; Kliest, 1985; Republic of Kenya, 2004). Approximately 70% of all energy consumed in rural Kenya is generated from wood fuel thus accelerating the pace of devegetation and land degradation (Republic of Kenya, 2000). The resulting depletion of the natural resources in Arid and Semi-arid lands (ASALS) can be attributed to anthropogenic factors and therefore pose a threat to the future generation who are expected to live on such marginal lands.

This paper focuses on Makueni District in eastern Kenya which has experienced low crop production per unit area, land degradation, high poverty level and inadequate water provision over the years.

The paper presents findings on food security status in the district, effects of land degradation on soil fertility, sediment load influxes and their effects on water resources and livelihoods of the rural households of Makueni District in a view to reducing poverty levels and increase livelihood levels.

Study Area

Makueni District covering 7440 km2 is one of the twelve districts that form the eastern province of Kenya as shown in figure 1. The district is one of the marginal areas and experiences two rainfall seasons but with marked spatial and temporal variations in amounts received. The northern parts with hilly masses of Mbooni and Kilungu receive annual rainfall of 800 – 1200mm while the drier southern part receives low rainfall. The district is served by Athi River as the perennial source of surface water with its tributaries such as Kambu, Kiboko, and Mtito-Andei. These rivers are only reliable as long as the district experiences sufficient rains. The ground water resources are scarce and there is a major problem with high salinity especially in Kathonzweni Division. Clean and safe water supply in the district is largely inadequate leading to proliferation of water borne diseases.

The district's environment is at the brim of total environmental destruction due to unabated felling of trees for charcoal burning and firewood. This has exposed huge tracks of land to continued water and soil erosion thus increasing sediment influxes into the rivers, earth dams and other sources of water. Moreover, the quality of land and crop productivity in marginal lands of the district is declining, thereby leading to increased food insecurity (Republic of Kenya, 2000; FAO, 2001, 2003). This has increased household poverty, poor health especially among children and high school dropout rate. The findings in this paper are useful in addressing food insecurity and reducing land degradation issue.

Study Methodology

This paper presents results of a field survey research carried in Makueni district from 2001-2007 (Wambua, 2008). A sample survey of 200 households was used to examine the socio-economic and environmental factors affecting food security and household poverty. Systematic random technique was used to select the households distributed in five divisions namely Kasikeu, Makindu, Kibwezi, Kathonzweni, and Wote as indicated in figure 2. Food security was assessed using FAO's nutritional requirement which is 2250 calories per adult person per day. Household food consumption and monthly income levels were used to compute food security status. The paper has also used secondary data from the Ministries of agriculture, Water and Irrigation to analyze food security, environmental degradation and socio-economic characteristics of the study area. Water samples drawn from water sources in the district were used to indicate the trends in soil erosion and sediment load influxes into these sources.

Results and Discussions

Food security status and the causes

The patterns of food production in Makueni District are characterized by considerable seasonal fluctuations which contribute to widespread food shortages in most of the households. According to the secondary data collected from the district agricultural office for a period of ten years from 1998 to 2007, Makueni district experienced 40% maize deficit, 87.2% bean deficit, and 32% pigeon pea's deficit. These crops form the staple diet to the Akamba community who live in the district. When the average food shortage data was computed, it showed that the district has been experiencing a food deficit of 56.15% which indicates that, food demand outstrips supply thus leading to food insecurity and subsequently, human suffering, high rate of school dropouts, rural – urban movement and poor health status in many households investigated.

Results from 200 households interviewed in the district shows different status of food insecurity as shown in table 1.These findings indicate that 35% of the households are extremely food insecure while 58.3% of the households were moderately food insecure. Only 6.5% were food secure. Analysis of the survey data shows that over 70% of the rural households are below food poverty line which implied that people do not meet their minimum food requirement. The high risk of food insecurity has contributed to the collapse of agro – pastoral systems and reduced income generating activities thus eroding the purchasing power of the rural households. This has driven people to charcoal burning as a means of earning some income and hence resulting to increased environmental degradation. The over-all implication has been declining crop production, increased sediment loads and poverty levels.

Causes of food shortages

The study results indicated that soil erosion by water is the major form of land degradation in Makueni district. Erosion in the cultivated fields is commonly associated with lack of ground cover for the first month after planting and this is generally the time at which heaviest rains can be expected. Farms highly affected were those along slopes and lacking effective conservation measures. Study findings showed that more than 80% of households interviewed live on one dollar (1 US$) per day and therefore it is difficult to practice soil and water conservation methods where soil erosion is rampant. Therefore, farms are experiencing nutrient deficiency and subsequently contributing to food shortages in the district.

In addition, rampant erosion on the grazing lands which was attributed to increased livestock numbers against diminishing land size due to land fragmentation. The tufted and patchy perennial grasses were grazed down thus exposing the intermitted bare soil to erosion and compaction by rain drops. Erosion removes the humus in the top soil, and compaction impedes the infiltration of rain water and the germination or growth of grasses and herbs (Tiffen, *et al*., 1994). Soil erosion in the district is also enhanced by the nature of the rainfall regime which is predominantly rainstorms.

These rainstorms which are relatively short and intense have great impact on soil erosion due to high surface runoff compared to low infiltration rate. Secondary data from Kenya Agricultural Research Institute (KARI) shows that the hill slopes of Makueni District loss 53.3 tones of soil per hectare in a year on the degraded grazing lands and 16.0 tones of soil per hectare on the cultivated fields. This indicates high sediment rates influxes in the seasonal rivers and sand dams. Areas of good grazing with bush woodland had the least soil loss of 1.1 tons per hectare. This is a major contributor to the increased sediment load influxes into the water sources and a reduction in water quality in terms of turbidity and colour.

Soil sampling and analysis was carried out on 20 different farms as shown in table 2 and the results were as follows; about 90% of farms sampled indicated low nitrogen and potassium levels, 95% showed low Cation Exchange Capacity (CEC), 50% showed moderate phosphorous level, 60% indicated moderate pH level. These results indicate consistently low levels in the macro nutrients and chemical properties of soil which control soil fertility and subsequently productivity. For instance, nitrogen encourages vegetative growth of the leaves and enhances plant photosynthesis process while phosphorous stimulates good development of roots and speeds up maturation of crops. Therefore, lack of nitrogen leads to stunted growth of crops followed by pre-mature yields while low potassium leads to poor development of leaves, stem and branches of the plant hence low yields. Similarly, CEC deficiency affects the total amount of nutrients available to plants as exchangeable cation and therefore leading to poor yields. These low levels of macro nutrients are as a result of soil erosion and land degradation caused by continuous farming and grazing of crop land and non crop land. This calls for use of fertilizers which is beyond the reach of majority of the households.

Poverty Indicators:

The impact of soil erosion has affected some of the welfare indicators such as income levels, sources of income, employment, infant mortality and nutrition. Over 80% of the households rely on agriculture which has been heavily affected by soil erosion. Sources of income are limited with very few members engaged in gainful employment. Results from the study indicated that majority of the households (60%) earn below ksh 2000 per month because of poor agricultural performance. These households were not engaged in any business activities and neither do they have employed members who can remit income.

They relied on farm produce that often was not enough and whenever it is available, they sell part of it to finance family expenses. Analysis of income status in the study area shows that over 70% of the rural households are below food poverty line, which implies that people do not meet their minimum food requirement. Food poverty line has been set at 2250 calories per day per adult person in Kenya, a figure based on FAO/WHO recommendations for food consumptions for specific age groups. In monetary terms, that has been calculated as the equivalent of Ksh.927 per adult person per month in rural areas (FAO 2004). In the study area, these amounts to Ksh.927 multiply by six members of the household (average household number) which equal to Ksh.5562 per month. Those households who spend less than this amount on food are considered to be food insecure and represent 88.5% of the sample households.

The district's Infant Mortality Rate (IMR) is 96 per 1000 live births which is higher compared to the National IMR of 61 per 1000 (Republic of Kenya, 2001). The reasons accounting for high IMR by the households interviewed was low income. Majority cannot afford health services offered at both Government and Private institutions. Due to high level of poverty, their eating habits are very poor hence the children are malnourished and weak.

The other major cause of high IMR is the prevalence of diseases such as malaria, diarrhea, intestinal worms and other water borne diseases due to low accessibility to clean water.

Reduction of poverty level remains one of the greatest challenges to the district and thus increased efforts to control soil erosion and land degradation is a sure way towards improvement in household's welfare. This will effectively reduce sediment load influxes into the seasonal rivers and increase water quality by reducing water contamination through sediment deposition.

Erosion, Sediment Influx and Water Sources:

Most of the streams are intermittent and only flow during the two rainy seasons(march –June and September-December). Prolonged droughts, coupled with soil erosion and siltation of water pans and dams due to high sediment influxes, has resulted into quick drying up of water resources. Makueni District reported scarcity of safe water at rates in excess of 80% during the poverty report carried out by the ministry of finance and planning in 2000 (Republic of Kenya, 2000). Majority of households (35%) draw water directly from traditional river shallow wells, while 55% get their water from different sources such as earth dams, boreholes, water pans and springs(see table 3 below). The quality of water from boreholes and protected springs is fairly good while the quality of water characteristics from traditional river wells, river streams, dams and pans differ in taste, colour and turbidity. About 7.5% of the households harvest water from house roofs during rains.

Problems of water in the district are the unevenly distribution of the water sources which affects socio-economic characteristics of the households. People walk long distances ranging from 5 to 15 km in search of water for domestic and livestock. This leads to waste of valuable man hours (5 - 8 hours per day) which can be used to generate incomes and subsequently reduce poverty level. More over, the overuse of the few existing water sources, sharing of the same sources with animals and poor sanitation have led to pollution of water sources thus increasing the likelihood of water contamination, and posing the danger of water borne diseases out break. The worst hit divisions are Kathonzweni, Kibwezi, and Makindu. There is need of drilling more boreholes and damning some of the rivers to enable sustainable rain harvest. The deposited sand is occasionally harvested for use for construction purposes in the urban areas. Most of the sand harvested is carried away with sizeable amounts of water. This has contributed to drying up of river beds, decreased groundwater recharge and increased soil erosion within the basins where sand is harvested.

Due to the problem of accessing safer water for domestic use, people have taken to the business of selling water as witnessed by significant number of people transporting water on bicycles, oxen carts and donkeys for sale at varies destinations. The price of water has increased from the normal Ksh. 2 per 20-litre container to Ksh. 20 for the same as the demand has far outstripped its supply. Few households are able to afford these facilities of transporting water. Households are forced to buy water not because they have money but due to dire need of safe water. This arises because of direct link between safe potable water and the reduction of infant mortality. Water borne and water related pathogens are major causes of seasonality or permanently debilitating diseases that severely affect household productivity. Therefore, development of water harvesting techniques and exploitation of ground water resources are important steps towards food security.

Table 4 indicates sediment loads in some of the rivers in the district. In addition, the many seasonal rivers, coupled with limited soil and water conservation and control measures in most parts of the district, contribute enormous surface and river bank erosive power due to the rains and are source of increasing sediment load influxes. The increasing trend in sediment load influxes in the lower reaches of the Athi River (Machakos and Makueni districts) is attributable to a high soil erodability due to poor soil structure which together with low vegetation cover at the beginning of the rain season, and the high intensity of torrential rainfall, lead to increasing susceptibility to land degradation (Tiffen, *et al*., 1994).

Measures to Abate the Problem:

In order to address the problems identified in this paper, the following measures are recommended:

- Better soil and water conservation measures to reduce levels and rates of soil erosion and soil fertility reduction. This is likely to increase food production, food security and increase household incomes and hence reduce poverty levels.
- Encourage tree planting as a means of reducing soil erosion, sediment load detachment and deposition as well as increasing groundwater recharge.
- Sediment traps and ponds should be constructed in well designated areas along the river course, basically to trap the flow and allow the deposition of sediments as the river flows downstream. These can be constructed in the middle reaches of the river where the river velocity is moderate and the slope is generally gentle.
- Encourage use of organic and composite manure from cattle sheds and farm residues as a way of improving soil fertility and subsequently increasing food production as well as households' income capacity to reduce poverty levels.

All these measures will help in reducing the sediment loads in the water and by extension reduce water quality degradation along the river courses. This will allow for safer use of the water resources by the people in the district.

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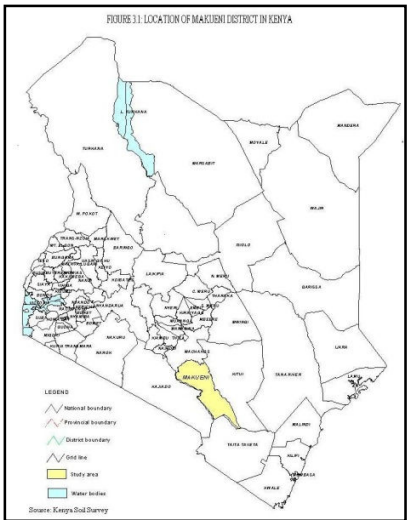

Figure 1: Makueni district in Kenya

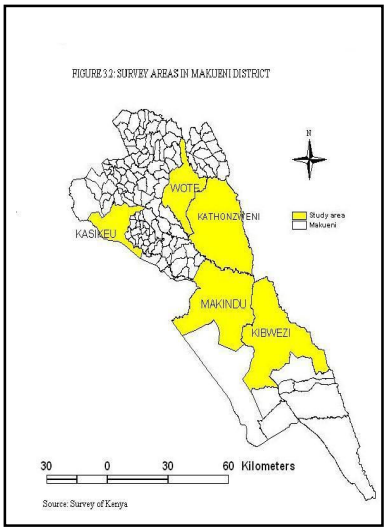

Figure 2: Study divisions in Makueni.

Table 1 Household food security status in Makueni district

Status	Frequency	percentage
High food insecure- always	70	35
Moderate food insecure- occasionally	117	58.7
Low food in secure- always	13	6.5
Total	200	100

Source: Field survey data 2001 – 2007

Table 2 Soil fertility component, Makueni district

Lab code/sample no	ph	%C	%N	K me/100g	P ppm	Ca me/100g	Na me/100g	CEC me/100g	Mg me/100g
250/1	6.50	1.18	0.12	2.10	27.50	5.50	0.30	10.20	1.42
251/2	5.70	0.98	0.11	1,90	18.50	4.55	0.20	8.40	1.50
252/3	6.10	1.18	0.13	0.55	22.70	5.1	0.20	15.20	4.55
253/4	6.40	0.56	0.07	2.00	26.50	3.55	0.40	8.00	1.45
254/5	5.60	2.25	0.34	0.51	12.50	8.55	1.20	12.30	6.00
255/6	6.90	1.39	0.15	0.41	87	4.50	0.20	9.30	2.00
256/7	6.10	1.56	0.16	1.90	17	2.90	0.20	7.20	1.83
257/8	6.50	0.36	0.04	1.40	5	1.20	0.10	5.30	0.67
258/9	5.90	1.27	0.17	1.30	3	4.55	0.05	7.30	1.50
259/10	8.40	0.56	0.08	0.43	10	5.45	0.10	12.80	2.53
260/11	7.90	1.14	0.11	0.28	29	2.20	0.20	0.90	1.83
261/12	5.30	1.56	0.14	0.2	25	22	0.80	6.20	1.92
262/13	5.81	2.67	0.28	0.48	17.1	4.2	1.30	15.80	1,87
263/14	5.91	0.88	0.07	0.44	7.6	9.1	0.60	0.70	3.00
264/15	5.05	0.58	0.12	0.56	9	12	0.40	7.00	3.65
265/16	6.42	0.51	0.09	0.39	4	5.6	0.20	19.20	1.74
266/17	5.76	0.57	0.14	1.40	6	4.3	0.70	8.00	9.33
267/18	5.11	1.50	0.05	1.80	13	2.2	0.30	12.10	2.98
268/19	6.30	0.71	0.05	1.12	19	7.0	0.08	11.40	1.3
269/20	6.50	0.95	0.07	0.51	82	6.5	0.10	9.00	1.75

Source: Field survey data 2001 - 2007

Key: Main soil properties

Ph level 6.5-7.5 is neutral, <5.6 too acidic, >8.3 too alkaline: percentage nitrogen (%N) <0.2 low, 0.2-0.4 moderate, >0.4 high: Potassium (K) <2.0 low, 0.2-1.50,>1.50 high: Phosphorous (P) <5.0 low, 5-20 moderate, >20 high: Cation Exchange Capacity (CEC) < 16 low, 16-24 moderate, >24 high:

Table 3 Sources of water for domestic and livestock use

Source	Consumer	%
Rivers	70	35
Dams	35	17.5
Water pans	20	10
Springs	35	17.5
Roof catchments	15	7.5
Boreholes	20	10
Piped water	5	2.5
Total	200	100

Source: Field Survey, *2001 – 2007*

Table 4 Suspended load and its volume, of selected streams in the Athi River drainage basin

Stream	Designation area	Catchment area (km^{-2})	Mean annual discharge (m^3s^{-1})	Suspended load (flux) (t $year^{-1}$)
Nairobi	Upstream/Headwater areas	75	1.3	2231
Athi (thwake confluence)	Middle areas (Machakos-Makueni district)	5724	23.6	131089
Athi (Tsavo)	Lowest parts	10272	33.6	753627

Source: Adapted from Kithiia (2006) pp. 87.