Evaluation of Climate Change Adaptation Strategies among Smallholder Farmers in Bungoma County, Kenya

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Abstract

Climate change exacerbates the already daunting challenge facing the agricultural sector, and this is particularly the case in developing countries. Innovations in agriculture have always been important and will even be more vital in the context of climate change as it allows farmers to adapt efficiently to the changing climate. There are roughly 800 million food insecure people in the world today, each having this status because food is unavailable, unaffordable or they are too unhealthy to make use of it or some combination of the three. Assessing the potential effect of climate change on food production requires understanding the underlying determinants of climate change adaptation strategies in Bungoma County and how they have affected smallholder farming. The objectives of the study were to identify and evaluate indigenous and emerging climate change strategies currently in use by smallholder farmers in the study area. Quality extension services, credit facilities and access to information are usually vital in facilitating adoption of better and affordable climate change coping strategies which enhances small holder's food production. The study identified various indigenous and emerging adaptation strategies and evaluated socio-economic and institutional factors influencing the choice of these strategies. The theory of utility, stated and revealed preference were used in the study. Purposive, multistage and systematic random sampling methods were used to select a sample of 150 smallholder farmers. Structured questionnaires and Participatory Rural Appraisal approach were the techniques used to collect data. The method of data analysis was both qualitative and quantitative. Mulching and soil fertility management were the most common coping and emerging strategies respectively. Unpredictable rainfall pattern and high temperatures were found to have adversely affected food production and rural livelihoods. Adaptations outside of agriculture were also important for livelihood diversification and increasing resilience to climate variability in study area. Government, research institutions and stakeholder need to provide climate change information to farmers through training. Soil fertility and water management were crucial in ensuring farmers adapted to climate change. Investments in infrastructure such as roads and irrigation systems, extension services, credit schemes, and climate information systems would help create the enabling conditions for adaptation to climate change.

Key words: Climate change, adaptation, adaptation strategies, food security and smallholder farmer

Introduction

Climate change has emerged as one of the defining political and socioeconomic issues of the twenty-first century. Although it has been part of the scientific agenda since the 1970s, it only really began to attract widespread international attention during the 1990s. Climate change is a complex issue that covers the full spectrum of scientific, economic, social, and political disciplines, and few people have the opportunity to attain a comprehensive and in-depth understanding of all facets of climate change. Over the past two decades, enormous progress has been made in the understanding of climate science, the likely repercussions of a changing climate on human and natural systems, and the options that are available to reduce the extent of future climate change (Anita *et al.*, 2010)

People have experienced climate change and adapted to it since human species evolved. The invention of agriculture was almost certainly a major adaptation to climate change. Yet much of what people have developed in response to climate change in such areas as domesticated crops, dry land management and many water harvesting techniques have been lost (Agarwal and

Narain, 1997). In times of disaster and climate change people depend on diversity of crops and livestock and their varieties of wild crops and animals which are more resistant to adverse climatic conditions. For many years, people have been fighting loss of biodiversity and adapting to climate change through migration, irrigation, water conservation techniques and reclamation. There are roughly 800 million food insecure people in the world today (FAO, 2002), each having this status because either food is unavailable to them, is unaffordable, or they are unhealthy to make use of it – or a combination of the three. Assessing the potential effects of climate change on food security requires an understanding of the underlying determinants of these three aspects of food security; availability, accessibility and utilization as well as how climate change affects each. From a public policy perspective, it is vital that adaptation strategies are integrated in the farming process as much as possible and those strategies which maintain or increase the resilience of farming systems are promoted.

There are three ways in which climate affects agriculture (Kurukulasuriya and Rosenthal, 2003). Firstly, changes in temperature and precipitation directly affect crop production and can even alter the distribution of agro-ecological zones. Secondly, runoff or water availability is critical in determining the impact of climate change on crop production, especially in Africa. Lastly, agricultural losses can result from climate variability and the increased frequency of changes in temperatures and precipitation (including droughts and floods).

Adaptation to Climate Change

Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001). Common adaptation strategies in agriculture include use of new crop varieties and livestock breeds that are better suited to current climatic conditions. Other strategies are irrigation, crop diversification, adoption of mixed crop and livestock farming systems, and changing planting dates (Kurukulasuriya and Mendelsohn, 2008). Climate change adaptation strategies are characterized by adjustment in ecological, social or economic systems in response to observed or expected changes in climatic stimuli and their effects and impacts in order to alleviate adverse impacts of change or take advantage of new opportunities. Adaptation can, therefore, involve building adaptive capacity thereby increasing the ability of individuals, groups, or organizations to adapt to changes and implementing adaptations decisions, that is, transforming that capacity into actions. Hence adaptations strategies are continuous stream of activities, actions, decisions and attitudes that informs decisions about all aspects of life, and that reflects existing social norms and processes. Anita *et al.*, (2010) point out that some adaptations occur without explicit recognition of changing risk, while other adaptations incorporate specific climate information and decisions. Since unintentional adaptation has the capacity to reduce the effectiveness of purposeful adaptation, the integration of adaptation actions and policies across sectors remain a key challenge to achieve effective adaptation in practice.

Major types of adaptations include reducing sensitivity of the affected system, which can be achieved, for example, by investing in flood defense or increased reservoir storage capacity; planting drought resistant crops or keeping drought resistant livestock that can withstand more climate variability; or ensuring that infrastructure in flood prone areas is constructed to allow flooding. Altering the exposure of a system to the effect of climate change can be achieved, for example, by investing in hazard preparedness and early warnings, such as seasonal forecasts and anticipatory actions. Also increasing the resilience of social and ecological systems, which can be achieved through generic actions which aims to conserve resources, but also includes specific

measures to enable specific population recover from loss (Anita *et al.,* 2010). The question then becomes how will adaptation be possible, on the basis of what knowledge, with the aid of what kind of innovations, within what institutional arrangements, generating what kind of conflict within and across societies, and how far and what are the limitations of societal systems to adapt to changing climatic conditions.

Studies indicate that Africa's agriculture is negatively affected by climate change (Pearce *et al*., 1996). Sub-Saharan Africa is currently the most food-insecure region in the world (The World Bank, 2008). Climate change could aggravate the situation further unless adequate measures are put in place. For smallholder farmers in Kenya, environmental and social consequences of climate change especially put their livelihoods at risk. In the recent past in Bungoma County, (PDA, 2010) farmers have tried to use indigenous knowledge to adapt to the changes. However, the adaptation strategies that are in place have not shown meaningful improvement and smallholder farmers continue to get less and less yields each year (FAO, 2002).

Adaptation to Climate Change in Kenya

Kenyan economy largely depends on agriculture and like other parts of the world has been experiencing pronounced climatic patterns since 1990. Because Bungoma County's agriculture is mostly rain fed, the pattern of food production has similarly been fluctuating and rapidly tending towards food insecurity. All these have negatively affected livelihood of smallholder farmers in the area. However, farmers in the County have adapted to strategies to counter the effects of changing climatic patterns (PDA, 2010). The effects of the adapted strategies have not been evaluated. Moreover, there has been little research done on evaluation of climate change adaptation strategies and their effect on food production in Kenya in general and Bungoma County in particular. These issues need to be addressed and documented.

The performance of agricultural sector is determined by efficiency of crop and livestock production which depends on a large number of factors. Most important are edaphic and climatic factors. The declining agricultural productivity in Kenya is worrisome and a real challenge for a government with a population of approximately 40 million to feed. Worse still is the expected adverse impact of global warming on agriculture in future. Bungoma County has been rich in crop and livestock production but the yields have been declining from 1990s (PDA, 2010). Against this background of limited arable land, predicted adverse climate conditions and declining agricultural productivity, the biggest challenge facing Bungoma County is how to intensify food production so that output can keep pace with rapid population growth without a large increase in land devoted to food production. Currently agricultural intensification is based on combination of inputs such as fertilizer and pesticides, plant breeding technologies, irrigation and improved agricultural practices such as multiple cropping. However, productivity continues to be undermined by unpredictable weather conditions and declining soil fertility. A better understanding of indigenous coping strategies and ongoing adaptation measure is important to inform policies aimed at promoting successful climate change adaptation strategies. While there is a growing body of knowledge on the effects of soils in agricultural productivity, there is a dearth of literature on the evaluation of climate change adaptation strategies in Bungoma County. In addition, adaptive mechanisms smallholder farmers use to circumvent the welfare impact of climate change have not been adequately studied in Bungoma. The study addressed these research gaps.

Theoretical Framework

One of the theories that are behind consumer behaviour in economics is the theory of utility. Utility as a concept in economics is seen as an abstract measurement of the degree of goal-attainment or want-satisfaction provided by a product or service. This is what informs the theory behind this study. One cannot measure directly how much utility a person may gain from a product or a service. However, inferences can be made about utility based on the person's behaviour, if it is presumed that people act rationally. In economics as explained by Train (2003), there is an assumption that a rational person acts to increase her utility.

Revealed preference theory is a method by which it is possible to discern the best possible option on the basis of consumer behaviour. Essentially, this means that the preferences of consumers can be revealed by their purchasing habits. Revealed preference theory came about because the theories of consumer demand were based on a diminishing Marginal Rate of Substitution (MRS). This diminishing MRS is based on the assumption that consumers make consumption decisions based on their intent to maximize their utility. While utility maximization was not a controversial assumption, the underlying utility functions could not be measured with great certainty. Revealed preference theory was a means to reconcile demand theory by creating a means to define utility functions by observing behaviour. Revealed preference methods use actual choices made by consumers.

Stated preferences are elicited directly based on hypothetical, rather than actual scenarios. Stated preference methods are criticized because the behaviour they depict is not observed and thus they generally fail to take into account certain type of real constraints (Louvier *et al*., 2000). Swait *et al.* (1994) explains that stated preferences can be used to cover a wide to cover a wide range of proposed quality or quantity changes in the attributes of public good. Hence they can be used to consider an array of choices that are fundamentally different than existing ones, as well as exploit information about attributes trade off. Revealed preference d ata have high "face validity" because the data reflect real choices and take into account various constraints on individual decisions such as market imperfections, budgets and time. Recent research indicates that combining the stated and revealed preferences methods through data fusion, which also known as data enrichment method, builds on the strengths and diminishes the drawbacks of each method. Haab *et al.* (2002) notes that the amount of information increases, and findings can be cross-validated. Use of revealed preference data ensures that estimation is anchored in observed behaviour. At the same time inclusion of stated preference responses to hypothetical changes enables identification of parameters that otherwise would be identified.

Conceptual Framework

Farmers will choose a climate change adaptation strategy which will increase their ability to satisfy their need of maximum food production. The indigenous coping strategies are mostly observed in their farms and we see them as revealed preferences. The stated preferences may be the emerging ways of adapting to climate change which may not be currently observed on their farms. The vulnerability context frames the external environment in which people exists. Peoples' livelihood and the wider availability of wealth are fundamentally affected by critical trends as well as by shocks and seasonality over which they have limited or no control. Shocks can destroy wealth directly in case of floods, drought and storm and also force people to abandon their home area and dispose assets such as land, livestock and produce prematurely as part of the adaptation strategy. Trends may be dangerous, though they are more predictable.

They have a particular important influence on rates of return and economics to chosen livelihood strategies. Seasonal shifts in prices, employment opportunities and food availability are one of the greatest and most enduring sources of hardship for poor people in developing countries.

The interactions between dependent and explanatory variables are illustrated in figure1. Human interference through activities can emit greenhouse gases into the atmosphere leading to climate change. Adaptation strategies through policy responses can result into positive outcomes of increased food production as the smallholder famers need to adapt to these climate changes. Effective adaptation coupled with policy responses lead to outcome of increased food production, livelihood diversification, increased farm income, Soil and water conservation and reduced pest and disease infections.

Research Methodology

Study Area

The study covered Bungoma County which occupies a total of about 2,068.5 square kilometers with a population of roughly 1,630,934 people and a population density of 482 persons per square kilometer (KNBS, 2009). The County is located between longitude 34 º 21.4` and 35 º 04` East and latitude 0 º 25.3 and 0º 53.2` North. There is a bimodal rainfall pattern; the long rains (March–July) and the short rains (August-October). The annual rainfall ranges between 1250 and 1800 mm. The altitude ranges between 1200 and 2000 meters above Sea Level (A.S.L) and temperature ranges from 21-25^{0}C during the year (GoK, 2005). The County is endowed with well-drained, rich and fertile arable soils but poor husbandry methods and a bulging population have resulted in declining yields, deforestation and soil erosion. Small scale crop and livestock production has been an important component of agricultural activity in this area. Crops commonly grown include; maize, sunflower, sugarcane, coffee, tobacco, potatoes, beans, kales, groundnuts and bananas. Livestock production includes; dairy cattle, goats, sheep and chicken. Out of the total labour force of about 565,000 people, 52% are engaged in agricultural production which provides 60% of all household incomes, 19% have wage-employment and 13% are self-employed (GoK, 2005). The number of unemployed is estimated at 200,000 people and 60% of the population lives below the poverty line. The poverty incidence in Bungoma is higher than the national average of 53% (GoK, 2005). Bungoma County was selected because it was one of the County's in Kenya which had high agricultural potential and with different agro-ecological and livelihood differences. The livelihood of smallholder farmers' have been affected by declining productivity and this was made worse by climate change. Secondly, the population growth in the County was high compared to the land resource available and thus there was need to evaluate climate change adaptation strategies so as to come up with sustainable food production system. Thirdly, the population growth rate was high compared to the land resource available hence the need to implement strategies to cope with climate change under intensive farming system.

Sample size and sampling procedure

The population for this study consisted of all smallholder farmers in the study area.

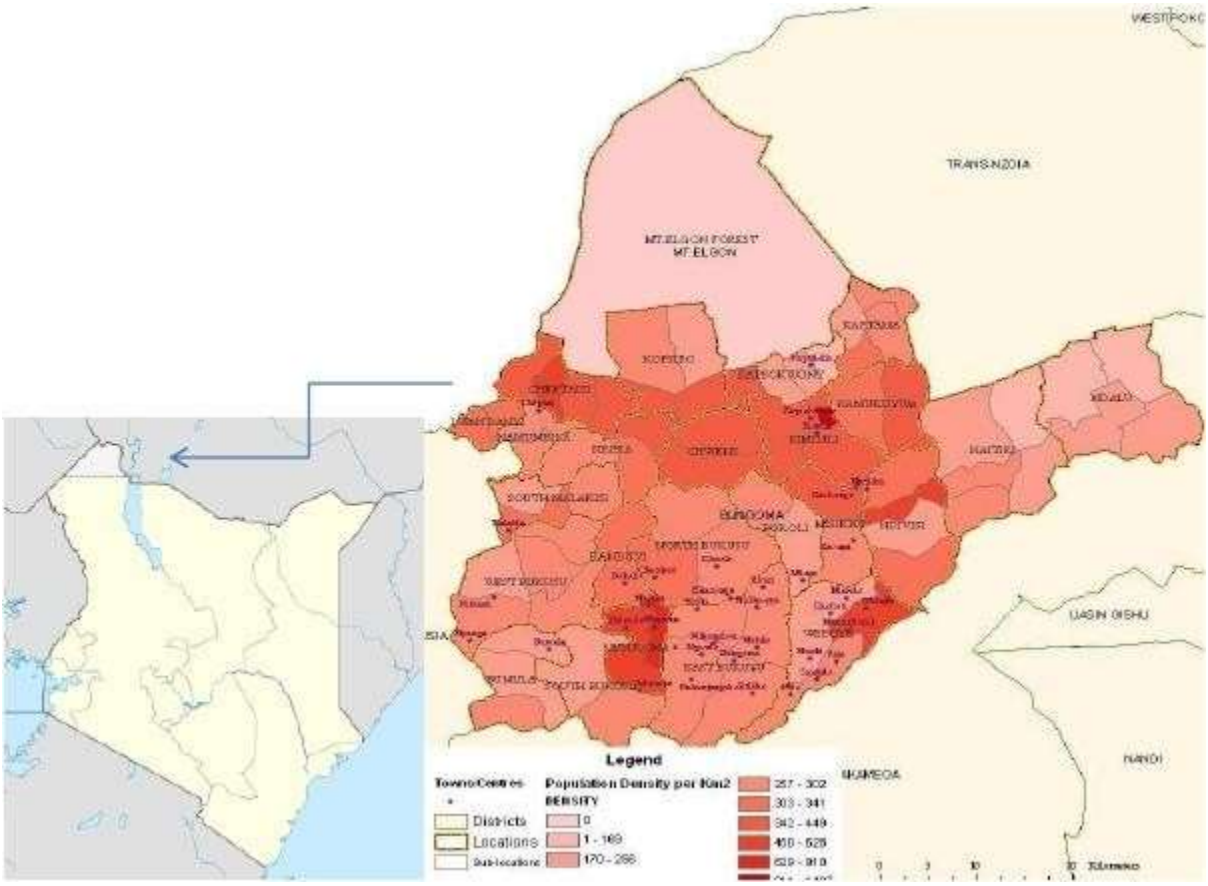

Figure 2: Map of Kenya showing Bungoma County and also map of Bungoma County (Source: Bungoma DDP, 2005-2010

A structured questionnaire was employed to obtain data while multistage sampling procedure was used to select the respondents. Purposive sampling was used to select 3 districts in the county with different livelihoods and agro ecological zones. At the second stage was to employ systematic random sampling was employed to select proportional number of farmers from each of the three districts. A sample of 140 farmers was selected from the population of smallholder farmers in the county. The required sample size was determined by proportionate to size sampling methodology (Anderson *et al.*, 2007).

$$n = \frac{pqZ^2}{E^2}$$

Where n = sample size, p = proportion of the population containing the major interest, q =0.9 = 1-p, z = confidence level ($\alpha = 0.05$) and E = acceptable or allowable error. Since the proportion of the population is not known then, p=0.9, q = 1-0.9 = 0.1, Z = 1.96 and E = 0.0500. This resulted to a sample population of 140 respondents but for easier divisibility of three districts, 150 farmers were selected. Systematic random sampling was used to select respondents from a list alphabetically arranged.

Data Collection and Analysis

The study used both primary and secondary data. Primary data were collected by use of questionnaires and a checklist. Structured questionnaire schedules were used in the individual interviews and administered by trained enumerators. A checklist was facilitated by involvement of the target community in sharing their lived experiences thus enabling generation of practical information on current indigenous (traditional) and adaptation strategies. This was done in two steps. Firstly, smallholder farmers in focal groups were asked to identify and categorize indigenous and emerging climate change adaptation strategies which they were themselves using and those used by other farmers in the study area. Secondly, they were required to evaluate these strategies using a checklist.

Results and Discussion

Household Characteristics of Farmers in Bungoma County

The mean age of the household head in the study area was about 41 years. The mean age for adapters of CCAS was about 40 years while that for non-adapters was about 52 years (Table 1). Age of the household head plays a key role in determining the decision to adapt to CCAS. Result of two-tailed t-test show that age was statistically significant at 1% indicating that non adapters of CCAS were more elderly than adapters. The mean number of children was about 4 for adapters of CCAS and about 7 for non-adapters. Result of two- tailed test show that number of children was statistically significant at 1% indicating that adapters had less children compared to non-adapters. Households with large families are sometimes forced to divert part of labour force to off-farm activities in an attempt to earn income in order to ease consumption pressure imposed by a large family. The mean farm size was 4.06 acres for adapters of CCAS and 5.29 acres for non- adapters (Table 1). The adapters had less land compared to non-adapters. Studies show land size has both positive and negative effect on adaptation. However, result of two-tailed t-test show that land size was statistically insignificant indicating that adapters and non-adapters sizes of land was nearly equal in terms of adaptation to climate change strategies.

Table 1: Description of farm and farmer characteristics in Bungoma County, Kenya.

Characteristic	Mean		Overall	t-ratio	Sig
	Adapters	**Non-adapters**			
Age(Years)	40.28	51.60	41.70	-3.549***	0.001
Number of children	3.72	6.60	4.1	-3.906***	0.000
Land size(Ha)	4.06	5.29	4.22	-1.66	0.245
Experience(Years)	13.40	20.00	14.28	-3.031***	0.003
Income (KES)	22423.32	284717.05	228995.82	-1.053	0.294
Extension(Contacts)	1.21	0.100	1.06	1.946*	0.054
Training(Contacts)	2.44	2.75	2.48	-0.366	0.715
Credit (KES)	32976.92	16500.00	30780.00	1.245	0.215

***** Significant at 1%; and * significant at 10 %**

In terms of farming experience, the mean number of years of farming was about 13 years for adapters of CCAS and about 20 for non-adapters (Table 1). However, result of two-tailed t-test showed that experience was statistically significant at 1% indicating that the more the years of farming experience the less the adaptation of CCAS. This may indicate that some farmers may have had bad experiences of this CCAS and decided to abandon them. This may also imply that those farmers who had less farming experience, mostly young, were more risk takers thus more likely to adapt to climate change strategies.
The mean income was KES. 22,423.32 for adapters of CCAS and KES. 28,471.05 for non-adapters. Result of two-tailed t-test show that off-farm income was statistically insignificant. It also indicated negative relationship between income and adaptation of CCAS. This meant that the more the income the less the adaptation of CCAS.

Adapters of CCAS had a mean of 1.21 contacts per year with extension officers as opposed to a mean of 0.100 contacts for non-adapters. Result of two-tailed t-test show that extension was statistically significant at 10% indicating that adapters of CCAS had more extension services than the non-adapters. The number of contacts with extension officers is a proxy measure for access to information (Adesina *et al*., 2000) and this positively contributes to awareness and subsequent adoption of new technologies. Agricultural extension agents frequently provide different messages throughout the year depending on prevailing activities and this could impact farmers differently.

In terms of training sessions, adapters of CCAS had a mean of 2.44 training contacts per year compared to non-adapters who had a mean of about 2.75 training contact (Table 2). Result of two-tailed t-test show that training was statistically insignificant. Training was negatively related to adaptation of CCAS. This meant that the more farmers were exposed to training the less they adapted CCAS. Training may have been on other aspects of farming other than on climate change. The mean credit for adapters of CCAS was KES 32,976.92 while for non-adapters was KES 16,500.00. The relationship between credit and adaptation of CCAS was positive. However, two-tailed test showed that credit was statistically insignificant indicating that adapters and non-adapters were equally availed with credit facilities.

Education level of the household head between adapters and non-adapters of CCAS was characterized as presented in Table 3. Adapters of CCAS had the highest percentage in Primary (17.7%) and tertiary (16.9%) educational levels while non-adapters had the highest percentage in non-formal (5%) and secondary (75.00%) and university (5%) educational levels. This implies that CCAS is more likely to be understood by farmers who had many years of education. Overall, a low percentage of farmers (5.00%) had attained university education. Result of a chi-square show that education was statistically insignificant showing that education level of the household head between adapters and non-adapters of CCAS was equally distributed.
Among the adapters of CCAS, 25.38% of the household heads were female and 74.62% were male while 20% of the household heads were female and 80% were male among the non-adapters (Table 2). Result of a chi-square show that gender of the household head was statistically insignificant indicating that gender of the household head between adapters and non-adapters of CCAS was equally distributed. Male-headed households, particularly in developing countries, have a higher accessibility to the requisite resources and information that gives them a

higher chance of adopting new innovations (Odendo *et al.*, 2009). In terms of group membership, 62.3% of the adapters of CCAS belong to a farmer group while 37.7% were not in farmer groups (Table 3). Among the non-adapters of CCAS, 45% were in farmer groups while 55.00% do not belong to a farmer group. Result of a chi-square show that group membership was statistically insignificant thus equally distributed.

Table 2: Categorical characteristics of the household head in Bungoma County

Characteristic	Category	Percentage			Chi-square	Sig
		Adapters	**Non-adapters**	**Overall**		
Education	Non formal	3.1	5.00	3.3		
	Primary	17.7	15.00	17.3		
	Secondary	60.8	75.00	62.7		
	Tertiary	16.9	0.00	14.7		
	University	1.5	5.00	2.0		
	Total	86.67	13.33	100	5.248	0.263
Gender	Male	74.62	80.00	75.33		
	Female	25.38	20.00	24.67		
	Total	86.67	13.33	100	0.270	0.603
Group Membership	Yes	62.3	45.00	64.7		
	No	37.7	55.00	40.0		
	Total	86.67	13.33	100	2.163	0.141

***** Significant at 1%; and * Significant at 10%**

Identification of Indigenous Climate Change Coping Strategies carried out by Smallholder Farmers in Bungoma County

Characterization of CCAS was done in order to determine how the practices varied across farmers in the study area. The results are given in figure 2 which shows the proportion of farmers (in percentage) practicing each coping strategy. The indigenous coping strategies were divided into crop and livestock strategies.

Indigenous Crop Coping Strategies

From the results, 24.4 % of small holder farmers used mulching as a strategy to combat climate change. This was because it was easy to get mulching materials as they are locally available and most of them had local knowledge on how to use the strategy. Tree planting strategy was used by 19.2 % of farmers. This was the second common strategy because of accessibility of tree seedlings to be planted and farmers had local knowledge on tree planting thus did not require more training. Planting of cover crops mostly sweet potatoes was at 14.6%. Farmers preferred sweet potatoes because apart from being utilized as food its vines were also used as livestock feed. Intercropping of crops like maize and beans, sugarcane and beans, millet and maize was practiced by 9.1%. Agroforestry, planting drought resistant crops, early planting, crop rotation and growing short seasoned crops strategies were at 8.7%, 7.7%, 6.6%, 5.6% and 4.2% respectively.

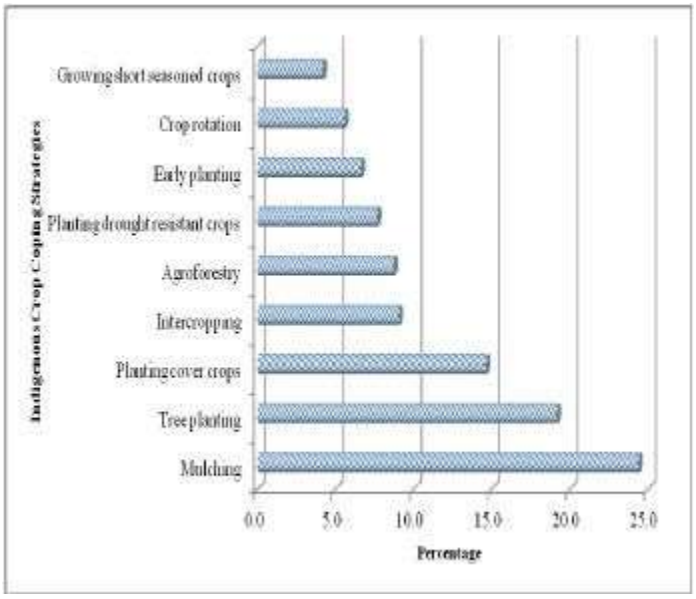

Figure 3: Indigenous crop coping strategies carried out by smallholder farmers in Bungoma County

Indigenous Livestock Coping Strategies

Bungoma County is a predominantly crop growing region. This could be one of the reasons why 32.59% of farmers had no any indigenous livestock coping strategy. Cross breeding was undertaken by 24.11% of farmers as a strategy in improving the local breeds so as to enhance productivity and was also cheaper than rearing pure breeds. 20.54 % of livestock farmers preserved livestock feed which they did use during unfavorable climatic conditions. Rearing local livestock, planting napier grass, Rearing mixed livestock, zero grazing and paddocking strategies were 12.05%, 3.57%, 2.68%, 2.68 and 1.57 % respectively. This can be illustrated below in figure 4

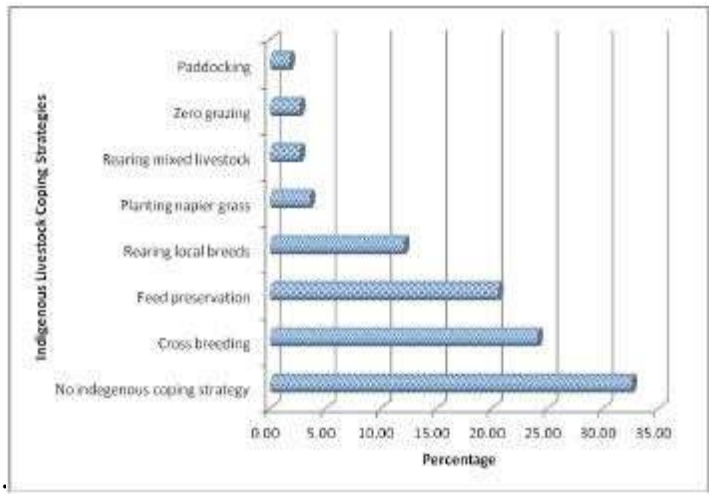

Figure 4: Indigenous livestock coping strategies carried out by smallholder farmers in Bungoma County

Emerging Crop Adaptation Strategies

Tree planting was the most common emerging crop adaptation strategy as it was preferred by 24.9 % of farmers. This has been due to encouragement by the public extension officers to farmers of planting at least 10% of their land acreage. Fast growing tree varieties especially *Eucalyptus species* from South Africa and *Gravilliea spp* have been extensively promoted by the Ministry of Agriculture and Ministry of Environments and Natural Resources for wood fuel and also timber production.

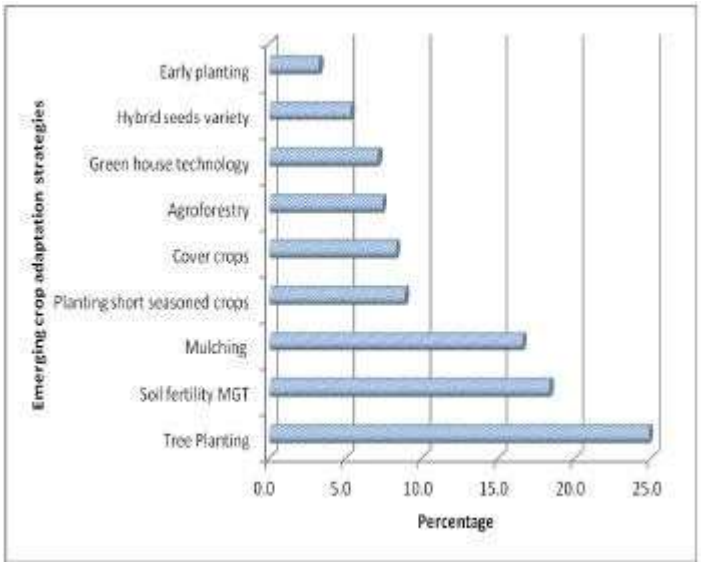

Figure 5: Identified emerging CCAS carried out by smallholder farmers in Bungoma County.

Due to declining fertility of the soils which have negatively affected productivity of farming in Bungoma County 18.3 % of small holder farmers preferred soil fertility management as a strategy in dealing with climate change (Figure 5). Soil fertility management strategies like minimum tillage, organic farming, terracing and building gabions were used by farmers. 16.6 % of farmers practiced mulching as an emerging strategy because mulching materials are cheap, locally available and can also be used as manure and soil conservation measure. As a result of soil cover by vegetation and residues, soil erosion through runoff are eliminated or greatly reduced thus crop production is more reliable. Smallholder farmers who planted short seasoned crops as a means of mitigating against climate change were 8.9 %. Cover crops and Agroforestry strategies were selected by 8.3% and 7.4% respectively. Cover crops like sweet potato were both used as food and livestock feed in form of vines thus having a dual purpose. Agroforestry strategy was being promoted by Kenya Forestry Services and Kenya Forestry Research Institute where farmers are encouraged to grow improved fallow crops. Green house technology was being practiced by 7.1%. Planting hybrid seed variety and early planting strategies were practiced by 5.3 % and 3.3% of farmers in the study area respectively.

Emerging Livestock Adaptation Strategies

Few smallholder farmers in Bungoma County rear livestock as the area is more suitable for growing crops. This was the reason why 30.7 % of farmers did not adopt to any emerging livestock adaptation strategy. Zero grazing was practiced by 18.1 % of smallholder farmers in the study area. This was because of low acreage of farms owned by these farmers. Feed preservation strategy was embraced by 14.7% of farmers. This was mostly through preservation of maize stovers, maize cobs and sugarcane tops. 9.7 % of farmers did paddocking of their land thus ensuring efficient grazing systems on the land. Cross breeds were kept by 9.2 % of farmers and because of increased productivity compared with indigenous cattle. Smallholder farmers who kept pure breeds were 6.7%. This low percentage was due to high costs of purchasing the breeds and also managing them in terms of housing, feeding, breeding and treating pure breeds though they were highly productive. Planting new varieties of napier grass, artificial insemination and rearing different breeds were emerging livestock adaptation strategies by 4.6%, 4.2 % and 2.1 % of farmers respectively (Fig.6).

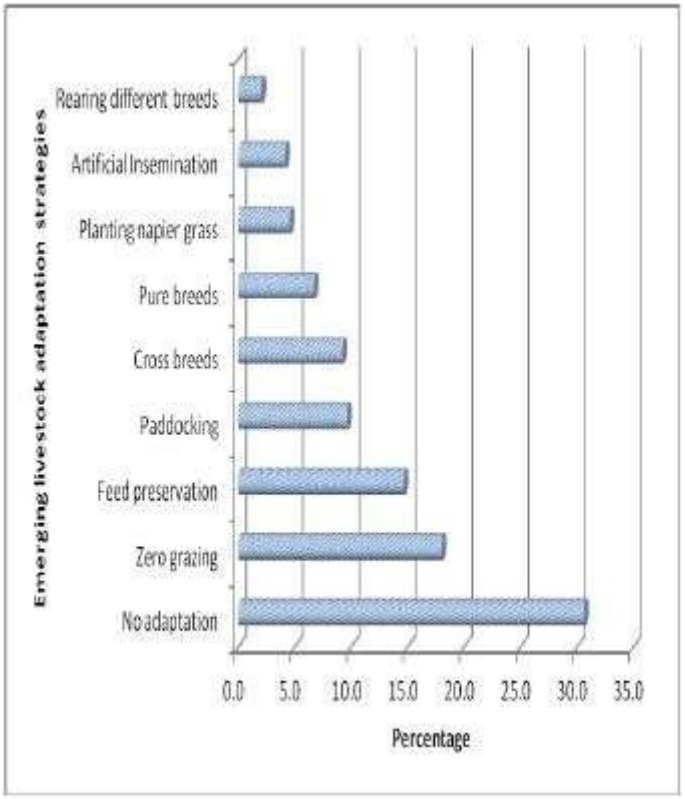

Figure 6: Emerging livestock adaptation strategy carried out by smallholder Farmers.

Conclusion.

Small holder farmers in the study area adapted to climate change by using different methods which were included in this study. Those who did not use any of the methods considered lack of information on climate change adaptation strategies as a constraint to adaptation. Climate change was a new phenomenon in the study area hence most of the trainings organized in the study area were on other issues rather than climate change and that was the reason why training was

insignificant but negatively related to adaptation to climate change. The smallholder farmers in the study area were predominantly crop growers. Climate change had adversely affected production of maize, beans and sugarcane which are their common crops. Most young farmers were willing to adapt to climate change strategies but cited lack of capital as a constraint. From the study, various indigenous coping strategies were identified for both crop and livestock production. Climate change was a new phenomenon in the area though smallholder farmers' perception of climate change was that temperatures were rising while level of precipitation was declining. Mulching was the most common indigenous crop coping strategy because mulching materials are cheap, locally available and most farmers had local knowledge on how to use the strategy. Tree planting, planting cover crops intercropping and planting drought resistant crop varieties were some of the other indigenous crop coping strategies. Cross breeding was the most common indigenous livestock coping strategy. The cross breeds produced more milk compared to local breeds and were also disease resistant and manageable in terms of feeds compared to pure breeds. Feed preservation, rearing mixed livestock and planting napier grass were other livestock coping strategies.

Declining soil fertility has negatively affected productivity of farming in the study area. Soil fertility management strategies and mulching, tree planting, planting short term crops and cover crops are some of the emerging crop adaptation strategies. Zero grazing, paddocking, cross breeds, pure breeds and feed preservation are some of the common livestock adaptation strategies. Farmers in most sites stressed soil and water conservation measures and fertility restoration through the use of manure and compost (but also inorganic fertilizer). Men cited planting trees and cover crops that help improve soil fertility and the need to combat soil erosion. The common farmers' adaptation strategies in the study area were growing a variety of crops, feed preservation, time of planting, rearing different breeds of cattle and soil fertility management. This was done to spread risks involved in farming due to unpredictable weather changes caused by climate change. Participants in the study emphasized community-based organizations and farmers' groups as key to adaptation to climate change. They recognized that such organizations enable farmers to exchange information, establish rotating credit schemes, access training and technologies, and secure better prices and markets. There is, therefore, need to aggressively create more awareness through trainings on climate change in the study area.

Policy Recommendations.

Adaptation of new and appropriate farm practices or technologies requires knowledge and experience. Successful adaptation of these measures will require greater access to information and advice through extension services, and access to inputs, as well as additional financial resources, particularly in the case of more costly investments such as irrigation and agroforestry. There should be more training specifically on climate change adaptation strategies and their impact on food production in the study area. Policymakers can facilitate adaptation of the most promising practices and technologies in several ways like expanding access to credit which can encourage the adaptation of more costly practices and technologies that offer multiple benefits in terms of adaptation, mitigation, and improved productivity. Promoting agricultural intensification to avoid the expansion of cultivated area, through investments in agriculture such as the provision of inputs, capacity development, and additional research and development would further facilitate the adaptation of climate change strategies.

Furthermore, though some carbon markets (such as the Clean Development Mechanism) farmers can be provided with financial incentives to smallholder farmers for soil carbon sequestration. These opportunities should be further explored while international climate negotiators intensify efforts to create additional incentives for agricultural mitigation.

Government investments in infrastructure such as roads and irrigation systems, demand driven extension services, affordable credit schemes, and climate information systems would help create the enabling conditions for adaptation to climate change.

Diversification of income sources is also a key adaptation strategy that should be encouraged further. This may include highly targeted efforts to broaden income-generating opportunities by creating opportunities for off-farm employment. Major changes within the agricultural system may be required in order to protect livelihoods and ensure food security. Responses to climate change need to encompass several levels, including crop and farm-level adaptations; collective action at the community level; and supporting policies and investments at national, regional, and global levels. This will require the involvement of all stakeholders. Potential strategies include infrastructural investment, water-management reform, land-use policy, and food trade. Conducting research on use of new crop varieties and livestock species that are better suited to drier conditions, encouraging informal social networks and investing in irrigation would be better policy interventions.

Further research.

The effect of poverty and household income on the uptake of climate change adaptation technologies should be investigated clinically in order to ensure that farmers are able to afford the technologies. Research on the relationship between farmers' perception on climate change and actual climate data in Bungoma County is important and should be conducted in order to effectively create awareness of climate change impact in the study area.

Research on the impact of climate change on the livelihoods of smallholder farmers in Bungoma County.

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