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**Original Article**

# Coping Strategies against Climate Change in Agricultural Production in Kitui District, Kenya

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**ABSTRACT**

The aim of this paper is to assess the coping and adaptation strategies that have been employed by farmers in their agricultural activities against the effects of climate change in Kitui district. It also looks at the factors that determine the coping strategies employed by the farmers. The study assessed the strategies which the farmers employed in an effort to mitigate against the negative effects of climate change on agricultural production. Kitui district is one of the semi-arid districts in Kenya where the effect of climate change has been felt in almost all sectors of the economy. The study utilized a descriptive research design in order to bring out the relationship between climatic elements, mainly rainfall and temperature and agricultural production and the coping strategies employed by the farmers to cushion their farming activities against the negative effects of climate change. Data was collected from 400 small scale farmers who owned less than five acres of land which was used for agricultural purposes. The data was collected using structured questionnaires, observation, interviews and focus group discussions. The data collected was on whether the farmers employed coping strategies, the factors that determined the strategies employed and why some farmers did not employ any strategies. The results of the study indicate that very few farmers 26% (104) employed coping strategies against climate change effects while majority of them 74% (296) did not. The results also show that the main strategies employed so as to mitigate against climate change were irrigation, digging of zia pits, planting drought resistant crops among others. The main factors that determined the coping strategy employed were availability of capital and proximity to the rivers.

**Key words**: Coping Strategies, Agricultural production, Food security.



## INTRODUCTION

### Coping Strategies Employed Against Climate Change in Agricultural Production

Agriculture is one of the economic activities which have been affected both negatively and positively by the changing climate. The arid and semi-arid regions have been affected negative especially in the agricultural sector. Temperatures have been increasing; extreme

climatic conditions have become more frequent while the amount and frequency of rainfall has reduced considerably. In this study, the farmers were asked to indicate the coping strategies which they employed in their farming practices so as to reduce the negative effects of climate change. Table 1 shows some of the strategies which the farmers employed. The results in table 1 show that different strategies were employed by the respondents so as to reduce the harsh effects of climate change on agricultural production. However, very few farmers employed these strategies. From the results, 296 (74%) of the respondents did not employ any strategies. Only 22 (5.5%) respondents used irrigation as a strategy to cope with the changing climate. 41 (10.2%) dug zia pits, 29 (7.2%) planted drought tolerant crops while 12 (3.2%) practiced crop rotation.

**Table 1: Coping strategies employed in reducing the effects of climatic change**

| Strategy | Frequency | Percent (%) |
|---|---|---|
| Crop rotation | 12 | 3.2 |
| Zia pits | 41 | 10.2 |
| Irrigation | 22 | 5.5 |
| Drought tolerant crops | 29 | 7.2 |
| None | 296 | 74 |
| **Total** | **400** | **100** |

A total of 296 (74%) of the farmers in the study (Table 1) did not employ any coping strategies to militate against climate change. The main reason given for not employing any coping strategy was inadequate funds which made it difficult for them to carry out such practices as irrigation or drilling of boreholes. IPCC (2001) notes that developing countries, which have greater vulnerability to climate change impacts, some of which are already being experienced, have particular concerns with respect to financing and building their capacity to adapt. A lot of finances which are required for the formulation and implementation of adaptation policies are either inadequate or not available in most of these countries (IPCC, 2001).

Like IPCC (2001), Tubiello *et al.,* (2008) also confirm that several barriers exist to the implementation of successful response options by farmers, especially in developing countries. In the developing countries, the existing human, technical, and economic capacity is low even when assessed against current production needs. Such barriers include lack of access to credit for investment; lack of access to knowledge, advice and inputs and existing social and cultural institutions. Other barriers include land tenure insecurity; inherent climate variability; limiting natural resources, including the quality of available land and water resources, especially in arid and semiarid tropical regions (Tubiello *et al*., 2008).

DANIDA (2007) argues that although climate change may also provide new opportunities, it is already demonstrated in Kenya with current climate variability that the poor and the marginal ASAL and Western Kenya flood prone lands may be particularly vulnerable to climate variability and change.

Perry *et al.,* (2005) acknowledge that the knowledge, tools and technology needed to support implementation of targeted adaptation strategies are in the early stages of development in some developing countries. There is need for increased awareness on the implications of climate change, particularly among policy-makers so that appropriate policies are formulated that would put in place the right adaptation tools and technology.

Oxfam (2012) recommends investing in reforestation and afforestation and reintroducing these modalities as effective and traditional adaptive measures for land use stability. Oxfam (2012) further affirms that afforestation intertwined with agriculture not only exerts a

favourable influence on soils, moisture regimes and crop microclimates, but also binds carbon and thus inhibits global warming.

Lack of knowledge on coping and adaptation strategies is seen as one of the causes of food insecurity in the study area because most of the farmers depend on rain for their agricultural activities. In the ASALs, the rainfall is most of the time very unreliable and unpredictable. Kitui district, being a semi-arid region, receives below average amount of rainfall (between 500mm and 1050mm depending on altitude) which cannot be relied on as the main source of water for agricultural activities. The unpredictability of the rainfall makes it difficult for farmers in the study area to prepare their farms and the required inputs as they wait for the rains.

Perry *at al*., (2005) indicates that adaptation to the impacts of climate change is emerging as a critical concern for countries in all regions of the world. The on-going rise in global temperatures has profound implications for the productivity, diversity and function of many ecosystems, and for the economies, livelihoods and cultures they support.

**Drought Tolerant Crops**

Only 7.2% (29) respondents planted drought tolerant crops as a means of climate change adaptation (Table 1). The crops planted were millet, sorghum, and pigeon peas. FAO (2008) reports that strengthening resilience involves adopting practices that enable vulnerable people to protect existing livelihood systems, diversify their sources of income, change their livelihood strategies or migrate, if this is the best option. Changing consumption patterns and food preparation practices may be sufficient to protect food security in many circumstances. However in many instances, people prefer to maintain their present consumption patterns and are very reluctant to make abrupt changes (FAO, 2008).

If more farmers in Kitui district planted drought tolerant crops, food availability and accessibility would improve because such crops can withstand the dry spells since they can survive with minimal moisture. This would improve their household food security. The main drought resistant crops that are planted in the Kitui district include millet, sorghum and pigeon peas which are used as food crops or as cash crops when they are sold so as to get some income in the household. Millet and sorghum have not been fully integrated in the household diets. Planting and consumption of drought resistant crops can only be accepted and practiced if as mentioned earlier, the farmers are willing to change their consumption habits. Both market forces and voluntary choices influence individual decisions about what food to eat and how to maintain good health under a changing climate (FAO, 2008).

Information gathered from the focus group discussion (FGD) indicated that most of the farmers did not grow the drought tolerant crops because the crops had limited market among the local people in the study area. Many farmers preferred to grow crops that would fetch quick money in the market, these including maize, beans, and vegetables among others but which could not withstand the high temperature and low rainfall received in the area. Some of the farmers also confirmed that millet and sorghum were not their diet favorite and that such crops were never part of their household meals. This may be the reason why the crops were planted by very few farmers in the study area.

**Irrigation**

In the study area, very few of the respondents 22 (5.5%) practiced irrigation. The source of the water for irrigation was mainly the boreholes which were dug by the farmers. Such farmers were able to plant a wide variety of crops which included both food and cash crops. Proximity to the rivers, whether season or permanent, was a major factor that determined the depth of the well. Figure 1, 2 and 3 show irrigated land which was one of the coping strategies that were employed against the changing climate In circumstance where a farmer's land was far away from the river, the water table was too low therefore making digging the well costly and unaffordable to many farmers.

GOK (2009b) indicates that more land can be reclaimed for crop use through development of irrigation infrastructure in the ASALs and reclaiming the waterlogged soils in the swampy areas. It estimates that intensified irrigation can increase agricultural productivity four-fold and, depending on the crops, incomes can be multiplied ten-times.

**Figure 1: An irrigated land with recently transplanted tomato seedlings in Yatta inKitui**

Irrigation which is one of the coping strategies employed by farmers is beginning to cause concern. Irrigation was carried out by farmers who had sunk wells only because Kitui district did not have any many permanent rivers apart from Athi river. Gregory *et al.,* (2005), report that an issue of concern in some regions is the changes in groundwater availability as a consequence of water extraction for irrigation in intensive crop production systems.

Empirical studies carried out in of Punjab province of India by Gregory *et al.*, (2005) show that extraction of underground water has led to significantly lower water tables which are expected to fall even further in the future. In addition to changes in aquifer and surface water dynamics, a significant consequence of this is the need to use ever increasing amounts of power (diesel and/or electric pumps) to access this dwindling resource which will result in increased carbon dioxide emissions to the atmosphere (Gregory *et al.*, 2005).

**Figure 2: An irrigated farm having kales (sukuma wiki) in Mutomo in Kitui district**

Oxfam (2012) acknowledges that in the arid region, rehabilitating existing irrigation systems and expanding irrigated agriculture can be a coping strategy to the effects of climate change. However, irrigation can be inefficient and wasteful of water unless it is done very

carefully and scientifically. It therefore must be accompanied by measures to rationalize water use through the widespread introduction of moisture saving technologies.

There is also a need for a multi-sectoral planning approach, integrating the different aspects of agricultural production, particularly soil and water management. The arid regions that receive low rainfall should have a mechanism of storing the rain water during the rainy season so that it can be utilized for irrigating the farms during the dry season.

Kitui district is such one region where water resources need to be stored for use during the dry season. If this was well planned and implemented, then food insecurity would be a thing of the past. This is because the farmers are willing and ready to work, only if they were given the right resources that are needed. It is common to see rain water flowing to waste during the rainy season in the developing countries which later dry up completely with no water stored for livestock use and irrigation.

**Figure 3: An irrigated farm having almost maturing tomatoes in Mutomo in Kitui**

## Zia Pits

This was another strategy that was employed in the study area by some farmers as a measure against climate change. Zia pits are wide and deep holes which are dug and used for growing crops. The pits help to capture dew and small sources of water and hold it so that plants can make use of it. The pits are able to retain rain water for long which is used by the crops for a longer period of time. The zia pits are first filled with manure before the crops are planted and later filled with water during irrigation or retain water from rainfall for a longer period of time. Figure 4 shows a banana plantation with zia pits which was a coping strategy that was employed by the farmers.

GOK (2010) through the NCCRS recommended the following strategies as measures to adapt to the changing climate:

i) Enhanced financial and technical support to the traditional high value crops programme so that indigenous and more drought tolerant crops like cassava, sorghum, millet, sweet potatoes can be reintroduced into the farming system.

ii) Promote irrigation agriculture by developing irrigation schemes along river basins and pans but also reconfiguring irrigated production systems to use water more efficiently and to accommodate the use of marginal quality water

iii) Diversifying rural economies through value addition to agricultural products and financial support to sericulture and apiculture with the aim of reducing reliance on climate sensitive agricultural practices.

iv) Develop special livestock insurance schemes that will provide an opportunity to spread and transfer climate change risks to livestock herders after decimation by starvation caused by drought.

v) Develop proper food storage facilities to cater for surplus harvest while promoting traditional and modern food preservation methods.

vi) Constructing inter-basin and intra-basin water transfers to channel water from areas with excess water to areas with water deficit.

These are some of the many strategies that were suggested in the NCCRS that should be implemented so as to mitigate against the negative effects of climate change. Promotion of irrigation as suggested by NCCRS is only possible if the farmers have access to water throughout the year. In Kitui district, irrigation would be a viable and sustainable strategy if the region had many permanent rivers or dam which would be regular sources of water.

**Figure 4: Zia pits in a young banana plantation in Mutomo in Kitui district**

Wreford *et al*., (2010) recommends that the first strategy is to reduce the rate and magnitude of climate change itself through reducing the human causes of climate change, which is mitigation of greenhouse gases. The second, Wreford *et al.*, (2010) suggests would be to promote adaptation to climate change to minimize the impacts and take advantage of new opportunities. Such adaptation strategies involve among others, planting drought resistant crops which can survive with little water or without water for a long time.

Perry *et al.*, (2005) concur with Wreford *et al.*, (2010) that as the impacts of climate change are increasingly felt, there is an immediate need to enhance efforts to integrate adaptation into core policy-making. Doing so, they report, requires mobilizing the full range of resources within and outside of the climate change community. At the same time, a long-term strategy for adapting to climate change needs to be developed especially in the developing countries.

Agricultural production (both crop farming and livestock rearing) is the main source of livelihood in the study area such that any disturbances that occur in the factors that influence it, disorganizes the whole food system. Measures should be taken so that the occurrences of such disturbances do not interfere with the food system in the area through the use of adaptation strategies. FAO (2008) acknowledges that any impacts on all forms of agricultural production will affect livelihoods and access to food so that producer groups that are less able

to deal with climate change, such as the rural poor in developing countries, risk having their safety and welfare compromised.

Deressa and Hassan (2009) recommend that the adaptation strategies should target different agro-ecologies based on the constraints and potentials of each agro-ecology instead of recommending uniform interventions. Adaptation options, which could be appropriate for different agro-ecological zones, include investment in technologies such as irrigation, planting drought-tolerant and early-maturing crop varieties, strengthening institutional set-ups working in research, educating farmers and encouraging ownership of livestock, because owning livestock may buffer the effects of crop failure or low yields during harsh climatic conditions (Deressa and Hassan, 2009). According to Wreford *et al*., (2010), adaptation in the climate change context may also involve adjusting to changes resulting from climate impacts elsewhere in the world (such as the possible effects on markets, changing comparative advantage, and increased migration) or changes resulting from mitigation actions.

All the farmers that formed the study population were small scale farmers who owned less than five acres of land. A large percentage of small scale farmers are not well placed to deal with challenges that come with a changing climate. Oxfam (2012) reports that adaptation measures come at a great financial cost for small scale farmers. They do not have the required support from the regional or national authorities. As a result they struggle to pay their loans back, which forces some to leave agriculture altogether. Insurance could be a great help but currently, bureaucracy makes the insurance process painful and time consuming so that many farmers are unable or reluctant to insure their crops. Therefore, adaptation policies and practice should have a particular focus on supporting smallholders (Oxfam, 2012).

Crop and livestock insurance is not a common practice in the developing countries though recently, some insurance companies have started offering insurance cover for farmers' crops while they are still in the farms. Crop and livestock insurance is a policy that is purchased by the farmers, ranchers and other producers so as to protect themselves against loss of their crops or livestock due to natural disasters. Farmers in the developing countries have not been given enough education on the benefits of crop insurance and are therefore still reluctant to take up the policy. In other circumstances, the capital involved in insuring the crops may also act as a hindrance to crop insurance especially for small scale farmers who rely entirely on their farms. Oxfam (2012) recommends development of educational programmed for farmers, managers and employees to disseminate knowledge on adaptation techniques.

This study also sought to find out the factors that determined the coping strategies which the farmers employed so as to cushion their agricultural activities against the harmful effects of climate change.

**Factors That Determine the Coping and Adaptation Strategies Employed**

The farmers that applied coping strategies were asked to indicate the factors that determined the strategies that they employed. The results in Table 1 show the several factors which determined the strategy employed. Out of the 400 farmers interviewed, 296 (74%) of the respondents did not employ any coping strategies to the changing climate while the remaining 104 (26%) did employ

Availability of capital is one of the main factors that determine the farmers' ability to employ coping and adaptation strategies to climate change effects. This implies that inadequate capital was one of the factors that have hindered farmers in the study area from employing coping strategies to climate change.

According to the study results in Table 2 that 28 (7%) of the farmers reported that capital availability determined the strategy that they employed. The respondents did not have adequate finances for digging bore holes to be used for irrigation. Most developing countries lack the financial capacity required so as to employ such strategies. Perry *et al*., (2005) points out that three Marrakesh Funds, the UNFCCC's Least Developed Countries Fund (LDCF) and Special Climate Change Fund (SCCF), and the Kyoto Protocol's Adaptation Fund (AF)

have been established to help address these needs. Although important, these funds are insufficient to meet developing countries' needs. Long-term, firm and regular financial commitments under the UNFCCC are needed to ensure the viability of these funds and continued support of adaptation in developing countries (ICCTF 2005). It will also be important to learn from the LDCF and SCCF experience to date when designing the AF, and to ensure that activities supported by the Marrakesh Funds complement each other as well as bilaterally and nationally funded climate change adaptation efforts (Perry *et al*., 2005).

**Table 2: Factors that determined the adaptation of coping strategies**

| Attribute | Responses | Frequency | Percent |
|---|---|---|---|
| **Adapt coping strategy** | Yes | 104 | 26 |
| | No | 296 | 74 |
| **Factors that determine the strategy employed** | Capital availability | 28 | 7.0 |
| | Strategy employed by neighbors | 21 | 5.3 |
| | Proximity to the river | 22 | 5.5 |
| | Availability of water | 33 | 8.3 |
| | None | 296 | 74.0 |

Another factor that was mentioned by the farmers that determined the coping and adaptation strategy which they employed was proximity to the river. Being a semi-arid region, Kitui district has only one permanent with several seasonal rivers. The farmers who lived close to rivers had an advantage because they were able to dig wells cheaply due to a shallow water table. These wells were used for irrigating the farms. Figure 5 shows a well being dug so as to be used for irrigation. Most farmers who lived far away from rivers did not dig wells because of the water table was too far and therefore too expensive to dig wells.

Figure **5**: A well being dug to be used for irrigation in Mutomo in Kitui district

Availability of water was also mentioned as a factor that determined the strategy employed. In the study area, rain water is reserved in shallow pans and dug out dam for a short period of time before it all dries up due to high temperatures. Such water was mentioned a factor that determined whether a farmer put in place any strategies. The water was used to irrigate small farms during the dry season in an effort to produce food to feed the household. The main problem with such a water source was that it could dry out at any time leaving the crops in the farms to dry because of the seasonality of the water source (Figure 6).

**Figure 6: A dam constructed on a seasonal river in Kitui Central**

Interviews conducted with the agricultural officers revealed that most of the farmers lacked knowledge on how to adapt to the changing climate. Such knowledge and demonstrations were available at the district agricultural office but which many farms did not have information about. The agricultural officers further revealed that a visit to farms to give on-farm advice to farmers was very rare because the department was severely understaffed. Perry *et al.*, (2005) report that integration of adaptation considerations into policy and decision making is a process that can begin now, to build up a needed base of experience and address current needs. They further report that in moving forward on this agenda, strategies are needed to ensure the development, deployment and diffusion of the knowledge, tools and technologies to support efforts to adapt to a changing climate and to share information, practices and lessons between countries. This can only take place if the information is passed on the farmers through extension services.

Results in Table 2 indicate that 21 (5.5%) of the farmers employed the strategies similar to those employed by other farmers in their neighborhood. This was due to the lack of appropriate information by the farmers who did not understand the importance of mitigating against the effect of climate change. Such farmers imitated what their neighbors did with the hope that it was the right farming practice employed.

## Coping and Adaptation to Climate Change

While climate change is seen as a relatively recent phenomenon, individuals and societies are used to adapting to a range of environmental and socio-economic stresses. In many parts of the world, and especially in semi-arid lands, there is an accumulated experience with phenomenon such as drought (Gregory *et al.,* 2005). Such experiences coupled with knowledge on adaptation to various changing phenomena are essential for communities' continuation of livelihood. Various methods have been employed worldwide so as to adapt to climate change.

One of the notable methods employed in the study area is irrigation. This is where the farms are watered with water from other sources other than natural precipitation. Irrigation is very effective because the crops are provided with water at a time when they require it. The water comes from dug wells, from nearby water sources like dams, rivers and lakes.

Green house farming was another adaptation strategy that was employed. However, the number of farmers who employed this strategy was so small that it was almost negligible. The study did not capture green house farmers because the number was too small and almost negligible. Green house farming is an expensive venture which requires ready capital that

should be easily available so as to ensure maximum yields. This may explain why the farming method is not widely practiced in the study area despite the fact that it is a suitable farming strategy against extreme weather.

Ochola (2009) reports that some of the ongoing regional projects in Kenya for climate change adaptation include:

- Climate Change Adaptation in Africa (CCAA) that focuses on research and capacity development to improve the capacity of vulnerable communities to adapt to climate change.
- The Africa Adaptation Programme (AAP) which aims to strengthen Kenya's institutional and systemic capacity to implement the NCCRS and to address climate change risks and opportunities through a national approach to adaptation.
- Kenya Adaptation to Climate Change in Arid and semi-arid Lands (KACCAL) which aims to facilitate long-term adaptation of the key stakeholders in the ASALs to climate change.

If these programs are fully implemented, then it is hoped that the country's adaptation strategies will effectively address climate change adaptation whose results will be greatly felt by the vulnerable populations in the agricultural sector in the arid and semi-arid regions.

**Table 3: Effects of the strategies in improving agricultural production**

| Responses | Frequency | Percentage |
|---|---|---|
| Yes | 63 | 15.8 |
| No | 41 | 10.2 |
| Not applicable | 296 | 74 |
| **Total** | 400 | 100 |

Only 63 (15.8%) of the respondents reported that the strategies which they had applied improved their agricultural production. Implementation of adaptation strategies need to be done skillfully for it to bear fruits. The farmers need knowledge on the best strategies that would yield results.

Lack of finances has been discussed as a major factor that hindered many of the respondents from applying adaptation strategies. As discussed earlier in 4.6.1, most farmers did not have another source of income apart from their farms. This brought about a circular causation pattern whereby the farmers did not have income to invest in the farms which resulted in less production, and therefore less to eat and to sell. This further resulted in reduced income in the household. Perry *et al.,* (2005) report that financing adaptation efforts is a critical concern for all countries and that billions of dollars will be needed to implement vulnerability reduction activities and address the immediate effects of climate change. They further report that integration of adaptation considerations into existing financial arrangements, such as national budgeting processes, bilateral and multilateral development funding, private sector investments, and insurance sector activities, can serve to leverage the funding required. The financial sector, insurance industry and international financial institutions have a role to play in providing the capital needed to reduce the impacts of extreme weather events (Perry *et al.,* 2005).

According to Tubiello *et al.,* (2008) report that the increase in temperature will improve the breeding conditions for pests and diseases. This will affect agricultural production negatively because if not well controlled, they will lead to a reduction in the yields. Tubiello *et al.,* (2008) suggest some of the adaptation strategies which include improving the effectiveness of pest, disease, and weed management practices through wider use of integrated pest and pathogen management. They also recommend the development and the use of varieties and species resistant to pests and diseases, and maintaining or improving quarantine capabilities and monitoring programs by using climate forecasting tools to reduce

production risk as some strategies that could help improve food production amid a changing climate.

The respondents were asked to indicate what according to their opinion would improve agricultural production in the study area. The results in Table 3 shows that 128 (32%) of the respondents wanted water to be provided so that it could be used for irrigation. 64 (16%) wanted to be provided with loans for agricultural purposes, 71 (17.8%) wanted agricultural extension services while 65 (16.2%) and 72 (18%) wanted farm inputs and certified seeds respectively.

**Table 5: Measures to improve agricultural production**

| Attribute | Frequency | Percentage |
|---|---|---|
| Agricultural extension services | 71 | 17.8 |
| Agricultural loans | 64 | 16.0 |
| Certified seeds | 72 | 18.0 |
| Provision of farm inputs | 65 | 16.2 |
| Provide water (dams and boreholes) | 128 | 32.0 |
| **Total** | **400** | **100** |

There is need to improve agricultural production in the study area. Measure need to be taken drastically to improve the productivity of this area which will help to improve food availability and accessibility. Gregory *et al.*, (2004) report that in attempting to adapt food systems to cope with climate and other environmental changes, it will be important to ensure that the changes proposed do not exacerbate climate change or other aspects of environmental degradation but that they should contribute to sustainability.

**Provision of Extension Services**

The respondents suggested provision of extension services as one of the measures that should be taken so as to increase dissemination of knowledge that would improve agricultural production. Agricultural extension is a mechanism on new technologies, more effective management options, and better farming practices can be transmitted to farmers (Owens *et al.*, 2003). Extension agents disseminate information on crop and livestock practices, optimal input use, and consult directly with farmers on specific production problems, thus facilitating a shift to more efficient methods of production (Dinar *et al.,* 2007). That is, agricultural extension not only accelerates the diffusion process and head option of new varieties and technologies but also improves the managerial ability of farmers and affects the efficient utilization of existing technologies by improving farmers' know-how (Dinar *et al., 2007*).

A discussion with four district agricultural officers revealed that the officers did not visit the farmers due to a shortage of staff and resources. Farmers that stayed close to the divisional and district headquarters managed to consult with the agricultural officers when they visited them in their officers. Farmers' field days were also a way of passing information to the farmers although they were not common due to lack of resources Most of the farmers who formed the FGD reported that they had never attended farmers' field days because either they never got information about them when they were held or they stayed too far away from the venues where they were held.

There is a long history of agricultural research and a well-developed agricultural research infrastructure that covers all ecological zones and caters for various agricultural activities, in Kenya. GOK (2004) reports that there are over 28 agencies which engage in agricultural research in Kenya. These organizations may be grouped into public-funded institutions such as the Kenya Agricultural Research Institute (KARI), the Kenya Marine and Fisheries Research Institute (KEMFRI), the Kenya Forestry Research Institute (KEFRI) and the universities; and commodity-funded institutions such as the Coffee Research Foundation (CRF), the Tea Research Foundation (TRF), and the Kenya Sugar Research Foundation

(KESREF). The main aim of these institutions is to conduct research with an aim of improving the performance of the agricultural sector in Kenya. The findings of such research should be disseminated to the farmers, who are the main consumers of the research results. The impact of research findings and technological breakthroughs on agricultural productivity has been limited because of lack of a comprehensive approach for disseminating findings arising from poor research-extension-farmer linkages (GOK, 2004).

Resources allocated to extension services, which in the first two decades after independence were about 5.9% of the total government annual budget, declined steadily to about 1.7% in financial year 2003/04 (GOK, 2004). GOK (2004) further reports that as a result of the severe budgetary constraints coupled with widespread misuse of even the little resources that were available, provision of extension services concomitantly declined significantly. Today, the extension system in place is not credible such that the information that is disseminated to farmers either does not reach all the intended audience or sometimes reaches when it already obsolete. Programs such as NALEP improved extension services to the farmers when they were implemented.

**Access to Credit Facilities**

Inadequate capital to invest in the farms is a major problem that faces farmers in Kenya and many developing countries. From Table 1, 64 (16.0%) of the respondents indicated that they desired to be given loan so that they could improve their agricultural practices. GOK (2009b) indicates that access to bank credit by farmers is still a major challenge despite the fact that Kenya has a relatively well developed banking system. It says that risks associated with farming business, coupled with complicated land laws and tenure systems that limit the use of land as collateral, makes the financing of agriculture by the formal banking industry unattractive.

**Access to Farm Inputs**

The results show that 65 (16.2%) of the respondents were of the opinion that agricultural production would improve if they were given farm inputs to use in crop production while 72 (18%) required certified seeds. In some instances, the seeds are not released on time when the farmers require them while at other times, some unscrupulous businessmen prepare and pack seeds which are not certified and which do not give the desired production by the farmers. Ayieko and Tschirley (2006) indicate that a well functioning seed system is one that uses the appropriate combination of formal, informal, market and non-market channels to efficiently meet farmers' demands for quality seeds. According to Nyoro and Ariga, (2004) the seed industry in Kenya is better developed compared to other countries within the region. However, high cost of seed relative to other purchased inputs, coupled with the inability of the formal seed system to meet the demand by farmers have been cited as bottlenecks to the seed industry

Apart from certified seeds, fertilizer is the other input that must be well utilized so as to achieve increased agricultural production. Duflo *et al.,* (2011) acknowledge that many agricultural experts see the use of modern inputs, in particular fertilizer, as the key to agricultural productivity. Pointing to the strong relationship between fertilizer use and yields in test plots, Morris *et al.,* (2007) argue that fertilizer generates high returns and that dramatic growth in agricultural yields in Asia can be attributed to increased use of fertilizer. The stagnation of yields in Africa can largely be explained by continued low use in Africa.

**Provision of Water**

Water is very important in agricultural production and in the general livelihood of people. Some of the respondents reported that if they were provided with water, then they would irrigate their farms and this would alleviate food shortages in the study area. Water from dams, water pans, wells and rivers would be a good source of water for agricultural use which

would serve as an alternative for rainfall. Mutimba *et al.,* (2010) indicate that the availability of water is often akey factor in determining the patterns of human settlement and the value of land for agricultural and livestock production. Within arid and semi-arid lands (ASALs), the food security of pastoral and farm households improves considerably during the wet years Mutimba *et al.,* (2010) further reports that Kenya is classified by the U.N. as a chronically water-scarce country, with poor replenishment rate. The country's natural endowment of freshwater is highly limited, with an annual renewable freshwater supply of about 647m3 per capita significantly below the 1,000m³ per capita set as the marker for water scarcity. The current level of development of water resources in Kenya is very low. Only 15 percent of the safe yield of renewable freshwater resources has been developed currently (Mogaka, 2006). It is important that alternative sources of water are sought so that the farmers can irrigate their farms and which will lead to a boost in food production in the study area.

**Table 5: Agriculture extension officers visits**

| Responses | Frequency | Percentage |
|---|---|---|
| Yes | 52 | 13.00 |
| No | 348 | 87.00 |
| **Total** | 400 | 100 |

The farmers in the study area were asked if they received agricultural extension services. Out of the 400 farmers that were interviewed, only 52 (13.0%) received such services while the remaining majority 348 (87%) never received the services. Owens *et al.,* (2003) report that agricultural extension is a mechanism by which information on new technologies, more effective management options, and better farming practices can be transmitted to farmers. GOK (2009b) acknowledges that agricultural sector extension service plays a vital role in the sharing of knowledge, technologies, agricultural information and linking the farmers to other sectors of the economy. The extension services are therefore one of the critical change agents required in the transformation of subsistence farming to modern and commercial agriculture, which is critically important in promoting household food security, improving income and reducing poverty (GOK, 2009b). This means that if the farmers in the study area received adequate advice and guidance from the extension officers, then the food insecurity experienced in the area would be drastically reduced to minimal levels. An interview with the district agricultural officers in the study area revealed that the farmers were not visited by the officers; a situation which they reported was due to limited resource allocation by the government. The agricultural officers at the same time acknowledged the importance of their services in improving the performance of the agricultural sector.

Al-sharafat *et al.,* (2012) report that extension starts with knowledge management and ends up with human enrichment. Agricultural extension by its nature has an important role in promoting the adoption of new technologies and innovations (Jamilah *et al*., 2010). Agricultural extension brings about changes through education and communication in farmers attitude, knowledge and skills. The role of agricultural extension involves dissemination of information; building capacity of farmers through the use of a variety of communication methods and help farmers make informed decisions (Sinkaiye, 2005). The extension services usually play a crucial role in providing information on sustainable agricultural practices among the farming communities.

Dinar *et al*., (2007) indicate that extension agents disseminate information on crop and livestock practices, optimal input use, and consult directly with farmers on specific production problems, thus facilitating a shift to more efficient methods of production. They report that agricultural extension not only accelerates the diffusion process and the adoption of new varieties and technologies but also improves the managerial ability of farmers and affects the efficient utilization of existing technologies by improving farmers' know-how. (Dinar *et al*., 2007) explains that production in many developing countries is very low

without much improvement yearly even when farmers try to apply modern technology because sometimes they end up using the wrong technology.

Al-sharafat *et al.*, (2012) acknowledge that proper management of information sets a foundation for the delivery of efficient and effective extension services by providing accurate information to those who need it, when they need it. Hosseini *et al.*, (2009) suggest that financial, social, human and organizational sustainability should be achieved over time and policies that provide affordable access to information need to be carefully identified and examined.

It is important that the significance of extension services in supporting agriculture be identified as one of the major approaches needed for the development of agricultural sector especially among small scale farmers in the developing countries. Also, measuring attitudes of farmers towards the extension services they receive is crucial in providing sustainable agricultural extension services (Al-sharafat *et al.*, 2012).

**Table 3 : Frequency of visit of extension officers to the farmers**

| Responses | Frequency | Percent |
|---|---|---|
| Once in six months | 14 | 3.5 |
| Once in a year | 38 | 9.5 |
| No visit | 348 | 87.0 |
| **Total** | **400** | **100** |

Farmers who got visits from extension officers reported that the officers' visits were not regular. Table 3shows that only 14 (3.5%) of the respondents were visited once in two months while 38 (9.5%) were visited once in a year. The remaining 348 (87.0%) of the respondents were never visited by the extension officers. Extension services are very essential in the performance of farm operations because such services helped to improve the farmers' agricultural activities. However, in the developing countries, such services are not available in most of the countries and if they are, they are over stretched due to limited personnel and other resources. Farmers learn the modern technologies and any new development in the farming practices through extension services.

The farmers were asked to indicate the measure which they used in an effort to improve their agricultural production (Figure 7). The results indicate that 112 (28%) farmers reported that they applied the indigenous knowledge which they had so as to improve their production.80 (20%) consulted with their neighbours, 13 (3.2%) sought help from NGO's while 195 (48.8%) did trial and error.

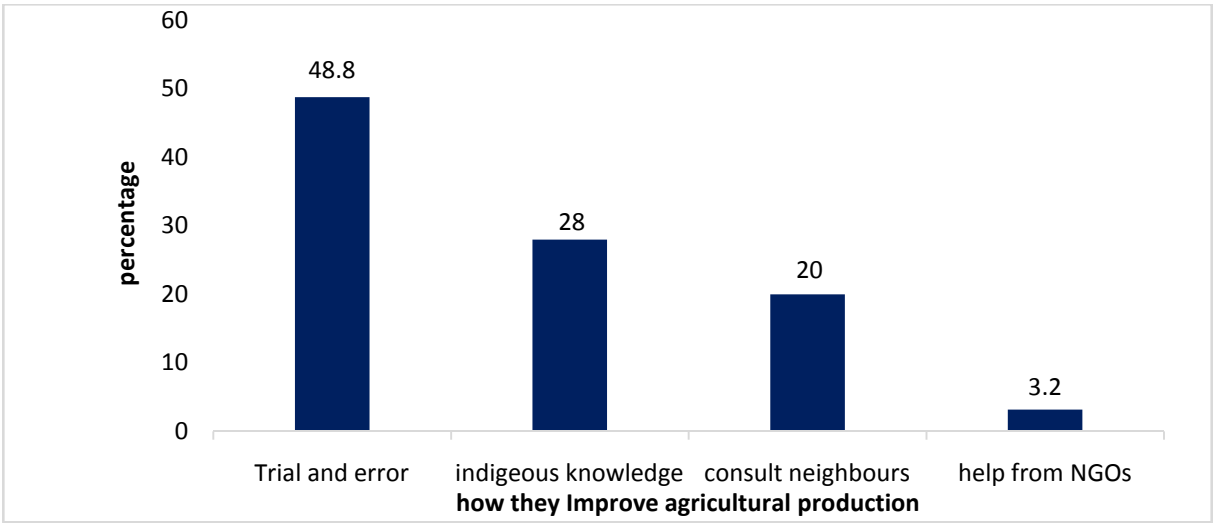


**Figure7: How farmers improve their agricultural production**

NGOs working in the region were very substantial in providing extension services to the farmers who sought their help. Dinar *et al.,(*2007) report that public and private extension services are found to be complementary in terms of their indirect effect and competitive in terms of their direct effect. In any case, the total impact of using both types of extension is greater than using either one, implying that they serve different purposes and farmers' needs**.** One measure that can be taken so as to maintain or improve agricultural production amid the changing climate would be to employ coping strategies so as to reduce the harmful effects. Such strategies vary among farmers and also among regions. Extension services were vital in farmers' advisory regarding the dissemination of information. Table 2shows that 348 (87%) of the respondents were never visited by agricultural officers. The farmers were asked to indicate how they improved their farming skills without extension services. 195 (48.8%) of the respondents indicated that they did trial and error in their agricultural production. Farmers tried out any measure which in their opinion would help them to improve their agricultural production in the absence of specialized technical advice.

## CONCLUSION

Apart from the low amounts, the rainfall was also unpredictable and unreliable making it difficult for the farmers to plan their farm calendar. The main coping strategies that were employed by the farmers were irrigation, digging zia pits, crop rotation and planting drought tolerant crops. Irrigation which would be an alternative to low rainfall was not widely practiced because the study area had only one permanent river. Digging borehole was too expensive for most of the farmers who could not afford because of the high poverty level in the study area. The water table was low which made sinking of wells too expensive. Farmers living near dry river beds had an advantage because the water table was near making the sinking of wells less costly and more affordable.

Most farmers did not apply any strategies to cushion their agricultural activities against the harmful effects of the changing climate. Most of the farmers lacked the knowledge required, but majority of the farmers cited limited finances as the main factor that prevented them from applying the coping strategies. A lacking or inadequate extension service was another factor that contributed to food insecurity in the study area. The agricultural extension officers cited limited staff and lack of resources as some of the factors that prevented them from visiting and advising farmers on the best agricultural practices.

Another factor that was reported that caused low agricultural production was lack of water. Being a semi arid area, the study region did not receive adequate and reliable rainfall. This necessitated the need for irrigation farming but which was not widely practiced because of lack of water for irrigation. The study area lacked permanent rivers except river Athi which was not adequate and was too far away for many of the farmers. Some of the farmers dug boreholes but which was too costly for most of the farmers to afford.

Planting of drought resistant crops was suggested as a measure that has been employed by some of the farmers as a means of reducing the effects of climate change on food production. This was seen as an appropriate strategy because such crops were able to survive with minimal moisture thus suitable for the semi arid region. Crop rotation was another strategy that was employed by a few of the farmers. This was appropriate because different crop types were planted depending on the season and weather conditions that were being experienced.

The study found that there was need to apply measures that would assist in coping with the adverse effects of climate change on agricultural production. Some of these strategies include digging bore holes that could be used for irrigation. Provision of credit facilities to farmers was another factor that was suggested by the farmers as a strategy that could help boost food production in the district.

The different scenarios of climate change impacts on crop production in various regions should be looked at very keenly, so that appropriate and specifically tailored adaptation measures for each region are implemented. The adaptation policy should also cover the possibility that at some point there may have to wholesale change to the agrarian specializations of the regions, their land-use and crop production patterns

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