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Farmer Adaptation Strategies To The Impacts Of Climate Variability In Kakamega County, Kenya

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ABSTRACT

Climate variability entails short to medium term fluctuations of climatic variables around mean state on climate scales. Impacts of climate variability include amongst others: increase in extreme weather conditions; land degradation, changes in rainfall patterns; diminishing natural resource productivity; and in some areas, irreversible loss of biodiversity. Agricultural sector is sensitive to climatic conditions and hence vulnerable to climate fluctuations. The severity of the aforementioned impacts depends on the extent of adaptation as this has the potential to substantially reduce many of the adverse impacts. This study assessed farmer adaptation strategies to climate variability in Kakamega county**,** Kenya. Multistage sampling strategy was used to obtain the geographical areas from where four hundred (400) farmers were randomly sampled. Semi structured questionnaires, Focus Group Discussions (FGDs), Key Informants interviews (KIIs) and observation check lists were used to collect data. Data were analyzed using SPSS statistical data package for social sciences version 17. The study established that farmers were adapting strategies to suit the changing climatic conditions and also taking advantage of presenting opportunities. The highest ranked strategies of adaptation embraced in livestock farming were: management of infections (57.9%); and adjustments in the feeding/fodder/pastures programmes (15.5%). Diversification of herds (4.5%) and value addition ranked as the least adaptive measures embraced (3.2%). Further, farmers had reduced the land under pasture or grazing in order to grow crops with the consequence of reduction in size of their herds. In crop production, the most highly ranked adaptive measures were: management of soil resource and other farm inputs (52.9%); intercropping (15.8%); and diversification (7.6%) which appeared in the third position. Intercropping helped to maximize on the utilization of small pieces of land as several crop were grown on the same piece of land at the same time. Diversification into growing drought tolerant varieties of crops such as sorghum, cassava, millet and cassava that withstood extended dry spells. Management of infections along with water resource ranked as the least adaptive measures embraced. Further, most farmers expressed that they had adopted several cropping cycles in the same growing season to maximize on the presenting favourable conditions such as unexpected increase in the rains. The study observed that a proportion of farmers still stuck to their old farming practices and recommended the need to enhance farmers' awareness which would enable them make informed adaptation decisions.

Keywords: Climate Variability, Impacts, Adaption

1. INTRODUCTION

Climate fluctuates naturally on all time scales diurnally, seasonally, annually and decadally. The short-medium term fluctuations around mean state on climate scales, is referred to as climate variability. Meteorological elements that fluctuate in this context comprise; (i) air temperature; (ii) precipitation (e.g., rain, sleet, snow and hail); (iii) atmospheric pressure; (iv) atmospheric humidity; (v) duration of sunshine; (vi) solar and terrestrial radiations; (vii) wind speed and direction; and (viii) evaporation and cloud cover (KMS, 2012; IPCC, 2007; IPCC, 1996). Literature indicates that the two most important meteorological elements are precipitation and temperature as they have attendant effects on the rest as aforementioned.Gabi, 2013; Oteng'i, 2009).

According to the IPCC fourth assessment report, (IPCC, 2007), global air temperature near the earth surface rose by 0.74°C during the period 1906 – 2005. The report further indicates that this could increase by an average of 6.4 °C during this 21st century. Likewise there is evidence that climate change and variability is altering precipitation patterns worldwide (Gabi, 2013 and Paige, 2013).

Climate variability has posses serious challenges in the agricultural sector which forms the mainstay of Kenya's economy. Some of the challenges that characterize agricultural landscape in Kakamega county comprise: (i) drought and seasonal rainfall uncertainties; (ii) high pest and disease infestation; (iii) increasing rates of soil erosion and consequent soil fertility decline; and (iv) short growing season due to delays in rainfall onset (KARI, 2013). This has negative impact on agricultural production subsequently reducing household income and subjecting communities in this county to high levels of food insecurity and very limited livelihood options (GoK, 2013a; GoK, 2013b; KARI, 2013). The extent to which the impacts of climate variability in agriculture are felt depends in large part on the extent of adaptation strategies adopted by farmers.

1.1 SCOPE

This study considered farm level adaptations that focus on analysis of decisions by farmers in agricultural management practices aimed at improving crop and livestock production in response to climate variability. Such practices entailed tactical decisions farmers made in response to seasonal climatic variations over relatively shorter time period. This, it was envisioned would improve the food security for the communities in Kakamega county. Agricultural systems under consideration were the cropping and livestock farming. Farmers practicing both subsistence and commercial farming formed part of the study.

1.2 SIGNIFICANCE

According to the NCCRS (GoK, 2010), temperatures have risen throughout the country; rainfalls have become irregular, unpredictable and more intense resulting in extreme harsh weather situation. The foregoing trend has been observed more specifically since the early 1960s (GoK, 2013b; GoK, 2010). The variation in climatic patterns has had adverse impacts in the agricultural sector which is linked directly or indirectly to the livelihoods of a majority of Kenyans (GoK, 2008a). Consequently, there is need to invest in adaptive measures geared towards minimizing the adverse effects while exploiting the opportunities created by the variability in climate. This study to determine farmers' adaptation strategies in the county is of great value.

1.3 JUSTIFICATION

The population in Kakamega county comprises of communities that heavily rely on subsistence farming for food and their livelihoods (Otolo and Wakhungu, 2013; GoK, 2013b). Such a population is vulnerable to the impacts of climate variability as the changes create unfavourable conditions for farming, impacting negatively on their food security. Projections indicate that the impacts of climate change and variability will worsen if adaptation measures are not embraced (IPCC, 2014; Voleizo and Wakhungu, 2011: GoK, 2010; GoK, 2008a; Maddison, 2007; Rosenzweig and Hillel, 1995). A study to determine whether farmers perceived the changes entailed in climate variability was therefore justified. Studies indicate that farmers who perceive the changes in climate adapt copping strategies better than those who don't (Maddison, 2007; Rosenzweig and Hillel, 1995).

2. MATERIALS AND METHODS

Kakamega County is located in Western Kenya. It comprises 12 sub-counties, namely; Kakamega North, Kakamega Central, Kakamega East, Kakamega South, Matete, Lugari, Likuyani, Navakholo, Mumias, Matungu Butere and Khwisero (GoK, 2008b).The county lies between longitude 34^0 and 35^0 E and latitudes 0^0 and 1^0 N of the Equator and within altitude 1,250-2000m. It has an area of about 3,224.9 square kilometers (GoK, 2009).

Kakamega county climate is predominantly hot and wet most of the years with mean annual rainfall between 1,800- 2,000 mm. The mean monthly trend of rainfall represents two maxima and minima over the year. The first and second maxima occur in April to June and August to November respectively (GoK, 2013c; GoK, 2010). Generally, there are two main cropping seasons in most parts of the county that coincides with the long rains and short rains. The average temperature in the county is 22.5 ^{0}C. January and February are generally considered as dry months.

2.1 AGRO ECOLOGICAL ZONES (AEZ)

Climate, vegetation and land-use potential have been used to assess land suitability for different agricultural applications. The major parameters of climate that affect plant growth are threefold: (i) the intensity and duration of rainfall; (ii) the relationship between annual rainfall and potential evapo-transpiration; and (iii) the year-to-year variation in rainfall and temperature. Based on the foregoing, Kenya is divided into seven AEZ using a moisture index based on annual rainfall expressed as a percentage of potential evaporation (Kabubo *et al.* 2007, Jaetzold *et al.,* 2011). Kakamega county comprises of the following AEZ: (i) the Upper Midland (UM) zones, lying between 1500-2000m; and (ii) Lower Midland (LM) zones at 1200-1500m (Jaetzold *et al.*, 2011). In the centre of the county, the rainfall is too high leading to leaching of soils. This provides suitable environment for fungal diseases. Therefore, this area is classified as UM 0 and is considered in agricultural planning as a forest zone. The UM zone is further subdivided into subzones; UM 1, UM 2, UM3 and UM4. These are the northeastern parts of the county where Lugari fall, with humid climate interrupted by four months of dry spell (November-February) restricting cultivation of perennial crops like bananas and sugarcane. There is one main growing season. The dominant crop, Saize is grown on large scale in the Lugari and Likuyani sub-counties. Sunflower is grown as cash crop.

The LM zone has two subzones; the LM 1 and LM 2. These are the sugarcane and the marginal sugarcane (*Sacharin sp*.) growing zone respectively. Malava and parts of Navakholo form the marginal sugarcane growing zones. Mumias, fall in LM1 zone where sugarcane is the dominant crop. Other crops such as beans (*Phaseolus Vulgaris L*), sorghum (*Sorhum vulgare*), millet (E*leusine coracana*) and horticultural crops are grown. Normally, there are two cropping seasons that coincide with bimodal rainfall regimes in which long rains fall between March and May and the short rains between October and December (GoK, 2010; GoK, 2008c). The main cash crops are sugarcane, tea (*Camellina sinensis*), and sunflower (*Helianthus annus*) while soya (*glycine max*), beans maize (*Zea mays*), potatoes (*Solanum tuberosum*) and bananas (*Musa paradisiaca*) cultivars are planted as food crops (GoK, 2008c). They also produce some fruits namely avocado (*Persea americana*), pawpaw (*Asimina triloba*), bananas and pineapples (*Ananas comosus*). Guavas (*Psidium guajava*) grow wildly in some parts of Kakamega central and Navakholo and compliment other fruits (GoK, 2008c).

Due to the foregoing, the land-use potential attributable to the existing micro-climate as aforementioned could influence the adaptation choices by the farmers in respective AEZ. Consequently, this study considered the adaptations in the respective AEZ zones.

2.2 SAMPLING PROCEDURE AND SAMPLE SELECTION

The study used combination sampling strategies. The study area, Kakamega county was purposively sampled due to reasons given under justification. Multistage sampling strategy was used to obtain the three geographical zones from where four hundred farmers were randomly sampled. A total of sixty (60) key informants who participated in the key informants interviews were sampled purposively from stakeholder organizations

2.3 DATA COLLECTION INSTRUMENTS

Data was sourced through questionnaires and focus group discussions and observation checklists. A questionnaire was administered to the 400 farmers. A total of 396 were returned and analysed appropriately. Direct observation were made and recorded in the checklist. This assisted the researcher to ascertain and authenticate the information gathered through questionnaires. There were two FGD sessions.

2.4 DATA PROCESSING, ANALYSIS AND PRESENTATION

Data was analyzed both descriptively and inferentially by use of the Statistical Package of Social Sciences (SPSS) version 17. Outcomes of analysed data were depicted in tables, graphs and other graphical presentations. The interaction of quantitative and qualitative variables availed input into the correlations that were computed.

3. RESULTS AND DISCUSSIONS

3.1 ADAPTATION STRATEGIES IN LIVESTOCK PRODUCTION

The respondents cited several adaptation strategies in livestock production as discussed hereunder. The adaptation strategies were considered per sub-county in order to establish if the different agro ecological zonation influenced the adaptation. It is important to note that although each strategy is considered as an entity, respective farmers had simultaneously adopted a combination of several strategies.

3.2 DIVERSIFICATION OF FARMING SYSTEMS IN KAKAMEGA COUNTY

Farmers have embraced various farming systems as indicated in Table.1 and Figure.1.

Table 1: *Diversification of Farming Systems per Sub-county in Kakamega County*

Farming System	Kakamega East	Lugari	Navakholo	Total	Av. %
Irrigation	5 (3.8%)	9 (6.4%)	24 (19.0%)	38	9.6%
Bee keeping (Apiculture)	14 (10.7%)	5 (3.5%)	3(2.3%)	21	5.3%
Fish farming (Aquaculture)	19 (14.5%)	25 (17.9%)	37 (29.4%)	81	20.4%
Zero grazing	28 (21.4%)	43 (30.9%)	17 (13.5%)	89	22.5%
Didn't indicate any diversification measure	65 (49.6%)	57(41.3%)	45 (35.7%)	167	42.2%
Total respondents	131 (100%)	139 (100%)	126 (100%)	396	100%

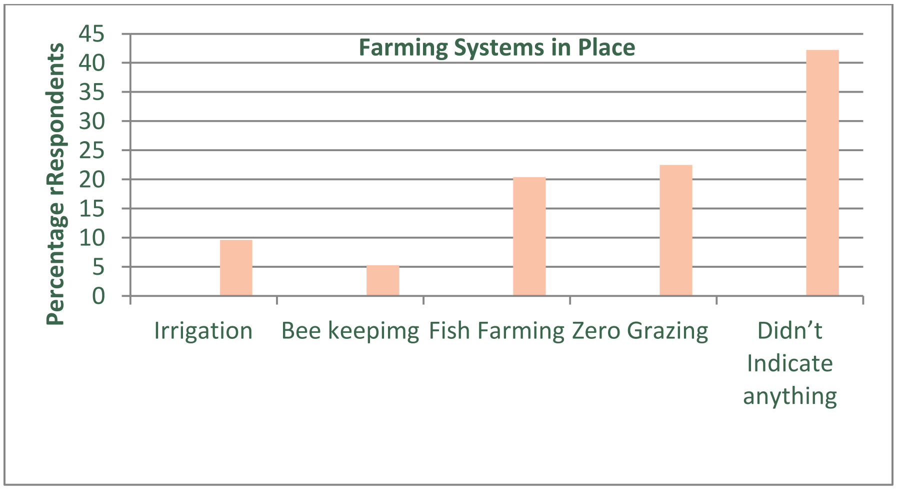

Figure 1: *Diversification of Farming Systems in Kakamega in County, Kenya*

The diversification of farming systems was as follows: Irrigation 9.6%; apiculture 5.3%; fish farming 20.4%; and zero grazing 22.5%. Forty two point two (42.2%) respondents had not embraced diversification in the farming systems. The strategies per sub-county are summarized in Figure 6.2

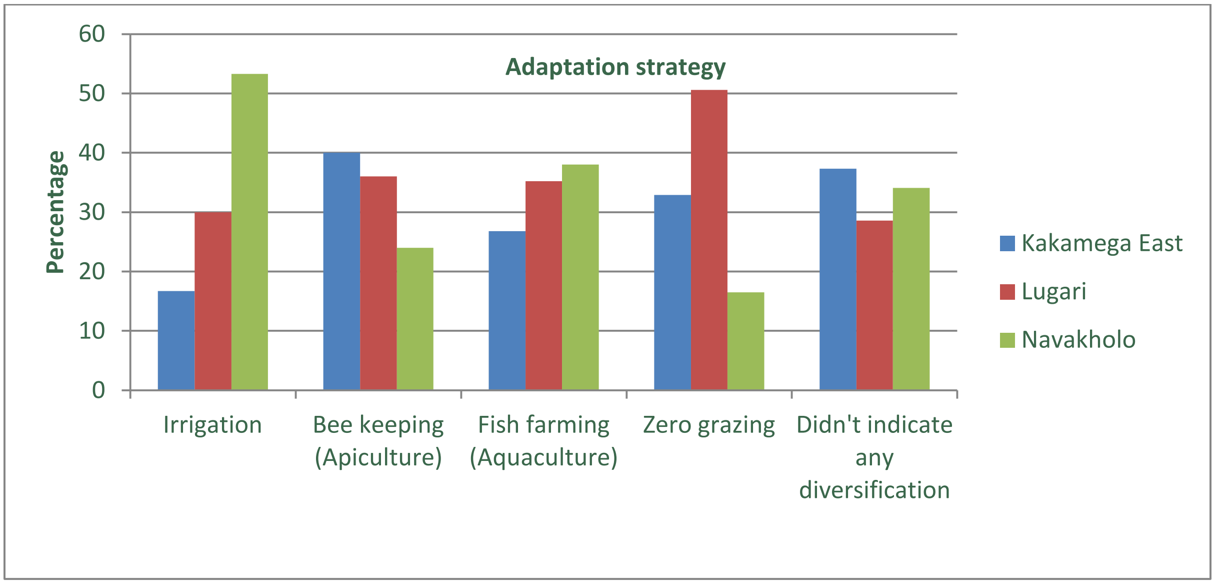

Figure 2: *Diversification of Farming Systems per Sub-county in Kakamega in County, Kenya*

From Figure 1 it is evident that not all households in the sub-counties have made changes in the existing farming systems as a way of adaptation. The summary per sub-county also indicates no significant difference in the strategies embraced by farmers. However, a few stand out for mention.

Navakholo sub-county had the highest number of farmers practicing irrigation (19.0%) and fish farming (29.4%). The irrigation was mainly in the riverine valleys where naturally flowing streams were diverted into the lowlands for growing crops during the dry spells. Bee keeping was embraced by farmers from mainly Kakamega East, at the rate of 10.7%. The proximity of Kakamega East to the forest has created a suitable ecological environment for bee keeping. Lugari had the highest number of farmers practicing zero grazing (30.9%). The uptake of all these farming systems had been facilitated by funding from the Economic Stimulus Programme (ESP).

3.3 OTHER ADAPTATION STRATEGIES IN LIVESTOCK FARMING

Additional adaptation strategies in livestock production are summarized in Table.2 and discussed hereunder.

Table 2: *Adaptation Strategies In Livestock Management in Kakamega County Kenya*

Strategy	Kakamega East		Lugari		Navakholo			FGD 1 Lugari	FGD 2 Kakamega
	Freq. (%)	Rank	Freq. (%)	Rank	Freq. (%)	Rank	Av.%		
Feeding/Fodder/ Pasture programmes	15 (11.4%)	2	21 (15.1%)	3	25 (20%)	2	15.5	2	1
Management of infections	86 (65.6%)	1	76 (54.7%)	1	67 (53.6%)	1	57.9	1	2

Diversification of herds	5 (3.8%)	4	5(3.5 %)	4	8 (6.3%)	4	4.5	3	4
Quality of breeds	13 (9.9%)	3	22 (16.8%)	2	20 (16.0%)	3	14.2	4	3
Value addition	2 (1.5%)	5	7 (5.0%)	5	4 (3.2%)	5	3.5	5	5
Didn't indicate any adaptation measure	10(7.6%)		8 (5.7%)		2 (1.6%)	4.6	4.9		
Total	131		139		126		100		

The management of infections ranked highest at 57.9% followed by adjustments in the feeding/fodder/ pasture at 15.5% and diversification in herds came third with 4.5%. Value addition was ranked fifth with only 3.5%, in the last position. To establish the preferred adaptation strategy in livestock production by famers per sub-county, a Spearman's rank order correlation was computed. The results are summarized in Table 3.

Table 3: *Spearman's Rank Order Correlations from the three Sub-counties and FGDs*

	Lugari	*Navakholo*	*FGD 1* **Lugari**	*FGD 2* Kakamega
Kakamega East	r=0.85±0.12*	r = 0.90±0.08*	r=0.85±0.12*	r=0.95±0.04*
Lugari		r=0.85±0.12*	r=0.95±0.04*	r =0.90±0.08*
Navakholo			r=0.95±0.04*	r=0.85±0.12*
FGD 1				r =0.90±0.08*

** Similarity in rankings*

From the results, the correlations computed between the ranking, Kakamega East versus Lugari, Kakamega East versus Navakholo, Lugari vs Navakholo as well as those of FGDs indicate that the correlations were significant. This implies that the ranking of all the strategies by the respondents in each of the sub-counties was similar. The most highly ranked strategies in all the sub-counties were management of infections and enhancement of feeding programmes. Specific farm operations in respect of the foregoing adaptation strategies are hereby discussed.

3.4 FEEDING/FODDER/PASTURE PROGRAMME

The details of the feeding programmes embraced by the respondents comprised adjustments in the kind of feeds and fodder for their livestock. Figure 3 shows the common feeding alternatives.

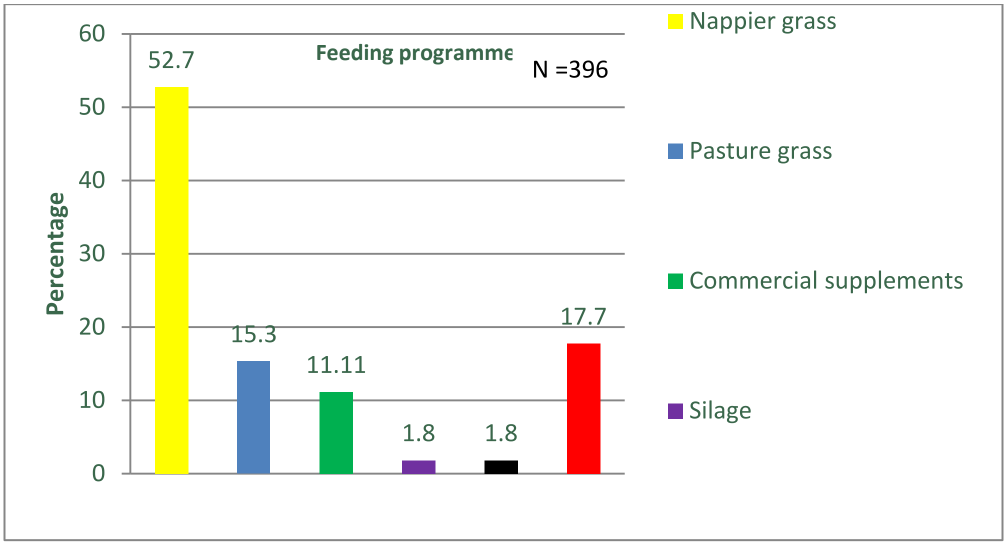

Figure 3: *Alternative Forage in Kakamega in County, Kenya*

In the existing climate variability scenarios, farmers grow mainly napier grass (*Pennisetum purrens and Pennisetum purpurem)* in all the sub-counties as fodder. Other feeding material identified as 'Others' in Figure 6.3 comprise remains of beans, sugarcane, maize stover, potatoe vines and banana leaves. A proportion of 17.7% supplement with commercial concentrates like dairy meal, poultry feed and salts. Hay and silage were the preferred alternatives especially during the dry spells amongst the farmers in Lugari AEZ. In the same zone, a notable adaptation strategy that ensured constant supply of concentrates was observed where farmers prepare their own cattle rations and concentrates. This is from remains of farm produce such as bean husks, amaranth grain, maize stove and sunflower husks amongst others. In this way, they control the nutritional constitution of the rations as opposed to the commercial ones that are not tailor made for specific region.

In Kakamega East, a few farmers had embraced a new pasture grass types from KARI Kakamega. These comprise; Guatemala (*Tripsacum laxum*), boma Rhodes (*Chloris gayana*), mulato (*Brachari racizinensis*) giant setaria (*Setari sphacelata*), and giant panicum (*Panicum maximum*). These fodder grasses are resistant to diseases and can tolerate drought hence very valuable especially during extended periods of dry spells. In addition, a number had adopted 'zero grazing', a labour intensive option of livestock farming where livestock especially cattle are confined in sheltered housing from where they are fed. This enabled the farmer to intensify the utilization of the small pieces of land as opposed to free range option which demand bigger acreage in form of grazing land and growing of fodder grasses. This management was particularly observed to have taken root in Lugari where previously, livestock have been kept on free range.

3.5 MANAGEMENT OF INFECTIONS

Management of infections was yet another very key adaptation strategy. The study established that farmers manage infections by spraying, vaccinating and de-worming their livestock. Where necessary, they also seek veterinary experts' services. Others expect the management of infections to be a responsibility of the Ministry of Agriculture and Livestock and Fisheries. This was evident in the management of outbreaks of diseases such as anthrax, Maize Lethal Necrosis, fowl typhoid, East Coast Feaver, newcastle, foot and mouth disease amongst others. Further, in Kakamega East most farmers rear the hardy zebu types of cattle (*Bos Taurus)* that are tolerant to most diseases.

3.6 IMPROVEMENT OF QUALITY OF LIVESTOCK BREEDS

There was evidence that the quality of genetic breeds was low amongst many farmers in all the sub-counties. This is because most of them prefer to rear the indigenous varieties. Nonetheless a few were cross breeding the indigenous with the exotic varieties. This was commonly observed in cattle which translated into small herds with better productive potential. Likewise, in poultry farming a number of Non-Governmental Organizations (NGO) such as *Techno-Serve* and institutions like KALRO facilitated farmers to breed cross breed chicken varieties that are more tolerant to diseases and more productive such as the KARI *Kienyeji* and the K*uroiler*. Few farmers kept the exotic varieties of poultry and attributed it to their vulnerability to diseases.

3.7 DIVERSIFICATION OF LIVESTOCK AND HERD SIZES

There were few farmers who had diversified into bee keeping (apiaries) and fish farming as facilitated by Economic Stimulus Programme (ESP) by the government. Bee keeping was particularly embraced by farmers in Kakamega East especially those close to the forest, which is a suitable habitat for the bees. According to literature, bee keeping provides nutritional and livelihoods requirements and can boost crop production by increasing pollination of food crops like maize and beans (KARI, 2010). However farmers have not been enthusiastic to embrace bee keeping in the county in spite of the efforts made by the ESP.

It was observed that few farmers had diversified into rearing small ruminants like rabbits, sheep and goats in spite of their tolerability to a number of climate related challenges. They expressed that this was attributable to lack of pastures. With respect to the size of herds, there were indications that farmers were rearing smaller herds of cattle to counter the challenge of scarcity of pasture and fodder. This was aimed to balance stocking rates with the available land as a way of ensuring sustainable resource use.

3.8 VALUE ADDITION

It was observed that persistent rains availed plenty of fodder and pasture; good harvest in sugarcane and tea; and high quantities of milk in some AEZ. Consequently, farmers occasionally experience gluts like in milk production and green vegetables. Most of this goes to waste and hence the need for value addition as an adaptive measure. In Lugari, a few farmers had embraced value addition as an adaptation strategy. Here, farmers have formed cooperatives and had procured milk coolers to enable them process yoghurt for sell. In

Kakamega East, a number of farmers are producing biogas from cattle dung and refining honey to enhance the sale value.

According to AGRF (2012), processors can only take 60% of milk and the other 40% goes to waste or is sold at low prices to middle men. Processing milk into powder, one method of value addition, provides safeguard for the glut. In a nutshell, value addition increases the shelf life of farm produce, creates multiple uses for it and markets both locally and internationally, ultimately creating more value for the producer and the manufacturer (AGRF, 2012, IFAD, 2009). It also enables movement of the finished goods, as opposed to the current movement of raw materials for products such as tea and, coffee.

3.9 ADAPTATION STRATEGIES IN CROP PRODUCTION

The respondents cited various adaptation strategies as summarized in Table 4.

***Table 4:** Adaptation Strategies in Crop Production in Kakamega in County, Kenya*

Strategy	Kakamega East		Lugari		Navakholo			FGD 1 Lugari	FGD 2 Kakamega	
	Freq. (%)	Rank	Freq. (%)	Rank	Freq. (%)	Rank	Av. %	Rank	Rank	Ave. Rank
Water sources management	11 (8.3%)	5	12 (8.6%)	3	18 (14.4%)	3	10.4	4	5	5
Management of soil and other farm inputs	58 (44.1%)	1	89 (64.2%	1	63 (50%)	1	52.9	1	1	1
Management of Infections	18 (13.8%)	4	25 (18%)	2	10 (7.9%)	4	13.3	5	4	3.8
Intercropping	21 (17%)	2	9 (6.5%)	4	30 (23.8%)	2	15.8	3	2	2.6
Crop Diversification	21 (16.0%)	2	4 (2.9%)	5	5 (3.9%)	5	7.6	2	3	3.4
Total	131		139		126		100			

To establish the preferred adaptation strategy in crop production by farmers per sub-county, a Spearman's rank correlation was computed and the results shown in Table 5.

***Table 5:** Spearman's Rank order Correlations for Rankings from the three Sub-counties*

	Lugari	***Navakholo***	***FGD 1 Lugari***	***FGD 2 Kakamega***
Kakamega East	r = 0.95±0.04*	r = 0.20±0.16	r = 0.90±0.08*	r = 0.90±0.08*
Lugari		r = 0.35±0.05	r = 0.85±0.12*	r = 0.95±0.04*
Navakholo			r = 0.50±0.33*	r = 0.10±0.44
FGD 1				r = 0.70±0.23*

** Similarity in rankings*

The management of infections ranked position one with 52.9% followed by intercropping at 15.8%. The least strategy embraced by farmers was crop diversification at position five with 7.6%.

Correlations computed between the ranking Kakamega East versus Lugari, Kakamega East versus FGD 1, Kakamega East versus FGD 2, Lugari versus FGD 1, Lugari versus FGD 2, Navakholo versus FGD 1 and FGD 1 versus FGD 2 had significant correlations, indicating that the rankings were similar. The results show that there were similarities in the rankings for the results from the three sub-counties. This implies that farmer adaptation strategies did were not different in the sub-counties. Specific farm operations in respect of each adaptation strategy are hereby discussed.

3.10 MANAGEMENT OF WATER RESOURCES

Water scarcity is a major factor limiting agricultural production for farmers with unreliable occurrence constraining the achievement of sustainable production (Duivenbooden *et al.*, 2000). Improved and efficient water use in climate variability scenario is therefore critical. As regards management of this resource, most farmers have invested limited resources to climate variability adaption in the context of water resource. Amongst the five adaptation strategies, it is the second last adaptation at position four with only 10.4% of the farmers having embraced it. This is in spite of the great potential for irrigation in the county especially in Lugari AEZ that experiences longer dry spells than Navakholo and Kakamega East. Some semblance of irrigation was observed only in Navakholo in the riverine valleys where mainly vegetables are grown for local consumption. In Lugari sub-county, relatively more farmers had sunk boreholes than in Navakholo and Kakamega East. Those served as the main source of water for their livestock and domestic use.

Irrigation practices could improve farm productivity and enable diversification of production in light of climate-related changes (Smit and Skinner, 2000). According to Duivenbooden *et al.*, 2000, irrigation supplements rainwater during dry spells and lengthens growing seasons. In furtherance of efficient utilization of water resource, efforts should be geared towards increasing capture and retention of water through construction of water pans, boreholes and other harvesting structures. This could ensure the availability of this resource during the dry spells and allow farming at the convenience of the farmer. It is in this vein that the government has put large swathes of land under irrigation. For instance in the 2014/2015 national budget, Kenya shillings 9.5 Billion (equivalent to US$126) was allocated to irrigation. County governments especially in the ASALs have followed suit and are directing large resources towards irrigation activities.

Famers should be facilitated with the appropriate infrastructure to be able to embrace irrigation. This is because a large percentage of Kenya's land mass lies in the ASALs. The future of Kenya's food security is therefore in irrigation of the vast dry lands. According to Vision 2030, the economic development blueprint of the country, irrigation is one of the strategy that will enable Kenya attain some of the tenets of the Vision (GoK, 2008a). That is why the country in implementing this has put large swathes of virgin lands in these less potential regions like Turkana and Tana River counties under irrigation.

3.11 MANAGEMENT OF SOIL RESOURCES AND OTHER FARM INPUTS

This ranked position adaptation strategy with 52.9% farmers having embraced it. Likewise, the FGD ranked it in first position. Challenges regarding soil were addressed as follows: (i) mulching with remains of plants; (ii) use of farmyard or green manure; (iii) planting fodder crops such as napier grass along the terraces; (iv) liming to address the acidity; and (v) terracing amongst others. Studies show improved yields in some crops such as maize when green manure from shrubs such as *Cassia spectabilis, Lantana camara, Tithonia diversifolia, Calliandra calothrysus and Grevillea robusta* is used (Niang *et al.*, 1996). Other strategies geared towards water and soil conservation entailed: (i) planting cover crops; (ii) maintenance of crop residues on the ground; (iii) construction of gabions; (iv) intercropping; (iv) terracing; and (v) contour planting. According to existing literature, a range of management practices can help reduce vulnerability by reducing runoff and erosion and promoting nutrient restocking in soils, while other techniques may improve the soil structure and fertility (Itulya, 1995; Nhemachena and Hassan, 2007).

Literature therefore proposes zero or minimum tillage which minimizes or eliminates tillage as a successful soil management strategy (IFAD, 2009; Okwach, 1999; Musandu, 1995). Zero or minimum tillage and maintenance of permanent soil cover increase soil organic matter thus reducing impacts from flooding, erosion, drought, heavy rain and winds (Rockstrom and Johnsson, 1999). However, there was no evidence of zero or minimum tillage strategy in the sampled areas. Gathering from evidence on the checklists and discussions at the FGD, the agronomic practices in use comprise intensive soil tillage using mainly the hoe or oxen driven plough. Further, land is permanently under crops resulting in aerobic mineralization of soil organic matter with the attendant degradation (Mbakaya *et al.*, 2009).

Regarding other farm in-puts, farmers indicated that these had increased over time. Farm inputs comprise amongst others, fertilizer, pesticides, insecticides, fungicides, labour, and seed. According to Tabu (2014), fertilizer use in Kenya is not as per recommended types and proportions. Often the cost of fertilizer is prohibitive for most farmers to afford. Yet according to Mbakaya *et al.*, (2009), the correct and efficient use of fertilizer holds the key to higher yields. Efforts should be made to ensure access to fertilizer by farmers even if it entails providing subsidies like it is done in European Union member states. Other considerations should entail provision of specific fertilizer requirements for the respective AEZ, improved soil testing mechanisms and through educating farmers accordingly.

3.12 INTERCROPPING

The strategy was ranked second position out of the maximum five with 15.8% of the farmers preferring it. FGD findings were highly correlated with these findings. Intercropping is yet another strategy observed to have taken root amongst many farmers. Although it was sighted in all the three sub counties, it was more common in Navakholo where mainly legumes are used as intercrops. According to Duivenbooden *et al.*, (2000), intercropping with legumes increases soil organic matter by fixing Nitrogen (N) in the process sparing the soil mineral N. This is thus a very convenient and inexpensive adaptation measure. It has many advantages over conventional options, including: (i) conserving and improving soil fertility; and (ii) increasing soil moisture and tolerance to drought.

Another strategy closely related to intercropping is mixed cropping or multiple cropping embraced by farmers in all the three sub-counties. This is a form of crop intensification that allows for utilization of the small pieces of land that are owned by most of the farmers. Studies show that multiple cropping of non-legumes with legumes is beneficial for various crops (Itulya, 1995; Adipala *et al.*, 1994; Kabubo *et al.*, 2007).

3.13 CROP DIVERSIFICATION AND MANAGEMENT OPERATIONS

Crop diversification was adopted by 7.6% of all farmer households and was ranked at position five. The diversification of crops addressed changes in the onset of the rainy season which farmers perceived to be 'late' and cessation which was perceived to be 'early', hence shortening season's duration. This entailed growing high yielding, fast or early maturing, disease, pest and drought tolerant/resistant/escaping, varieties. Examples are the traditional high value crops such as sorghum, millet, cassava, sweat potatoes, some nuts varieties and the hybrid upland rice varieties; NERICA-1, NERICA- 4, NERICA-10 and NERICA-11 from the African Agricultural Technology Center (AATC). A study by Nyandiko, (2008) established that these traditional high value crop varieties play a significant role in household food security in the then Ikolomani division of Kakamega district. Therefore, the adoption of new crop varieties, including hybrids, to increase the tolerance and suitability of plants to temperature, moisture and other relevant climatic conditions is a desirable adaptation strategy.

In some cases farmers changed the types of crops altogether. For instance in Kakamega East, *Eucalyptus grandis* and *Eucalyptus cladocalyx* are planted for their timber, building poles, fuel-wood, and soil erosion control as the trees are resistant to diseases. The farmers indicated that there was more income from the trees than conventional crops. These results are consistent with those of other studies that indicate that adaptation to climate variability for most crops require consideration of crops with increased tolerance to these factors (Southworth *et al.*, 2000, Musandu 1995; KARI, 2012; Mendelson, 2006).

Another farming practice embraced was changing the timing of farm operations which involve production decisions, such as planting/sowing, harvesting, tillage and spraying. These were adjustments that enabled them to take advantage of the changing duration or anticipated changes of growing seasons. Amongst the specific approaches cited by farmers here entailed: (i) staggering planting; (ii) planting early; (iii) dry planting; and (iv) use of wetland to extend growing seasons. This adaptation focuses on crop management practice geared towards ensuring that critical crop growth stages do not coincide with very harsh climatic conditions such as mid-season droughts and pests' infestation. The changing of farm operations has the potential to maximize farm productivity during the growing season and to avoid heat stresses and moisture deficiencies (Smit and Skinner, 2002).

Farmers have also increased the growing cycles of crops within seasons. The agricultural terrain in the county is conventionally dominated by one main cropping season in a calendar year occurring in March to August. However due to climate variability, this is no longer the practice because what has been considered as the short cropping season is now dominated by a repeat of what is grown during the main cropping season. This was particularly evident in Lugari, and Navakholo. Farmers grow maize in addition to the short, fast maturing crops immediately after harvesting the main crops. At the FGD's and KIIs, it was established that this enabled them to take advantage of beneficial weather conditions such as increased rains and increased temperatures. This corroborates existing literature that temperature increase may allow earlier maturation and harvesting of crops. This avails opportunity of two or more cropping cycles during the same season (Rosenzweig and Parry, 1994). This however no longer encourages long fallows for restoration of soil fertility as has been in the past (Mbakaya *et al.*, 2009).

An observable adaptation strategy embraced by farmers is crop rotation. During the FGD, they indicated that they had found it effective in the management of the Maize Lethal Necrosis (MLN) disease that had decimated their maize crop. Literature indicates that crop rotation disrupts the lifecycles of the pests, improves soil fertility especially if rotation is with legumes (Hella. *et al.*, 2008; KMS, 2012; Mbakaya, 2007).

Finally in crop management practices, it was observed that crops hitherto considered indigenous to certain AEZ were being grown in other sub-counties. For example the shift from maize to cash crop such as sugarcane and other perennial crops like bananas in Lugari is an indication of such changes. Farmers cited the low returns from maize farming because of the infestation by the MLN.

3.14 MANAGEMENT OF DISEASES, WEEDS AND PESTS

The management of diseases, pests and weeds is ranked at position three (3) with 13.3% of the farmers having adopted it. This implies farmers do not consider it as a threat the way they perceive management of soil and farm inputs. At the FGD sessions, it was established that most of the farmers do not consider this as their core responsibility. They indicated that they expected Ministry responsible for agriculture take charge whenever there was an outbreak of diseases.. The farmers further observed that the process is expensive, beyond their reach and hence could not do much to forestall the challenge.

The foregoing notwithstanding, there were control measures undertaken by a few farmers for example by way of spraying with insecticides, fungicides and herbicides similar in livestock adaptation discussed earlier. Amongst the infections commonly sprayed comprised; the cassava leaf spot disease, the cabbage black rot, the potato blight and a myriad of fungal and bacterial infections. They cited high infection rates in the green house soils where the spraying was mandatory.

Weeds compete with crops for fertilizer which eliminate yield-enhancing effects of fertilization. The study established that the commonly used approach to control weeds is to commence the weeding immediately they germinate to forestall the competition with the crops. Other control measures comprise growing of resistant or tolerant varieties of crops.

Finally, some respondents indicated they had succeeded in the management of infections and pests by intercropping and crop rotation. These findings are consistent with those of Adipala *et al.*, (1994), that established that intercropping and crop rotation are suitable disease and pest control measure in agricultural practice. According to Adipala *et al.*, (1994) this involves mechanisms such as interception of spores by resistant or non-host plants, reduction in density of susceptible plants, induced resistance or cross protection and provision of unfavourable microenvironments for the pests and causal agents.

Finally it was generally observed that although the conventional farming system in the county is mixed crop and livestock production, the trends had changed in the recent past and many farmers were investing more resources in adaptation strategies in crop farming as opposed to livestock production. This was attributable to the drastic reduction in farm sizes which could not enable them to keep livestock that demand bigger parcels of land.

4. CONCLUSION AND RECOMMENDATIONS

The study concluded that some farmers were making adjustments in their farming practices to suit the changing climatic conditions in order to lessen the potential damage. A proportionate category of farmers has embraced adaptation strategies which comprised; diversification of farming systems, development of alternative feeding programmes for the livestock, embracing the traditional high quality drought resistant crops, adjusting the farming activities such as sowing to suit the changes in the weather patterns amongst others. They also took advantage of opportunities presented by the variability such as increased rainfall and temperatures. However some farmers still stuck to their old ways and had not embraced any form of adaptation.

It was observed that the adaptation strategies were haphazardly embraced without regard to the unique climatic and social-cultural vulnerabilities existing in the respective AEZ. This was mainly because the key actors in the adaptation process such as the research institutions and government agents treated adaptation to climate variability as a stand-alone activity. Adaptation is a cross-sectoral activity which should bring together actors from different stakeholders so that there are no contradictions or duplication of activities. Therefore a common basis for cooperative adaptation activities for all sectors and decision-making levels should be encouraged. Consequently, appropriate infrastructure such as a legal and institutional framework that supports an integrative approach is desirous. This will enhance the exploitation of the potential synergies without fear of conflicts and contradiction.

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5. REFERENCES

Adipala, E. Okoboi, C. A., Tahkan, T. P., and Mukerlere, Z., (1994). *The effect of inter-cropping Zea mays with finger millet on Physoderma maydis and Exserohilum turcinum infections.* The East African Agriculture Journal: 67 (1- 2): 311-315.

AGRF, (2012). *Agribusiness in Africa should embrace value addition*. Proceedings of the African Green Revolution for Africa Forum in Arusha, Tanzania. . http://www.fao.org/docrep/W4347E/w4347e00.htm#Contents. Accessed; 15th June, 2013

Duivenbooden, V.. N., Pal, M., Studer C., Bielders C. L., and Beukes D. J., (2000). *Cropping systems and crops complementarity in dry land agriculture to increase soil water use efficiency. a review;* Netherlands Journal of Agricultural science (48) 213-236

Gabi, H., (2013). *Climate Wire; Journal of Proceedings of the Natural Academy of Sciences*, www.eenews.net. Accessed; 10th October, 2014 www.economicsclimatechange.com/.../understanding-farmers-perceptions.31st October 2014

GoK, Government of Kenya, (2008a). *Kakamega District Development Plan (2008- 2012)*. Ministry of Planning National Development and Vision 2030,Government Printers, Nairobi.

GoK, (2008b). *The Eighth National Development Plan* (2008- 2012). Ministry of Planning National Development and Vision 2030; Government Printers, Nairobi.

GoK, (2008c). *Ministry of Agriculture Livestock Development*. Government Printers, Nairobi.

GoK, (2009). *The National Population Census Report*. Kenya National Bureau of Statistics. http://cdkn.org/wp-content/uploads/2012/04/National-Climate-Change-Response. Accessed; 5th January 2015

GoK, (2010). *National Climate Change Response Strategy; Ministry of Environment and Mineral Resources.* http://www.environment.go.ke. Accessed; 5th January 2013.

GoK, (2013a). *Kenya's economic survey report* 2013. http://www.usearchmedia.com/download/?kw=kenya economic survey report 2013&s. Accessed; 20th May, 2014

GoK, (2013b). *Agricultural Sector Development Strategy, 2010- 2020.* Ministry of Agriculture Livestock Development quarterly bulletin. Government Printers, Nairobi

GoK, (2013c). *Sectoral Adaptation and mitigation interventions.* http://www.environment.go.ke. Accessed; 20th July, 2014

Hella, J., Van huylenbroeck, G. and Lambiti, M.E., (2008). *Adaptive efforts to rainfall variability and soil Erosion problem in Semi-arid: Journal of Sustainable Agriculture.* Smallholder farmers' Vol. 2, pg 123

IFAD, (2009). *Research and innovation for smallholder farmers in the context of climate Change*. Discussion paper by round table team third second session; www.elsevoiur.com/locate:139-158. Accessed; 13th March, 2013.

IPCC, (1996). IPCC *Second Assessment Report.* www.ipcc.ch/.../sbsta-19-statement-Revision-1996.pdf. Accessed; 3th March, 2013.

IPCC, (2014). *IPPC Fifth assessment reports.* ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_LONGER. Accessed; 15th October, 2014

Itulya, F. M., (1995). *Influence of intercropping and nitrogen fertility on yields of Kale and Beans.* The easy African Agricultural journal 60 (3) 167-174.

Jaetzold, R. Scmidt, H. Hornetz, B. and Shisanya, C., (2011). *Farm Management Handbook, Natural conditions and farm management information.* Part A: West Kenya. VOL II, 2nd Edition, Part A., Western Kenya, Subpart A1.

Kabubo, J., Fredrick, M. and Karanja, K., (2007). *The Economic Impact of Climate change on Kenyan Agriculture*. A Ricardian Approach by Development Research Group; The World Bank Sustainable Rural and Urban Development WPS4334. Accessed; 27th January, 2013.

KARI, (2010). *Information brochure series 2010/130. Technology, Packaging and Transfer* http://www.kari.org. Accessed; 20th November 2014

KARI, (2012). *Inventory of KARI Technologies, Innovation and Information.* Eastern African Agricultural Production Project (EAAPP). Nairobi, Kenya. ISBN No. 9966-879-95-1

KARI, (2013). *Annual report: Regional Dairy Centre of Excellence*. http://www.rdce.or.ke. Accessed; 20th December 2014.

KMS, (2012). A monthly bulletin, http://www.kainet.org.ke/node/98754. Accessed; 13th January, 2013.

Lukuyu, B., Gachuiri, C.K., Lukuyu, M. N., Lusweti, C. and Mwendwa, S., (2012). *Feeding*

Maddison, D., (2007). *The Perception of and Adaptation to Climate change in Africa.* The World Bank Development Research Group for Sustainable Rural and Urban Development: A Policy Research Working Paper 4308 report: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=100554. Accessed; 11th October, 2011.

Mendelson,A.S., (2006*).Farmers' Perceptions and Adaptation Strategies to Climate Change.* http://www.icid18.org/files/articles/128/1277906560.pdf. Accessed; 2nd February, 2014.

Mbakaya, D., (2007). *Annual Report for KARI Kakamega showing mean maize yields for each soil fertility demonstrated technology in Kabras long rains*. KARI, http://www.kainet.org.ke/node/98754. Accessed; 3rd June, 2013.

Mbakaya, D. S., Okalebo, J. R., Muricho, M. and Lumasayi, S., (2009*). Effects of liming and inorganic fertilizers on maize yield in Kakamega North and Ugunja Districts, Western Kenya*. www.kari.org/biennialconference/conference12/docs/.Accessed; 3rd June, 2014.

Musandu, A. A., (1995). *Effect of green manure and Zea mays crop residue on phosphate availability and fixation in Kenyan soils.* Journal of East African Agriculture, 60(3), 175-179.

Niang, A.M., Gathumbi, S., and Amadalo B., (1996). *The potential of short duration improved fallow for crop productivity enhancement in the highlands of Western Kenya.* The East African agricultural journal: 62 (1) 103-114.

Nhemachana, C., Hassan, R., (2007). *Micro-level analysis of farmers' adaptation to climate change in Southern Africa.* International food policy research Institute, http://www.icid18.org/files/articles/128/1277906560.pdf

Nyandiko, N, O., (2008*). The role of social characteristics and indigenous crops on food security in Ikolomani division, Western Kenya*. Unpublished Master of Science Thesis, MMUST, Pp. 63.

Okwach, G. E. and Simiyu C. S., (1999*). Effects of land management on runoff, erosion and crop production in semi –arid area of Kenya.* East African Agricultural Journal 65 (2), 125-142ISSN 1916-252. Accessed; 14th March, 2013.

Oteng'i, S. B. B., (1995). *An investigation of the influence of mulching and agroforestry on the microclimatic conditions affecting soil moisture and yields of maize/bean intercrop in semi-arid areas of Laikipia district, Kenya*. Unpublished PhD Thesis, UoN, Pp 44.

Oteng'i, S. B. B., (2009). *Application of Climatology in Sustainable Tropical Farming Systems.* MMUST, Press and Scholarly Open Press.

Otolo, J. R. A., Wakhungu, J.W., (2013). *Factors Influencing Livelihood Zonation in Kenya.* Vol. 1 No. 12 - International Journal of Education . http://www.ijern.com/December-2013.php, Accessed; 7th January, 2015

Rockstrom, J. and Jonsson, L., (1999). *Conservation tillage systems for dry-land farming. On-farm extension and research experiences:* In the East African Agricultural and Forestry Journal. TEEAL, 65 (1-2). 101-114 ISSN: 0012-8325.

Rosenzweig, C. and Parry, M.L., (1994). *Potential impact of climate change on world food. supply*. www.nature.com/nature/journal/v367/n6459/abs/367133a0.html.Accessed; 30th November, 2013.

Rosenzweig, C. and Hillel, D., (1995). *Potential Impacts of Climate change on Agriculture and Food Supply.* www.economicsclimatechange.com/.../understanding-farmers- perceptions. Accessed 30th January 2014

Smit, B. and Skinner M. W., (2000). *Adaptation options in agriculture to climate change: a Typology*. Mitigation and Adaptation Strategies for Global Change 7: 85–114, 2002. © 2002 Kluwer Academic Publishers. Printed in the Netherlands University .

Southworth J., Randolph, J.C., Habeck M., Doering O.C., Pfeifer, R.A., Rao, D.G.,and Johnston, J.J., (2000). *Agriculture, ecosystems and the environment.* www.elsevier.com/locate/agree. Accessed; 3rd September, 2014.

Tabu J.C. (2014). *All Lives in the Balance. The Great Climate Chaos.* http://www.geoengineeringwatch. Accessed; 3rd September, 2014.

Volenzo T. E., Wakhungu, J.W., and O. J., (2013). *Alternative Dairy Feeding Strategies and climate Change mitigation.* Challenges and Opportunities. International Journal of Disaster Management and Risk Reduction. http://www.journal.admcrk.com/Volume_5_Issue_2.php. Accessed 7th January, 2013