SMALLHOLDER FARMERS PERCEPTION OF CLIMATE CHANGE IMPACT ON BIODIVERSITY IN VARIED AGROECOLOGICAL ZONES IN KENYA

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ABSTRACT
Global warming has resulted in climate risks such as persistent droughts in tropical countries, including Kenya. Farmers are now changing agricultural practices to cope with drought, which is usually accompanied by variation in biodiversity. The present study determined how farmers perceived the changes over a period of 30 years. Semi-structured questionnaires were used to collect data in Bungoma, Nakuru, Kajiado, Embu (Mbeere) and Kilifi Counties. Weather stations and the Kenya Meteorological Services provided climatic data. Results showed that rainfall fluctuated and amount increased slowly over time; rainy seasons decreased and storms became frequent. Dry periods were frequent and annual temperatures were increasing. Some animals, plants, birds and insects had either disappeared like elephants and lions in Mbeere, butterflies and termites in all sites; mosquitoes, weevils and red mites in all sites, tortoise and scorpions in Mbeere, *Jatropha curcas* and *Lantana camara* in Mbeere increased in numbers; others emerged (great grain borer in Mbeere and Kilifi, black Indian crow in Kilifi, *Ipomoea* species in Kajiado and *Prosopis juliflora* in Kilifi). Some invasive plant species such as *Prosopis juliflora* were out-competing crops and pastures, predators were invading homesteads, carnivorous birds were becoming omnivorous and insect vectors and pests like mosquitoes and weevils were extending their habitats to former cooler areas. Farmers were harvesting and conserving water in water pans, zai pits and terraces. They were also planting fast-growing multipurpose trees such as *Senna siamea*, rearing diverse animals and growing drought tolerant crops. It was evident from this study that climate change had a severe impact on biodiversity within the stressed habitats and some species were already being replaced by aliens. It is recommended that Governmental and Non-Governmental Organizations should create more awareness and promptly support farmers to adapt and mitigate climate change challenges.
Key words: Biodiversity, Adaptation, Climatic Information, Alien Species

INTRODUCTION
Kenya is endowed with a variety of ecosystems which support a variety of biodiversity, making the country a custodian of unique heritage of different natural resources. The country's biodiversity is estimated to include 24,375 species of animals, 6,817 species of higher plants and 1,841 species of micro-organisms, including viruses, monera, micro-fungi, protista and excluding macro-algae (Stuart *et al*., 1996). The biodiversity and sustainable development are intricately linked. People value biodiversity for various reasons such as spiritual, ecological, aesthetic, cultural, economic, scientific, food, medicine, fuel, shelter and industrial products sources (Almquist *et al*., 1993; Stuart *et al*., 1996). The biodiversity potential varies with the type of ecosystem. For instance, the grasslands, arid and semi-arid lands (ASALs), which comprise about 80% of the country with potential for pastoralism and act as gene pools of wild relatives of domesticated crop varieties such as sorghum, rice, tef, and peas. However, about 10% of these grasslands and 5-20% of ASALs have been lost due to agricultural expansion, leading to lose of some species diversity (Ogola *et al*., 1997). Plants especially in the forests have been noted to be more sensitive to small fluctuations and changes in rainfall patterns than mean annual rainfall, as this affects flowering patterns and seed dispersal resulting in heavy mortality (Trenberth, 2011). The ecological interface is affected more by climatic changes and it is at this point where the impact is more evident. As the temperatures increase, ecological zone boundaries shift mainly with distance from the sea and altitude with plants, animals, birds and insects shifting their habitat range from hotter to cooler regions and lower to higher altitudes (IPCC, 2007). Selective grazers are the first victims of climate change among animals, while herbaceous plants die faster than trees. In general, Classulacean Acid Metabolism (CAM) plants increase their productivity more than Calvin Cycle plants when temperature and carbon dioxide increase in the environment (Olindo, 1991).

This climate change impact on biodiversity is getting aggravated by human activities such as: clearing of more land for crop production, infrastructure, buildings and mining; over-exploitation of some economic species; application of insecticides, herbicides and fertilizers that eliminate organisms such as soil borne micro-organisms, pests and weeds, or cause eutrophication. Consequently, some alien species have become opportunistic where some have impacted negatively by decimating native species. These include cactus (*Opuntia stricta*), sage (*Lantana camara*), Maques (*Prosopis juliflora*) and wild morning glory (*Ipomoea* spp.) (Ogola *et al*., 1997).

A number of climate change hazards have already been experienced in Kenya, such as frequent droughts, dry spells and increased heat stress (Intergovernmental Panel on Climate Change (IPCC), 2007). These hazards are accompanied by outbreaks of pests and diseases of crops, livestock and human beings, thereby adversely impacting on food, health, water, energy and the sustainable livelihoods of the poor. Some animals, birds and insects that are not capable of tolerating such changes either die or migrate to other areas. Plants on the other hand either die off or develop protective features.

General Circulation Models indicate that future climatic changes in Kenya will result in an increase of annual temperature of 2.5 to 5.0^{o}C with an increase of 0-25% in precipitation (Ogola *et al.*, 1997). Although past climatic variations were attributed mainly to natural processes, the observed changes are now largely due to anthropogenic causes (Watson, 2001), especially increased emissions of and subsequent concentration of greenhouse gases in the atmosphere, which cause global warming accompanied by a shift in rainfall patterns. This has resulted in changes in frequency, intensity, duration of extreme events such as more hot days, heat waves, heavy precipitation and fewer cold days. The extent to which these changes affect biodiversity is not easy to predict with precision as there are many variables involved.

In general, climate change affects biodiversity and ecosystems and it is important to conceptualize that higher temperatures are not necessarily associated with negative effects, because when coupled with high rainfall they may support better plant yield. These changes of temperature and rainfall have been noted to cause oscillation of animal and bird population. Flamingoes of Lake Nakuru fluctuate with lake water salinity, which on the other hand determines the amount of algae, *Spirulina platensis* their main food, prevalence (Ogola *et al*., 1997).

Many rural communities are unable to cope, mitigate or adapt to continued climate change due to dependency on rain-fed agriculture and other activities (Watson, 2001). They are unable to access appropriate climatic information and services because of the weak institutional and policy support and take time to realize implications on biodiversity changes (United Nations Development Program, 2008). Vulnerability of the poor to changing climate is a priority development agenda for policymakers and development agencies (World Bank, 2009). Farmers in Kenya have noted that high temperatures coupled with high humidity favour high populations of insect pests and high incidences of pathogens, although increased temperatures and rainfall have increased crop yields in some other regions.

It is also known that some animals are more tolerant to climate changes than others. Eland and oryx can withstand temperature fluctuation of 7°C, while staghorn and elkhorn corals are favoured by the rise of temperature at the expense of normal star corals. Generally, herbivores decrease in numbers if the precipitation is between 200–1200 mm, and selective grazers are the first to be affected. It is now known that about 44% of fauna has succumbed to climate change (Ogola *et al*., 1997). Generally, pests and diseases respond to very narrow temperature and precipitation fluctuation ranges. Humidity and high temperatures favour outbreaks of diseases by promoting breeding of vectors such as mosquitoes, while plant diseases such as coffee berry disease are enhanced by strong winds (Makanya *et al*., 2008).

There are several efforts to support adaptive research and actions related to climate change, although capacity remains limited (Chakeredza *et al*., 2009). One of these is Climate Adaptation Project (CAPro) of Egerton University funded by the Rockefeller Foundation to support smallholders in five different agro-ecological regions of Kenya. To do this end, reconnaissance surveys were done to document the biophysical, climatic and biodiversity changes within the five study sites. This study provides a summary of findings on information collected from the field.

METHODOLOGY

Reconnaissance Survey

This study was done in five different agro-ecological zones in Kenya (Figure 1). These zones were selected based on their agro-potentials as farmers were expected to have different challenges. They included Bungoma (lake basin high potential crop-livestock), Nakuru (highland medium potential crop-livestock), Kajiado (arid and Semi-arid pastoral-livestock), Mbeere (semi-arid pastoral-livestock) and Kilifi (coastal lowland crop-livestock) (Table 1).

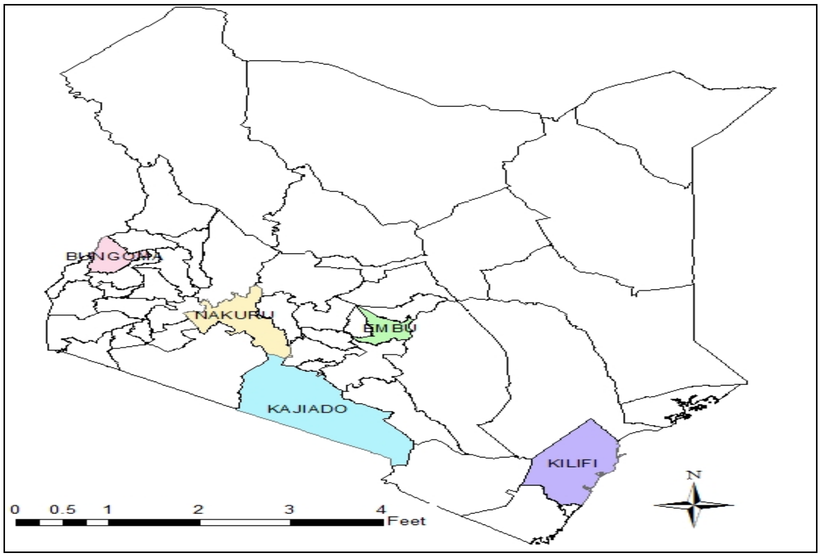

Figure 1: Map of Kenya showing location of study sites (adapted from Arid Lands Newsletter, 2013)

Table 1: Biophysical features of the study sites

Study site	Alt (m asl)	Coordinates		AEZs	Major soil types
		Lat (S)	Long (E)		
Bungoma	1200-4000	0°28'-10°30'	34°20'-35°15'	LM 1-3	orthic Acrisols, with humic Acrisols and (ferralo-) orthic Acrisols, with ferralic Arenosols; orthic Acrisols;
				UM 1-4	orthic and ferralo-orthic Acrisols with Lithosols; rhodic and orthic Ferralsols; orthic Acrisols, with humic Acrisols and (ferralo-) orthic Acrisols, with ferralic Arenosols
Kajiado	910-2000	1°0'-°20'	36°0'-38°0'	LH 2-3	Solonetz, Fluvisols, Solonchaks, Cambisols, Vertisols
				UM 3-5	Leptosols, Luvisols, Andosols, Nitisols, Vertisols, Phaeozem,
				LM 4-6	Ferralsols, Luvisols, Arensools, Regosols, Leptosols, Lixisols.
Kilifi	60-450	3°16'– 4°0'	39°05'-40°0'	CL 3	Ferralsols
				CL 4	Acrisols
				CL 5	Luvisols and Planosols
				CL 6	Cambisols and Lithosols
				CL 3	Ferralsols
Mbeere	1200-1500	0°20'-0°50'	37°16'-37°56'	TA	Eutric Astosols
				LH 1	Eutric Astosols
				UM 1	Andosols/Nitisols
				UM 2-4	Nitisols/ Ferralsols
				LM 3	Arenosols
				LM 4	Regosols/ Ferralsols
				LM5	Lithosols/Cambisols
				TA	Eutric Astosols
Nakuru	1520-2500	0°10'-0°50'	35°50'-36°40'	Zones II, III and IV	Andosols, Ferralsols, and Solonetz, Fluvisols and Solanchaks along lakebeds

The researchers collected information pertaining to location, topography, soils, vegetation cover, climatic information and farmers' perceptions of the impact of climate change on biodiversity for a period of about 30 years. The information also included adaptation strategies practiced by the farmers towards climate change. All this information was collected from the documents in relevant government offices and focus group discussions. The offices visited included agriculture, forestry, wildlife, and weather stations.

Climate Change Adaptation Strategies Data Collection

Participatory Rural Appraisal (PRA) methods were used where the following protocol was developed to guide farmers in group discussions. The PRA was divided into two phases:

(a) In phase one, semi-structured questionnaire was used and participants divided into groups where they freely discussed issues and ideas on a variety of topics such as causes, indicators and effects of climate change, adaptations and resources and their sources.
(b) Scoring and ranking of key or major adaptive measures that are likely to be implemented in each site.

Climatic Data Analysis

The parameters analysed were mean annual rainfall, rainfall amounts in blocks of years, intensity of rainfall and onset of rainfall during the rainy season. The intensity considered the total amount of rainfall in a selected month per day during those days with rain. Analysis of onset focused on the first day of rain in the selected month. Unfortunately many sites, except Bungoma were keeping good temperature records and therefore temperature records were not included in results.

Biodiversity Change Information

This was done through farmers' group discussions using structured questionnaires. Farmers reported diverse plants, animals, birds and insects that have disappeared completely, reduced in numbers, increased or emerged as new species in the areas.

RESULTS

The results indicate that in most of the sites, the rainfall followed a defined trend, marked by slight increase over time.

Kilifi

In Kilifi, Mtwapa station provided rainfall data, which was available from 1980 to 2008. The rainfall data showed a general increase over time (Figure 2). The rainfall was bimodal, although one peak was much higher than the other.

Kajiado

The Isinya station provided data for Kajiado from 1962 to 2010. The data depicted an increasing trend over time (Figure 3). The two rainfall peaks were distinct and the difference not very large as compared with the data obtained from the station at the coast.

The intensity of rainfall increased in the months of March and December as the number of days of rainfall reduced. In the month of April, the intensity of rainfall decreased as the rain came later, the number of days of rainfall decreased and the rainfall amounts also decreased.

Mbeere

The Kiritiri station provided data for Mbeere site. The data covered the shortest period of all the sites, a period of only 10 years from 2001 to 2010 (Figure 4). The main rainfall peak occurred with a different time from the other sites. This was in the month of November when the other sites had the lowest peak.

Nakuru

The Menengai station provided data for Nakuru site. The data covered the longest period of all the sites, from 1927 to 2011. The general trend was an increase of rainfall over time (Figure 5). The rainfall was tri-modal with the highest peak in April, the second highest in August and the lowest in November.

Bungoma

The Nzoia station provided climate data for Bungoma site. It covered the years 1983 to 2011 with a break of three years where there was no data; 2003, 2004 and 2005 (Figure 6). The rainfall data did not show many fluctuations although it peaked every 4-5 years. The rainfall received was high with about 1500 mm being the minimum over the data collection period. The trend showed an increase over time. The annual pattern was bimodal, although the difference between peaks was not large. The peaks were not sharp but were smooth.

The intensity of rainfall increased for the months of April and December where the rainfall was coming later in the month and for a reducing number of days. In the month of March, the rainfall was coming earlier and the number of days have been increasing leading to a reducing intensity.

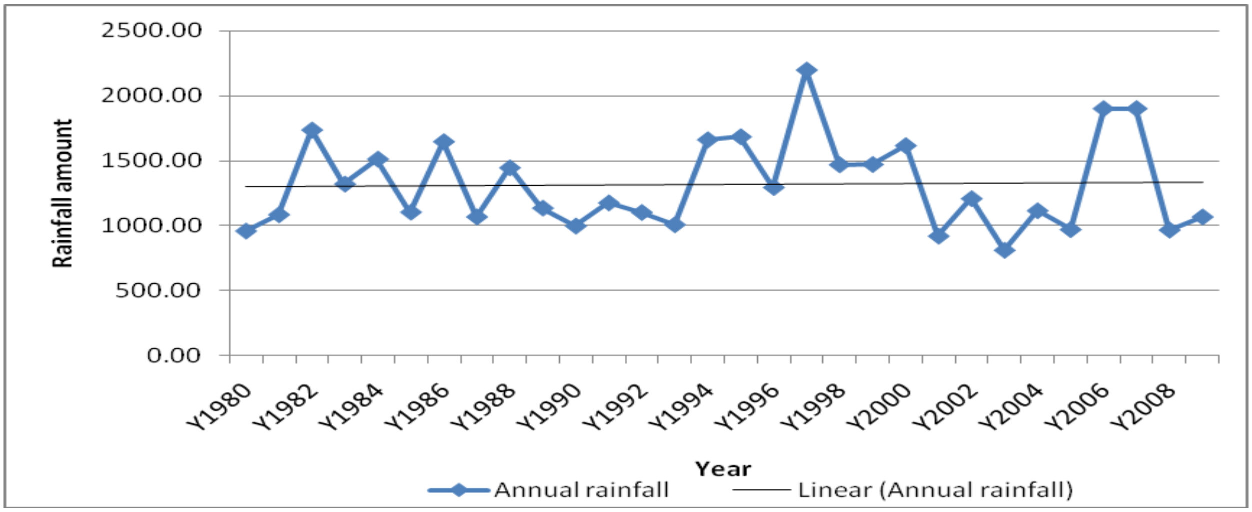

Figure 2: Mean annual rainfall amount since 1980 in Kilifi (Mtwapa station)

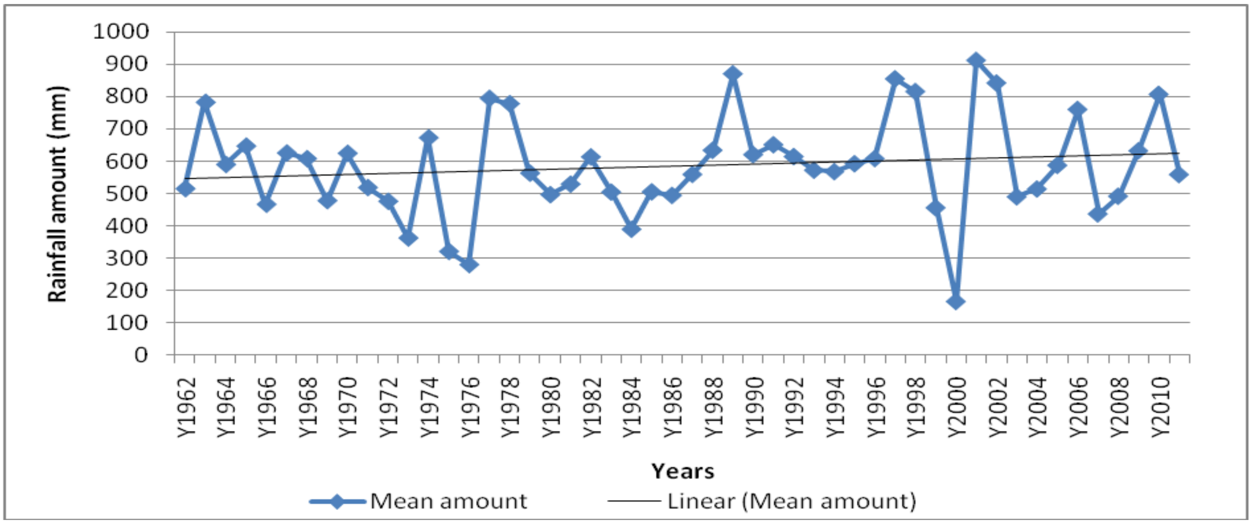

Figure 3: Annual rainfall since 1962 in Kajiado

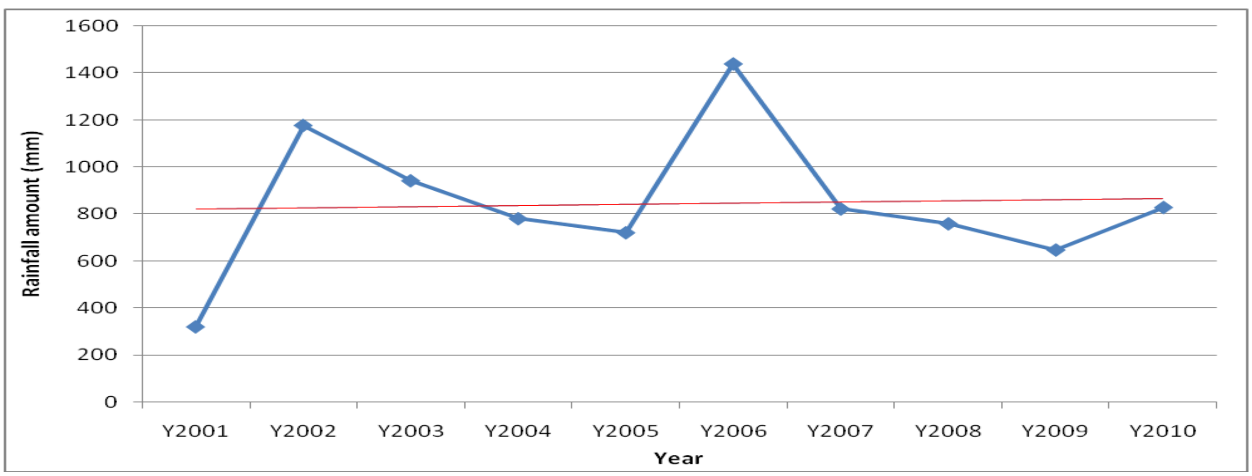

Figure 4: Annual rainfall amount in Mbeere

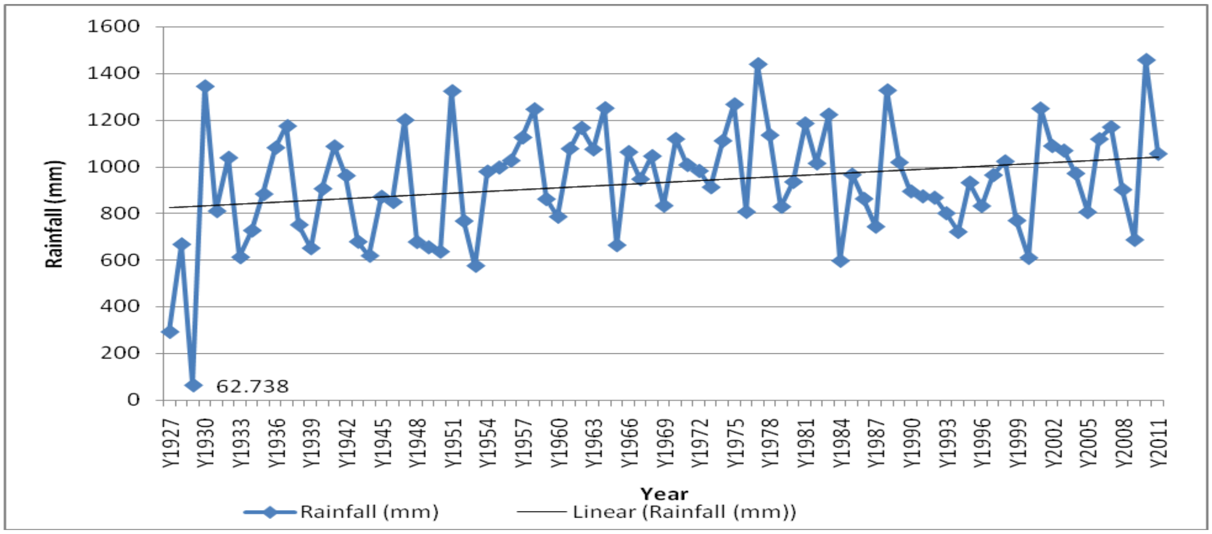

Figure 5: Annual rainfall amount since 1927 at Nakuru

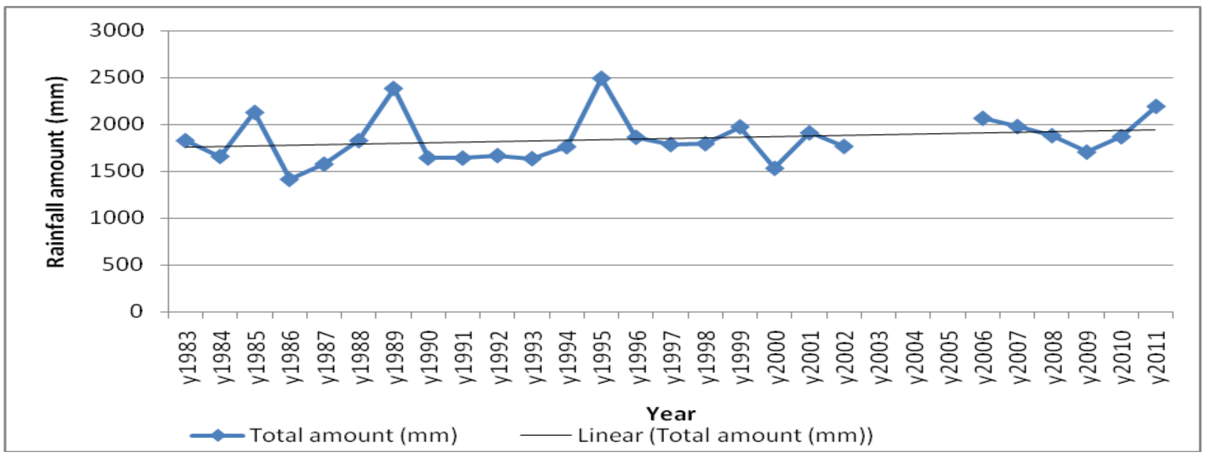

Figure 6: Annual rainfall amount in Bungoma since 1983 (Nzoia Station)

Tables 2 to 8 show the impact of climate change on biodiversity and its implication on farmers' livelihoods, stakeholders involved in biodiversity issues, the kind of support farmers get from these stakeholders and how different organisms have changed over time in their distribution within different agro-ecological zones. The farmers in the five sites use some adaptation strategies to climate change, including growing of drought-tolerant crops, harvesting water in different ways such as roof water harvesting, water pans, and rearing different animal species. The common climate change mitigation strategies used included agroforestry and use of energy saving woodfuel stoves, which would minimize the amount of carbon dioxide emitted into the atmosphere, which is the major cause of anthropogenic induced greenhouse effect, culminating in global warming.

Table 4 shows that only farmer to farmer support together with that from both NGOs and CBOs reach farmers in appropriate time. Most of governmental organizations delay the support mainly due to periodic allocation of funds from the National Treasury and slow procurement procedures.

Although the Ministry of Agriculture, Livestock and Fisheries (MOALF) releases its funds or support late to the farmers, it is considered by farmers as the most effective, mainly due to its elaborate extension services network. These officers interact with farmers at grassroot levels.

Locusts and army worms were among insects that have disappeared from many sites. This is because they are constantly monitored and controlled as they appear. Turtle and elephants are among animals that have disappeared in some sites due to water scarcity and poaching. The insects that have appeared in areas where they were not common include mosquitoes, which breed in warm habitats. *Synadenium glaucesens* is one of plants disappearing in habitats due to deliberate destruction due to its toxic sap, while *Prosopis juliflora* is among those emerging in different habitats due to its invasive effects.

Table 2: Impact of climate change on biodiversity and its implication on farmers' livelihoods

Biodiversity changes	Major effects	Response/actions
Changes in forest	Collect firewood, collect building materials, purify air	Take more time to collect firewood, expensive building materials, polluted air
Changes in plant species	Medicinal plants destroyed	Have to source them from far
Changes in animals and birds	Animals and birds used as food	Food has become expensive
Changes in insects	Some eaten e.g. termites, others disease vectors e.g. mosquitoes, others crop pests e.g. aphids and predators e.g. lady birds	Food security affected, disease outbreaks
Changes in human/wildlife conflicts	Destroy food crops, livestock and human life	Food security affected, human life loss,
Changes in land terrain, water courses	Search for water, food and firewood	Time to search for water, food and firewood increases

Table 3: Stakeholders involved in biodiversity issues

Stakeholder	Activities	Support provided	Timelines of support
Farmers	Plant trees, crops and keep animals	Protect trees, crops and animals	+
Extension officers (MOALF)	Sensitize farmers on biodiversity issues	Organize farmer groups, training	-
Herbalists	Use plant and animal resources	Plant trees and keep animals for medicine	-
Environmental officers		Enforce laws	-
NGOs and CBOs	Encourage tree planting	Provide tree seedlings	+

Legend: + timely, -not timely

Table 4: Ranking of stakeholders in order of support provided per site

Study site	Stakeholder/MOA	KFS	KWS	NGO	ENV
Bungoma	+++	-	-	+	++
Nakuru	+++	++	-	+	-
Kajiado	+++	++	+	-	-
Mbeere	+++	++	+	-	-
Kilifi	+++	++	+	-	-

Legend: +++ number one, ++ number two, + number three

Table 5: Insect species fluctuation over time due to climate change

Study site	Disappeared	Decreased	Increased	Emerged
Bungoma	Armyworms (*Spodoptera exempta*), locusts (*Shistocerca gregaria*)	Butterflies (*Rhopalocera* spp.), grasshoppers (*Caelifera* spp.), termites (*Termitoidae* spp.), (*Rhipicephalus appendiculatus*), jiggers (*Tunga penetrans*)	Mosquitoes (*Culicidae* spp.), cockroaches (*Blattaria* spp.)	-
Nakuru	Locusts (*Shistocerca gregaria*)	Termites (*Termitoidae* spp.), butterflies (*Rhopalocera* spp.)	Mosquitoes (*Culicidae* spp.), weevils (*Curculionoida* spp.), aphids (*Aphidoidea* spp.),	-
Kajiado	-	Armyworms (*Spodoptera exempta*), grasshoppers (*Caelifera* spp.), bees (*Anthophila* spp.)		-
Mbeere	Locusts (*Shistocerca gregaria*), armyworms (*Spodoptera exempta*)	Grasshoppers (*Caelifera* spp.), bedbug (*Cimex lectularius)*, bees (*Anthophila* spp.)	-	Large grain borer(*Stephan opachys truncates* Osama)
Kilifi	Locusts (*Shistocerca gregaria*)	Grasshoppers (*Caelifera* spp.), rhino beetles (*Dynastinae* spp.), jiggers (*Tunga penetrans*)	Large grain borer (*Stephanopachys truncates*), armyworms (*Spodoptera exempta*)	Large grain borer (*Stephanopach ys truncates)*

Table 6: Animal species fluctuation over time due to climate change

Study site	Disappeared	Decreased	Increased	Emerged
Bungoma, Nakuru & Kajiado	-	-	-	-
Mbeere	Elephants (*Loxodonta* spp.) hyena (*Hyaenidae* spp.)	Eland, snakes (*Serpentes* spp.), lions (*Panthera leo*), (hyenas (*Hyaenidae* spp.), rhinos (*Rhinocerotidae* spp.)	Tortoises (*Testudinidae* spp), scorpions (*Scorpiones* spp.), mongoose (*Herpestidae* spp.)	-
Kilifi	Turtle (*Testudines* spp), elephants (*Loxodonta* spp.)	Dik dik (*Madoqua* spp.), wild pigs (*Sus scrofa)*	-	-

Table 7: Plants species fluctuation over time due to climate change

Study site	Disappeared	Decreased	Increased	Emerged
Bungoma and Nakuru	-	-	-	
Kajiado	-	-	-	*Ipomoea* sp.
Mbeere	-	*Ximenia americana, Osyris latifolia, Dalbergia melanoxylon, Carissa edulis*	*Moringa oleifera, Jatropha curcas, lantana camara*	-
Kilifi	*Synadenium glaucesens, Cordia ovalis*	*Tamarindus indica, Ziziphus mauritiana, Landolphia kirkii, Vitex ferruginea, Garcinia livingstonei*	*Aloe volkensii*	*Prosopis juliflora, Pennsetum clandestinum*

Table 8: Birds species fluctuation over time due to climate change

Study site	Disappeared	Decreased	Increased	Emerged
Bungoma and Nakuru	-	-	-	-
Kajiado	-	-	Mouse birds (*Coliidae* spp.)	-
Mbeere	-	Owls (*Strigiformes* spp.), Eaglets, thieri (local name), weaver birds	*Quelia quilea*	-
Kilifi	Black crow (*Corvus* spp)	Weaver birds (*Ploceidae* spp.)		Kite (*Milvus migrans*), Black Indian crow

DISCUSSION

The climatic changes have showed different trends within and among study sites. These have consequences on biodiversity dynamics within different regions of Kenya. From Figures 2-6, it is evident that rainfall is generally slightly increasing, but this trend can have a local variation, causing different perceptions within the same community (Trenberth, 2011). In the coastal Kilifi, Mtwapa that is next to the sea does not show a distinct change may be due to the influence of land and sea breezes, therefore, natural factors have less impact on biodiversity compared to anthropogenic factors. However, the trend with all other sites far from the sea such as Kajiado, Mbeere, Nakuru and Bungoma showed slight increase. Based on the annual totals, the wet years are usually followed by dry periods. Ogola *et al*. (1997) reported that in Kenya rainfall is higher at the coast, but decreases inland and increases on high mountains with relief rainfall.

The effects of these fluctuations in annual rainfall distribution on biodiversity are intensified by changes on the onset of rainfall and duration. Most of these study sites receive Long Rain Season (LRS) in March-May period which is showing a shift towards coming late and ceasing earlier. In sites like Nakuru, the rainfall fluctuation causes oscillation of flamingoes in Lake Nakuru from more than 2 million during dry years but few thousands during wet years due to presence or absence of their major food component, the *Spirulina pratenses*, a blue green algae whose population is more in alkaline than in dilute water (Ogola *et al*.,1997). The black crow had disappeared and black Indian crow was emerging in Kilifi as the former depends on rare worms and the latter on green maize which was available (Table 8). Mouse birds and *Quelea quelea* birds had increased in Kajiado and Mbeere, respectively, due to introduction of crops such as tomatoes and rice. Owls, eaglets and weaver birds were reducing in Mbeere due to reduced forest cover and millet cultivation. Locusts and army worms were disappearing in both Bungoma and Mbeere mainly due to human control, while butterflies, grasshoppers, termites, ticks, jiggers, and bees have been decreased by deforestation, reduced surface water and application of pesticides by man (Table 5). Insects that were reported to have increased include mosquitoes, cockroaches, aphids, red mites and weevils due to rising temperatures making habitats more suitable for their breeding.

A number of animals had been affected by climate change, those favoured by dry conditions increased in numbers. Tortoises had moved to nearby hydroelectric dams in Mbeere, while elephants and hyenas had moved to national parks (Table 6). Other animals that had followed same pattern by decreasing in numbers included eland, lions, and rhinos in Mbeere, dik diks and wild pigs in Kilifi. Tortoise and scorpions were increasing in their frequency in Mbeere due to rising temperatures. This result agreed with the work done by Makanya *et al*. (2008) in Kajiado where it was noted that as climate continued to be variable, coupled with intensive human activities, some animals and birds shifted their habitats and moved into national parks. Worden *et al*. (2009) working on possible adaptation mechanisms in the Kenyan rangelands noted that this biodiversity response to harsh climatic changes can be detrimental to endemic species.

Some plant species had either reduced in numbers, increased or emerged mainly in Kajiado, Mbeere and Kilifi Counties (Table 7). These Counties had low and unreliable rainfall. As some plant species decreased in number when the conditions were not favourable they created space for the invasive species such as *Ipomoea* species in Kajiado, which is reported to have emerged since 1993 and is now overshadowing grasses, thereby threatening grazing areas (Kangethe, personal communication). Other species included *Prosopis juliflora* that emerged in Kilifi in 1973 after being introduced in Tana River and Baringo Counties to combat desertification. It is invasive such that it has formed impenetrable pockets of thickets in Kilifi. However, unlike *Ipomoea* species that is not economically utilized by the pastoralists of Kajiado, *Prosopis juliflora's* wood is used for posts, charcoal, firewood, and pods for livestock fodder. Green *et al*. (2003) reported that such alien species tend to be generalists in spatial and temporal distribution and so gain greater competitive success and threaten native species. Other species reported included those reduced through overharvesting such as *Osyris latifolia* (illegal exports to Asian countries for perfumes) and *Carrisa edulis* (herbal medicine) in Mbeere, while some had increased due to deliberate propagation such as *Moringa oleifera* (herbal medicine and vegetable), *Jatropha curcas* (biofuel) and *Lantana camara*.

The smallholders were aware of climate change. It was evident from this study that climate change had a more severe impact on biodiversity within the already stressed habitats and some species were being replaced by aliens (Makanya *et al*., 2008). The work done by Makanya *et al*. (2008) in Kajiado showed that biodiversity changes were encouraged by bush burning, deforestation, firewood collection and animal trampling.

CONCLUSION AND RECOMMENDATIONS

Biodiversity in Kenya is under stress from the vagaries of climate change with many species changing their ecological distribution, their numbers and their breeding patterns.

It is recommended that smallholders get timely information and support from Government and Non-Governmental Organizations to implement adaptation and mitigation strategies to climate change.

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