EFFECTS OF SUGARCANE FARMING ON AGRO-BIODIVERSITY IN MUMIAS DIVISION, KAKAMEGA COUNTY, WESTERN KENYA

BY

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ABSTRACT

Sugarcane farming is a commercial monocultural land use practice which can often lead to reduction in agro-biodiversity. Commercial sugarcane farming in western Kenya is cultivated under three categories: small scale (outgrowers), large scale and nuclear estate. The study was carried out in Mumias division of western Kenya where 68 percent of the land is under commercial sugarcane cultivation while 32% is left for subsistence agriculture and other land uses. Previous studies carried out in the region did not directly link sugarcane farming to the loss of agro-biodiversity. The objectives of the study were to: identify and compare the diversity of subsistence food crops grown in the study area before and after the introduction of commercial sugarcane farming; assess the effects of commercial sugarcane farming on agro-biodiversity in the study area. There was higher agro-biodiversity in the study area before the introduction of commercial sugarcane farming. The declined when commercial sugarcane was introduced. Data collection methods included: questionnaires, interviews, field observation and Participatory Rural Appraisal tool for primary data. A sample size of 90 respondents purposively selected from a total study population of 4384 sugarcane farmers in the division. Secondary data was obtained from journals, text books, government reports from the Ministry of Agriculture and newspapers. Quantitative data was analyzed using descriptive statistics such as frequencies and percentages. Qualitative data that was collected through in-depth interview and Focus Group Discussion was transcribed and organized into themes and subthemes. Data was presented in the form of tables and graphs. The indigenous crops grown in the study area before commercial sugarcane farming were established as maize, bambara groundnuts, simsim, sorghum, finger millet cassava, sweet potatoes, groundnuts, and indigenous sugarcane with maize occupying the largest acreage among small scale farmers. Common indigenous vegetables included, spider plant, jute mallow, african nightshade, pumpkin leaves, sunhemp, african kales and vine spinach. With the introduction of commercial sugarcane farming in the 1970s, the land under subsistence agriculture declined thus affecting agro-biodiversity in the study area in the following ways: vine spinach became extinct, acreages under maize, sorghum, finger millet, cassava and sweet potatoes reduced in 1970s and 1980s and increased in 1990s and 2000s. However, cassava declined in the same period. The research also established that sugarcane farming did not have any effect in the cultivation of groundnuts and bambara groundnuts. Indigenous vegetables normally grown in kitchen gardens and abandoned cattle sheds declined as a result of commercial sugarcane farming. The study concluded that commercial sugarcane farming was one of the major factors that had an effect on agro-biodiversity in Mumias division of western Kenya. Other factors included pests and diseases, change in tastes and preference and introduction of exotic crops such as kales. It is recommended that agricultural extension officers should sensitize farmers to allocate specific portions of land for subsistence crops to ensure food security and conservation of agro-biodiversity.

CHAPTER ONE
INTRODUCTION

1.0. Background to the Study

Biological diversity (biodiversity) refers to all species of plants, animals and micro organisms existing and interacting within an ecosystem (Vandermeer and Perfecto, 1995). It performs key ecosystem services and if correctly assembled in time and space, it can lead to agro ecosystem capable of sustaining soil fertility, crop protection and productivity (Altieri, 1994). Biological diversity is being irreversibly lost through extinctions caused by the fragmentation and destruction of natural habitat, pollution, over-exploitation, introduction of exotic species and monocultural activities. Of these, habitat fragmentation and habitat loss have had the greatest impact on biodiversity (Noss, 1995), particularly in human-dominated regions where the natural vegetation has been replaced by crops and concrete. Agro- biodiversity refers to the aspects of biodiversity that affect agriculture and food production (FAO, 1999). Agro biodiversity plays a key role in ensuring that there is increased productivity, food security, and economic returns from selling of the crops

Monoculture is a practice that involves the cultivation of a single crop on a farm or in a region or country (Farlex, 2012). Monocultural farming involves clearing of large tracts of land to create more space for the cultivation of the single crop (Altieri, 2000a). Similarly in monocultural farming system other subsistence crops are often abandoned with more focus and attention being given to the individual monocultural crop. This in the end may lead to decline of some crops that are very useful to human beings and are a source of food security to the community (FAO 2008a). Monoculture also involves mass application of fertilizers, herbicides and pesticides (Panneton *et al.*, 2001). The application of such chemicals destroys weeds some of which are

useful sources of food and medicines. FAO (2008a) reported that monoculture reduces biodiversity, which is necessary for the survival of healthy ecosystems. It is not clear whether a similar effected is being experienced in Mumias Division.

In Kenya, sugarcane is commercially grown in Western and Nyanza provinces. Currently sugarcane occupies 107,622 hectares of arable land and is grown primarily by small scale farmers followed by large-scale farmers and nucleus estates. Sixty eight percent (68%) of the land in Mumias division is put under sugarcane cultivation; this implies that a very small portion of the land (32%) in the division is left for subsistence farming (GoK 2002). The growing of sugarcane was generally considered to alleviate poverty by expanding income generation possibilities. However statistics and observation indicate that poverty in this region remains prevalent (GoK, 1999).

Nekesa and Meso (1997) indicate that traditional food crops were abundant in the Mumias district before sugarcane was introduced. Crops such as cassava, finger millet, sorghum, sweet potatoes, bambara groundnuts and simsim were common and ecologically adapted to the region. Other crops common in the region included groundnuts, indigenous vegetables, yellow maize, beans, sunflower, yams, soya beans and green grams (Netondo *et al.,* 2010). Waswa *et al.* (2009) reported that presently, sugarcane is the most widely grown commercial crop, having replaced most indigenous crops and vegetables. However, indigenous crops such as groundnuts and bambara groundnuts are often intercropped with commercial crops such as sugarcane and maize during the first three month of cultivation. Sugarcane is normally grown in a continuous monoculture with usually no more than a few months break between removing the last ratoon crop and replanting the field (Chirchir *et al.,* 2008). Waswa *et al.* (2009) further reported that

competition for land use among crops in the Mumias sugarbelts has tended to favour sugarcane and maize at the expense of indigenous food crops such as cassava and sweet potatoes. The total yields of sugarcane in Mumias sugarbelt was 69.71 tonnes per hectare in 2009 and 63 tonnes per hectare in 2010 (MSC 2010). The optimum yields can be up to 120 tonnes per hectare (MSC 2010).

During the past 25 years, there has been concern about the depletion of natural resources in general and agro-biodiversity in particular (Stavin, 1990). Saving the remaining world's agro-biodiversity has become an important public policy issue in the international, regional, and national level (Netondo *et al.*, 2010). This is because agro-biodiversity, especially biological resources form a basis for global as well as national economic and ecological security. The main cause of agro-biodiversity degradation is policies, which encourage the spread of monoculture and destruction of indigenous genetic resources. In Kenya about 5 percent of the trees and 8 percent of herbaceous plants species are endangered as a result of monoculture (Clark, 2000).

The growing of sugarcane on monoculture involves clearing of large areas of vegetation to create room for cultivation. For this, all the trees and bushes are to be cleared without leaving any obstruction in between. This exposes the soil to the battering action of rain, wind and water (Mishra, 2010). Extensive soil erosion follows in such an area. This is often followed by a reduction in the number of wild plant species, animal species and crop species diversity (Mishra, 2010). It is not clear whether a similar effect is being experienced in Mumias division.

Monocultural sugarcane farming involves severe disturbance such as soil tillage by use of machinery such as tractors, intense deforestation, high inputs of fertilizers and pesticides (FAO

2001). This is compounded by farmers subdividing their land into smaller fragments, hence further threatening crop diversity. In so doing, it alters the natural habitat, hence reducing agro-biodiversity more rapidly. Sugarcane farming involves various field management activities such as gapping and weed control through mechanical methodologies of control. In the long run, the pesticides and herbicides destroy the natural vegetation in the region by either disrupting the nutrient flow to the plants or altering the natural condition required for the natural growth of the various plant species. This in turn leads to reduced plant species diversity. In Mumias division, some farmers prefer burning their sugar fields before harvesting. Fire could destroy more plant species, contributing to decline in species diversity in the region. According to Robertson and Thorburn (2007), more than 70% of the organic matter in sugarcane is lost to the atmosphere through burning of the sugarcanes before harvesting.

Since the introduction of sugarcane in Mumias division, the land under this crop has been expanding greatly. It is thought that this increase in land under sugarcane may have an impact on agro-biodiversity. Many crop varieties have often simply been allowed to disappear. Monoculture crops are often hybrid varieties of a traditional species. The improved variety produces more, prompting the farmers not to bother planting the older variety and it slowly disappears (FAO, 1998). This may eventually lead to food insecurity.

1.2 Statement of Problem

Kenya has 1580, 000 hectares of land set aside to sugarcane farming producing nearly 5 millions tones a year (Frances, 2000). This implies that large-scale sugarcane growing as a land use type may cause variation in agro-biodiversity and hence the services they provide. For example, expansion of land under sugarcane translates into loss of agro-biodiversity and diminishes the

land available for subsistence farming and agricultural diversification. While statutory firms monopolizing sugarcane farming have profit making as their main goal and it is not clear whether conservation of biodiversity is embedded in their policy and action plan (UNEP, 2002).

Commercial sugarcane farming which is monocultural in nature is documented to have effects on agro-biodiversity loss or agro-biodiversity simplification. In the coastal regions north and south of Durban, South Africa, commercial sugarcane farming has completely transformed large tracts of land leading to a reduction in the size of land under maize, wheat and sorghum (Cheesman, 2006). Waswa *et al.* (2009a) reported that presently, sugarcane is the widely grown commercial crop in Nzoia sugar belt, having replaced most indigenous crops like cassava and vegetables, despite their ecological suitability and high nutritive and income value. Previous research carried out in South Nyanza by (Eileen, 1987) revealed that as sugarcane production expands, it mainly replaces subsistence crops such as maize.

Research carried out in the study area focused on various issues for example, Andika and Onyango (2006) focused on home garden vegetables production and maintenance in relation to sugarcane production in Butere-Mumias district. GoK, (2002) documented effects of increasing sugarcane production on poverty, health hazards and nutrition in Kenya. The International Congress on Agriculture and Biodiversity (ICAB) suggested that more research needs to be done to establish the link between agriculture, trade, and its effects on biodiversity (UNEP, 2002). The current study therefore focuses on the effect of sugarcane farming on agro-biodiversity in Mumias division of Kakamega County, Western Kenya with main purpose of establishing whether commercial sugarcane farming simplifies agro-biodiversity.

1.3 Objectives of the Study

The general objective of this study was to assess the effects of sugarcane farming on agro-biodiversity in Mumias division of Mumias district.

Specific objectives

i. To identify and compare the diversity of subsistence food crops grown in Mumias division before and after the introduction of commercial sugarcane farming.

ii. To assess the effects of commercial sugarcane farming on agro biodiversity of crops in Mumias division.

1.4 Justification of the Study

Before the introduction of commercial sugarcane farming, farmers in Mumias division had approximately an average of 8 acres of land under subsistence crops per household (Mulaa, 1981). Currently each farmer holds approximately 4 acres of land (KWAHO, 2005). Sugarcane farming occupies 0.7 hectares per household (MSC, 2007).

To date, Nyanza and Western provinces have some of the highest levels of poverty and the lowest human development indices in Kenya (SID, 2007), indicating that commercial sugarcane farming, though occupying large pieces of land (KWAHO, 2005), has had little positive impact on the livelihoods of small-scale farmers. For instance out of a population of about 4.3 million people in western province, about 1.8 million are considered poor (Waswa *et al.*, 2012).

The study focused on Mumias division because it is a major sugarcane growing area in Kenya and houses Mumias Sugar Factory, which is the largest sugar factory in Kenya. The Sugar industry in Kenya directly or indirectly supports 5 million people representing about 16 percent

of the entire population. Sugarcane growing is also a major source of income to over 150,000 shareholders (Kenya Sugar Industry, 2005). However, the concern is that despite large portions of land in the study area being dedicated to sugarcane farming, food insecurity is increasing in the same region (Ekesa *et al.*, 2008)

So far no research has directly focused on the impact of sugarcane farming on agro-biodiversity in Mumias division in particular, and the western Kenya sugar belt in general. This study provides information on the subsistence crops grown before the introduction of sugarcane. The study also provides information on the changes in the size of land under subsistence crops in the region as a consequent of the introduction of commercial sugarcane farming. It gives researchers, environmental organization, government and policy makers' information that can help to come up with appropriate strategy to be adopted in the management and conservation of agro-biodiversity. This research is important in sensitizing the community on the effect of sugarcane farming on subsistence crops and vegetables. It is against this background that the study investigates the effect of sugarcane farming on agro-biodiversity in the Mumias division which is adjacent to the Kakamega tropical equatorial forest. The results are expected to sensitize the Ministry of Agriculture and related stakeholders on the importance of good agricultural practices that can safeguard food security as well as conserve agro-biodiversity. The results are also expected to sensitize farmers in the study area to allocate specific portions of land for sugarcane farming as well as other portion of land for subsistence crops so as to ensure food security and conservation of agro-biodiversity.

1.5 Review of Related Literature

Losses of agro-biodiversity are undeniably occurring in many parts of the globe, often at a rapid pace (Lekha and Abdul, 2011). These losses require counter measures such as increased efforts towards conservation by many different means. Thus, in order to conserve agro-biodiversity the character, and condition of remaining natural and semi-natural ecosystems and how vulnerable these ecosystems are to deterioration or destruction, should be identified. One of the causes of loss in diversity in the whole world includes cultivation of crops such as sugarcane on monoculture.

Commercial sugarcane farming has been practiced in western Kenya for nearly forty years (Netondo *et al.*, 2010). This monocultural land use is associated with loss of natural vegetation and cropland, thus undermining the food security status of the region (Netondo *et al.*, 2010). Like other extensive land use systems, the threat of commercial sugarcane farming to biodiversity conservation cannot be underrated. While intensive farming involves more investments in external input and technology, to increase yield per unit area, extensive farming often involves encroachment on various forms of virgin land such as forests, steep lands and swamplands. Both land use systems are associated with degradation risks including loss of biodiversity (Kapoor and Blackmore, 2000) and variation in the ecosystem that could affect the agro ecosystem negatively through a vicious cycle pattern.

Modern intensive agriculture utilizes a narrow range of crop species and genetic varieties, which have been bred for high yield, including response to inorganic fertilizers and resistance to selected pests and diseases (FAO 1999). In sugarcane farming, chemical pesticides replace natural controls on population of weeds, insects and pathogens (Altieri 2000b). Decomposition is

altered because plant growth and soil fertility is maintained, not through nutrient recycling but with fertilizers (Atkins and Cox 1979). This is accompanied by a drop in the diversity of invertebrates, consumers, predators and parasites (Altieri, 1994) a feature further exacerbated by use of pesticides.

Substitution of annual for perennial vegetation such as sugarcane may cause the soil to be left bare especially when vegetation are uprooted or burnt in preparation for the ploughing and planting (FAO, 1999). This decreases the quantity of organic matter input, residues and the mineral nutrient content of which may be substituted by inorganic fertilizers. Decrease in organic matter or burning of residues also reduces soil cover (FAO, 2005). These are reflected by decreased biomass, diversity and complexity of rooting systems particularly the absence of deep rooting plants (FAO, 2005). Phosphorous rich run off from sugarcane field in Florida is held largely responsible for the decline in the everglades (REAP, 2004). This is a natural poor wetland where saw grass thrived because naturally low levels of phosphorous inhibited the growth of more aggressive species such as cattails (REAP, 2004). Between 1970 and 1988, soil fertility declined by 26 percent in one of the main sugarcane growing areas of Negro in the Philippines (REAP, 2004). In Papua New Guinea, soil fertility has declined by about 40 percent over the last 3 decades in heavy sugarcane cultivation regions (WWF, 2004). This led to lower sugarcane yields hence higher application rates of fertilizers. Increased application of fertilizers altered the natural habitat making the area uncondusive for the growth of various plant species such as sweet potatoes, yam, bean and cassava (FAO, 2005) that were in the past years very common in the region. This in the end led to reduced plant species diversity in the affected regions.

Sugarcane farming leads to increase in the size of the fields and progressive specialization in production goals leading to homogenization of the landscape both within farms and across substantial area or region (UNEP, 2007). Such homogenization reduces the complexity of the interface between units on the landscape and leads to reduced biological migration, habitat diversity, and disruption of nutrient flow. According to World Wildlife Fund, the cultivation of sugarcane has caused a greater loss of biodiversity on planet earth than any other crop (WWF, 2004). Fifteen countries around the world devote between 10-50 percent of their land to sugarcane cultivation, and in seven countries, sugarcane covers more than 50 percent of the land (REAP, 2004). This has led to a decline in both wild plant species and crop species diversity and in the end food insecurity. For instance, commercial sugarcane cultivation in Guatemana replaced bananas which was used both for export and consumption (Suarez, 1996).

To date, humans have destroyed about 44% of the world tropical forests (WRI, 1990). Approximately 80% of the total of 20 million ha/yr of land that is deforested is due to monoculture of crops such as sugarcane (Pimental *et al.*, 1986). The deterioration of current agricultural land combined with increasing population results in approximately 15 million new agricultural lands being needed each year to grow food crops such as sorghum, finger millet, cassava and sweet potatoes that can satisfy the increasing human needs. The current dominance of intensive monocultural production in much of the world which relies on lower levels of varietal diversity, has led to significant reduction in the genetic diversity of crops and wild plant species under active management. In some areas agricultural overproduction of one crop is related to species decline and extinction (RSU, 1985).

The greatest impact of sugarcane on agro-biodiversity arises from clearance of land for cultivation. Since the mid 19th Century, when Europeans settled in Herbert river catchments in Australia, land clearance resulted in a substantial reduction in *Melaleuca spp.* of the rainforest and Eucalyptus dominated land cover (Johnson, 2000). This was accompanied by increase in sugarcane plantation and a decline in agro-biodiversity. Johnson *et al.* (1997) noted that sugarcane growing in Australia led to clearance of large areas of riverine rainforest and riparian habitats and loss of mangroves. These studies were not exhaustive because they ignored indigenous crop plants and their diversity. Commercial sugarcane farming has completely transformed large tracts of land especially in the coastal regions north and south of Durban, South Africa (Cheesman, 2006). These led to a reduction in the size of land under maize, wheat and sorghum. In Brazil, significant areas of cerrado habitats have been lost to sugarcane cultivation and other agricultural activities (REAP, 2004). Among the crops plants affected are the maize which has declined. The total agricultural land in Brazil increased from less than 130 million hectares in 1950 to 250 million hectares in 1990. This increase is as a result of production of monocultural crops such as soya beans and oranges for export and sugarcane for energy production (World Bank, 1994). The increase in monoculture led to decline in the size of land under subsistence crops such as sorghum and finger millet and perhaps others not mentioned in the report. UNEP (2002) noted how 16th Century Spanish and Portuguese colonists began converting land in Latin America for large-scale cultivation of crops including sugarcane. This led to a decline in subsistence crops such as maize and sweet potatoes and ecosystem services that they provide.

In Cuba, 65% of the land is under agriculture with sugarcane representing about 50% of this land (Vales *et al.*, 1998). In the same country 82% of the highland landscape is affected by different

levels of soil erosion. Most of the Cuban soils are compact and lack organic matter as a result of use of heavy machinery and fertilizers (Ana, 2001). This altered condition can only support a few species of plants and crops that can adapt to the region. Some of Cuba's indigenous plants and animals are cleared and threatened for sugarcane which is Cubas main export. For example, more than 30 different kinds of bananas grew on the island before 1959, but most of the banana trees have been replaced by sugarcane (Stoner, 2011). Cuba was once almost entirely forested, by the late 1950s but only 14 percent of the country has remained under forest cover (Stoner 2011). In South Africa herbicides are reported to kill the edible weeds such as amaranths in sugarcane farms (FAO, 2008a). A similar effect may have occurred in the sugar belt of western Kenya but this is yet to be documented.

Although sugarcane farming is widespread in the tropics and subtropics (Rehm and Espig, 1991), its production in Kenya started in the 1920s at Miwani and Ramisi in Nyanza and Coast provinces, respectively. Today, sugarcane farming is widespread in Western and Nyanza provinces of Kenya. In Kenya, small scale farmers (outgrowers) are the majority and constitute about 88% of the total land under sugarcane in Kenya occupying 107622 hectares (KSI 2005). Outgrowers produce about 90% of the total sugarcane production (FAO, 1998a).

The total yields of sugarcane in Mumias sugarbelt was 69.71 tones per hectare in 2009 and 63 tones per hectare in 2010 (MSC 2010). The optimum yields can be up to 120 tones per hectare (MSC 2010). Whilst the revenues from high value cash crops like sugarcane should be more than sufficient to meet the household's basic needs and nutritional requirements, this does not always happen (Waswa *et al.*, 2012). This is partly because men tend to control the revenues from cash crop production and have different spending priorities from those of women. To date, Nyanza

and Western provinces have some of the highest levels of poverty and food security and the lowest human development indices in Kenya (SID, 2007), indicating that commercial sugarcane farming, though popular, has had little or no significant positive impact on the livelihoods of small-scale farmers.

The Ministry of Agriculture has initiated various programmes to boost the cultivation of indigenous crops in the country (GoK, 2006). Waswa *et al.* (2009a) reported that besides water scarcity, use of most land for sugarcane farming is emerging as a key driver of the low agricultural productivity. Netondo *et al.* (2010) reported that contemporary forms of agriculture, particularly sugarcane monoculture in Mumias and Nzoia sugar belt has contributed to accelerated agro-biodiversity erosion by replacing traditional farming technologies, which mostly encourage crop diversification. Netondo *et al.* (2010) indicated that among the crops that are declining in Mumias include finger millet, cassava, sorghum and simsim. Before sugarcane farming was introduced in the Nzoia and Mumias sugar belts in the mid 1970s, farmers grew a wide variety of subsistence crops, which is indicative of the high potential for crop diversification in the area today.

Waswa *et al.* (2009b) also reported that presently, sugarcane is the widely grown commercial crop, having replaced most indigenous crops like cassava and vegetables, despite their ecological suitability and high nutritive and income value. Previous research carried out in South Nyanza by (Eileen, 1987) revealed that as sugarcane production expands, it mainly replaces subsistence crops such as maize. Netondo *et al.*, (2010) indicated that so far no tangible research has focused on the impact of sugarcane farming on agro-biodiversity in Kenya. The International Congress on Agriculture and Biodiversity (ICAB) suggested that more research needs to be done to establish

the link between agriculture, trade, and its effects on biodiversity (UNEP, 2002). Similarly, Oniang'o *et al.*, (2005) suggested that more research and development is required in food Production and Dietary diversity and health in the former Butere- Mumias district. It is against this background that the study was initiated to investigate the effect of sugarcane farming on agro-biodiversity in Mumias division of Mumias district with emphasis on subsistence crop species and indigenous vegetables diversity in the region. It was aimed at determining the effect of sugarcane farming on crop diversity with a view to recommending measures of conservation.

1.6 Scope of the Study

The study was limited to Mumias division of Mumias district. The division is a major sugarcane growing zone in Kenya. The division was studied as a representative of the whole district because nucleus, large scale and small scale sugarcane farming is carried out here. The division comprises the highest concentration of land under sugarcane farming. This is the division where sugarcane farming was first started.

1.7 Limitations to the Study

During fieldwork, the researcher was faced with various limitations as discussed below:

a) **Bad Weather**

Mumias division lies within the Lake Victoria basin and experiences a modified equatorial climate which is characterized by two rainy seasons. The heavy rains worsened the conditions of the roads and delayed the focus group discussions and the administering of the questionnaires as the data collection exercise coincided with the onset of long rains. As a result the data collection

process had to take a longer time than expected. However this was overcome by carrying out focus group discussions in classroom to avoid interference.

b) Low literacy levels and poor record keeping

Due to ignorance and low literacy levels of some of the respondents interviewed, it was difficult to establish the approximate acreages of their farms within the stated time. This situation forced the researcher to use estimates based on strides made along the farm. This exercise was tedious and cumbersome and it somehow slowed down the pace of data collection. Estimating individual acreage per crop especially for vegetables was not possible since intercropping is quite common for the farmers in the study area and vegetables are grown in small kitchen gardens. The researcher therefore used the number of farmers growing specific indigenous vegetable to identify the trend in the diversity of indigenous vegetable over the four decades.

c) Expectation of payment in exchange for information

Most of the respondents expected pay for the information they were divulging because they believed that the researcher was going to benefit from it. To overcome this, the researcher took time to explain to the respondents that the research would be of importance to the respondents. For instance, the research would help them come up with better ways of allocating sizes of land to various crops and in turn curb against food insecurity.

1.8 Conceptual Framework

Agro-biodiversity is greatly determined by human factors and specifically agriculture. Therefore increase in agricultural activities leads to disruption of agro-biodiversity on the surface of the earth. Conversion of land to agriculture leads to increases albedo levels (the proportion of light

energy which is reflected from the land surface), increases heat transfer to the atmosphere, reduces evapo-transpiration from plants and trees, compacts soil (which increases rainfall runoff), increases erosion, and affects air turbulence (and therefore air movements and winds) (Rainforest Conservation Fund, 2012). Sugarcane farming contributes greatly to erosion of agro-biodiversity in Mumias division of Kakamega County.

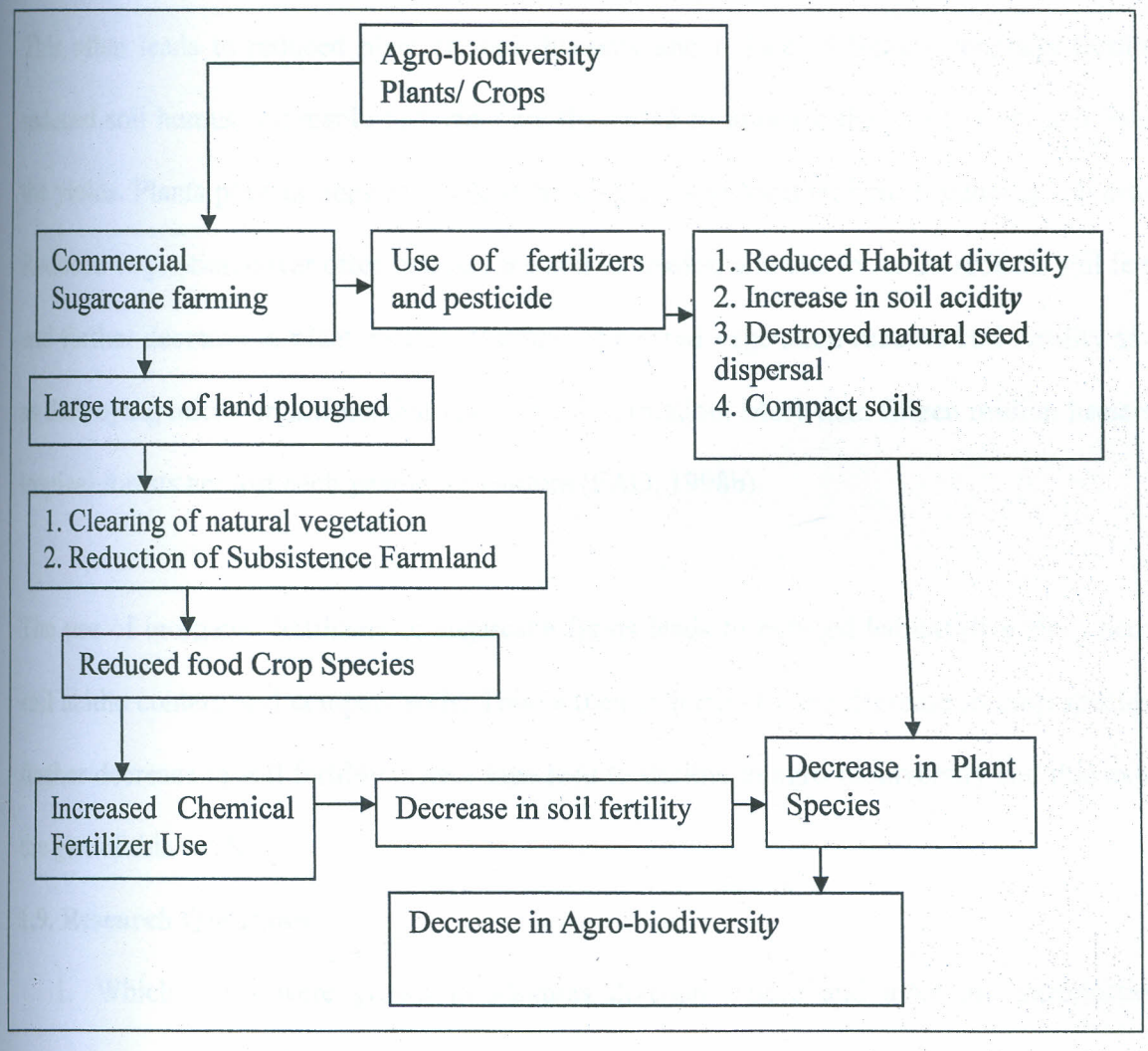

Figure 1: Conceptual Framework
Source: Researcher

As indicated in Figure 1, the main factor contributing to agro-biodiversity loss is technologically advanced monocultural agriculture such as commercial sugarcane farming. In commercial sugarcane farming, various activities are involved. These activities include large tracts of land being ploughed and the use of fertilizers. To begin with, forests and other natural vegetation are cleared to create farmlands. This is done through uprooting of various plant species. Alternatively, the vegetation is first burnt hence causing the destruction of various plant species. This often leads to reduced plant species diversity and reduced foliage, eventually leading to reduced soil humus. Inorganic fertilizers are then used to improve the soil fertility and increase the yields. Plants play an important role in holding the soil together hence reducing soil erosion. Reduced vegetation cover often exposes the soil to erosion and this in return reduces soil fertility and further decrease in plant species. Burning of cleared vegetation reduces soil fertility as well as destroying micro-organisms that assist in soil formation. More than fifteen million hectares of tropical forests are lost each year to agriculture (FAO, 1998b).

The use of inorganic fertilizers in sugarcane farms leads to reduced habitat diversity, increased soil acidic content and compact soils. This is then reflected by the decrease in crop species and further decrease in soil fertility. These then lead to decline in agro-biodiversity and this explains the gist of this work.

1.9. Research Questions

1. Which crops were grown in Mumias division before and after the introduction of sugarcane farming?
2. How did the introduction of commercial sugarcane farming in Mumias division interfere with agro-biodiversity?

3. What were the causes of change in the size of land under subsistence crops in Mumias division?

1.10. Assumption

Other factors have also contributed to decline in agro biodiversity include

1. Changes in consumption tastes and preferences,
2. Pests and diseases,
3. Labour intensiveness
4. Lack of skills and knowledge of cultivation of the indigenous crops
5. Introduction of exotic plant species such as exotic kales.

CHAPTER TWO

2.0 STUDY AREA

2.1 Location and Size

The study was carried out in Mumias division of Mumias district in Western Kenya. (Figure 3). The study area covers an area of 214 km^2. It is one of the divisions in Mumias district of Western Kenya. The division is bordered by Matungu to the north and north east, Shibinga to the east, Central Marama and Etenje to the south (GoK, 2010). The study area lies between longitude 34^0 21^1 East and 34^0 41^1East and latitude 0^0 15^1North and 0^0 29^1 North of the equator (GoK, 2002). Figure 2 and 3 show the map of Kenya and the map of Mumias division and the surrounding regions.

Figure 2: Map of Kenya
Source: Ogonda and Obara (1990)

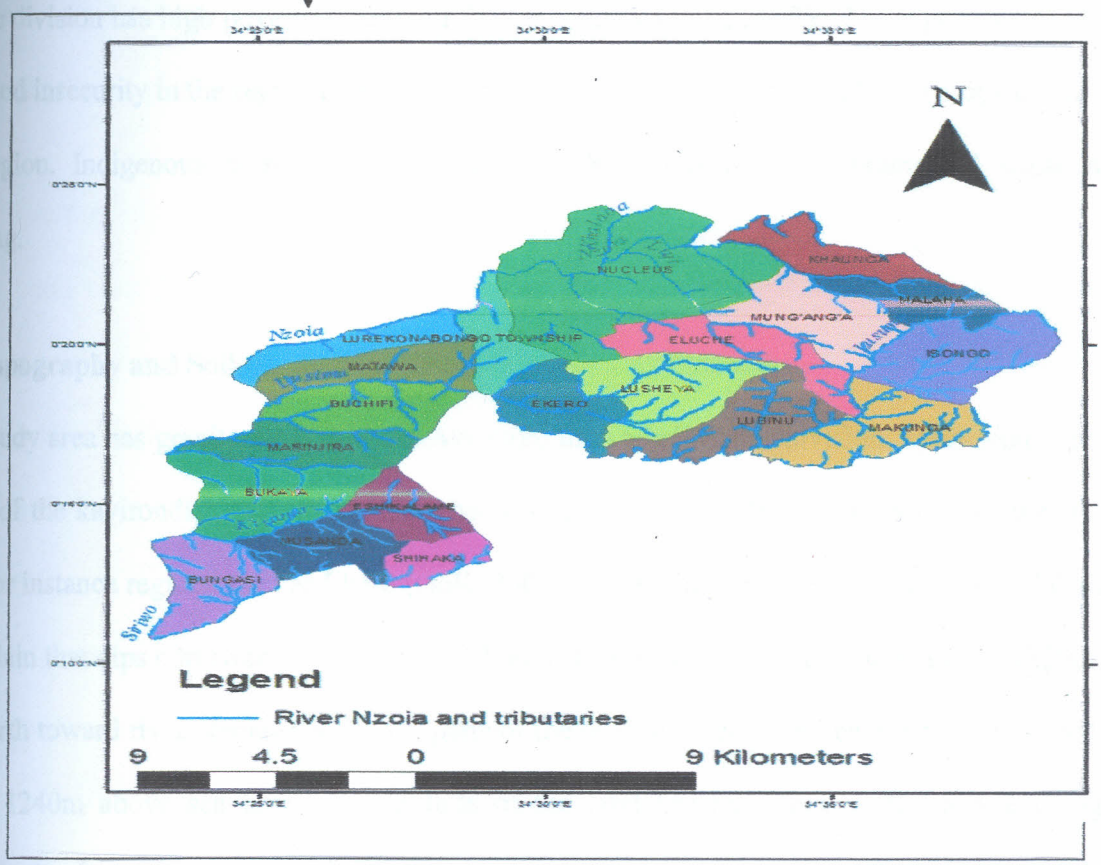

Figure 3:-Study Area
Source: Researcher

Mumias division was chosen as the study area since it is a representation of the whole Mumias sugar belt where small scale, large scale and nucleus sugarcane farming are carried out. The study area is predominated with sugarcane farming as a cash crop with a few other food crops such as maize, sorghum, finger millet and beans for subsistence (GoK, 1992). The region hosts the largest sugar processing company not only in Kenya but also in East and Central Africa (Mandere, 2003). The company is supplied with sugarcane from contracted, out grower farmers (OG), factory farms referred to as nucleus estate (NE) and non- contracted farmers. This study area has fertile soil and favourable climate for the cultivation of subsistence crops and vegetables yet the division has high poverty levels and food insecurity (GoK, 2002). The high poverty rates and food insecurity in the region implies that there is a change in the trend of food crops grown in the region. Indigenous crop species diversity has been replaced by commercial sugarcane farming.

2.2 Topography and Soils

The study area has granite rocks which cover more than a half of the division. Meta-sedimentary rocks of the kavirondian system, on the other side cover most of the southern part of the study area for instance regions such as Ekero (GoK, 2002). The region also has an extensive undulating peneplain that dips northwards from about 1641m to 1500m above sea level to a further 1250m to the north toward river Nzoia. The lowest parts of the division include Shibale which is located at about 1240m above sea level. The altitude of the land has an effect on the nature of agro biodiversity found in the region. Cassava, sorghum and finger millet are more prominent in the lower regions such as regions bordering river Nzoia. These crops can withstand high temperature

which is available in the region. These low altitude regions are also good for the cultivation of sunhemp.

Higher altitude areas such as those surrounding Mumias town have higher rainfall of up to 2873 mm and are popular in the cultivation of exotic crops such as maize, indigenous crops such as simsim, sweet potatoes and indigenous vegetables such as African night shade, vegetable amaranths, cowpeas, African kales and spider plant (Infonet-Biovision, 2010). Pumpkins also thrive well in the relatively higher regions and especially in abandoned cattle shed and kitchen gardens (GoK 2002). Sugarcane is cultivated in both the high and low regions including along river banks. Pulses such as groundnuts are grown throughout the division as intercrops with maize, cassava, sorghum and sugarcane.

The soils in the division are categorized as lowland and upland soils (MSC 2010). Lowland soils are clays and water logged, found in swampy areas such as along river Nzoia while upland soils are red loamy and well drained and is found in the southern parts of the study area. These regions include regions include Lubinu and Lusheya. The soils range from shallow to moderately deep orthic Acrisols to Ferralsols and are developed on granites. Large parts (79%) of the area including Ekero, Munganga, and Eluche have well drained soils which are aerosols, ferrasols and alisols. The well-drained, well-aerated, deep soils containing adequate organic matter and well supplied with available nutrients in the study area, do support various crops such as sugarcane, root crops such as cassava and sweet potatoes, pulses such as groundnuts and bambara groundnuts, and cereals such as maize, sorghum and finger millet. The soils also support the cultivation of indigenous vegetables such as vegetable amaranths, cowpeas, African kales, pig weed and African night shade. However, due to the continuous production of sugarcane and

maize, the soils in terms of potassium levels are generally very poor. Fertilizer application is necessary for high crop yield (Mandere, 2003). Despite the low soil fertility, these soils can support crops such as sorghum and finger millet since they are tolerant of shallow soil and droughty conditions (Obuoyo, 2005). Despite the soils having the potential to support the growing of various crops, sugarcane is popularly grown in the region on monoculture while only a small portions of land is dedicated to the mentioned indigenous crops. Figure 4 shows the agro ecological zones of Mumias division and surrounding divisions.

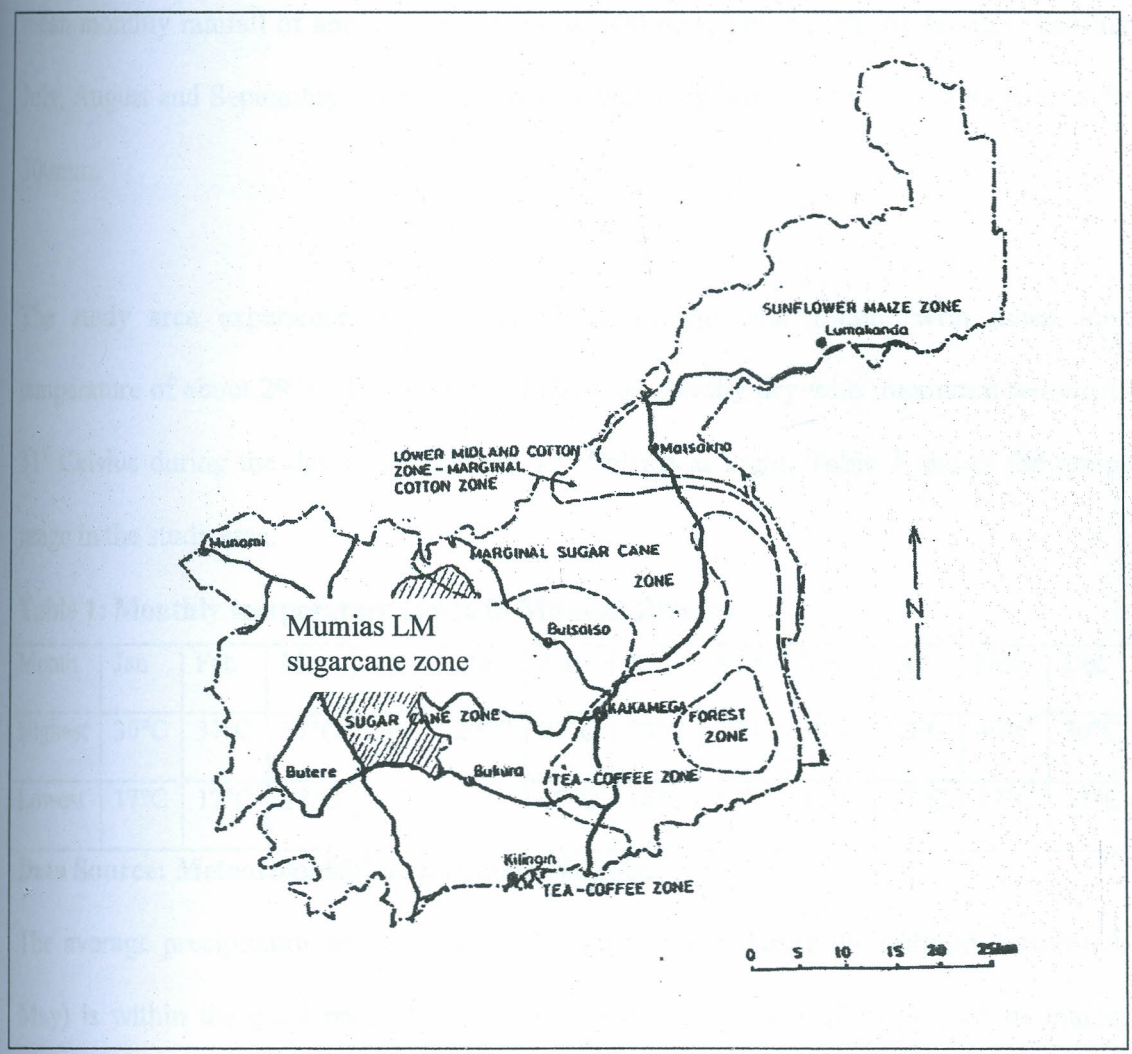

Figure 4: Map of Mumias Division and Neighboring Areas Showing Agro- ecological Zones Source; GoK-2008

Study Area

2.3 Climate

The study area as a whole receives high rainfall all the year round with two rain seasons, long rain and short rain season. The annual rainfall ranges between 1597-2873 mm per annum with a mean of 1700mm per annum. Long rains are experienced between March and May with an average rainfall ranging from 600mm to 750 mm. The highest rainfall is registered in May while the lowest rainfall is recorded in July. The study area therefore has enough soil moisture and the potential to support agriculture. Short rains are experienced between October and December with mean monthly rainfall of about from 300mm to 500 mm. The months of January, February and July, August and September, are the dry month with very little rainfall ranging from 200mm to 300mm.

The study area experience high temperatures all the year round, with mean maximum temperature of about 29^0 C. February and March are usually dry with maximum temperatures of 31^0 Celsius during the day and minimum 17^0 Celsius at night. Table 1 shows the temperature range in the study area.

Table 1: Monthly temperature range in Mumias Division

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Highest	30°C	31°C	31°C	29°C	29°C	28°C	29°C	29°C	30°C	30°C	30°C	30°C
Lowest	17°C	17°C	18°C	18°C	18°C	17°C	16°C	17°C	17°C	17°C	17°C	17°C

Data Source: Meteorological department, Nairobi.

The average precipitation amounts received in the region during the optimal season (March to May) is within the good precipitation range for the cultivation of crops such as maize, sweet potatoes, groundnuts and indigenous sugarcane which does best with rainfall ranging from 600mm-900mm during the growing season. The high rainfall and high temperature are

favourable for the cultivation of indigenous vegetables such as cowpeas, vegetable amaranths, pig weed, African kales and African nightshade.

The average precipitation received in the region during the short rain season (October to December) is sufficient for the cultivation of crops such as simsim which requires rainfall range of between 300mm to 500mm (Infonet-Biovision, 2010). The low rainfall received in January, February, July August and September and high temperatures during this period can sustain indigenous crops such as bambara groundnuts, sorghum, cassava, finger millet and indigenous vegetables especially sunhemp which are well adapted to these climatic conditions and can survive in regions with unreliable water.

2.4 Drainage

The sources of surface water in the study area are rivers and streams. The study area is dissected by river Nzoia, and small streams such as Lairi, and Viratsi. The rivers flow all year round from the Mount Elgon/Cherangani hills area to Lake Victoria contributing significantly to the flow into the Nile Basin (MSC, 2010). All the surface water drains towards river Nzoia which flows within less than ½ kilometer away from the Mumias Sugar Company (MSC, 2010). The rivers provide adequate water for both domestic and agricultural purposes (GoK, 2002). The entire division is well drained with a great potential for both the cultivation of diversity of crops ranging from monocultural sugarcane, subsistence crops such as sorghum, finger millet, cassava, sorghum and indigenous vegetables (GoK, 2002). In sub surface water resources, the study area has a higher potential in the northern parts especially in Isongo where underground water occurs at shallow levels (MSC, 2010). The Mumias Sugar Company (MSC) nucleus estate, in particular, has 870 ha of poorly drained lowlands, from which production is generally low. The soils in these lowlands

are mainly silt loams with an impermeable layer underlying the 0-50M topsoil, which is the cause of poor sub surface drainage in the area. However, these soils are suitable for sugarcane production if they are effectively drained (Home, 1991 quoting Bookers 1970). These poorly drained wetlands close to river Nzoia are well suited for the cultivation of crops such as yams.

2.5 Agro ecological zones

The study area falls in the moist mid-altitude agro-ecological zone which falls within sugarcane growing zones (Jaetzold and Schimdt, 1982). The region is in LM_1 zones based on altitude, which ranges between 1100-1500 meters above sea level. The highest region rises up to 1641m above sea level. The altitude then falls steadily to the lowest region of 1240m above sea level in the northern regions. Annual rainfall averages 700-1800mm and is bi-modal. The rainfall amount and pattern are modified by altitude, with higher elevation areas receiving relatively more rainfall than the lower elevations. The first rain season in a year starts in February/March and second in August/September.

2.6 Land Use

The main land use in the study area is agriculture mainly monocultural sugarcane farming with industrial sugar milling. Sugarcane farming occupies about 68 percent of the land in the division while 32% is occupied by subsistence food crop cultivation. The land tenure system is freehold with most owners having title deeds. However, land is continually being subdivided into uneconomical units and distributed to children seeking ownership rights.

Maize is the staple food crop grown in the area. Other crops grown include finger millet, sorghum, cassava, simsim bambara groundnuts, groundnuts and sweet potatoes. Horticultural

crops like bananas, kales, French beans, onions and tomatoes are also grown. Groundnuts, bambara groundnuts and simsim are grown on small scale. Extension staff normally encourage the households to grow indigenous crops mainly sorghum, finger millet, cassava and sweet potatoes in order to ensure availability of sufficient food in the region (GoK 2008).

Indigenous vegetables found in the area include, spider plant *(Cleome gynandra)*, jute mallow *(Corchorus olitorius)*, African nightshade *(Solanum scrabrum)*, vegetable amaranths *(Amaranths blitum)*, pig weed *(Amaranths pilmeri)*, cowpeas *(Vigna unguiculata)*, pumpkin leaves *(Cucurbita moschata)*, sunhemp *(Crotalaria brevidens)* and African kales *(Brassica* carinata (Abukutsa, 2007). The government is encouraging the local community to grow these indigenous vegetable since they have high level of nutrients. The study area is rich in diversity of indigenous vegetables that needs to be sustained since they play a key role in food security, and in medicinal values (GoK, 2008). Pig weed, jute mallow, spider plant, vegetable amaranths, African night shade and pumpkins are normally found in abandoned cattle sheds and kitchen gardens. Sunhemp and jute mallow are commonly cultivated along river banks. Cowpeas and African kales are commonly intercropped with maize sorghum and sugarcane.

Both indigenous and exotic tree species are propagated in the study area. These trees include Eucalyptus *(Eucalyptus spps)*, Grevillea *(Gravillea rubusta)*, Kay apple *(Dovyalis caffra)*, *Cassurina equisetifolia*, Umbrella *(Terminalia mentalis)*, Pine *(Pinus patula)*, Muhoma *(Cassia spectabilis)*, Kassod tree*(Cassia siemea)*, Gliricidia *(Gliricidia sepium)*, Flamboyant tree *(Delonix regia)*, Moringa *(Moringa oleifera)*, Pepper tree *(Schinus molle)*, Jacaranda *(Jacaranda mimosaefolia)*, Nile tulip tree *(Markhamia lutea)*, Cordia abysinica *(Cordia abysinica)*, Nandi flame *(Spathodea nilotica)*, Date palm *(Phonex spps)*, *Podo spps*, African palm tree *(Spathodea*

companulata), Dove weeds *(Croton spps)* Elgon teak/African and Olive wood *(Olea africana)* (GoK, 2007).

The introduction of sugarcane farming has led to change in land use. Most of the farmers have changed from subsistence farming to commercial sugarcane farming. Farmers also practice mixed farming, growing crops and keeping livestock (GoK, 2007). Livestock farming especially cattle, poultry, sheep and goats is a common venture but on small scale. Acreage under pasture in the division is low as most of the land is dedicated to sugarcane as a cash crop and food crop production. Livestock farming has declined in the region with only a few farmers opting for zero grazing (GoK, 2007). Reduction in livestock has led to reduction in organic manure which in the end has led to reduction in the cultivation of subsistence crops and indigenous vegetables which rely heavily on organic manure as a source of nutrients. For instance, indigenous vegetables such as black night shade which used to grow naturally on the farms, has virtually ceased to grow naturally after commercial sugarcane farming was introduced (Abukutsa, 2007).

2.7 Population Characteristics

Mumias district has high population density of 546 persons per km^2. This translates to an approximate population of 512686 people in the district. The population growth rate is 2.4% (GoK, 2002). Mumias division has 4384 sugarcane farmers. The number of farmers in Mumias division accounts for 17% of the total number of sugarcane farmers in the Mumias district. Most of the inhabitants belong to the Wanga sub tribe of the Luhya community with a few other communities settling around the Mumias urban center that houses the Mumias Sugar Company (KWAHO, 2005).

Most of the people are settled in their ancestral land, where subdivision of land into small holder unproductive units is common. Settlement patterns in the division is determined by several factors which include fertility of soils, and the level of economic development e.g. location of industry and urbanization. Most of the population is dispersed where farming land is located. There is a nucleated close to Mumias sugar factory, Mumias town and other small market centre. Mumias division has the highest population density as compared to the neighboring East Wanga division, attributed to its urban status and the presence of Mumias Sugar Company. The migration of people into towns has led to sprawling of slums e.g. Nubian and Mjini estates in Mumias town (GoK, 2002). Urban poverty (people living below the UN level of US $ 1/day) is attributed to unemployment, emergence of squatters and low incomes especially among the casual labourers.

Despite the high population in the division and the small farm sizes most of the inhabitants of the division are engaged in sugarcane farming as an income venture. Sugarcane is harvested after 18-24 months; in the meantime therefore, farmers are left without a viable source of income till the next harvesting season. Many families spare very small pieces of land that are used for food crops such as finger millet, sorghum, and simsim resulting into increased food insecurity in the household.

CHAPTER THREE

3.0 METHODOLOGY

3.1. Research Design

The design used in data collection was survey where respondents were asked questions, through the use of questionnaires and in-depth interviews on subsistence crops grown before and after the introduction of sugarcane farming. Questions on the size of land under sugarcane farming before and after the introduction of sugarcane farming were asked. Respondents were also asked questions on the possible causes for the change in the size of land under sugarcane farming and indigenous crops in the stud area. The survey design was used because of the following reasons: (i) it allows measuring of variables through asking people questions; (ii) it enables the examining of relationships among variables, (iii) surveys use qualitative and quantitative measures and (iv) surveys attempt to capture patterns of past behavior (Babbie, 1990). The survey design was therefore, the most appropriate for this study since it sought to establish historical and current trend in the size of land under sugarcane and indigenous crops and the effects associated with each increase in size of land under sugarcane since 1971s. Explanatory research design was used to explain the main causes of changes in the size of land and number of farmers growing indigenous crops between 1960s and 2000s.

3.2 Sampling Procedure

The study was part of the VicRes project which covered the three divisions of Mumias district whose total population was 25412 sugarcane farmers as shown in table 2.

Table 2: **The size of land under sugarcane and the number of sugarcane farmer in Mumias Sugar district**

Division	No of Sugarcane Farmers (2007)	Area (Acres)
Matungu	9,890	7589.80
East Wanga	11,138	9291.81
Mumias	4,384	2916.23
Total	25,412	19797.84

Two percent (2%) of the 25412 which is the total population of sugarcane farmers in the three divisions was used to get a sample population 508 respondents (Netondo *et al.*, 2010). Basing on the number of sugarcane farmers per division this was divided in the respective ratios as follows.

Matungu= 9890÷25412×508=198 respondents

East Wanga=11138÷25412×508=222 respondents

Mumias=4384÷25412×508=88 respondents

The respective ratios are as shown

Matungu:East Wanga: Mumias=198:222:88

Mumias division had a farmer population of 4384. This implied that 17.3% of the farmers from the division were selected as shown below.

88÷508×100=17.3%

The sample size for this study was 88 respondents but it was then rounded up of 90 respondents. Mumias division was selected because it lies in the Lake Victoria basin and is a major sugarcane-growing zone in Kenya. The division also contains small scale and large scale farmers as well as the factory nucleus estate farms.

Respondents Characteristics

Out of the respondents interviewed 38 were large scale while 52 were small scale. For the large scale farmers 31 were male while 7 were female. Among the small scale farmers 34 were male

while 18 were female. They were purposively sampled with the aid of local leaders basing on their age and the duration they had stayed in the division. The selected people were adult male and female aged above fifty year and had lived in the division for more than thirty years. The sample was a representative of the entire population. Out of the respondents interviewed 65 were male while 25 were female. Majority of the respondents were male because most of the household heads in the region are male. The respondents' characteristics were as shown in Table 3 below.

Table 3: Respondents age characteristics.

Age Set	Number of Respondents	Male	Female	Percentage No. of Respondents
50-59	43	31	12	48
60-69	31	23	8	34
70-79	15	10	5	17
80-89	1	1	0	1
Total	90	65	25	100

3.3 Data Collection Techniques

3.3.1 Data Collection Procedure

The study was preceded with a pilot survey conducted in the division. The reconnaissance was aimed at familiarization with the areas of study, making necessary logistical arrangements with respondents and local authorities, pre-testing research instruments (questionnaires and interview schedules) and the collection of background information.

3.3.2 Primary Data

Primary data collection tools included; (i) Questionnaires (ii) Interviews (iii) Participatory Rural Appraisal (PRA).

3.3.1.1 Questionnaires

Questionnaires were administered to selected sugarcane farmers (respondents) and Key Informants (KI), who were specific individuals having specialized information on sugarcane farming and biodiversity in the area. The selected people were adult male and female aged above fifty year and had lived in the division for more than thirty years. The questionnaires were administered to the farmer in an interview session aimed at understanding the effect of sugarcane farming on biodiversity. A well-written introductory statement was used clearly stating the purpose of the study. The respondents were assured of anonymity so as not to make them feel the information could be used against them. The questionnaire emphasized that there is no right or wrong answers to reassure the respondents that they were not stupid. The KIs included local opinion leaders, village elders, chiefs, assistant chief and sugarcane farmers. These individuals were selected by use of purposive random sampling from all the villages within the study division.

Questions were aimed at acquiring information on impact of sugarcane farming on crop diversity, and vegetables species diversity in Mumias division between 1960-2006. Since sugarcane was introduced in the area in 1972, this time period (1960-2006) was selected since it could give information on the trend in status of biodiversity before and after the introduction of sugarcane in the area. Sugarcane takes between 18 and 24 month to mature. The ten year range was chosen because it gives a farmer at least two growing seasons. It also gives a farmer chance to harvest subsequent ratoons and hence making the farmer to have more knowledge about the crop and give informative responses. Trends in the change of agro biodiversity with increasing acreage of sugarcane were also captured.

3.3.1.2 Interviews

Interviews were conducted on local opinion leaders such as district agricultural officers Mumias district and Western Provincial Agricultural Officers Headquarters at Kakamega. The interviews were aimed at identifying the observed changes in crop species diversity and the orphaned crops in the region. The district officer Mumias district was also interviewed to find the effect of sugarcane farming on agro biodiversity in the division.

3.3.1.3 Participatory Rural Appraisal

To validate data on long-term effect of sugarcane farming on crop species diversity, Focus Group Discussion (FGD) as one of the Participatory Rural Appraisal (PRA) tools was used. The PRA tools used included the trend line, priority matrix and transect walks. Trend lines were used to identify the sizes of land under various crops between 1960s and 2000s. Since indigenous vegetable are mostly grown as intercrops, priority matrix were used to identify how farmers prioritize and allocate land to indigenous vegetables. Priority matrix was also used to identify the causes of change in biodiversity in the division. A group of thirty seven respondents were selected by purposive random sampling with aid of local authorities and gathered for the discussion. The selected people were adult males and females aged above fifty years and had lived in the division for more than thirty years. The group was gathered and asked to discuss the causes of the change in the size of land under indigenous crops in the study area. The Focus Group Discussion validated information on the changes that have occurred in the subsistence crops and vegetables in Mumias division for a thirty year time period. Data on the sizes of land under various crop species diversity was grouped at a ten year intervals so as to provide information on the progressive changes in crop diversity over the period of time in the region.

Information on the crop species that are termed to be extinct, endangered and prevalent in the region was also captured by Focus Group Discussion.

3.4 Secondary Data

Secondary data was obtained from documented information, journal texts, newspapers, magazines, and government reports relating to effect of monoculture on biodiversity.

This data was collected from Maseno University library; Mumias district information and documentation centre. Information was also obtained from the Ministry of Agriculture, Mumias district headquarters. Secondary data was also acquired from published literature, obtained from Kenya Agricultural Research Institute (KARI) offices in Kakamega.

3.5 Techniques of Data Analysis and Interpretation

The data collected from the study was analyzed by both qualitative and quantitative methods using Statistical Package for Social Sciences (SPSS) computer programme version 17. Descriptive statistics was used to explain the quantitative parts where percentages of various responses were used and presented in form of tables and figures

Frequencies of the number of farmers growing and those who do not grow certain crops such as maize, cassava, bambara groundnuts, sweet potatoes, finger millet, simsim, sorghum and indigenous vegetables were computed. This was used to identify and rank the endangered crop species in the district. Frequencies of the specific causes that led to the various crops not being grown were also computed. This was used to identify the main causes of changes in agro-biodiversity in the region. The mean size of land under the individual crops from 1960s to 2000s was also computed.

3.6 Data Presentation

Data was presented in the form of tables and graphs.

CHAPTER FOUR
RESULTS AND DISCUSSION

4.0 Introduction

This chapter analyses the effects of sugarcane farming on subsistence crop species in Mumias division of Western Kenya. Data on the crops grown in the region in the 1960s before sugarcane was cultivated on commercial scale and the crops grown between 1970s and 2000s after the introduction of commercial sugarcane farming are presented and analyzed. This chapter hence addresses objective one and two of the study since it answers the question as to whether the introduction of commercial sugarcane farming has led to any changes in the type of crops grown and acreages under subsistence crops in the region. The results discussed in this chapter clearly show that increase in the land under sugarcane has led to a decline in the size of land under subsistence crops. The results have also shown that, sugarcane farming has had an indirect effect on the indigenous vegetable species especially those that grew in the wild, but which have since been cleared from the sugarcane plantation since they are viewed as weeds.

4.1. Subsistence Crops Grown in Mumias Division before the Introduction of Commercial Sugarcane Farming

In Mumias division, commercial sugarcane farming was introduced in 1972 concomitant with the introduction of Mumias Sugar Company. There are nine types of food crops that were common in Mumias division in 1960s before the introduction of commercial sugarcane farming. Different crop species and varieties were grown as intercrops and this reduced the risk of economic loss caused by variation in weather condition or from pest attack (Brader, 1987). In the 1960s, the farmers focus was on maximizing food security rather than maximizing yield (Tscharntke *et al.*, 2005). Field data has revealed that out of the land cropped with traditional crops not all crops

were given the same preference. Cereals such as finger millet, sorghum and maize together with cassava occupied a larger portion while simsim occupied the least portion. Subsistence crops grown in the region by the farming households before the introduction of commercial sugarcane farming are shown in the Table 4.

Table 4: Types of Subsistence Crops Grown and Acreages of Land under Crops in Mumias Division before the Introduction of Commercial Sugarcane Farming

Total size of land per household (acres)	Total size of land under crops(acres)	Types of Crops Grown	Mean Acreages per household	Percentage acreages under each crop(%)
8	7.82	Indigenous Sugarcane	0.16	2
		Maize	2.34	30
		Sorghum	1.34	17
		Cassava	1.22	16
		Finger millet	0.94	12
		Ground nuts	0.64	8
		Sweet potatoes	0.56	7
		Bambara groundnuts	0.55	7
		Simsim	0.07	1

Source: Field data, 2007

Table 4 shows that maize was the dominant food crop followed by sorghum, cassava, finger millet while indigenous sugarcane was the second least grown food crop. Simsim was the least grown crop in the stud area.

Indigenous Sugarcane (*Sacharum officinaram)*

Sugarcane was cultivated on small pieces of land of about 0.16 acres of land per household. It occupied only 2% of the total size of land under subsistence crops (Table 4). It was cultivated by about 14% of the household (Figure 5). These were the local sugarcane varieties (*mikhonye cha eshinyala and mikhonye cha kampala)* that were either red or green in colour and were mainly chewed raw. These varieties were commonly planted along the banks of Rivers such as river Nzoia or in kitchen gardens. Only ripe sugarcane harvested while unripe plants were left on the plot. In this way, the field was never cleared. This soft sugarcane comprised of sweet fibers that could be chewed raw. These species were often sold on the local markets such as Mumias, Ekero and Ejinja to generate household income.

Figure 5 shows the percentage number of households in Mumias division growing subsistence crops in 1960s.

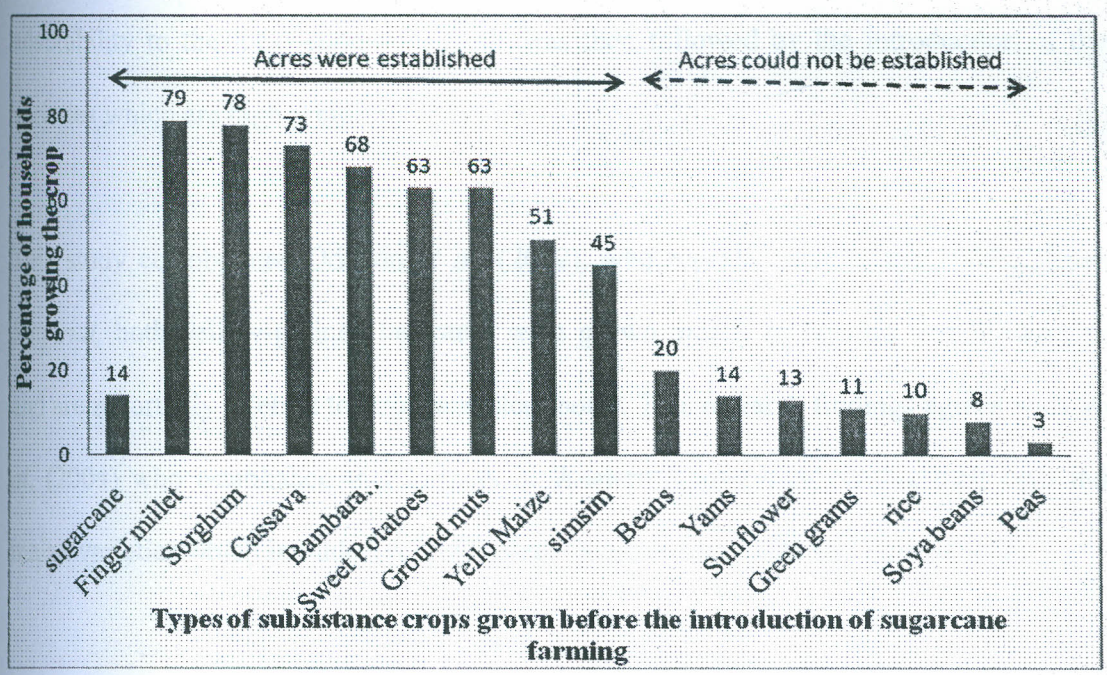

Figure 5: Percentage Number of Households in Mumias Division Growing Subsistence Crops in 1960s

Maize *(Zea mays L.)*

Maize occupied the largest acreages per household with an average of 2.34 acres (Table 4). This translates to about 30% of the total size of land under subsistence crops per household in the study area. Maize, occupied the largest portions of land because '*ugali*' is the stable food of the community. It was also sold on the local markets such as Ekero for household income. Despite maize having occupied the largest portion of land, this study established that only (51%) of the households grew it (Figure 5). The research established that this was because some households solemnly relied on other food crops such as sorghum and fingermillet as staple food crops. The most common maize varieties grown were the unimproved landraces such as yellow maize (*shipindi)* in luhya and the white or have mixed colours (*namba nane*). *Namba nane* landrace had a large white kernel/white cobbed and was characterized by a typical eight lines per cob of the maize. These landraces were local and were highly regarded by the farmers because of their adaptability to the local conditions. This was then followed by the introduction of the hybrid varieties which are high yielding.

This study corroborates Odendo *et al.* (2002), who reported that in the 1960s, *Nyamula and Shipindi,* both yellow-grained landraces were grown mostly in Nyanza and Western provinces and are reportedly tolerant to striga and stem borer. This research findings agrees with Muasya *et al.* (2004) who established that farmers in Western Kenya highly value their own indigenous maize varieties which included yellow maize, ugandan composite and *namba nane.*

Sorghum (*Sorghum bicolour L.* Moench)

Sorghum was an important crop for rural food security in Mumias division in 1960s. In 1960s, it occupied a mean of 1.34 acres of land per household accounting for about 17% of the land under

subsistence crop and was ranked second to maize (Table 4). The crop was grown by about 78% of the respondents (Figure 5). During this period, sorghum was a staple food crop in the region. Most farmers grew local land races. These varieties take 120 days to mature. Sorghum grain was utilized in preparing foods like "ugali", porridge and for making alcoholic beverages. The crop was also sold in local markets such as Shivale. Ekesa *et al.* (2008) reported that sorghum and finger millet were the Kenyas pre-colonial staple food crops. EPZI (2005) also reported that in Kenya sorghum, was used as a staple food crop and was predominantly traditionally grown in Eastern, Western, and Nyanza provinces.

Cassava (*Manihot esculenta Rantz*)

Cassava is a semi-woody plant that grows to a height of two to three meters. It was a common subsistence food crop in Mumias division in the 1960s. It is the root crop that was given the highest priority. It occupied an area of about 1.22 acres per household (Table 4) accounting for about 16% of the total land under subsistence crops and was ranked third. It was cultivated by about 73% of the household in the division. The most common cassava varieties grown were the bitter and the sweet ones depending on the level of toxic cyanogenic glucosides. Cassava is normally ready for harvesting after nine (9) to twelve (12) months. Obuoyo (2005) observed that after maturity, the tubers can store very well in the ground without rotting for as long as four (4) years. Cassava enhanced household food security and was a source of income to the locals who sold it in Mumias town and other neighboring towns.

Finger Millet *(Eleusine coracana L.* Gertn)

Finger millet was the fourth staple food crop in Mumias division in the 1960s. The crop takes approximately 125 days before it is ready for harvesting (Obuoyo, 2005). It occupied 0.94 acres

of land per household which was 12% of the total size of land under subsistence crops in the division (Table 4). It had the highest number of household (79%) growing it. Finger millet was very important because it was ground into flour that was used to make porridge or 'ugali'. This crop is very rich in calcium potassium and iron that is necessary in the development of bones. It is also good for expectant women, and is considered as food for adults of different ages. It is a favourite food of hard toiling class and also very nutritious to persons suffering from diabetes. The two main types of finger millet that were in the region were the brown and the creamy white finger millet. Our findings are in agreement with Styslinger (2011) who reported that finger millet is a staple grain for much of the world's population, particularly in South Asia and East Africa, and has been cultivated for thousands of years.

Bambara Groundnuts (*Vigna subterranea L.* Verde)

Bambara groundnut was cultivated on about 0.55 acres of land per household. This was about 7% of the total size of land under subsistence crops (Table 4). The crop was cultivated by about 68% of the household in the division in the 1960s (Figure 5). The main landraces available were the medium –sized brown and purple, and the large brown tinted type. Bambara groundnut is very important source of nutrients. Brough and Azam- Ali (1992) reported that bambara groundnut seed makes a balanced food as it contains sufficient quantities of carbohydrate (63%), protein (16.25%) and fats (6.3%) with relatively high proportions of lysine and methionine as percentage of the protein (6.6 and 1.3%), respectively. In Mumias division, seeds were mixed cooked with maize (occasionally after overnight soaking), or on their own, and served as a snack. It could also be cooked fresh in pods or roasted. Despite its importance, bambara groundnuts was not very popular in the region. It was cultivated as an intercrop with other crops such as maize, sorghum and cassava. On the contrast, Rachie and Silvestre, (1977) reported that bambara groundnut has

been ranked as the third most important grain legume, after groundnut *(Arachis hypogaea L.)* and cowpea *(Vigna unguiculata)* in semi-arid Africa. He noted that the crop has not been accorded due attention in research. Wutoh *et al*, (1983), reported that bambara groundnut is an ancient crop grown in Africa from Senegal to Kenya. Heller *et al*. (1997) reported that bambara groundnuts is chiefly grown in western Kenya.

Groundnuts (Arachis Hypogaea L.)

Groundnuts were grown in Mumias division in 1960s with an average of 0.64 acres per household. This was about 8% of the total size of land under subsistence crops (Table 4). They were often grown as intercrops with other crops such as maize, cassava and sorghum. 63% of the household interviewed in the region grew groundnuts (Figure 5). The most common groundnuts varieties were the local landraces. As food, groundnut was used for human consumption in the form of raw, boiled or roasted nuts, as edible oil and protein by being pounded and used as a vegetable oil for cooking, or made into paste (*munyova*) and eaten with sweet potatoes and cassava. For cash, groundnuts, was sold in the local market such as Mumias as boiled unshelled and shelled roasted nuts. KARI (1997) reported that in Kenya, groundnut production was carried out since the beginning of the last 20th Century. The main growing areas cited were in the Western and Nyanza Provinces but patches of cultivation were scattered in other provinces (KARI, 1997).

Based on the size of land allocated to it, groundnuts were popular and ranked 5th in Mumias division. Because of the high nutritional value of the seeds and their pleasant flavour, groundnut is one of the most important human food in the subtropics (Waele, 2001). Groundnuts are processed into a wide variety of edible products such as oil, groundnuts butter, salted groundnuts

and various confections (Waele, 2001). It also has the advantage of fixing nitrogen in the soil when intercropped which benefits subsequent crops.

Sweet Potatoes (*Ipomoea batatas*)

Sweet potatoes were an important source of food to the local Wanga community of Mumias division in 1960s. It occupied about 0.56 acres of land per household. This was about 7% of the total size of land under subsistence crops (Table 4). This crop was grown by about 63% of the household in the region (Figure 5). Findings by Nekesa and Meso (1997) indicated that sweet potatoes were abundant in the in Mumias district before sugarcane was introduced. The crop was grown twice a year and this made it available throughout the year. The varieties that were prevalent were the indigenous ones that are white and red or purple in colour. The roots are eaten either boiled or roasted alone or with other foods such as tea. The young leafy shoots were at times eaten as a green vegetable in the region. Sweet potatoes are rich in carbohydrates and are high in protein. During planting, mounds were preferred by farmers working entirely with hand tools. In some areas, broad raised beds were used.

Simsim (*Sesame indicum* L.)

Simsim occupied the least size of land in 1960s with 0.07 acres per household accounting for only 1% of the size of land under subsistence crops (Table 4). Despite the small size of land under simsim, it was cultivated by about 45% of the household in the division (Figure 5). The most common varieties of simsim in the region were the white and the brown varieties. Simsim was roasted and eaten as a delicacy to accompany tea or was also bounded together with groundnuts to form a delicious pastes that would be eaten or mixed with indigenous vegetables. Simsim has a pleasant taste with an oil content of 48-55% which is the highest of any oil crop

while the protein content ranges from 44 to 48%. Earlier findings by FAO (1998b) indicated that simsim is an ancient crop in Kenya though it is currently neglected. Likewise KARI (1997) also showed that simsim is believed to have originated from East Africa, and this is supported by the existence of a very large number of its wild relatives in Africa.

Soya Beans, Beans, Yams and Green Grams

Other crops that were grown in the region included, beans by 20% of the respondents interviewed, yams (14%), sunflower (13%), green grams (11%) rice (10%), soya beans (5%) and peas (3%) (Figure 5). However, these crops occupied very small pieces of land and the crops were intercropped with other crops such as maize.

4.1.2. Indigenous Vegetable

Indigenous vegetables that were very common before the introduction of commercial sugarcane farming mainly included, spider plant (*Cleome gynandra)* jute mallow (*Corchorus olitorius)*, African nightshade (*Solanum villosum)*, vegetable amaranths (*Amaranths blitum)*, pig weed (*Amaranths pilmeri)*, cowpeas (*Vigna unguiculata)*, pumpkin leaves (*Cucurbita moschata)* sunhemp (*Crotalaria brevidens)*, African kales (*Brassica carinata)* and vine spinach (*Basella alba)*. These vegetables provided the body with necessary vitamins that is important in protecting the body against diseases. These vegetables grew in the wild, grew as weeds on farms or were cultivated by farmers. These vegetable species have high growth rates, especially in soils rich in organic matter. They take about 3-4 weeks to mature. Some farmers use them as soil fertility indicators (Nekesa and Meso, 1997). When broadcast in the field at close spacing, indigenous vegetables can suppress other, non-edible weeds, especially on fertile soils. These crops also suppress pests (Nekesa and Meso, 1997). The main method of cooking these vegetables was

boiling without fats. Table 5 shows the common indigenous vegetable species that were common in the 1960s before the introduction of commercial sugarcane farming in Mumias division.

Table 5: Common Indigenous Vegetable species in Mumias Division before the Introduction of Commercial Sugarcane Farming.

Luhya Name	English	Scientific Name
Tsisaka	Spiderplant	*Cleome gynandra*
Likhubi	Cowpeas	*Vigna unguiculata*
Lisutsa	African nightshade	*Solanum villosum*
Omurere	Jute mallow	*Corchorus olitorius*
Lisebebe	Pumpkins	*Cucurbita moschata*
Litoto	Vegetable amaranths	*Amaranths blitum*
Emiro	Sunhemp	*Crotalaria brevidens*
Kanzira	African kale	*Brassica carinata*
Inderema	Vine spinach	*Basella alba*
Tsimboka	Pig weed	*Amaranths dubians*

Source: Field data 2007

Figure 6 shows the number of respondents growing indigenous vegetable species before the introduction of commercial sugarcane farming. The vegetables were grown as intercrops with other stable food crops such as maize and sorghum.

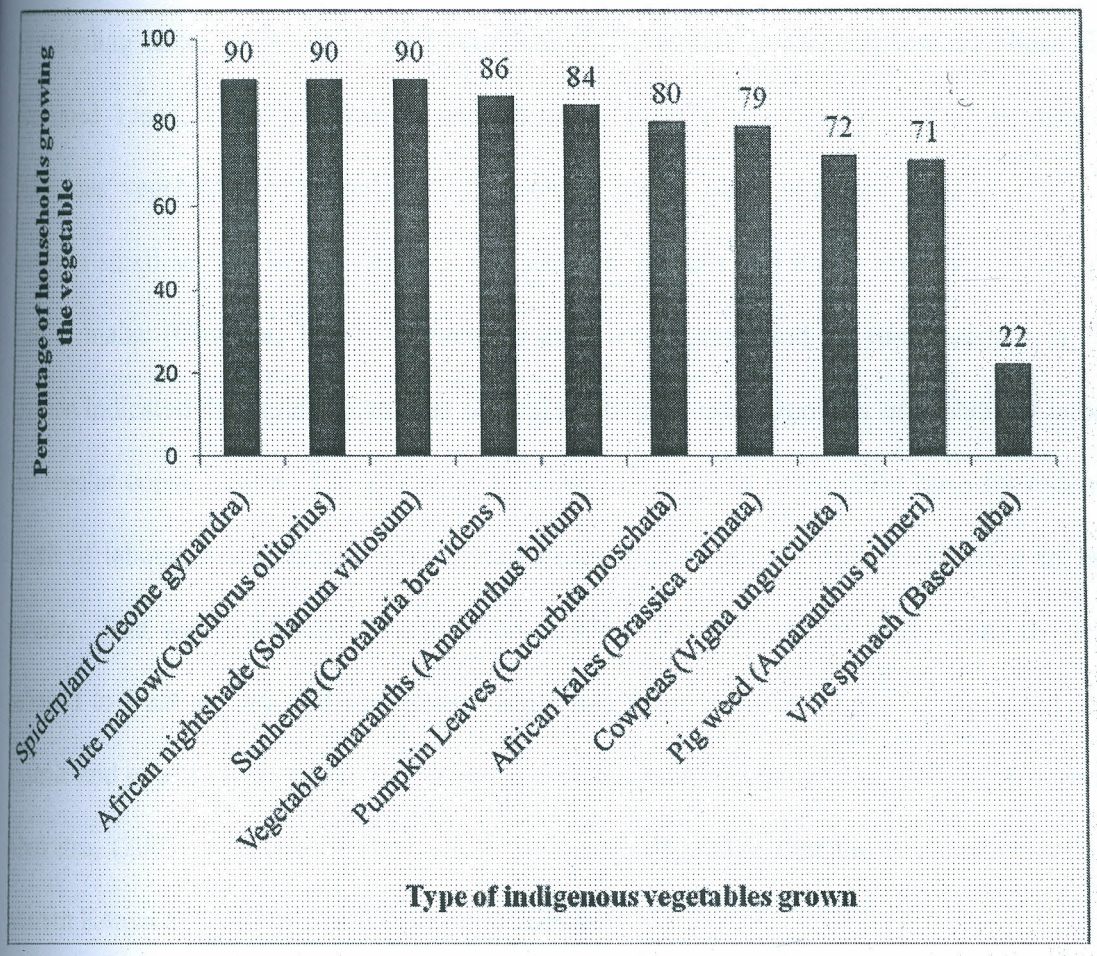

Figure 6: Percentage Number of Household in Mumias Division Growing Specific Indigenous Vegetable Species in 1960s.

Source: Field data 2007

Spider Plant/Tsisaka-Luhya (*Cleome gynandra)*

The study established that spider plant (*Cleome gynandra),* was the most common indigenous vegetable species in the 1960s with 90% of the household growing this vegetable species on their farms (Figure 6). The leaves of spider plant contain 5% protein, 6% carbohydrates and are rich in vitamin A and C (Obuoyo, 2005). Once dried, the leaves can be stored for up to two years and this is helpful during famine years (Infonet- biovision, 2010). They can be grown as much as twelve times in a year (Obuoyo, 2005). The high fibre content of the leaves enables them to be stored for a long time. Spider plant is delicious and takes long before spoiling. The vegetable has

an appealing taste, were often fried with cows' fat which is less expensive. These findings confirmed Ivens, (1967); Chweya and Mnzava, (1997) who reported that in Kenya, the indigenous vegetables commonly grown include spider plant (*Cleome gynandra* L.). It was grown in small sectors of the farm such as kitchen gardens and along the rows of staple crops such as maize (Chweya, 1997). Indigenous knowledge possessed by rural women in Mumias division indicated that spider plant has several medicinal uses (Opole *et al.*, 1995). It is believed that regular consumption of spider plant by expectant women eases child birth by reducing the length of labour, helps them regain health faster and stimulates milk production in lactating mothers. This was confirmed by (Kokwaro, 1976). The concoction made from the leaves is believed to treat scurvy and marasmus, while sap from bounded leaves is squeezed into ears nostrils and eyes to treat epileptic fits and recurrent malaria (Opole *et al.*, 1995). A recent study Abukutsa, (2007) also identified the African Leafy Vegetable that the respondent preferred in western Kenya as Spiderplant (*Cleome gynandra*)

Jute Mallow/ Murere-Luhya (*Corchorus olitorius)*

Jute mallow was common in the region with 90% of the respondents growing the crop on their farms. It was mostly grown along banks of rivers such as river Nzoia. Temperatures from 20°C to 40°C and high relative humidity of 70%–80% are favourable for successful cultivation. Such climatic conditions are achievable in Mumias division. Jute mallow requires 5–8 cm of rainfall weekly and more during the sowing period (Obuoyo 2005). The jute mallow is harvestable three (3) to four (4) weeks after planting and can be re-harvested three (3) or four (4) times a season. The leaves are very nutritious, rich in iron, protein, calcium, thiamin, riboflavin, niacin, folate, and dietary fiber (Infonet- Biovision, 2010). Palada and Chang, (2003) reported that jute mallow is native to Africa and a very important source on nutrients.

African night shade/ Lisutsa-Luhya (*Solanum villosum)*

African nightshade was grown by 90% of the respondents in Mumias division making it to be the joint most popular vegetable species in the region together with jute mallow and spider plant (Figure 6) in the 1960s. African nightshade grew in the wild, were cultivated in organic plots such as kitchen gardens, or grew as weeds in the farms. The focus group participants stated that most of the wild vegetables such as African night shade had a large number of seeds. Therefore, these wild vegetables would probably spread easily and continue to grow over the years, thus, there was no need perceived for cultivation. Their leaves were eaten as a cooked vegetable, often mixed with other vegetables such vegetable amaranths. The common varieties of nightshade in the region were the bitter taste and the 'sweet'. For the bitter one, the water was discarded particularly after being boiled. The raw leaves of African nightshade contain 4% protein, 6% carbohydrates and are moderately high in vitamin C (Infonet- biovision, 2010). African nightshades can grow on a wide range of soil types but do not tolerate drought (AVRDC, 2004). These findings are in agreements with Were (1989) and Abukutsa (2003) who reported that African nightshade *(Solanum villosum)* among other leafy vegetables were used as food and were popular among the Luhya communities of western Kenya. These study finding are similar to those of Keller (2004) who indicated that African nightshade was the most important vegetable for farmers in Arumeru, Singida and Muheza districts, Tanzania but was only or mainly gathered from the wild.

Sunhemp/ Miroo-Luhya (*Crotalaria brevidens)*

Sunhemp was the fourth common indigenous vegetable in the region with 86% of the respondents growing the crop on their farms. This crop is rich in vitamin A and C and minerals required by the local community of Mumias division. Chweya and Eyzaguirre (1999) reported

that traditional leafy vegetables especially sunhemp have been important ever since to meet the nutritional needs of Tanzanian people.

Vegetable Amaranths/ Litoto-Luhya (*Amaranths blitum)*

Vegetable amaranths were cultivated by 84% of the respondents (Figure 6). These vegetables grew in the wild, grew as weeds on farms or were cultivated by farmers. The common varieties in the region were the dark green, red, purple coloured varieties. This vegetable species was ranked fifth in importance in Mumias division. The leaves were cooked alone or combined with other leafy vegetables such as spider plant and pumpkins. The leaves are rich in calcium, iron and vitamins A, B and C. (Palada and Chang 2003). The results are in agreement with Stallknecht and Schulz-Schaeffer, (1993) and Keller, (2004) who reported that Vegetable amaranth species are collected from the wild for subsistence, while only few are cultivated or occur as protected weeds in backyards and home gardens. Though these vegetable species ranked fifth in importance in Mumias division, Vegetable amaranth ranked second in the humid districts of Arumeru and Muheza and only fourth in the dry Singida and Kongwa districts of Tanzania in 2004 (Keller, 2004).

Pumpkin/ Liseveve-Luhya (*Cucurbita moschata)*

Pumpkins have long-running, bristled stems, large deeply-lobed leaves often containing white blotches and yellow or orange flowers separated into male and female types on the same plant (Infonet Biovision 2010). Eighty Percent (80%) of the households in Mumias division cultivated pumpkin leaves in the 1960s (Figure 6). The younger leaves are collected and the outer tough skin of petioles (stalk of leaf) removed (together with the large leaf veins) then washed, chopped and boiled. Leaves and flowers of pumpkins are used as vegetables. Besides, the fruit is boiled

and eaten as a meal. Pumpkin fruit contains 1% protein and 8% carbohydrates, and the dried seeds contain 23% protein, 21% carbohydrates and up to 50% oil, (Woomer and Imbumi, 2005). Pumpkin leaves were often eaten to prevent the body from diseases because they provided vitamin A.

This crop was usually grown in areas with high nutrient concentrations such as kitchen waste dumping sites, former cattle sheds and demolished mud huts. Pumpkins are drought tolerant plants and once established the leaves are harvested all the year round. Field research indicated that the main reason responsible for the high number of households (80%) cultivating pumpkins is the nutritive value of pumpkin fruit and pumpkin leaves. Lactating women in the Mumias division are normally fed on pumpkins. Swai (1991) confirmed that malnutrition among children, pregnant and lactating mothers can be partially alleviated by consumption of dark green leafy vegetables such as pumpkin leaves, which are excellent sources of proteins, vitamins and minerals.

African Kale/ Kanzira-Luhya *(Brassica carinata)*

African kale was popular in the region in 1960s and was grown by 79% of the households (Figure 6). Abukutsa (2007) reported that African kale was popular in three countries of East Africa including Kenya. They reported that vegetables such as African kale have been grown and consumed by the people of East Africa for many years. Ekesa (2009) reported that African kale have high nutritive value, they contain high levels of minerals especially calcium, phosphorous and iron, vitamins and proteins and in most cases, the vitamin supersedes that found in popular exotic vegetables.

Cowpea/ Likhubi-Luhya (*Vigna unguiculata)*

Cowpea was cultivated by 72% of households in Mumias division in 1960s (Figure 6). Cowpeas are basically annual crops grown for their leaves and seed. Their fresh leaves can be boiled and eaten or dried and preserved for future use. Cowpea bean contains 61-66% carbohydrates, 24-25% proteins and 1-2% fat (Bressoni, 1985). The seed pods, leaves and young stems are edible. Tender cowpeas leaves and shoots contain 4% protein, 4% carbohydrates and are rich in carbohydrates, calcium, phosphorous and vitamin B (Obuoyo, 2005). The roots of cowpeas have the ability to fix nitrogen in root nodules through symbiosis with rhizobium bacteria (Woomer *et al.*, 2002). The growth habit is climbing, spreading or erecting. A recent study by Ekesa *et al.* (2009) revealed that the most popular indigenous vegetable was cowpea leaves, which had been consumed by 85% of the households. In this study, cowpeas was ranked 8th with 72% of the respondents cultivating an indication that in the 1960s, cowpeas was not as popular as it is today in the region.

Pig weed/ Tsimboka-Luhya *(Amaranths dubians)*

Pig weed was cultivated by 71% of the respondents (Figure 6). The vegetable mainly grows in the wild or semi cultivated land hence referred to wild amaranths. The PRA discussion established that prior to the introduction of sugarcane in Mumias division, pig weed grew naturally in the wild and on the fertile farms in the rain season. The PRA also established that this vegetable species also require fertile soils rich in organic manure from animal wastes and decomposing kitchen wastes. Nekesa and Meso (1997) indicated that many traditional African vegetables including pigweed may be classified as 'edible weeds'. Most African leafy vegetables are just common weeds of cultivation that occur during rainy seasons and shortly after, most of

them can be easily found growing in degraded land and built-up areas, along rivers, roadsides and forest edges (Wild Living Resources, 2011) The vegetables are very good sources of vitamins such as vitamin A, vitamin B6, vitamin C, riboflavin, and folate, and dietary minerals including calcium, iron, magnesium, phosphorus, potassium, zinc, copper, and manganese (Muthaura *et al*, 2010). Pig weed occupy an important role in household nutrition throughout the world particularly in rural areas. Indigenous vegetables such as pigweed can contribute substantially to food security in the developing world and therefore need to be fully integrated in our farming systems (Muthaura *et al*. 2010).

Vine spinach/ Inderema *(Basella alba)*

Vine spinach grows well in hot and humid climates and in areas lower than 500 m above sea level. It requires high temperatures to mature. It grows best in sandy loam soils rich in organic matter with pH ranging from 5.5 to 8.0 (Infonet- biovision, 2010). Vine spinach is high in vitamin A, vitamin C, iron, and calcium. Vine spinach was the least common vegetable species in the region in 1960s being found on only 22% of the households farms (Figure 6). This vegetable grew in the wild. Vine spinach has the highest value of carbohydrate content of 6.2g/100g and protein contents of 2.1g/100g. The PRA findings also established that currently vine spinach has become extinct in the region. Abukutsa (2011) confirmed that of the approximately 200 indigenous species of plants that were used by Kenyans as vegetables in the past, most were either collected in the wild, semi-cultivated, or cultivated. Now many are either unknown or extinct. The research established that vine spinach is one such indigenous vegetable in Mumias division.

4.2. Effect of Commercial Sugarcane Farming on Subsistence Crops in Mumias Division in 1970s

Agricultural diversity in Mumias division started deteriorating with the introduction of sugarcane as a monoculture crop which was believed to generate more income. This led to the simplification of biodiversity through the introduction of commercial sugarcane farming which occupied most of the farms. With the introduction of commercial sugarcane farming in 1972, bigger portions of land were designated for sugarcane farms leaving small portions assigned to subsistence crops such as maize, sweet potatoes, sorghum, finger millet, cassava and pulses such as simsim, groundnuts and bambara groundnuts. This contributed to the deterioration of agro biodiversity. The decline of traditional varieties/landraces of subsistence food crops is called genetic erosion (Picone and van Tassel, 2002). This eventually leads to loss of genetic diversity, thus loss of genes necessary for improvement of food crops against pests, diseases, environmental stresses like water deficit and salinity. By losing landraces through commercial sugarcane farming, there is the undermining of the ability of crops to adapt to future conditions, including climate change (Picone and van Tassel, 2002). Table 4 shows how the introduction of commercial sugarcane farming impacted on the growing of subsistence crops in the study area in the 1970s.

Table 6: **Types of Crops Grown and Acreages of Land Under Crops in Mumias Division after the Introduction of Commercial Sugarcane Farming (1970s)**

Total size of land per household (acres)	Total size of land under crops(acres)	Types of Crops Grown	Mean Acreages per household	Percentage acreages under each crop (%)
6.5	6.31	Sugarcane	2.25	36
		Maize	1.52	24
		Sorghum	0.58	9
		Cassava	0.51	8
		Finger millet	0.38	6
		Ground nuts	0.45	7
		Sweet potatoes	0.33	5
		Bambara groundnuts	0.22	3
		Simsim	0.07	1
		Others	0.07	1

Source: Field data 2007

Sugarcane (*Sacharum officinaram*)

Commercial sugarcane farming was the most dominant crop in the study area in 1970s. It occupied a mean of 2.25 acres of land per household accounting for about 36% of the land under crop cultivation. The study established that the average size of land under sugarcane cultivation increased from 2% in 1960s to 36% in 1970s (Tables 4 and 6). The reasons given by the respondents for the increase in the size of land under sugarcane was that Mumias Sugar Factory was established in 1973 (Kenya Sugar Board, 2011) and many farmers registered as outgrowers. The company offered ready market and improved incomes.

Maize (*Zea Mays L)*

Maize was established as the second in 1970s with 1.52 acres of land per household under the crop (Table 6). It occupied about 24% of the total size of land under crop cultivation. This was a

6% decline from the 30% size under the crop in 1960s (Tables 4 and *6*). The reasons given by the respondents for the decline in the size of land under maize were as follow. Fifty two percent (52%) of the respondents attributed the decline in maize to sugarcane farming which caused a major shift household crop cultivation patterns. Eileen, (1987) established that the expansion of land under sugarcane replaces the area under maize. The PRA established that in the 1970s, the common maize species cultivated were the hybrid varieties which had replaced the local landraces that were prevalent in the 1960s. In Mumias division, the decline of local maize landraces such as (*namba nane)* and (*shipindi*) as a result of introduction of hybrid varieties implies a decline in genetic diversity a situation that could lead to extinction if conservation measures are not put in place.

Sorghum (*Sorghum bicolour L.* Moench)

Sorghum was the third common subsistence crop in Mumias division in 1970s with 0.58 acres of land per household under the crop (Table 6). It occupied about 9% of the mean size of land under crop cultivation per household in the division this was an 8% decline from the 17% size under the crop in 1960s (Table 4 and 6). Various reasons were given by the respondents for the decline in the size of land under sorghum. Sixty seven percent (67%) of the respondents attributed the decline in the size of land under sorghum to sugarcane farming. Fourteen percent (14%) of the respondents attributed the decline to pests and diseases especially the birds that attack the crop when nearing the harvesting season and reduces yields. Nineteen percent (19%) of the respondents attributed the decline to change in tastes and preference with preference being given to maize. Romain (2001) reported that sorghum has lost much of its traditional area of growth in Africa to the introduced maize which is particularly vulnerable to droughts and low soil fertility. As indicated by Upreti and Ghale (2002) and FAO (2004) commercialization of agriculture such

as sugarcane monoculture farming may significantly contribute to food crop diversity loss including sorghum in the study area.

Cassava (*Manihot esculenta Rantz)*

Cassava occupied an area of about 0.51 acres per household accounting for about 8% of the total land under subsistence crops in 1970s (Table 6). It was ranked forth in popularity. This was an 8% decline from the 16% under cassava in 1960s (Table 4). The reasons given by respondents for the decline in cassava were sugarcane farming as reported by 78% of the respondents. Twenty two percent (22%) respondents attributed the decline to pests such as moles and diseases such as cassava mosaic diseases having discouraged many of the farmers from growing the crop.

Akhwale *et al.* (2006) also attributed the decline in cassava in western Kenya to pests and diseases especially the cassava mosaic disease. Waswa *et al.* (2009a) reported that sugarcane is the most widely grown commercial crop, having replaced most indigenous crops like cassavas and vegetables in sugar belts, despite their ecological suitability and high nutritive and income value.

Finger Millet *(Eleusine coracana L* Gertn)

Unlike in 1960s where finger millet was ranked fourth in popularity, in 1970s, finger millet was ranked fifth in popularity. It occupied 0.38 acres of land per household which was 6% of the total size of land under subsistence crops in the division (Table *6*). This was a 6% decline from the 12% that was under the crop in the 1960s (Table 4). The reasons given by respondents for the decline in size of land under finger millet were sugarcane farming as reported by 81% of the respondents. Fifteen percent (15%) of the respondents, attributed the reduced size of land under

finger millet on the farms to change of taste and preference especially by the young generation between age 5 and to 18 years who prefer maize meal (ugali) made from maize other than one made from finger millet. Labour intensiveness especially during weeding was cited by 4% as a major cause to the decline in the size of land under finger millet. National Research Council (1996) pointed out that finger millet is being rejected in favour of other monoculture crops such as sugarcane, maize and sorghum, which provide more income. However, sugarcane farming is not the only cause for the decline in finger millet. Louise *et al.*, (2001) reported that farmers in Malawi are neglecting their own traditional crop varieties and their wild relatives in favour of maize monoculture and other market-driven crops such as cotton.

Sweet Potatoes (*Ipomea batatas*)

Sweet potatoes occupied 0.58 acres of land per household accounting to about 5% of the total size of land under subsistence crops in the division This was a 2% decline from the 7% under the crop in 1960s (Tables 4 and 6). The reasons given by the respondents for the decline included sugarcane farming as reported by 41% of the respondents. Fifty percent (50%) of the respondents attributed the decline to pests and diseases especially the moles. Nine percent (9%) of the respondents reported that the decline in the size of land under sweet potatoes was land fragmentation.

Similar results were obtained in Swaziland (FAO, 2008) where it was established that establishment of sugarcane plantations led to reduction of land under sweet potatoes and other activities. Studies have shown that the most common viral diseases affecting sweet potato in western Kenya are Sweet Potato Feathery Mottle Virus (SPFMV), Sweet Potato Chlorotic Stunt Virus (SPCSV) and Sweet Potato Mild Mottle virus (SPMMV) (KARI 2005. Likewise, Woolfe

(1992) reported that *Meloidogyne spp* (root rot) and *Rotylenchus reniiformis* is the major known bacterial diseases of sweet potatoes in the tropics.

Groundnuts (*Arachis Hypogaea L.*)

Groundnuts occupied 0.45 acres of land per household accounting to about 8% of the total size of land per household under crops in 1970s (Table 6). This indicated that there was a very small decline (1%) in the size of land allocated to groundnuts between 1960s and 1970s (Tables 4 and 6). The reason given by the respondents for the decline in groundnuts were labour intensiveness as reported by 60% of the respondents and pests and diseases as reported by 40% of the respondents. They maintained that sugarcane did not have any negative effect on the cultivation of groundnuts. Netondo *et al.* (2010) reported that despite large sizes of land in Mumias and Nzoia sugarbelt having been converted to sugarcane growing, some crops such as groundnuts are still being grown by some farmers because they are usually intercropped with sugarcane in the early stages of sugarcane growing up to about one(1) meter height.

Bambara Groundnuts (*Vigna subterranea L.* Verde)

Bambara groundnuts occupied 0.22 acres of land per household accounting to about 3% of the total size of land per household under crops in 1970s (Table 6). This indicated that there was a 4% decline from the 7% allocated under bambara groundnuts in 1960s (Table 4).Various reasons were given by the respondent for the decline in the size of land under bambara groundnut. Thirty six percent (36%) of the respondents attributed the decline to labour intensiveness, twenty four percent (24%) of the respondents attributed the decline to change in taste and preference with preference being given to groundnuts. Forty percent (40%) of the respondents attributed the decline in the size of land under bambara groundnuts to cultural noms associated with the

cultivation of bambara groundnuts. For instance a person putting on shoes should not cross a farm is under bambara groundnuts. The respondents indicated that bambara groundnuts are grown on small scale and as intercrops with sugarcane and maize and do not require special pieces of land to be set aside for their cultivation. Ngugi (1995) reported that bambara groundnuts is usually intercropped with crops such as maize, sugarcane and finger millet. However, it is important to note that the intercropping of groundnuts or bambara groundnuts with sugarcane is practiced in the first eight months of sugarcane crop life (FAO 2004). Nekesa and Meso, (1997) and Andika *et al.* (2010) reports indicate that cultivated area and production trend of oil crops like bambara groundnuts have remained fairly constant in Mumias district. Other findings by Ngugi (1995) indicated that bambara groundnut production is declining in Kenya due to high cost of purchasing seeds and cultural erosion with the young generation shifting from bambara groundnuts to groundnuts. In Nigeria, Tanimu and Aliyu (1995) reported that bambara groundnuts cultivation has declined due to neglect since it is not used for industrial purposes compared to other legumes such as groundnuts. Swanevelder (1995) reported that bambara groundnut is a neglected crop in South Africa owing to the labour intensive harvesting process.

Simsim (*Sesumum indicum L.*)

The findings of this study from 1970s clearly indicate that in Mumias division, one of the least crops grown in the region from the 1970s was simsim with mean size per household is repistaring negligible (Table 6). In 1970s only 0.07 acres of the total size of land under crops per household was under the simsim. This accounted for only 1% of the total size of land under crops. The findings indicate that there was no change in the size of land under simsim between 1960s and 1970s (Tables 4 and 6). Various reasons were given by the respondents for the small size of land under simsim and for the lack of change in the size of land under simsim over the two decades.

Ninety percent (90%) of the respondents reported that the cultivation, harvesting, drying and processing of simsim is labour intensive and requires specialised skill. Pests and diseases were reported by 10% as a major cause of the small size of land under simsim. KARI (1997) indicated that many pests are known to attack simsim but the most important one in Kenya is the web-worm (*Antigastra catalaunalis*). (Mponda 1996; Mponda *et al.*, 1997a; Mponda *et al.*, 1997b) also shows that simsim is labour intensive and requires new virgin land with high soil fertility.

Indigenous Vegetables

Indigenous vegetables that were very common after the introduction of commercial sugarcane farming mainly included spider plant, jute mallow, African nightshade, vegetable amaranths, pig weed, cowpeas, pumpkin leaves, sunhemp and African kales. These Indigenous vegetables species were grown as intercrops in the region and on rotational basis in the same year. The research established that sugarcane farming had an indirect effect on the cultivation of these indigenous vegetables. Figure 7 shows the Percentage number of household in Mumias division growing specific indigenous vegetable species in 1970s.

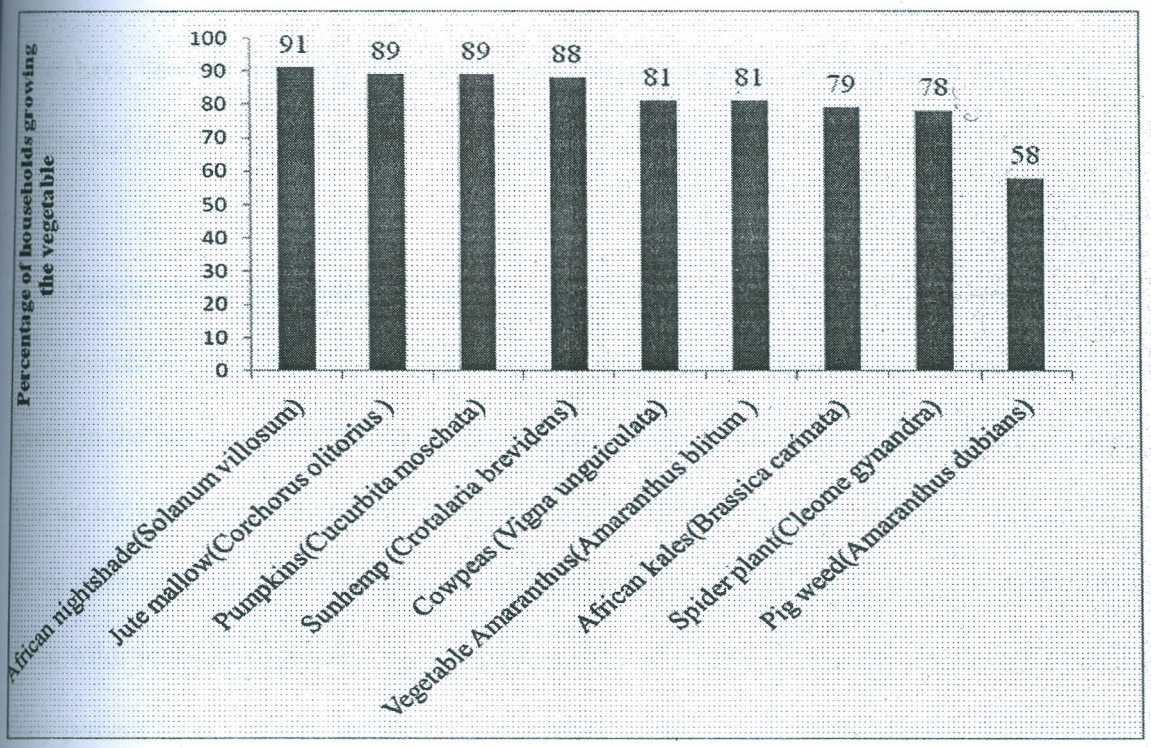

Figure 7: Percentage Number of Household in Mumias Division Growing Specific Indigenous Vegetable Species in 1970s.

Source: Field data 2007

Vine Spinach (*Basella alba)*

The research findings established that vine spinach (*Basella alba*) which used to be common in the region in 1960s as reported by 22% of the households before the introduction of sugarcane cultivated. Among the respondents interviewed, none of them had vine spinach on their farms. During a Focus Group discussions, the respondents reported that the clearing of large pieces of land to create space for sugarcane farming altered the natural habitat for the growing of vine spinach which used to grow in the wild. The respondents also reported that change in tastes and preference with more preference being put on exotic vegetables such as kales has led to a decline in vine spinach. Grivetti, (1976) and Fleuret, (1979) reported that most farmers' throughout

Africa have been abandoning traditional varieties of crops in preference to introducing high yielding varieties.

African night shade (*Solanum villosum*)

The research established that in 1990s African nightshade was the most common vegetable species in the region with 91% of the respondents growing it (Figure 7). This was a 1% increase from the 90% growing the crop in 1960s (Figure 6). The reason given by 40% of the respondents for the increase in the size of land under African night shade was that this vegetable species grew in the wild, in kitchen gardens and in cattle shed and didn't necessarily need to be cultivated. Forty percent (40%) of the respondents reported that these vegetables species are delicious and were preferred by most old people. Forty percent (40 %) of the respondents also indicated that the crop is medicinal and was used in curing stomach ache. Twenty Percent (20%) of the respondents indicated that these vegetable species can stay for many days after cooking without getting spoilt. Oniang'o *et al.* (2003) reported that African nightshade can be consumed as an accompanying relish for ugali, and can be combined with less bitter greens for a more balanced flavor. Medicinally, they reported that it is used to cure tooth aches and stomach pains.

Jute Mallow (*Corchorus olitorius)*

A reducing trend was noted in the number of the respondents growing jute plant (luhya murere) vegetable species in 1970s. Eighty nine percent (89%) of the respondents grew the vegetable species in 1970s (Figure 7). This was a one percent (1%) decline from the 90% of the respondents under the vegetable in 1960s (Figure 6). Jute mallow was ranked second in popularity in the region. Ninety Percent (90%) of the respondents attributed the decline identified in the number of farmers growing jute plant to change in eating habits with preference being

given to exotic vegetable species. The research findings are also in agreement with those of Jeanne (2009) who reported that as a result of crop westernization with emphasis on exotic and hybrid species, at least 200 indigenous crops once heavily cultivated in Africa including such species as jute mallow have been declining in the world.

Pumpkins (*Cucurbita moschata*)

Eighty nine percent (89%) of the respondents cultivated pumpkins on their farms in 1970s (Figure 7). This showed that there was a 9% increase in the number of households growing pumpkins from 1960s to 1970s. It was ranked second together with jute mallow in popularity in the region. Ninety Percent (90%) of the respondents attributed the increase in the size of land under pumpkins to the fact that pumpkins played a key role in nutrition. They reported that the fruit is eaten as a meal and the leaves as vegetable. The respondents also pointed out that the crop occupies a very small piece land and could easily be grown and managed on both cultivated and non cultivated piece of land.

Sunhemp (*Crotalaria brevidens)*

The study established that in 1970s, sunhemp was cultivated by 88% of the respondents (Figure 8). This was a 2% increase from the 86% of the respondents who cultivated the crop in 1960s (Figure 6). Sunhemp was ranked fourth in popularity in 1970s. However the Focus Group Discussion reported that the increase in sunhemps popularity was because the crop is delicious and preferred by most people of all generations. Infonet-Biovision (2010) notes that these vegetable species is rich in vitamin A and C.

Cowpeas (Vigna unguiculata)

The research established that the number of farmers growing cowpeas in 1970s were 81% (Figure 7). This was a 9% increase from the 72% of respondents who grew the crop in 1960s. Fifty percent (50%) of the respondents attributed the increase to ready market of the crop on the market. Thirty percent (30%) of the respondents reported that the increase in cowpeas was due to its delicious tastes and nutritional value. Cowpea bean contains 61-66% carbohydrates, 24-25% proteins and 1-2% fat (Bressoni, 1985). Cowpeas leaves and shoots contain 4% protein, 4% carbohydrates and are rich in carbohydrates, calcium, phosphorous and vitamin B (Obuoyo, 2005). Ten (10%) also reported that cowpeas yield more as compared to other indigenous vegetables. They reported that it has a higher vegetative value and the seeds are also used for food. Ten percent (10%) of the respondents attributed the increase in cowpeas to the availability of seeds on the market at a cheaper price. The seeds cost lower (Ksh40 per glass) as compared to the other indigenous vegetables. A recent study by Ekesa *et al*, (2008) indicated that cowpeas are the most popular vegetable species in the neighboring Matungu division. The yields of cowpeas are always higher and the crop can withstand harsh conditions (Ekesa *et al*, 2008). Wanjekeche *et al*., (1997) confirmed that basing on tastes and preference cowpeas was the second highly accepted legume after pigeon pea in the Cheptuya village of North Western Kenya.

Vegetable Amaranths (*Amaranths blitum)*

In the 1970s vegetable amaranths was either cultivated or at times grew as weeds in farms. The research established that 81% of the respondents grew vegetable amaranths in Mumias division in 1970s (Figure 7). This was a 3% decline from the 84% of household who grew the vegetable in 1960s. Various reasons were advanced to have attributed to the decline in vegetable amaranths in the region. The PRA established that this vegetable species growing in sugarcane farms were

usually considered as weeds hence were uprooted. Nekesa and Meso (1997) indicated that many traditional African vegetables may be classified as 'edible weeds'. This is in agreement with recent reports in Uganda (Byanjeru 2007) and South Africa (FAO, 2008). In the later case (FAO, 2008), reported that herbicides are reported to kill the edible weeds in sugarcane farms in South Africa.

African Kales (*Brassica carinata*)

The research established that 79% of the respondents grew African kales in 1970s (Figure 7). These findings showed that there was no change in the number of households cultivating African kales in 1960 and 1970s (Figures 6 and 7). The research established that African kales grew in kitchen gardens and semi cultivated field. These vegetable species were reported to be delicious and preferred by households of all age groups because of their nutritive value. African kale have high nutritive value, they contain high levels of minerals especially calcium, phosphorous and iron, vitamins and proteins (Ekesa *et al.*, 2009).

Spider plant (*Cleome gynandra)*

Spider plant was cultivated by 78% of the respondents (Figure 7). This was a 12 % decline from the 90% of households who grew the vegetable in 1960 (Figure 6). Unlike in 1960s where spider plant was the most popular vegetable species in the region, in the 1970s, it was the second least vegetable species in popularity. Various reasons were reported to have contributed to the great decline in spider plant. Forty one percent (41%) of the respondents attributed the decline experienced in the 1970s to sugarcane farming. They reported that the vegetable was uprooted from sugarcane farms as weeds. Fifty percent (50%) of the respondents attributed the decline to change in tastes and preferences with preference being given to exotic kales (*sukumawiki*). Nine

percent (9%) of the respondents indicated that they did not have enough skill in the cooking of indigenous vegetable. They reported that spider plant takes a long time in preparation and requires special skill during cooking. Poor cooking skills would lead to it being bitter and less delicious.

Obuoyo, (2005) reported that spider plant is a common weed of disturbed and cultivated ground, road sides and is distributed throughout most of Africa. Mathenge (1995) and Nekesa and Meso (1997) pointed out one problem facing indigenous vegetable in Kenya is lack of awareness of their nutritive value and the general notion that African traditional vegetables are 'backward'. This has led to large scale genetic erosion in their traditional areas of cultivation including wild relatives in their natural environment (Chweya and Nzava 1997).

Pigweed (*Amaranths dubians)*

This vegetable species was given negligible attention by the respondents interviewed. They reported that pigweed grows in the wild mostly in cowshed and kitchen dumping site. Pigweed was cultivated by 58% of the respondents in 1970s (Figure 7). This was a 13 % decline from the 71% of the respondents who grew the crop in 1960s. The reasons given for the decline in this vegetable species were the decline in the number of livestock in the region as reported by 21% of the respondents. They reported that the decline in livestock has led to a decline in animal wastes. Pigweed commonly grows in kitchen gardens and cattle sheds. Fifty percent (50%) of the respondents attributed the decline to change in tastes and preference with many community members preferring exotic species. Pig weed was viewed as a poor mans crop in the region. Twenty nine (29%) reported that weeding especially in sugarcane plantations destroys most the

pigweed. FAO, (2008) reported that the disappearance of vegetable such as pigweed puts the world's food supply at risk. Diversity allows the species to adapt to various pests and diseases.

4.3. Effect of Commercial Sugarcane Farming on Subsistence Crops in Mumias Division in 1980s

Findings from the research have established that as the size of land under sugarcane increased in the 1980s, the size of land under indigenous crops declined over the same period. FAO (2008) reported that instead of planting a wide variety of different crops such as sorghum, bambara groundnuts, finger millet, sweet potatoes and soya like in the 1960s, many farmers have concentrated on growing a single cash crop such as sugarcane. This has lead to heavy losses in the world's agricultural biodiversity such as cassava. FAO (1998) reported that change in land use particularly conversion to monoculture leads to loss of agro-biodiversity.

Table 7: Types of Crops Grown and Acreages of Land under Crops in Mumias Division after the Introduction of Commercial Sugarcane Farming (1980s)

Total size of land per household (acres)	Total size of land under crops(acres)	Types of Crops Grown	Mean Acreages per household	Percentage acreages under each crop(%)
6	5.64	Sugarcane	2.72	48
		Maize	1.12	20
		Sorghum	0.35	6
		Cassava	0.28	5
		Finger millet	0.21	4
		Ground nuts	0.49	9
		Sweet potatoes	0.23	4
		Bambara groundnuts	0.19	3
		Simsim	0.05	1

Source; Field data 2007

Sugarcane (*Saccharum officinarum)*

In the 1980s, sugarcane occupied 2.72 acres of land per household. This accounted for 48% of the total size of land under crops cultivation in the division compared to 36% in 1970s (Tables 6 and 7). Reasons given by the respondents for the increase in the size of land under sugarcane were as follows. Sixty percent (60%) of the respondents of the respondents attributed the increase to good payment from the Mumias Sugar Factory as compared to income generated from other subsistence crops. Thirty percent (30 %) of the respondents reported that the farmers could easily get loan from Mumias Sugar Company that would enable them pay fees for their children without straining. Ten percent (10%) of the respondents reported that Mumias Sugar Company provided inputs such as seedlings and fertilizers making the cultivation of the crop demanding in terms of input costs.

Maize (*Zea mays L.*)

Maize occupied 1.12 acres of land per household accounting for 20% of the total size of land under crops in 1980s (Table 7). This was a 4% decline from the 24% size under the crop in 1970s (Table 6). The reasons given by the respondents for the decline in the size of land under maize were as follows; fifty two percent (52%) of the respondents attributed the decline to sugarcane farming. They reported that much of the land that was previously under maize was transformed into sugarcane farms hence reducing the size of land available for maize cultivation. Similar findings were reported in Brazil (Carlos, 2009) where sugarcane replaced other crops such as maize with confirmed decline of land area under the crop and increase in sugarcane. Cunneyworth (2001) reported that due to the population increase of 2.7% in Kenya, a critical point has been reached in some areas of the country where the land parcels received by the younger generation are too small and/or too degraded for adequate food security for their own

families. He further reported that the lands are inadequate for the production of maize which is a staple food the community. The respondents further reported that in the 1980s, the common maize varieties cultivated were the hybrid varieties which had replaced the local landraces that were prevalent in the 1960s. Ninety percent (90%) of the respondents reported that the hybrid landraces are high yielding and matured faster as compared to the indigenous land races

Sorghum (*Sorghum bicolour L.* Moench)

In the 1980s, sorghum occupied 0.35 acres of land per household. This accounted for 6% of the total size of land per household under crops (Table 7). The study established that there was a 3% decline in the size of land under sorghum from 1970s to 1980s (Tables 6 and 7). Various reasons were given by the respondents for the decline in the size of land under sorghum. Sixty seven percent (67%) of the respondents reported that the decline in the size of land under sorghum was due to sugarcane farming. Fourteen percent (14%) of the respondents attributed the decline in the size of land under sorghum to pests and diseases especially the birds that attack the crop when nearing the harvesting season which hence reduced yields. Nineteen percent (19%) of the respondents attributed the decline to change in tastes and preference with more preference being given to maize. The results of this study are similar to the findings of Carlos (2011), who reported that the growing competition for land use between sugarcane and staple foods in Brazil resulted in declined production areas of land for staple foods such as sorghum between 1990 and 2005. Cagley *et al.*, (2009) reported that despite sorghums important role, both consumption and production per capita has declined in the last 20 years in sub Saharan Africa. In southern and eastern Africa, this is largely due to a movement toward maize as a result of research-led productivity increases, government policies of increasing profitability, and easier processing. A similar effect of rubber monoculture has been reported in Thailand where limited land area is

dedicated for the growing of indigenous crops such as sorghum (WRM, 2008). Yield losses caused by insect pests are estimated to cost US sorghum producers $80 million annually (Pimentel 2007).

Finger Millet *(Eleusine coracana L.* Gertn)

Finger millet occupied 0.21 acres of land per household accounting for about 4% of the total size of land per household under crops in 1980s (Table 7). This was a 2% decline from the 6% under the crop in the 1970s (Tables 6 and 7). Various reasons were given by the respondents for the decline in the size of land under finger millet. Eight one percent (81%) of the respondents reported that the decline in the size of land under finger millet was due to sugarcane farming. Labour intensiveness especially during weeding was cited by 15% as a major cause of decline in the size of land under finger millet. Four percent (4%) of the respondents attributed the decline in the size of land under finger millet to change in tastes and preference especially the youth children who preferred ugali made from maize than one from finger millet. They reported that finger millet was associated with the poor and the old.

FAO (2008) is in agreement that finger millet, which is a traditional subsistence staple grown in western Kenya and throughout East Africa has been declining over the last 50 years due to changing farming systems such as commercial monocultural farming. Oduori (2005) reported that the decline in the size of land under finger millet is the difficulty in weeding which is complicated by wild relatives of the crop (e.g. *Eleusine indica*) that look like finger millet at the time of weeding. Cagley *et al.*, (2009) reported that some indigenous crops require more labour and this difficulty is particularly pronounced in finger millet cultivation. Mburu, (1989) reported that finger millet hectarage in Kenya has been declining since 1978 with a greater variation in

hectarage than production. The decline in finger millet hectarages in Kenya since 1978 can be attributed to high labour requirement and low yield per hectare compared to competitive crops like maize (Mitaru *et al.*, 1993). During this period, the farmers preferred maize which produced more and its ugali was preferred by many young people aged below 18 years.. National Research Council, (1996) confirmed that the poor attitude to the crop is also a major constraint to finger millet production in western Kenya. The crop is termed as a poor person's crop or famine food.

Cassava (***Manihot esculenta*** **Rantz)**

Cassava occupied an area of about 0.28 acres per household accounting for about 5% of the total land under subsistence crops per household in 1980s (Table 6). It was ranked forth in popularity in 1980s. This was a 3% declines from the 8% under cassava in 1970s (Tables 6 and 7). The reasons given by respondents for the decline in the size of land under cassava were sugarcane farming as reported by 53% of the respondents. According to 22% of the respondents, the decline in the size of land under cassava was as a result of pests such as moles and diseases such as cassava mosaic disease that have discouraged many of the farmers from growing the crop. Twenty percent of the respondents indicated that the decline was attributed to the fact that the respondents viewed that cassava was a poisonous crop that was dangerous to the health.

FAO (2004) report cautions that the replacement of local crops with large scale monocropping might lead to the simplification of agro ecosystem such as crops that are used directly or indirectly for food, fodder, fibres, fuels and pharmaceuticals. Cassava is one such crop. The potential loss of agro biodiversity presents risks of food production as well as posing a serious threat to rural livelihood and long term food security. NEPAD (2004) reported that the severe disease (Cassava Mosaic Disease) was first reported in Luwero district, 200 km north of

Kampala, where it had destroyed approximately 2,000 ha of cassava. Consequently farmers became discouraged and ceased growing cassava resulting into a drastic decrease in cassava production in the Uganda. They further reported that the epidemic continued to traverse and devastate cassava crops in the rest of the country and it proceeded to Kenya, the Democratic Republic of the Congo (DRC), Tanzania and Sudan where it has continued to devastate crops.

Sweet Potatoes *(Ipomea batatas)*

Sweet potatoes occupied an area of about 0.26 acres per household accounting for about 4% of the total land under subsistence crops in 1980s (Table 7). This was a 1% declines from the 5% under sweet potatoes in 1970s (Table 6). The reasons given by respondents for the decline in sweet potatoes were sugarcane farming as reported by 41% of the respondents. Fifty percent (50%) of the respondents pointed out that pests such as moles and diseases such as sweet potatoes blight were the main cause responsible for the further decline in size of land under sweet potatoes. Woofle (1992) reported that the size of land and research under sweet potatoes and other root crops and tubers has been neglected in favour of more prestigious cereals and other export cash crops such as sugarcane. Moles were mentioned as the main pest which attacks sweet potatoes. Surveys have consistently listed virus diseases, especially sweet potato virus disease (SPVD), as the most important diseases of this crop, yet they remain the most difficult diseases to manage (Valverde *et al*, 2007).

Groundnuts (*Arachis Hypogaea* L.)

Groundnuts occupied an area of about 0.26 acres of land per household accounting for about 9% of the total land under subsistence crops in 1980s (Table 7). This was a 1% increase from the 8% under groundnuts in 1970s (Tables 6 and 7). The reasons given by respondents for the increase in

groundnuts were ready market for the crop in the local markets such as Ekero and Mumias. This was reported by 40% of the respondents. Sixt percent (60%) of the respondents reported that the increase was probable because groundnuts are often intercropped with sugarcane. As the size of land under sugarcane increased, it provided more space for the cultivation of groundnuts in the region. Nekesa and Meso (1997) indicated that the intercropping may have contributed to the sustenance of the indigenous crops like groundnuts in the study area.

Bambara Groundnuts (*Vigna subterranean L.* Verde)

Bambara groundnuts occupied an area of about 0.19 acres of land per household accounting for about 3% of the total land under subsistence crops in 1980s (Table 7). This indicated that there was no change in the size of land allocated to bambara groundnuts between 1970s and 1980s (Tables 6 and 7). The reasons given by respondents for the lack of change in the size of land under bambara groundnuts in the 1980s included the fact that bambara groundnuts are grown on small scale and as intercrops with sugarcane and maize and do not require special pieces of land to be set aside for their cultivation. The respondents also reported that bambara occupies very small of land because the crop is attacked by termites and hence reducing the yield. Heller *et al*, (1997) reported that if bambara seed remain underground for a long time, they are attacked by termites. If stored when shelled, they are attacked by common bean weevil hence lowering yield. During Focus group discussion, the respondents indicated that bambara ground nuts are very expensive to buy yet there is no ready market for the crop after harvesting. Surveys carried out in Nairobi indicated that bambara groundnuts is more expensive than other pulses in the city (Heller *et al.*, 1997). However the survey also established that the demand for the crop is quite low.

Simsim (***Sesumum indicum L.)***

The findings of this study from 1980s clearly indicate that in Mumias division, simsim still remained one of the least grown crops with the mean size per household being negligible (0.05 acres) per household (Table 7). This accounted for only 1% of the total size of land under crops per household. The findings indicated that there was no change in the size of land under simsim between 1970s and 1980s (Tables 6 and 7). Various reasons were given why the size of land under simsim was very small and with no change in acreages between 1970s and 1980s. Labour intensiveness was reported by 48% of the respondents as the main cause for the small size of land under simsim. Forty two percent (42%) of the respondents attributed the small size of land under simsim to the introduction of commercial sugarcane farming. They reported that the introduction of commercial sugarcane farming has contributed to the decline in the size of land under simsim since the land is rendered infertile and unsuitable for the cultivation of this crop. Pests and diseases were reported by 10% of the respondents as a major cause of the small size of land under simsim. KWAHO (2005) reported that with increase in population in Mumias district, and change in farming preferences, cultivation of simsim has declined. Bell *et al.*, (2001) reported that there is a substantial decline in the productive capacity of soils under sugarcane monoculture farming. KARI (1997) reported that many pests are known to attack simsim but the most important one in Kenya is the web-worm (*Antigastra catalaunalis*). KARI (1997) further reported that late-planted simsim was heavily attacked by web-worm in 1981 at Mtwapa and at Kakamega where it fed on the pods and leaves.

Indigenous Vegetables

The research established that there were major changes in the number of households growing indigenous vegetables in 1980s. There was a decline in number of farmers growing vegetables

such as African nightshade and increase in number of households growing vegetables such as spider plant. The research established that in the 1980s, no household had vine spinach on their farms.

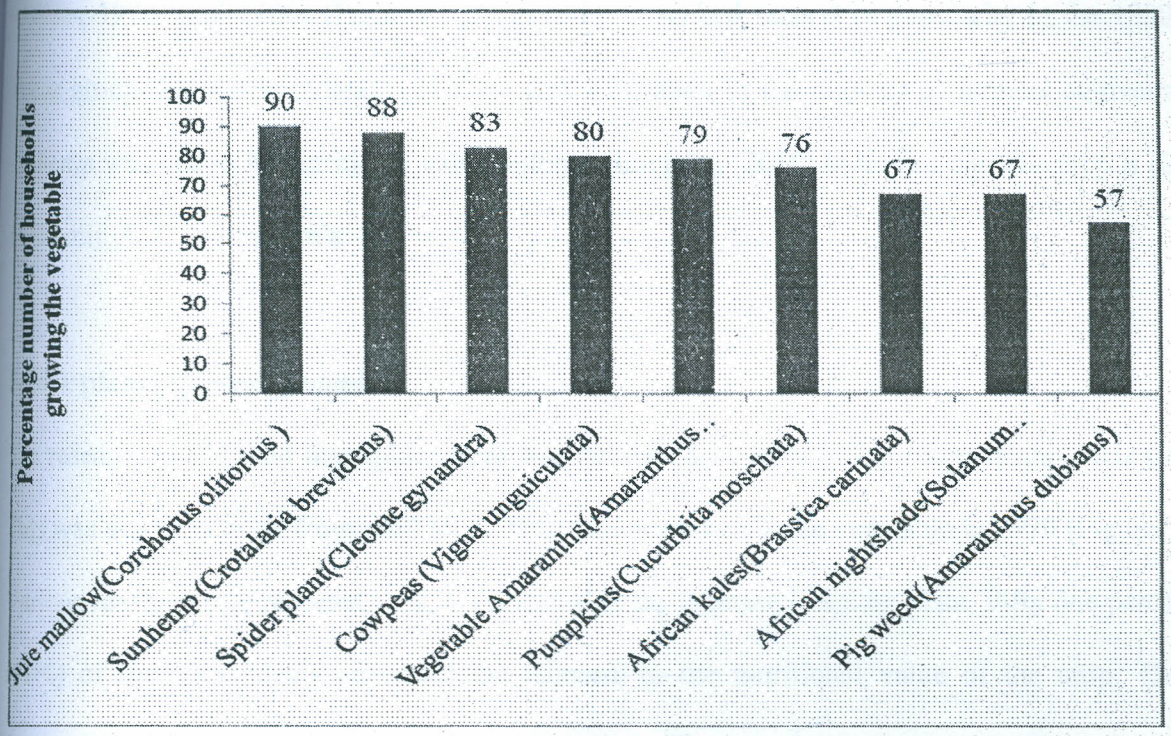

Figure 8: Percentage Number of Household in Mumias Division Growing Specific Indigenous Vegetable Species in 1980s.

Source: Field data 2007

Jute Mallow (*Corchorus olitorius)*

The research established that in 1980s, jute mallow was ranked first in popularity with 90% of the households growing the vegetable (Figure 8). This was a 1% increase from the 89% who grew the crop in 1970s. Eighty percent (80%) attributed the increase in the number of households growing jute mallow to its nutritional value. The respondents reported that the vegetable was good for breast feeding mothers. Boyd (2011) indicated that the leaves are very nutritious, rich in iron, calcium, thiamin, riboflavin, niacin, folate, and dietary fiber.

Sunhemp *(Crotalaria brevidens)*

The study established that in 1980s, sunhemp was cultivated by 88% of the respondents (Figure 8). This showed that there was no change in the number of households cultivating sunhemp between 1970s and 1980s (Figure 7). Sunhemp was ranked second in popularity in the 1980s. Focus group discussion indicated that the lack of change in the number of farmers cultivating sunhemp was due to its nutritional value. Infonet-Biovision (2010) indicated that this crop is rich in vitamin A, C and minerals.

Spider plant (*Cleome gynandra*)

The research established that spider plant was cultivated by 83% of the respondents (Figure 8). This was a 5 % increase from the 78% of households who grew the vegetable in 1970 (Figure 7). Various reasons were reported to have attributed to the increase in spider plant. Fifty one percent (51%) of the respondents attributed the increase to the nutritional value of the crop. They reported that during this time, agricultural extension officers had sensitized the local community on the importance of spider plant in nutrition. Spider plant contains 5% protein, 6% carbohydrates and is rich in vitamin A and C (Obuoyo, 2005). Thirty percent (30%) of the respondents indicated that the increase in spider plant is because of its medicinal value. The crop is reported to control constipation. John and Eyzaguirre, (2006) pointed out that the government programs increasingly supported the consumption of indigenous vegetables such as spider plant through public advertisements and partnership with major Kenyan supermarkets who market these vegetables.

Cowpeas (Vigna unguiculata)

The research established that 80% of the households cultivated cowpeas in 1980 (Figure 8). This was a 1% decline from the 81% of respondents who grew the crop in 1970s (Figure 7). Cowpeas were ranked the fourth popular vegetable crop species in the region as compared to its lack of popularity ranking 8th in 1960s. Seventy percent (70%) of respondents reported that the main causes of decline in the number of households growing cowpeas leaves were change in tastes and preference with more preference being given to exotic kales. Thirty Percent (30%) of the respondents reported that the decline was as a result of pests such as aphids and diseases such as fusarium wilt which lower the yield. However, Ekesa *et al.* (2008) reported that the decline in the number of households growing indigenous vegetables such as cowpeas in the neighboring Matungu division was due to commercial sugarcane and changing dietary patterns.

Vegetable Amaranths (*Amaranths blitum)*

Vegetable amaranths used to grow in abandoned cow sheds which were normally very fertile. In the 1980s vegetable amaranths were either cultivated by 79% of the respondents (Figure 8). This was a 2% decrease from the 81% who grew the crop in 1970s (Figure 7). Sixty percent (60%) of the respondents reported that the decline was attributed to the vegetable being uprooted as weeds from sugarcane plantation. Thirty percent (30%) of the respondents attributed the decline to the decline in the number of livestock reared which led to decline in manure. They reported that the vegetable requires soils that are very fertile.

Pumpkins (Cucurbita moschata)

Seventy six percent (76%) of the respondents cultivated pumpkins on their farms in 1980s (Figure 8). This showed that there was a 13% decline in the number of households growing

pumpkins from 1970s to 1980s. It was ranked sixth in popularity in the region in 1980s. Eighty percent (80%) of the respondents reported that the main causes of decline in the number of households growing pumpkin leaves were change in tastes and preference. The young generations prefer exotic kales (*sukumawiki*) as compared to pumpkin leaves. Twenty percent (20%) of the respondents attributed the decline to the decline in the number of livestock reared which led to decline in manure.

African Kales (*Brassica carinata*)

The research established that 67% of the respondents grew African kales in 1980s (Figure 8). This findings show that there was a 12% decline in the number of households growing African kales in 1970s (Figure 7). Fifty percent (50%) of the respondents stated that the decline was due to change in tastes and preference among the young generation aged below 40 years who prefer exotic kales over the African kales. Abukutsa, (2007) indicated that African kales face strong competition from exotic Kales (*sukumawiki-swahili*) which is preferred by most of the young generation in the Western Kenya. Forty one (41%) of the respondents reported that African kales are uprooted as weeds from sugarcane farms. Fort five percent (45%) of the respondents reported that the decline was due to African kales taking a lot of time in cooking. Gudrun (2004) indicated that newly introduced vegetables especially exotic kales were said to take short time when cooking as compared to the indigenous types.

African night shade (*Solanum villosum*)

Whereas African nightshade was the most common vegetable species in the region in 1970s (Figure 8) in 1980s, it was ranked 8th in popularity. Only sixty seven percent (67%) of the respondents were growing the vegetable in 1980s and compared to 91% of the respondents

growing it in 1970s (Figure 7 and 8). This was a 25% decline from 1970s to 1980s. Forty one percent (41%) of the respondents attributed the decline in the number of household cultivating African nightshade to sugarcane farming. They reported that this vegetable species would grow in the wild or semi cultivated land. However, they are uprooted as weeds in sugarcane plantations hence reducing their population. The crop is also destroyed from its natural habitat when the land is being cleared to create space for sugarcane farming. Fifty percent (50%) of the respondents indicated that the decline in the number of households growing African night shade was change in tastes and preference with preference being given to exotic kales.

Pigweed (*Amaranths dubians*)

Pigweed was cultivated by 57% of the respondents in 1980s (Figure 8). This was a 1 % decline from the 58% of the respondents who grew the crop in 1970s. This vegetable commonly grew in abandoned cattle sheds, and kitchen gardens. The reasons given for the decline in this vegetable species was decline in livestock numbers in the region which led to a decline in soil fertility. Twenty two percent (22%) of the respondents attributed the decline to change in tastes and preference with many community members preferring exotic species. Thirty percent percent (30%) reported that weeding especially in sugarcane plantations destroyed pigweed which were destroyed as weeds from there natural habitat.

4.4 Effect of Commercial Sugarcane Farming on Subsistence Crops in Mumias Division in 1990s

The research findings established that in the 1990s, the trend in the size of land allocated to various crops changed. The size of land under sugarcane started declining while the size of land under specific crops such as maize, sorghum, cassava finger millet, simsim and sweet potatoes started increasing. There was no change in the size of land allocated to groundnuts and bambara ground nuts. With the increase in food insecurity in the region, some farmers started abandoning the cultivation of sugarcane on monoculture in favour of indigenous food crops. Vaughan (2000) reported that farmers in Mumias within the Community Rehabilitation and Environment Program (CREP) have found that the main solution to food insecurity is to abandon the growing of sugarcane altogether and grow food crops. The table 8 shows the size of land allocated to various crops in 1990s.

Table 8: Types of Subsistence Crops Grown and Acreages of Land Under Crops in Mumias Division after the Introduction of Commercial Sugarcane Farming (1990s)

Total size of land per household (acres)	Total size of land under crops(acres)	Types of Crops Grown	Mean Acreage per household	Percentage acreage under each crop (%)
5.5	5.33	Sugarcane	2.3	43
		Maize	1.3	24
		Sorghum	0.4	8
		Cassava	0.27	5
		Finger millet	0.21	5
		Ground nuts	0.47	9
		Sweet potatoes	0.23	5
		Bambara groundnuts	0.17	2
		Simsim	0.02	0

Source: Field data 2007

Sugarcane (*Saccharum officinarum)*

Sugarcane occupied an area of about 2.3 acres per household accounting for about 43% of the total land under subsistence crops in 1990s (Table 8). This was a 5% declines from the 48% size under sugarcane in 1980s (Table 7). The reasons for the decline in the size of land under sugarcane farming were attributed to low payment, delayed payment and expensive charges on input from the Mumias Sugar Company as reported by 95% of the respondents (Table 9). Ninety two percent (92%) of the respondents indicated that delayed harvesting of sugarcane from the farms resulted into sugarcane spoilage in farms and declining in value. Ninety two percent (92%) of the respondents reported that sugarcane was poorly transported resulting into sugarcane spillage on the way to the factory and the losses were incurred by the farmer. Ninety percent (90%) of the respondents reported that they did not trust Mumias Out growers Company (MOCO) which is reportedly involved in weighing of the sugarcane. The farmers believed that MOCO corruptly stole from them during weighing and this made farmers to incur losses. Eighty percent (80%) of the respondents reported harvesting of the sugarcane leading to sugarcane being left on farms and this led to low returns from the factory. Sixty seven percent (67%) of the respondents indicated that the decline was due to poor quality seed cane offered by the factory. Finally sixty seven percent (67%) of the respondents reported that arsonist burnt sugarcane while still in the farms making farmers to incur great loses (Table 9). KWAHO (2005) pointed out that in the last five years cash flow from the sugar industry had not been very reliable due to delayed payments to farmers.

Table 9: **Respondents Perception of the Causes of the Decline in the Size of Land Under Sugarcane**

Causes	Percentage number of Respondents
Expensive charges on input	95
Poor payment	95
Delayed Payment	95
Delayed harvesting	92
Cane Spillage	92
Manipulation of weighing Bridge	90
Poor Harvesting Technique	80
Poor quality of Seed cane	67
Risk of burning	67

Source; Field data 2007

Maize *(Zea may l.)*

Maize occupied an area of about 1.3 acres per household accounting for about 24% of the total land under subsistence crops in 1990s (Table 8). This was a 4% increase from the 20 % size under maize in 1980s (Table 7). During the first three months of maturity, they are often intercropped with beans and cowpeas. However in the next two to three month before maturity, they are cultivated as monoculture. The increase in the size of land under maize was partially attributed to conversion of sugarcane farms into maize as reported by 52% of the respondents. Furthermore forty eight percent (48%) of the respondents attributed the increase in the size of land under maize to the fact that maize is a staple food in the region and a source of food security. The respondents further reported that in the 1990s, the common maize species cultivated were the hybrid species which had replaced the local landraces that were prevalent in the 1960s. The seeds of the hybrid varieties were readily available on the markets and the hybrid species produces higher yields as compared to their local counterpart. Maize is the most important staple food in sub-Saharan Africa and is the main food crop in Kenya, representing 3 percent of Kenya's gross

domestic product (GDP) and 21 percent of the total value of primary agricultural commodities (GoK, 1998)

Sorghum (*Sorghum bicolour L.* Moench)

In the 1990s, sorghum occupied an area of about 0.4 acres per household accounting for about 8% of the total land under subsistence crops in 1990s (Table 8). This was a 2% increase from the 6% size of land under sorghum in 1980s (Table 7). Various reasons were given by the respondents for the increase in the size of land under sorghum. Sixty seven percent (67%) of the respondents reported that the increase in the size of land under sorghum was due to the decline in the size of land under sugarcane. Thirty three percent (33%). of the respondents attributed the increase to the campaign by the government and Non Governmental Organisation (NGOs) encouraging people to grow more indigenous crops to curb against food insecurity. This was also validated during a focus group discussion. Sorghums are rich sources of micronutrients (minerals and vitamins) and macronutrients carbohydrates, proteins and fat which makes it suitable for obese and diabetic people (Mamoudou *et al*, 2006).

Finger Millet *(Eleusine coracana L.* Gertn)

In the 1990s, finger millet occupied an area of about 0.21 acres per household accounting for about 5% of the total land under subsistence crops per household in 1990s (Table 8). This was a 1% increase from the 4% size under finger millet in 1980s (Table 7). The reasons given by respondents for the increase in the size of land under finger millet in the 1990s included the decline in the size of land under sugarcane farming as reported by 50% of the respondents. Increase in knowledge and awareness on the nutritional value of finger millet was reported by fifty percent (50%) of the respondents. They reported that the agricultural extension officers had

organized meetings and encouraged people to grow more indigenous crops such as finger millet in the division. Okuthe *et al.*, (2007) confirmed that the growing of improved finger millet varieties in Kenya had been promoted by agricultural extension service as one of the ways to achieve food insecurity.

Cassava (*Manihot esculenta Rantz*)

In the 1990s, the size of land under cassava was 0.23 acres accounting for 4% of the total size of land under crops (Table 8). There was a one percent (1%) decline in the size of land under cassava in 1980s and 1990s (Tables 8 and 7). The reasons given by the respondents for the decline in the size of land under cassava included change of tastes and preference with more households preferring maize, sorghum, finger millet and sweet potatoes as a stable food over cassava. This was reported by 50% of the respondents. Twenty percent (20%) of the respondents reported that to cassavas had a record of having caused death among children in the neighboring regions. For instance two children in Kegati division in Kisii central district on Sunday 3rd October 2010 after consuming poisonous cassava. This was discouraged farmers from increasing the size of land under cassava. (Tylleskar 1994) confirmed the fact that consumption on a daily basis of cassava that contain undecayed residues of linamarin may result in symptoms of chronic poisoning and paralysis called *konzo* in Nigeria. Tylleskar (1994) further indicated that diseases such as cassava blight and pests such as nematodes damage cassava roots and lead to low productions of cassava.

Sweet Potatoes (*Ipomea batatas)*

In the 1990s, the size of land under sweet potatoes was 0.23 acres accounting for 5% of the total size under crops (Table 8). This implied that there was a 1% increase in the size of land under

sweet potatoes from 1980s to 1990s (Table 7). Reasons given by the respondents for the increase in the size of land under sweet potatoes were as follows. Sixty seven percent (67%) of the respondents reported that the increase in the size of land under sweet potatoes was attributed by the decline in size of land under sugarcane farming. Thirty three percent (33%) of the respondents reported that the slight increase in the size of land under sweet potatoes was as a result of ready market for the crop in major towns such as Nairobi. FAO (2001) reported that sweet potato production has responded to strong urban demand and is a major traded commodity. Steady demand increases due to a shift in urban consumption patterns and this has led to a constant development of supply chains from the major production regions especially western Kenya.

Groundnuts (*Arachis Hypogaea L.)*

In the 1990s, the size of land under groundnuts was 0.47 acres per household accounting for 9% of the total size under crops (Table 8). This indicated that there was no change in the size of land allocated to groundnuts between 1980s and 1990s (Table 7). During a focus group discussion, the reasons given by the respondents for the lack of change in the size of land under groundnuts was the fact groundnuts are often intercropped with sugarcane meaning that no special land is required to be set aside for the cultivation of groundnuts. They reported that the decline in the size of land under sugarcane did not affect the size of land under groundnuts since they are grown on small scale. Waele (2001) reported that the groundnuts are preferred because of its nutritional value. Because of the high nutritional value of the seeds and their pleasant flavour, Waele (2001) reported that groundnut is one of the most important human food in the subtropics.

Bambara Groundnuts (*Vigna subterranean L.* Verde)

In the 1990s, the size of land under bambara groundnuts was 0.17 acres per household accounting for 3% of the total size under crops (Table 8). This indicated that there was no change in the size of land allocated to bambara groundnuts between 1980s and 1990s (Tables 8 and 7). During a focus group discussion, the respondents reported that the lack of slight change in the size of land under bambara groundnuts were the fact that bambara groundnuts are often intercropped with sugarcane and only occupy a small portion of land. The respondents also reported that the younger generations are shifting from bambara groundnuts to groundnuts and therefore not much land is set aside for the cultivation of bambara groundnuts. Contrary to our findings by Ngugi (1995) indicated that bambara groundnut production is declining Kenya due to high cost of purchasing seedlings and cultural erosion with the young generation shifting from bambara groundnuts to groundnuts. In Nigeria, Baudoin and Mergeai (2001) reported that groundnuts have a wider market as compared to bambara groundnuts which is not sold on world market.

Simsim (*Sesame indicum L.*)

The findings of this study from 1990s clearly indicate that in Mumias division, simsim still remained one of the least grown crops in the region with the mean size per household being negligible. In 1990s 0.02 acres of land per of the households interviewed was under simsim on their farms. The findings indicated that there was a 1% decline in the size of land under simsim between 1980s and 1990s (Tables 8 and 7). Various reasons were given by the respondents for the decline in the size of land under simsim. Fifty percent (57%) of respondents reported that labour intensiveness was the main cause for the small size of land under simsim. Thirty three percent (33%) of the respondents attributed the decline in the size of land under simsim to the introduction of commercial sugarcane farming. They reported that the introduction of commercial

sugarcane farming may have contributed to the decline in the size of land under simsim since the land is rendered infertile and unsuitable for the cultivation of this crop. Pests and diseases were reported by ten percent (10%) as a major cause of the small size of land under simsim. FAO (2008) reported a decline in the number of farmers growing simsim in Mangeni division of Swaziland due to introduction of monocultural sugarcane farming. This effect is also similar to the soya monoculture in Argentina which is reported to have threatened the production of other food crops, particularly simsim (Joensen *et al*, 2005). *Alternaria sesame* infection was reported by Ojiambo *et al*. (1998) to have infections levels of 11% in Mumias region. This disease discouraged many farmers from growing the crop. USDA (2006) further reported that for years the U.S. was totally dependent on imported sesame seed since harvesting was labour intensive.

Indigenous Vegetables

Major changes were also noted in the trend in the number of farmers cultivating indigenous vegetable in 1990s. Jute mallow, sunhemp, cowpeas, vegetable amaranths, pigweed, pumpkins and African kales declined. During this decade, African kales experienced the highest decline. African night shade and spider plant increased during this decade. Figure 9 below shows the percentage number of household in Mumias division growing specific indigenous vegetable species in 1990s.

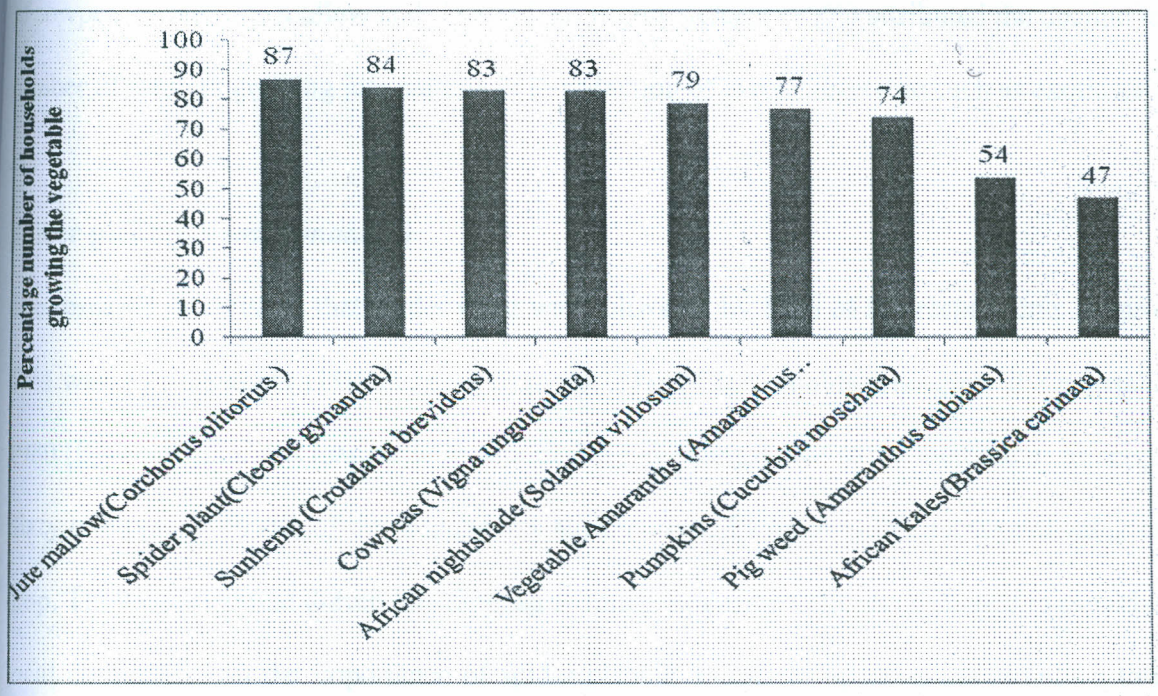

Figure 9: Percentage Number of Household in Mumias Division Growing Specific Indigenous Vegetable Species in 1990s.

Source: Field data 2007

Jute Mallow (*Corchorus olitorius)*

Just like in 1980s, the research established that in 1990s, jute mallow was still ranked first in popularity with 87% of the households growing the vegetable (Figure 9). This was a 3% decline from the 90% of the respondents who grew the crop in 1980s. The Focus Group Discussion established that the crop is still popular in the region because it is either cultivated or grows in the wild. It also revealed that the crop has a ready market in the major towns such as Nairobi. Ekesa *et al.* (2009) reported that jute mallow was popular in the nearby Matungu division because it was either grown in the wild or was cultivated. However, they also mentioned that the popularity of Jute mallow could be attributed to the fact that it is common among the community in western Kenya to cook two or three indigenous vegetables together and the most common mixture is that

of cowpea leaves, jute mallow and slender leaf. Eighty percent (80%) attributed the decline in the number of farmers growing jute mallow to introduction of exotic vegetable such as exotic kales.

Spider plant (*Cleome gynandra)*

The research established that spider plant was cultivated by 84% of the respondents (Figure 9). This was a one percent (1%) increase from the 83% of households who grew the vegetable in 1980 (Figure 8). Various reasons were reported to have contributed to the increase in spider plant. Sixty one percent (61%) of the respondents attributed the increase to the nutritional value of the crop. They reported that during this time, agricultural extension officers continued to sensitize the local community on the importance of spider plant in nutrition. Spider plant is known to have high levels of beta-carotene, fibre, vitamin C, and significant amounts of calcium, magnesium, and iron (Styslinger, 2011). Thirty percent (30%) of the respondents indicated the crop is delicious and has medicinal values. These vegetable was reported to treat constipation. In Uganda, Styslinger (2011) reported that the plant is used to speed up the process of childbirth and ease labour pains and assist women to regain strength and increase lactation after birth. Spider plant remedies are used to treat headaches, stomach aches, constipation, vomiting, diphtheria, vertigo, pneumonia, and ear infection (Styslinger, 2011).

Sunhemp (*Crotalaria brevidens)*

The study established that in 1990s, sunhemp was cultivated by 83% of the respondents (Figure 9). This implied that there was a 5% decline in the number of households cultivating sunhemp between 1980s and 1990s (Figure 8). Sunhemp was ranked third in popularity in 1990s. The reasons given by the respondents for the decline in sunhemp cultivation were pests and diseases as reported by 59% of the respondents. The respondents reported that this crop is easily attacked

by white fly which lower yield. Obuoyo (2005) reported that sunhemp is found in most parts of the tropics and sub tropics of the world including Africa. Mirghali *et al.* (2007) pointed out that the average yields in vegetable species such as *Corchorus spp* is low in Sudan compared to the potential due to pests and diseases and the availability of high costs of pesticides

Cowpeas (Vigna unguiculata)

The research established that the numbers of farmers growing cowpeas in 1990s were 83% (Figure 9). This showed that there was a 3% decline in the number of respondents cultivating this vegetable species (Figure 8). During this period, cowpeas were ranked fourth in popularity. Sixty percent (60%) of the respondents attributed the decline in the number of farmers growing cowpeas to pests such as aphids and diseases such as fusarium wilt. Forty percent (40%) of the respondents attributed the decline to change in tastes and preference with preference being given to exotic kales. Blackman and Eastop (1984) reported that cowpea is infested by a range of pests; one of its key pests being aphids. Several species of aphids that infest cowpea include cowpea aphid (*Aphis craccivora* Koch.), bean aphid (*Aphis fabae* Theobald), cotton aphid (*Aphis gossypii* Glover) and violet aphid (*Myzus omatus* Laing) (Gichimu and Ndong'a (2006). Gichimu *et al.* (2006) further noted that Cowpea aphid (*Aphis craccivora* Koch.) is among the most troublesome pests of cowpea and a big problem to farmers in Kenya.

African night shade (*Solanum villosum*)

African nightshade was ranked 5th in popularity in 1990s. It was cultivated by 79% of the respondents (Figure 9). This was a 12% increase from the 67% of the respondents who were growing the vegetable in 1980s (Figure 8). The reasons given for the increase in African night shade in 1990s were the decline in the size of land under sugarcane as reported by 20% of the

respondents. The respondents reported that the decline in sugarcane created more space for the cultivation of indigenous crops such as maize which were often intercropped with African nightshade. Eighty percent (80%) of the respondents reported that the extension officers introduced exotic varieties which yielded more, hard broader leaves and were less bitter in taste. According to Oniang'o *et al.* (2003), African Vegetable Research Development (AVRDC), have developed one cultivar that does well in Kenya, known as Giant Nightshade. This variety has a bigger, sweeter leaf, and would likely appeal to adults as well as children. In addition, they reported that the promotion of the nightshade plant in eastern Kenya, especially Nairobi, has created a strong market for this crop, with a high profit potential.

Vegetable Amaranths (*Amaranths blitum*)

In the 1990s vegetable amaranths were cultivated by 77% of the respondents (Figure 9). This was a 2% decrease from the 79% who grew the crop in 1980s (Figure 8). Forty percent (40%) of respondents attributed the decline to the vegetable being uprooted as weeds from sugarcane plantation. Forty Percent (40%) of the respondents attributed the decline to the lifespan of vegetable amaranths. They reported that vegetable amaranths wither within one and a half months making it unreliable for food security. Ten percent (10%) of the respondents attributed the decline to change in tastes and preference with preferences being given to exotic kales.

Pumpkins (*Cucurbita moschata)*

Seventy four percent (74%) of the respondents cultivated pumpkins on their farms in 1990s (Figure 9). This implies that there was a 2% decline in the number of households growing pumpkins from 1980s to 1990s. It was ranked seventh in popularity in the region in 1990s. Eighty percent (80%) of the respondents attributed the decline to reported change in tastes and

preference. The young children prefer exotic kales as compared to pumpkin leaves. Twenty percent (20%) of the respondents indicated that the decline was due to decline in the number of livestock reared in the region which led to decline in manure. They reported that the vegetable requires soils that are very fertile.

Pigweed (*Amaranths dubians*)

Pigweed was cultivated by 54% of the respondents in 1980s (Figure 9). This was a 3 % decline from the 57% of the respondents who grew the crop in 1980s. Sixty eight percent (68%) of the respondents attributed the decline in this vegetable species to the decline in number of livestock reared which led to decline in manure. They reported that the vegetable requires soils that are very fertile. The respondents reported that the vegetable thrives well both in cultivate and in the non cultivated places that are rich in humus. Twenty two percent (22%) of the respondents attributed the decline to change in tastes and preference with many households preferring exotic species. Thirty percent (30%) reported that weeding especially in sugarcane plantations involves the uprooting of pig weeds which are viewed as weeds. In a study by Maundu, (1995) on Kenyan indigenous vegetables, it is assumed that due to clearing of land, over-stocking, over-exploitation and possibly climate change there occurred a continual loss of wild food species at the farm and village level. This would mainly concern wild vegetables that grew only in uncultivated land e.g. in forests.

African Kales *(Brassica carinata)*

The research established that 47% of the respondents grew African kales in 1990s (Figure 9). This findings show that there was a 20% decline in the number of households growing African kales in 1990s (Figure 8). The research further established that in the 1990s, African kale was the

least grown crop in the region. Fifty percent (50%) of the respondents the decline to change in tastes and preference among the young generation aged below 40 years who prefer exotic kales over African kales. Thirty percent (30%) of the respondents reported that African kales are uprooted as weeds from sugarcane farms. Ten percent (10 %) of the respondents indicated these vegetable species no longer thrives well due to the decline in the number of livestock in the region which has led to decline in animal manure. Ten percent (10%) of the respondents attributed the decline to the long duration required in the cooking of African kales. The respondents indicated that cooking of African kales often mixed with other vegetables such as spider plant takes approximately one hour.

4.5 Effect of Commercial Sugarcane Farming on Subsistence Crops in Mumias Division in 2000s.

In the 2000s the research findings established that the mean size of land under sugarcane per household declined even further while the size of land under the main subsistence crops increased. The respondents reported that during this period, the increase in knowledge on the importance of indigenous crops in nutrition and food insecurity in the region led to the increase in the size of land under indigenous crops as farmers reduced the size of land under sugarcane. The farmers also reported that poor payment from Mumias Sugar Company prompted many farmers to abandon the growing of sugarcane and instead allocate more land to the cultivation of indigenous crops such as maize, sorghum, finger millet, cassava and sweet potatoes.

Table 10: Types of Crops Grown and Acreages of Land under Crops in Mumias Division after the Introduction of Commercial Sugarcane Farming (2000s)

Total size of land per household (acres)	Total size of land under crops(acres)	Types of Crops Grown	Mean Acreages per household	Percentage acreages under each crop(%)
5	5.34	Sugarcane	2	38
		Maize	1.6	30
		Sorghum	0.47	9
		Cassava	0.13	2
		Finger millet	0.32	6
		Ground nuts	0.46	9
		Sweet potatoes	0.28	5
		Bambara groundnuts	0.07	1
		Simsim	0.01	0

Source: Field data 2007

Sugarcane (*Saccharum officinarum*)

Sugarcane occupied an area of about 2 acres of land per household accounting for about 38% of the total land under subsistence crops in 2000s (Table 10). This was a 5% decline from the 43% size under sugarcane in 1990s (Table 8). The reasons given by respondents for the decline in the size of land under sugarcane farming were poor payment as reported by 95% of the respondents, expensive charges on input from the Mumias Sugar Company as reported by 95%, delayed harvesting of sugarcane from the farms (92%), and poor transportation as reported by (92%). SUCAM (2002) confirmed that excessive deductions an taxation of farmers income and delayed payments to farmers are some of the key problems affecting Mumias sugarcane farmers. Farmers in Trans-Mara zone and Awendo ranked low cane prices, high cost of inputs, delayed payment for delivered cane, delayed harvesting of cane as major problems facing sugarcane farmers (Wawire *et al.*, 2010).

Maize (*Zea mays L.*)

Maize occupied an area of approximately 1.6 acres per household accounting for 30% of the total size of land under subsistence crops in 2000s (Table 10). This was a 6% increase from the 24 % size under maize in 1990s (Table 8). Increase in the size of land under maize was attributed to decline in the size of land under sugarcane as reported by 52% of the respondents. In addition 48% of the respondents attributed the increase in the size of land under maize to better prices of maize. This is supported by information from FIPS AFRICA, (2006) which is reported to have been working with Butere Mumias district farmers since 2005 by providing them with appropriate farm inputs in small affordable quantities. Their efforts led to land under maize increasing in the region by a factor of 2.75 (FIPS AFRICA, 2006).

Sorghum (*Sorghum bicolour L.* Moench)

In the 2000s, sorghum occupied 0.47 acres of land per household. This accounted for 9% of the total size of land under crops (Table 10). The study established that there was an 8% increase in the size of land under sorghum from 1990s (Tables 10 and 8). Fifty six percent (56%) of the respondents attributed the increase in the size of land under sorghum to sugarcane farming. Other reasons advanced by the farmers for the increase were the campaign encouraging people to grow more indigenous crops such as sorghum in Mumias was also reported to be responsible for the increased land under sorghum in the 2000s.

Finger Millet *(Eleusine coracana L.*Gertn)

Finger millet occupied an area of about 0.32 acres per household accounting for about 6% of the total size of land under subsistence crops in 2000s (Table 10). This was a 1% increase from the 8% size under finger millet in 1990s (Table 8). Two reasons stated by the respondents for the increase in the size of land under finger millet were: decline in the size of land under sugarcane (66% of the respondents) and presence of ready market attributed the increase to ready market for the crop both locally and in towns such as Nairobi (33% of the respondents). Focus Group Discussion also attributed the increase to more efforts of the agricultural extension officers who organized meetings and encouraged people to grow more indigenous crops such as finger millet. The growing demand for finger millet in various parts of Kenya (KARI 2005) is an incentive for increased cultivation of finger millet.

Cassava (*Manihot esculenta Rantz*)

Cassava occupied an area of about 0.14 acres per household accounting for about 2% of the total size of land under subsistence crops in 2000s (Table 10). This was a 2% decline from the 4% size

under finger millet in 1990s (Table 8). The decline in the size of land under cassava in 2000s was due to some cassava varieties (bitter type) that were termed as poisonous having caused death in other parts of the country. This was reported by 25% of the respondents. ISID (2002) reported that in the Butere/Mumias District 10 people died after eating poisonous cassava believed to have originated from Uganda on 23rd March 2002. The affected areas were Musanda, Ekero, Mayoni, Matungu, and Namulungu. Daily Nation 6th September (2001) reported of three brothers having died after eating boiled cassava in Watuka village, Makueni division, Makueni district. (Daily Nation, 4rd October 2010) reported that cassava has caused death to two children in Kegati Division in Kisii Central District after consuming poisonous cassava. Dulce *et al.* (2008) reported that the cyanogens present in cassava and cassava products can cause acute intoxication leading sometimes to death.

Pests and diseases also contributed to the decline as reported by 22% of the respondents. Such pests included moles while diseases included cassava mosaic diseases. However, 53% of the respondents still maintained that the decline in the size of land under cassava was due to sugarcane farming. The above mentioned reasons have been reported by Solomon (2007) who showed that certain varieties can cause cyanide poisoning, leading to paralysis and death. In Burundi, yields from cassava reduced by more than 80% and cassava because of cassava mosaic disease (GLCI, 2010).

Sweet potatoes (*Ipomea batatas*)

Sweet occupied an area of about 0.28 acres per household accounting for about 5% of the total size of land under subsistence crops in 2000s (Table 10). This was a 1% increase from the 5% size under finger millet in 1990s (Table 8). Sixty percent (60%) of the respondents stated that the

increase in the size of land under sweet potatoes increased due to ready market from neighbouring towns such as Mumias and other towns such as Nakuru and Nairobi. The high income from sale of sweet potatoes encouraged more farmers to grow the crop hence the increase in acreage per household. This was supported by Woolfe (1992) that in Kenya, there is a very large urban population which consume sweet potatoes prompting for an increase in their production. 40 % of the respondents reported that the increased size in the size of land under sweet potatoes were the decline in the size of land under sugarcane which created more space for sweet potatoes.

Groundnuts (*Arachis Hypogaea L.)*

Groundnuts occupied an area of about 0.46 acres per household accounting for about 9% of the total size of land under subsistence crops in 2000s (Table 10). This implied that there was no change in the size of land under groundnuts between 1990s and 2000 (Tables 10 and 8). The reason given by the respondents for the lack of change in the size of land under groundnuts was the fact that groundnuts are delicious and preferred by most people in the region. The crop is found to be delicious and rich in protein, minerals and edible oils. They can be eaten on their own or blended with other dishes such as finger millet, and simsim to improve taste and nutritional value. However the sizes of land per household under groundnuts are small since the households opt to put more land on maize, sorghum and finger millet which are considered to be staple food crops in the region. Okiror et. al., (1997) reported that several constraints have been identified as limiting in groundnut production in Western Kenya. Amongst them are the small farm sizes (1.7 to 2.5 ha per family), and the very small proportions (0.01 to 0.12 ha per household) under groundnuts (Langat *et al.*, 2006). Both maize and sorghum are always given priority over other crops through timely planting and/or cropping area size, with maize dominating in the wetter

zones and sorghum in the drier zones (Rees *et. al.*, 1998). The research established that sugarcane farming did not have any effect on the cultivation of groundnuts in 2000s.

Bambara Groundnuts (*Vigna subterranean L.* Verde)

Bambara groundnuts occupied an area of about 0.07 acres of land per household accounting for about 1% of the total size of land under subsistence crops in 2000s (Table 10). This showed that there was a 1% decline from the area under bambara groundnuts in 1990s (Table 8). Various reasons were given for the decline in then size of land under bambara groundnuts in the 2000s, ninety percent (90%) attributed the decline to expensive bambara groundnut seeds and lack of market for the crop. Ten percent (10%) of the respondents reported that the decline was as a result of change in tastes and preference with many young people preferring groundnuts over bambara groundnuts. The research established that sugarcane farming did not have an effect on the cultivation of bambara groundnuts. However, FAO (2008) reported that sugarcane farming has replaced many indigenous crops such as bambara groundnuts cassava and millet in many region of the world.

Simsim *(Sesame indicum)*

Just like the 1990s, the research established that out of the respondents interviewed, 1% of them cultivated simsim in the 2000s (Table 10). This showed that the percentage size of land under simsim was negligible. The reason given by the respondents for less land being under simsim were similar to those given in 1990s. Similar results have been reported by Mishra (2008) who reported that most of the oil seeds and pulses such as simsim have been neglected through monoculture of crops such as sugarcane, wheat, rice and maize which occupied major areas of Indian farmlands. Simsim have nodules on their root which fix nitrogen in the soil. With the

decline in the size of land under simsim, farmers have to purchase more and more nitrogenous fertilizers from the markets. This results into a pressure on the national economy. KARI (1997) showed that simsim improvement has been restricted to plant selection and virtually no breeding work has been undertaken in Kenya. This is possibly due to the fact that very little interest has been taken in simsim, which for years has been considered a minor crop of little importance compared to the cereals, tree and tuber crops in high yielding areas (KARI 1997). Research question which states that did the introduction of commercial sugarcane farming interfere with the agro-biodiversity in Mumias division is answered. Based on the changes it is concluded that sugarcane farming interfered with agro-biodiversity in Mumias division.

Indigenous Vegetables

The research established that the greatest decline in indigenous vegetables was experienced in 2000s. The number of farmers growing all indigenous vegetables declined. African kales had the highest decline. The Figure 10 shows the number of households cultivating indigenous vegetables.

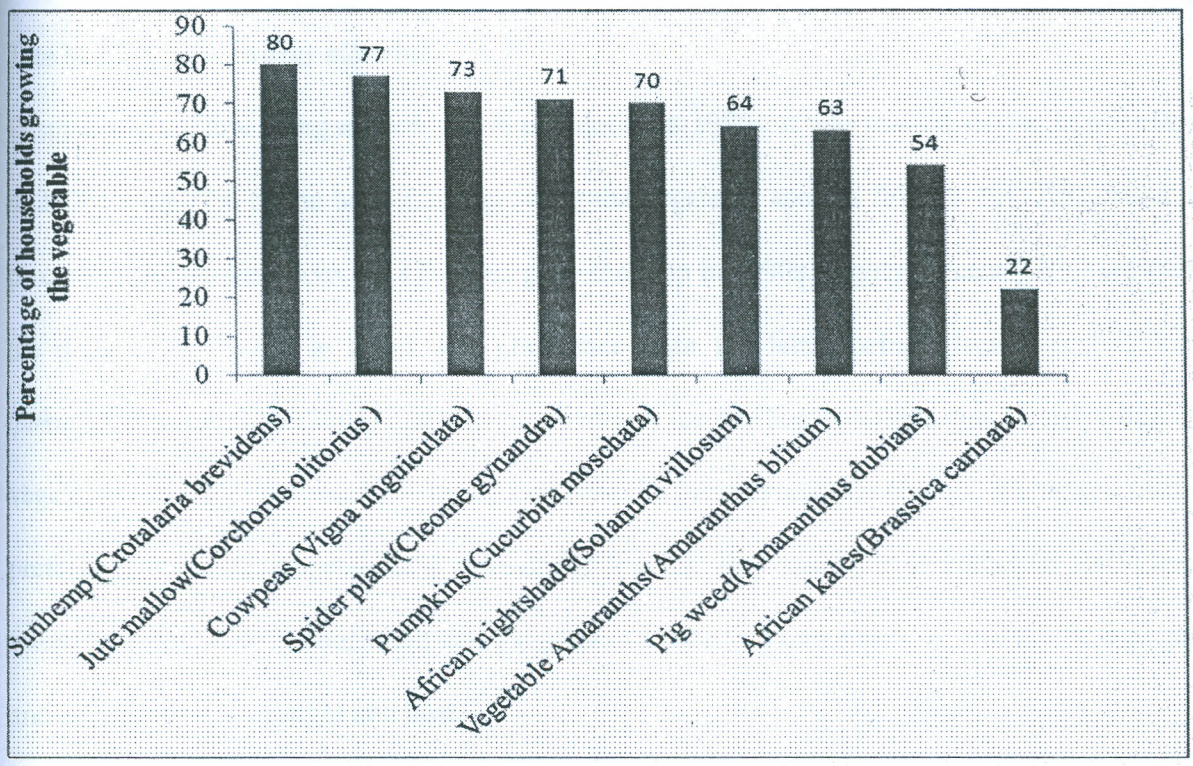

Figure 10: Percentage Number of Household in Mumias Division Growing Specific Indigenous Vegetable Species in 2000s.

Source: Field data 2007

Sunhemp (*Crotalaria brevidens*)

The study established that in 2000s, sunhemp was cultivated by 80% of the respondents (Figure 10). This showed a 3% decline in the number of households cultivating sunhemp between 1990s and 2000s (Figures 10 and 9). Sunhemp was the ranked first in popularity in 2000s. The reasons given by the respondents for the decline in sunhemp were pests and diseases as reported by 55% of the respondents. However, despite the decline, the crop still ranks first in popularity. The respondents reported that this is mainly because the seeds are less expensive and readily available in the local markets such as Mumias as compared to the seeds of other indigenous vegetables. The cost of a glass of this seeds ranged from Ksh 50 to Ksh. 60 in the nearby Mumias Market.

Jute Mallow (*Corchorus olitorius)*

Despite jute mallow being ranked first in popularity in 1990s, it was ranked second in popularity in 2000s with 77% of the households growing the vegetable species (Figure 10). This was a ten percent (10%) decline from the 87% who grew the crop in 1990s. Eighty percent (80%) attributed the decline to change in tastes and preference with the latter being given to exotic kales (*sukumawiki)*. Obuoyo (2005) had similar finding in the dry Siaya district. She reported that this vegetable is losing importance as eating habits of the local population change, showing a marked preference for exotic vegetables in spite of the fact that the vegetables is nutritious and drought tolerant. ECHO (2011) confirmed that the plants tolerate wide extremes of soil, are easy to grow and are resistant to drought and heat.

Cowpeas *(Vigna unguiculata)*

The research established that the numbers of farmers growing cowpeas in 2000s were 73% (Figure 10). This was a ten percent (10%) decline in the number of respondents cultivating this vegetable species in 1990s (Figure 9). During this period, cowpea was ranked third in popularity. Seventy percent (70%) of the respondents attributed the decline in the number of farmers growing cowpeas to pests and diseases such as aphids. Forty percent (40%) of the respondents still attributed the decline to the introduction of exotic kales which is preferred by majority of the young generations. However, the research established that cowpeas become more popular in 2000s as compared to 1990s. The respondents reported that this was because the vegetable yields more, has ready market, and is nutritious. Oiye at al., (2009) confirmed in western Kenya that the most abundant and consumed African leafy vegetable, accounting for most of the dietary vitamin A is the cowpea leaves.

Spider plant (*Cleome gynandra*)

The research established that spider plant was cultivated by 71% of the respondents (Figure 10). This was a thirteen percent (13%) decline from the 84% of households who grew the vegetable in 1990 (Figure 9). It was ranked fourth in popularity. Various reasons were reported to have contributed to the decline in spider plant. Sixty one percent (61%) of the respondents attributed the decline to longer time taken in cooking of the vegetable. The vegetable takes a long time of approximately one hour in cooking. Thirty percent (30%) of the respondents attributed the decline to expensive seeds on the market. The research established that in the nearby Mumias market, the cost of a glass of spider plant seeds ranges from Ksh 130 to Ksh. 150 which the cost of cowpeas of the same quantity ranges from Ksh. 30 to Ksh. 50.

Pumpkins (*Cucurbita moschata*)

Seventy percent (70%) of the respondents cultivated pumpkins on their farms in 2000s (Figure 10). This showed that there was a 4% decline in the number of households growing pumpkins from 1990s to 2000s. It was ranked fifth in popularity in the region in 2000s. The reasons provided for the decline in the number of farmers growing pumpkins in 2000s were similar to the reasons provided in 1990s. They attributed the decline to the decrease in the number of livestock in the region as reported by 30% of the respondents and change in tastes and preference as reported by 70% of the respondents.

African night shade (*Solanum villosum*)

African nightshade was ranked 6th in popularity in 2000s. It was cultivated by 64% of the respondents (Figure 10). This was a 15% decline from the 79% of the respondents who were growing the vegetable in 1990s (Figure 9). The reasons given by the respondents for the decline

in the number of households cultivating African nightshade in 2000s was; expensive seeds as reported by 50% of the respondents. They indicated that the cost of a glass of nightshade seeds was approximately Ksh 200 which was deemed to be expensive. Pests and diseases especially the birds were reported by 40% of the respondents as one of the reasons for the decline. Ten percent (10%) of the respondents indicated that the decline was due to the long time of approximately one hour required in the cooking of the vegetable.

Vegetable Amaranths (*Amaranths blitum*)

In the 2000s vegetable amaranths was cultivated by 63% of the respondents (Figure 10). This was a 14% decline from the 77% of respondents who grew the vegetable species in 1990s (Figure 9). Eighty percent (80%) of the respondents attributed the decline in vegetable amaranths to a short life spun of the vegetable. They indicated that the leaves wither away after approximately one and half month hence this vegetable cannot be relied upon for a long time in curbing against food insecurity.

Pigweed *(Amaranths dubians)*

Pigweed was cultivated by 54% of the respondents in 1980s (Figure 10). This implied that there was no change in the number of respondents who grew the crop in 1990s and 2000s (Figure 9 and 10). The PRA findings indicated that this vegetable is viewed as a poor mans crop and not cultivated by many people. The respondent also indicated that in most cases the crop used to grow on its own without being cultivated. With the decline in livestock in the region, there was a decline in animal manure in the region and this contributed to the decline in the vegetable species.

African Kales (*Brassica carinata)*

The research further established that in the 2000s, African kale was the least grown cop in the region. The research established that only 22% of the respondents grew African kales in 2000s (Figure 10). These findings show that there was a 25% decline in the number of households growing African kales in 2000s (Figure 9 and 10). The PRA discussion confirmed that the main cause of the decline in the cultivation of African kales was the introduction of exotic kales which is preferred by the young generations. They also reported that cooking of African kales which is often mixed with other indigenous vegetables consumes more time as compared to the exotic kales. African kales take approximately one hour to be cooked and the lid needs to be placed tightly. Ekesa *et al.* (2008) reported that in the nearby Matungu division, no household interviewed was growing African kale despite its popularity in the region. Rhoades & Nazarea, (1999) reported that the introduction of new varieties of vegetables like exotic kales lead to the number of local landraces as well as associated local knowledge being diminish.

In general, the study established that sugarcane farming had an indirect effect on all indigenous vegetable species. This was because indigenous vegetables occupy a very small piece of land and are grown as intercrops on kitchen gardens, and abandoned cattle shed. The introduction of commercial sugarcane farming led to a decline in grazing fields which in turn led to the decline in the number of livestock in the region. This led to a decline in indigenous vegetables that grew in the fertile kitchen gardens and abandoned cattles shed. The study also established that sugarcane farming is responsible for the extinction of vine spinach in the stud area.

CHAPTER FIVE

5.0. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 SUMMARY

The summary of the study is organized according to the objectives of the study.

Objective (1) sought to identify the subsistence crops grown in the study area before the introduction of commercial sugarcane farming. With regard to this objective, the study established that the indigenous crops grown in the region before the introduction of commercial sugarcane farming were maize, sorghum, finger millet cassava, sweet potatoes, groundnuts, bambara groundnuts, simsim and indigenous sugarcane. Maize occupied the largest portion. Yellow maize, *namba nane* maize, cassava (the sweet and the bitter varieties), and indigenous sugarcane occupied the second least size of land in the 1960s. The indigenous vegetables that grew in the study area included Spider plant, Jute mallow, African nightshade, Vegetable amaranths, Pig weed, Cowpeas, Pumpkin leaves, Sunhemp, African kales and Vine spinach. These vegetables grew as weeds on farms or were cultivated by farmers in kitchen gardens.

Objective (2) sought to assess the effects of sugarcane farming on agro-biodiversity in Mumias division. In this context, the study established the following: Commercial sugarcane farming occupied 35% of the land in 1970s, increasing to 48% in 1980s then declining to 43% in 1990s and 38% in 2000s. The reasons for the decline were expensive charges on inputs, poor payment and delayed payment (95%), delayed harvesting and cane spillage (92%), manipulation of weighing bridge (90%), poor harvesting technique (80%), poor quality of seed cane and risks of sugarcane burning while still on the farm (67%).

The size of land under indigenous crops such as maize declined in 1970s and 1980s by 6% and 4% respectively but later increased in 1990s and 2000s by 4% and 6% respectively. The sizes of land under sorghum declined by 8% and 3% in 1970s and 1980s respectively but increased by 2% in 1990s and 1% in 2000s (Table 6, 7, 8 and 10). The sizes of land under finger millet declined by 6% and 2% in 1970s and 1980s respectively. The size then increased by 1% in 1990s and 2000s. The sizes of land under sweet potatoes declined by 2% and 1% in 1970s and 1980s respectively but increased by 1% in 1990s and 2000s (Table 6, 7, 8 and 10). The causes for the decline in the size of land under indigenous crops such as maize, finger millet, sorghum and sweet potatoes in 1970s and 1980s included sugarcane farming, pests and diseases, labour intensiveness and change in tastes and preferences. The increase noted in 1990s and 2000s was because the size of land under sugarcane declined over this period and the fact that agricultural extension officers enlightened the community on the importance of indigenous crops in nutrition.

The sizes of land under cassava declined by 8% and 3% in 1970s and 1980s respectively. There was a further by 1% decline in 1990s and 2000s (Table 6, 7, 8 and 10). The size of land under groundnuts declined by 1% in 1970s. There was 1% increase in 1980s. No change noted in 1990s and 2000s (Table 6, 7, 8 and 10). The size of land under bambara groundnuts declined by 4% in 1970s. There was no change in 1980s and 1990s. A further 1% decline was noted in 2000s (Table 6, 7, 8 and 10). Simsim was cultivated on the least size of land (1%) in the division in 1960s. There was no change in 1970s 1980s. One percent (1%) decline was noted in 1990s and 2000s. The causes for the decline in the size of land under cassava included pests and diseases and the fact that cassava contains poison that was dangerous to the health. The decline in the size of land under simsim was because of sugarcane farming, pests and diseases and labour intensive. Groundnuts and bambara groundnuts are often intercropped with other crops such as sugarcane

and maize and therefore did not require a specific portion of land to be set aside for their cultivation.

The number of farmers growing indigenous vegetables such as african nightshade increased by 1% in 1970s, declined by 25% in 1980s. A twelve percent (12%) increase was noted 1990s and a 15% decline in 2000 respectively (Figure 6,7,8,9 and 10). The number of farmers growing spider plant declined by 12% in 1970s, increased by 5% and 1% in 1980s and 1990s respectively, and then a 13% decline was noted in 2000s (Figure 6,7,8,9 and 10). There was a 1% decline in the number of farmers growing jute mallow 1970s. The number increased by 1% in 1980s then declined by 3% and 10% in 1990s and 2000 respectively (Figure 6,7,8,9 and 10).

The number of farmers growing pumpkins increased by 9% in 1970s. It then declined by 13%, 2% and 4% in 1980s, 1990s and 2000s respectively (Figure 6,7,8,9 and 10). There was a 2% increase in the number of farmers growing sunhemp in 1970s. There was no change in 1980s. There was a 5% and 3% decline in1990s and 2000s respectively (Figure 6,7,8,9 and 10). Cowpea increased by 9% in 1970s. The number then declined by 1%, 3% and 10% in 1980s, 1990s and 2000s respectively (Figure 6,7,8,9 and 10). Vegetable amaranths declined by 3% in 1970s, 2% in 1980s and 1990s and a further 14% decline was noted in 2000s (Figure 6,7,8,9 and 10). African kales declined by 12% in 1980s, 20% in 1990s and further declined by 25% in 2000s (Figure 6,7,8,9 and 10). The number of farmers growing pigweed declined by 13%, 1% and 3% in 1970s, 1980s and 1990s respectively. There was no change in 2000s (Figure 6,7,8,9 and 10). Vine spinach is extinct in the region. The reasons for the decline in the number of farmers growing these vegetables included: changes in consumption tastes and preferences, pests and diseases, a long time required for cooking vegetables such as african nightshade and spider plant, lack of

skills and knowledge in preparation, and introduction of exotic plant species such as exotic kales and expensive seeds. The main reason for the increase in the number of farmers growing spider plant, jute mallow and african nightshade in 1980s and 1990s was the introduction of agricultural extension officers who sensitized the community on the importance of these vegetable species in nutrition.

5.2 CONCLUSIONS

The first section draws conclusions based on the main findings in relation to the two research objectives. First, in identifying and comparing the diversity of subsistence foods grown in Mumias division before and after the introduction of commercial farming, the study established that there were many subsistence crops and indigenous vegetables grown before the introduction of commercial sugarcane farming. This contributed to high agro-biodiversity in the region. Currently, the study established that these indigenous crops are still available in the region apart from vine spinach which is extinct. These subsistence crops and indigenous vegetables were mostly landraces which had not undergone any improvement through breeding. These research findings have implications on the food security measures and nutrition currently being undertaken by the ministries of Agriculture and Health

Second, the assessment of the effects of sugarcane farming on agro-biodiversity of crops in Mumias division established that the agro-biodiversity declined from 1970s due to the introduction of commercial sugarcane farming. This was portrayed by the decline in the size of land under indigenous crops and decline in the number of farmers growing indigenous vegetables while the land under sugarcane increased over the same period. The increase in agro-biodiversity in 1990s and 2000s was attributed to decline in income from sugarcane prompting farmers to

reduce land under sugarcane. The increase in commercial sugarcane farming could lead to a great decline in agro-biodiversity in Mumias division. This decline could eventually lead to extinction of some crops that play a key role in curbing against food insecurity. The research findings have serious implications to the Ministry of Environment, Health and Agriculture due to the role played by crops in maintaining agro-biodiversity. Whereas commercial sugarcane farming was contributing factor to the decline of agro-biodiversity in Mumias division, other contributing factors to the decline in subsistence crops and indigenous vegetable diversity, included: changes in consumption tastes and preferences, pests and diseases, labour intensivenes, lack of skills and knowledge, and introduction of exotic plant species such as kales.

5.3 RECOMMENDATIONS

Based on the findings of the study, it was recommended that

1. Agricultural extension officers need to sensitize farmers in the study area to allocate specific portions of land for sugarcane farming as well as other portion of land for subsistence crops and vegetable cultivation to ensure food security and conservation of agro biodiversity.
2. Conservation measures to be put in place for indigenous crops such as bambara groundnuts and simsim, indigenous vegetables such as african kales which are threatened with extinction.
3. Investigate the relationship between sugarcane farming and soil fertility, and how this contributes to loss of plant diversity.

5.4 AREAS FOR FURTHER STUDY

1. Effects of sugarcane farming on ecosystem services in Mumias Sugar belt.
2. Effects of sugarcane farming on wild plant and animal species diversity.

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