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Influence of Rainfall Variability on Tomato Production among Small Scale Farmers in Kieni East Sub County, Kenya

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ABSTRACT

In Kenya, horticultural farming within the agricultural sector contributes 25 percent to the national Gross Domestic Product and to job creation for the majority of the households. About one third of Kenya's population live in the Arid and Semi-Arid Lands largely depends on rain-fed agriculture as a source of livelihood. The spatial and temporal rainfall variations that characterize these regions is thought have adverse effects on tomato production, with scanty information existing in literature. This study examined the influence of rainfall variability on tomato production among small scale farmers in Kieni East Sub County, Kenya. The study was conducted in four wards of Kieni East Sub County, Kabaru, Thegu River, Narumoru/ Kiamathaga and Gakawa. Cross sectional survey research design was used in this study. Household questionnaire survey and interview was used to collect primary data from a sample of 45 farmers randomly selected and proportionately distributed among the four wards. Specific objectives were to: establish rainfall characteristics between 1981 and 2014 and establish farmers' adaptation strategies to rainfall variability on tomato production in the study area. Rainfall data was obtained from Kenya Meteorological Department in Nairobi. Data on farmer's adapatation strategies was obtained from the farmers in Kieni East Sub County. The data collected was analyzed using descriptive statistics, frequencies, percentages, means, and tables with the aid of Statistical Package for Social Science (SPSS) version 20.0. The study benefited the Ministry of Agriculture, farmers and policy implementers in improving tomato production in areas that are characterized by varying rainfall patterns.

Keywords: adaptation strategies, rainfall variability, small scale farmers, tomato production.

1. Introduction

Horticultural productions in many parts of the world have been affected by global warming, resulting in worldwide food shortages and starvation. For example high temperatures and water shortages have

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destroyed tomato produce, which has led to a decrease in the income of the farmers (Masahumi et al., 2011). Food production and access to food in many African countries is projected to be severely compromised by rainfall variability (IPCC, 2007). Although studies have shown a 2 percent overall increase in global land precipitation (IPCC, 2012), rainfall characteristics have shown considerable variations from region to region with some areas experiencing decline and in others increase in precipitation due to increased extreme weather patterns. Falkenmark (2007) notes that according to projections, there will be increasing challenges in terms of increased water stress and areas suitable for agriculture along the margins of the arid and semi-arid lands (ASALs) are expected to decrease significantly, thus reducing the horticultural productions.

The sub-humid climatic zone of Africa permits the cultivation of a variety of crops in a pattern that emerged in earlier centuries in response to local conditions (Ziervogel, et al., 2008 and Onyekwelu et al., 2006). This vulnerability is particularly high in Africa where agricultural production is the primary source of livelihoods for 66 percent of the total active population (ILO, 2007). The effects of weather variability are uncertain, but adverse impacts are likely in many regions. The future of African agriculture and food security depends on the outcome of weather variability, indigenous responses to global change, development efforts in the next few decades and global patterns of commodity production and demand (IPCC, 2007). Consequently any significant change in rainfall on a global scale has impact on the tomato cultivation and consequently affect the world's food supply (Kumar et al., 2012). The IPCC projections and studies suggest that the changing climate is likely to impact heavily on tomato production, adversely affect human health and wealth through climate induced heat stresses and diseases as well as alter the hydrological cycle in various countries (IPCC, 2012).

Increased intensity and frequency of storms, drought and flooding, have altered hydrological cycles, and precipitation variance which have implications on future food availability and the potential impacts highly on rain fed agriculture *vis-à-vis* irrigated systems (FAO, 2007). Rain fed farming is very susceptible to weather fluctuations and over the last three decades the frequency of droughts and floods in East Africa has increased resulting in crop failures, water shortage and loss of livestock (Salami, Kamara, Brixiova, and Bank, 2010). More erratic rainfall patterns and unpredictable high temperature spells were capable of reducing tomato production and unless measures were undertaken to mitigate the effects of climate change, food security in developing countries was under threat and was to jeopardize the future of the tomato growers in these countries (Kumar, et al., 2012). Agricultural production remains the main source of income for most rural communities (about 86 percent of rural people, about 2.5 billion, depend on agriculture for their livelihood (The World Bank, 2008). Therefore, the improved adaptation of the agricultural sector to the adverse effects of climate change will be imperative to protect and improve the livelihoods of the poor and to ensure food security (FAO, 2012).

Tomato is one of most important edible and nutritional vegetable crops in the world and ranks next to potato and sweet potato with respect to world vegetable production. Tomato originated in the South America and was later introduced to Africa. It is widely cultivated in tropical, sub-tropical and temperate climates. FAO (2008) estimates that 126 Million tons of tomatoes were produced in the world and China, the largest producer accounted for about one fourth of the global output, followed by United State, Turkey, Iran, Mexico, Brazil, and Indonesia. It is one of the most economically important vegetable crops and is widely cultivated in the world with the total tones in area and production of 5,227,883 ha and 129,649,883 in 2008.

About 80 percent of Kenya's population lives in rural areas and derive their livelihood from agriculture, and even for the urban poor, majority make a living from agricultural related activities like selling of tomato, spinach, cabbages, and cereals (HCDA, 2008). For the rural people, food insecurity is affected by the frequent droughts, floods of different intensity and marketing systems (IFAD, 2011). Therefore a decline in agriculture has thus far reaching implications in terms of employment and income inequality as well as food security for the people of Kenya. In Kenya, Horticulture (growing of vegetables and fruits) is mainly practiced through rain fed though a number of farms, especially the ones growing horticultural crops for export, also use irrigation. The sub-sector is characterized by a tremendous diversity in terms of farm sizes, variety of produce, and geographical area of production. Farm sizes range from large-scale estates with substantial investments in irrigation and high level use of inputs, hired labour and skilled management to small-scale farms, which might be less than one acre (HCDA, 2011)

The beneficial effect of the dietary intake of tomato fruits on human health is linked to the antioxidant activity of tomato phytochemicals, specifically the ability to detoxify reactive oxygen species and reduce occurrence of prostate cancer (Frusciante et al., 2007 and Panthee et al., 2007). Tomato (lycopersicon esculentum) belongs to Solanaceae family. Tomato is one of the Fresh Fruits and Vegetables, (FFV) of high-value that is widely consumed fresh (salads), cooked (sauces and soup) or processed (ketchup) for it is rich in minerals, vitamins and dietary fibres and grown in almost every country of the world (Naika et al., 2005 and Rice et al., 1987). Again, epidemiological studies reinforce the fact that the consumption of tomatoes can go a long way to reduce the occurrence of human prostate cancer (Kotake-Nara *et al*., 2001). Different regions have different names for tomato: tomate (Spain, France), tomat (Indonesia), faa ke'e (China), tomato (West Africa), pomodoro (Italy), and *nyanya* (Kiswahili) (Rice et al., 1987).

Tomato cultivation is practiced through rain fed, irrigation systems and also currently in green houses. Tomato is cultivated mainly by small scale farmers and also under contract farming (HCDA, 2013). The total water usage of a crop of tomato varies tremendously, depending on the prevailing climatic conditions during growth, thus, under hot and relatively dry summer conditions, 550 mm to 600 mm of water may be required (HCDA, 2008). Kenya has experienced climate related impacts such as prolonged drought and frost. In some of the productive agricultural areas; hailstorms, extreme flooding, receding of lake levels, drying of rivers has led to large economic losses and adversely impacting on food security In 2008 and 2011 drought events led to drop in agricultural productivity by 72 percent and 13 percent respectively (GoK, 2010). GoK, (2010) indicates that floods cut off links and destroyed the roads, making transportation expensive and delaying farm produce tomato incusive to the markets.

Some of the tomato growing areas for both markets are Embu, Meru, Nyeri and Murang'a where the altitude is 800-2500 metres above sea level (HCDA, 2008). The national average tomato yield in Kenya is about 30.7 ton per hectare (GoK, 2010). The total domestic value in the horticulture sector in 2013 amounted to Kshs 177 billion cultivated in an area of 605,000 Ha with a total production of 132 million Metric tons and during the year 2011, the area under tomatoes in Kenya was 21,000 Ha (HCDA, 2013).

1.1 Justification and significance of the study

In the ASALs of Kenya horticultural practices in agriculture is crucial to Kenya's overall economic and environment development. In Kenya, where the poverty rate is 52 percent and 73 percent of the labor force depends on agricultural production for their livelihood, poor farmers are likely to experience many adverse impacts from rainfall variations (FAOSTAT 2010). The horticultural sector contributes to food security, wealth creation, poverty alleviation and gender equity especially in rural areas. In the year 2013 the area under vegetable production was 340,000 Ha with a production of 4.3 million MT and a monetary value of Kshs 70 billion (HCDA, 2013). During the year 2013, the area under tomatoes farming was done in 23,865.6 Ha, and the total production for the country was 494,036.5 Metric tons with a value of Kshs 14.1 billion (HCDA, 2013). This provided revenue to the County governments and contributed to food security, income and jobs in both rural and urban areas.

Tomato production is mainly by smallholder farmers and has been conventionally under open and rain-fed field conditions until recently when production under modified high tunnels popularly known as 'greenhouses'. Greenhouse method of farming was pioneered by a few farmers and has gained massive adoption despite the high cost of installation. In the last 2 to 3 years tomato farming provided a large number of jobs in urban and rural areas of Kenya, Kieni East Sub County inclusive. In the year 2011, Nyeri County produced 7916 MT of tomato, with a value of Kshs 230,000,000 and in the same year Kieni East Sub County produced 3700 Metric tons of tomato with a value of Kshs 74,000,000 which represents 46 percent and 32 percent respectively of the Nyeri County tomato production, an indication that tomato is a major crop in Kieni East (HCDA, 2011 and Kieni East Sub County Agriculture Office, 2013), Tomato farming contributes to employments, food security, gender equality and improved living standards of the people living in Kieni East Sub County. A decline in agriculture has thus far reaching implications in terms of employment and income inequality as well as food security for the country (IFAD, 2011).

This study provided an understanding of the relationship between rainfall variability and farmers' adaptation strategies to rainfall variability for tomato production in Kieni East Sub County that would lead to high yields hence improving the family livelihoods of the area and other parts of the country. Furthermore, the study will serve as a useful reference material and guide to future prospective researchers who would want to research into similar area related to climate variability influence and adaptation in various regions in the world. The study will significantly benefit the Ministry of Agriculture, County Agriculture Officers, Kenya Agricultural and Livestock Research Organization (KALRO), Agricultural Extension Officers, Farmers Training Centre, Farmers' policymakers and policy implementers in trying to mitigate tomato farming and seasonal variations of rainfall in the entire country.

2. Literature review

2.1 Rainfall variability

Data from the Kenya Meteorological Department (KMD) shows evidence and impacts of climate change in Kenya over the last 50 years (GoK, 2010). In regard to rainfall patterns, there has been a general decline with time of rainfall in the main rainfall season of March-May (the 'Long Rains') and a tendency for the October-December (the 'Short Rains') to extend into the normally hot and dry period of January and February. Any change in rainfall pattern may impact on the agricultural sector in particular and other socio-economic activities in general (Clement, 2009). In Kenya, majority of rural farmers depend heavily on rain-fed agriculture hence rural livelihoods are highly vulnerable to rainfall variability such as less than normal rainfall, normal rainfall but in a few days or even more rainfall than normal, (Seitz and Nyangena, 2009). The Semi-arid areas receive low and erratic bimodal rainfall that is highly variable both in space and time notes (UNDP, 2013).

Over 80 per cent of total agriculture globally is rain-fed, projections of future precipitation changes often influence the magnitude and direction of climate impacts on crop production (Olesen and Bindi 2002; Tubiello et al, 2002). A lot of literature on climate acknowledges that extreme weather events lead to poverty, inequality and disrupt lives and livelihood in many parts of Sub Saharan Africa (Mc Carthy et al, 2001). Many of the largest reductions in crop productivity have been attributed to anomalously low precipitation events (Kumar et al, 2004). El Niño and La Niña are both important influences in agriculture and risk of extreme events put the region on the alert against a possible drought and related food crisis, particularly in countries near the core of the South East African climatic region (Clay et al, 2003).

More erratic rainfall patterns and unpredictable high temperature spells reduce crop productivity (Kumar et al, 2012). The global climate model predicts that rainfall variability may range 5 to 20 percent in Kenya by the year 2030 (World Wide Fund, 2006). Hydro-meteorological risks such as droughts, cyclones and floods not only endanger human lives and property but also have devastating impact on food production and farmers' livelihood systems sometimes across countries and continents (WMO, 2009).

There have been observable changes in rainfall amounts, timing and distribution, thus lowering agricultural production (Huho and Kosonei, 2013). Lobell and Burke (2008) report that a change in growing seasonal precipitation by one standard deviation can be associated with as much as a 10 percent change in crop production. Kenya experienced a severe drought in the year 2009 that led to famine which affected 10 million people countrywide after poor harvest and crop failure (Kenya Red Cross, 2009). Lobell (2010) noted that high climatic variability represents a delicate balance between agricultural production and food security. He further argued that the changes in the agriculturally-relevant variables of climate such as increasing temperatures and declining levels and distribution of rainfall are likely to reduce yields of crops such as, tomatoes maize, among others in Kieni East Sub County and other semi-arid regions of the world. However, not all changes in climate and climate variability are seen as negative. In some areas, such as parts of the Ethiopian highlands or Mozambique, climate change may extend the agricultural growing seasons as a result of increased temperatures and rainfall changes (Thornton, et al, 2006).

Exposure to impacts of rainfall variability and extremes, most particularly drought, poses substantial risks to people living in Central Kenya, especially those deriving their livelihood from rain fed farming in the rural areas causing widespread famine (Ogolla et al, 1997). According to IPCC (2007), East Africa has been faced by large variability in rainfall with occurrence of extreme events in terms of droughts and floods. Droughts in the last 20 years 1983/84, 1991/92, 1995/96, 1999/2001, 2004/2005, led to famine. El-Niño related floods of 1997/98 were severe events and La Niña in the year 1999 and the year 2000 was the most severe in the last 50 years. About 80% of the total land area of Kenya is occupied by the arid and semi-arid lands. The rainfall is sparse and is also characterized by high variability between years and seasons. It is also extremely unpredictable. In addition, the rain often occurs as very localized and intense storms which cause flooding and heavy run-offs. Sometimes massive soil erosion results due to the scant vegetation cover (Ojany, F.F and Ogendo, R.B, 1988).

2.2 The effects of rainfall variability on tomato production

Rain fed farming is very susceptible to weather fluctuations and over the last three decades the frequency of droughts and floods in East Africa has increased resulting in crop failures, water shortage and loss of livestock (Salami, Kamara, Brixiova, and Bank, 2010). More erratic rainfall patterns and unpredictable high temperature spells are capable of reducing tomato production. Therefore stringent measures need to be undertaken to mitigate the effects of climate change, food security in developing countries which are under threat to jeopardize the future of the tomato growers (Kumar, et al, 2012). Agricultural production remains the main source of income for most rural communities where about 86 percent of rural people, about 2.5 billion, depend on agriculture for their livelihood (The World Bank, 2008). Improved adaptations of the agricultural sector to the adverse effects of climate change will be imperative to protect and improve the livelihoods of the rural poor and to ensure food security (FAO, 2012).

Water stress and long dry periods cause tomato buds and flowers to wilt and drop off, and the fruits to split. However, if rains are too heavy and humidity is too high, the growth of mould increase and the tomato fruits rot (Naika et al, 2005), increase incidences of early and late bright diseases and eventually reduces the yields. Unpredictable drought is the single most important factor affecting world food security and the catalyst of the great famines of the past and decreased precipitation could cause reduction of irrigation water availability and increase in evapo-transpiration, leading to severe crop water-stress conditions and vegetables and in particular tomato, being succulent products by definition, generally consist of greater than 90 percent water (Kumar et al, 2012).

2.3 Tomato production

Table 2.1 illustrates how the farmers in Kieni East Sub County carry out the tomato production througout the year. The farmers have two seasons when they plant tomato, in May and December.

Table 2.1 : Tomato Growing Calendar

Jan	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
weeding	Harvesting ←→ Preparing land Making seed beds Marketing ←→			Transplanting Weeding Spraying Staking Pruning		Harvesting Marketing		Preparing Land Making seed beds			Transplanting weeding

Source: Field Data 2014

Tomato harvesting is ideal when it is warm. Grading, packing and marketing can commence about 14 weeks from transplanting. Tomatoes are ready to be harvested when their colour is even and texture is soft but resilient. They ripen from the bottom or "blossom end" to their tops or "shoulders" where they are attached to the stem. Hand labour was used for all activities like harvesting, grading and

packing. Tomatoes are often harvested at the mature green stage just as reddish areas on the fruit start to appear, the shape of the fruit depends on the cultivar. (Naika et al, 2005). After picking, the fruit is generally graded according to size, by hand, as well as by colour and quality. First grade fruits must be sound, free from diseases, cracks, blemishes, foreign matter or spray residues, and be well-shaped and uniform in size and colour and generally command better prices on average. Each size, colour and quality grade is packed separately for marketing in wooden or plastic crates weighting fifty and seventy kilograms. The package is not standardized by law but has established itself in the market with more or less standard weight (Ssejjembe, 2008).

The potential customers check on fruit size, colour the general quality they prefer and how they want it presented, whether plastic or wooden trays. Periodic visits should be made to various market outlets to assess needs, to compare one's standards of quality, grading, packing, trays, and prices of one's competitors (NaanDanJain Irrigation, 2008). Tomato is transported to the markets, in wooden or plastic containers "crates" which are designed to prevent damage to the fruit. Tomato fruit ripen in transit or in storage before they are marketed. Ripened fruit tends to have better flavours. Expected yields can be up to 4 kg of fruit per plant with field yields of about 20 tons per hectare being achievable.

Figure 2.1 shows the average price of tomato per kilogram from the year 2006 to year 2012 in Kenya.

Figure 2.1 shows the average price of a kilogram of tomato has been on a gradual increase since the year 2006 but dropped significantly in the year 2009 and again adopted the rising trend in the subsequent years. The variability of price is as a result of production, human and rainfall factors. It was noted that during the periods of high rainfall the demand of tomato increased and this led to high market prices and consequently the tomato farmers were able to receive high income.

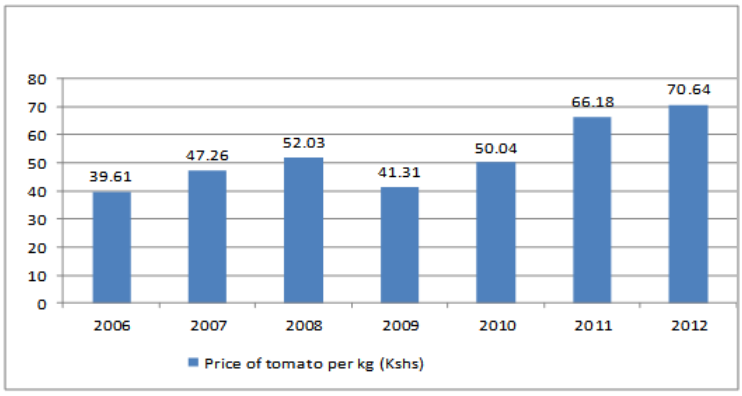

Figure 2.1: Average Price of Tomato per kilogram since 2006 in Kenya.
Source: Statistical Abstract, 2013

2.4 Farmers' adaptation strategies to rainfall variability on tomato production

IPCC (2007) defines climate adaptation as initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Droughts poses the main threat to rural agricultural livelihood sources and therefore emphasis must be put on drought adaptation and mitigation strategies. The tomato sub-sector is among the rapidly evolving sub-sector worldwide due to increasing population, decreasing land sizes and changing climatic conditions (Odame et al, 2008. According to the study report of Bryan et al., (2013) to the World Bank on adaptation of smallholder agriculture to climate change in Kenya, farmers employ a plethora of adaptation strategies such as changing crop variety, changing planting dates and changing crop type. Over 80 percent of the Kenya landmass falls under arid and semi-arid climates where droughts and floods are the main characteristics of rainfall. Evidence of climate change has become more pronounced in through the alternating cycles of droughts and floods. Such cycles have been experienced in Kenya in 2004, 2006 and 2009 where droughts were interposed with floods, thus affecting tomato yields (Kenya Red Cross Society, 2009).

Plate 1: Tomato Packed in Wooden Crates ready to Transport to the Market
Source: Field data (2014)

Adaptation to rainfall variability is crucial because of the shocks and risks that are visited on farmers. This section therefore examines how farmers adapt to the effects of rainfall variability on tomato production in the Kieni East Sub County. Majority of people across the globe depend much on the available natural resources for survival and livelihood, especially the poor in ASALs who are often vulnerable to climate variability and change (Morton, 2007). Food and Agricultural Organization (FAO, 2008) noted that adaptation is critical in protecting livelihoods and food security in many developing countries. It involves all actions aimed at coping with climatic changes that cannot be avoided and at reducing their negative impacts and also that enhance the capability to capture any benefits of climate change. Adaptation involves the action that the local people take in response to, or in anticipation of, projected or actual changes in climate to reduce adverse impacts or take advantage of the opportunities posed by climate change (Parry et al, 2005). In West and East Africa, communities living in particularly in ASALs and other dry land have developed traditional water harvesting systems in response to the increasingly frequent droughts (Jama et al, 2009).

Another important issue that has been largely overlooked in the impacts and adaptation studies is that of the inter- and intra-seasonal variability of rainfall. Long-term changes in climatic such as temperatures and rainfall may be dealt with quite successfully if the right crop species/ varieties or cropping techniques are applied (Serigne, Kandji and Jens, 2006). Other agricultural adaptation strategies include; provision of downscaled weather information and farm input and water harvesting e.g. building of sand dams for irrigation. There is protection of natural resource base (soil and water conservation techniques); use of different crop varieties and changing planting dates. Finally there is increased use of water and soil conservation techniques and diversifying from farm to non–farm activities and research and dissemination of superior (drought tolerant, salt-tolerant, pest and disease resistant) crops (GoK, 2010)

FAO (2007) adds that rainfall variability adaptation for agricultural cropping systems requires a higher resilience against both excess of water (due to high intensity rainfall) and lack of water (due to extended drought periods). Adaptive strategies include develop capacity for drought early warnings, changes in cultivated land area in line with control of pests, weeds, parasites and use of irrigation and fertilizers. Other strategies include changes in crop location, improved flood control activities, rescheduling of planting dates, and wider use of early-maturing varieties (Serigne, Kandji and Jens, 2006). Crop rotation means planting different crops on the field each season and only returning the same crop after at least three growing seasons. This interrupts the life cycle of pathogens and reduces the chance of damage by diseases and pests (Naika et al, 2005). Tshiala and Olwoch (2010) identified irrigation as an effective adaptive strategy that enhances the improvement of tomato yield. The most commonly reported adaptation strategies of smallholder farmers to climate change in sub-Saharan Africa are changing crop varieties, changes in planting dates, irrigation, soil conservation measures, tree planting, water harvesting and changing crop types (Bryan et al, 2013). These adaptation strategies have the potential to help farmers show resilience in the wake of the shocks of the varying rainfall amounts and would contribute towards refinement of policies to deal with rainfall variability on tomato farming.

3. Objectives of the study

The specific objectives of this study were:

i. To establish the rainfall characteristics between 1981 and 2014 in Kieni East Sub County.

ii. To establish farmers' adaptation strategies to rainfall variability on tomato production in Kieni East Sub County.

3.1 Methodology and study area

Kieni East Sub County is in Nyeri County in Central Kenya. It is expansive and occupies about 817sq km (Statistical Abstract, 2013). In terms of geographical coordinates, the region lies between 0° 00' to 0° 24' South and 37° 00' to 37° 12' East. It borders Meru Central Sub County to the North, Mathira Sub County and Nyeri Municipality to the South, Mount Kenya to the East and Kieni West Sub County to the West. Mt Kenya serves as a major a water tower and a National Park of the Kieni East Sub County. Land size per household varies across the Sub County but with an average of 2 hectares (Jaetzold R,

Schmidt H and Shisanya C, 2006). Land ownership is predominantly freehold and the majority of the farms in the area are small scale. The growing seasons are largely determined by rainfall patterns, the two distinct rain seasons occurring between February-June and October – December. The area comprises of four administrative wards namely; Kabaru, Thegu River, Narumoru/ Kiamathaga and Gakawa.

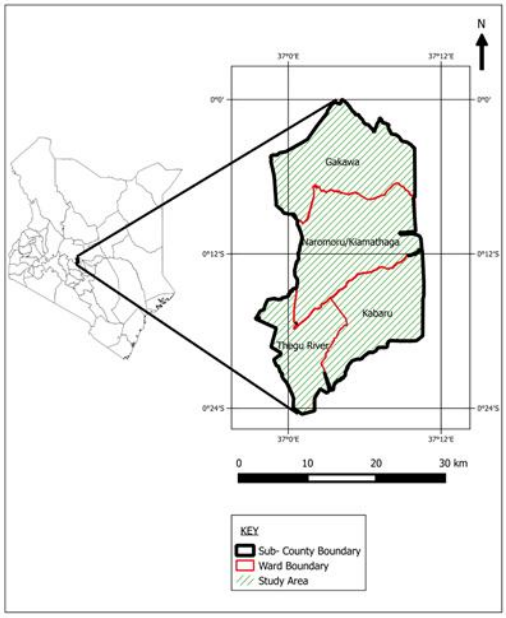

Figure 3.1 Location and Size of the Study Area
Source: Kieni East Agricultural Office, 2013

4. Results and discussion

4.1 Rainfall variability

The first objective was to establish the rainfall characteristics between 1981 and 2014 in Kieni East Sub County. The study established the rainfall characteristics over the past thirty three years (1981 – 2014) in Kieni East Sub County. Rainfall variability observed in both annual and seasonal trends was significant as revealed in Figures 4.1. The annual rainfall variability trend showed some anomalies which give evidence which portray the varying and unpredictable nature of the rainfall pattern in the study area. The country's climate permits production of a wide range of tomato varieties throughout the year and when produced timely, they can provide a reliable and regular source of income to the producers.

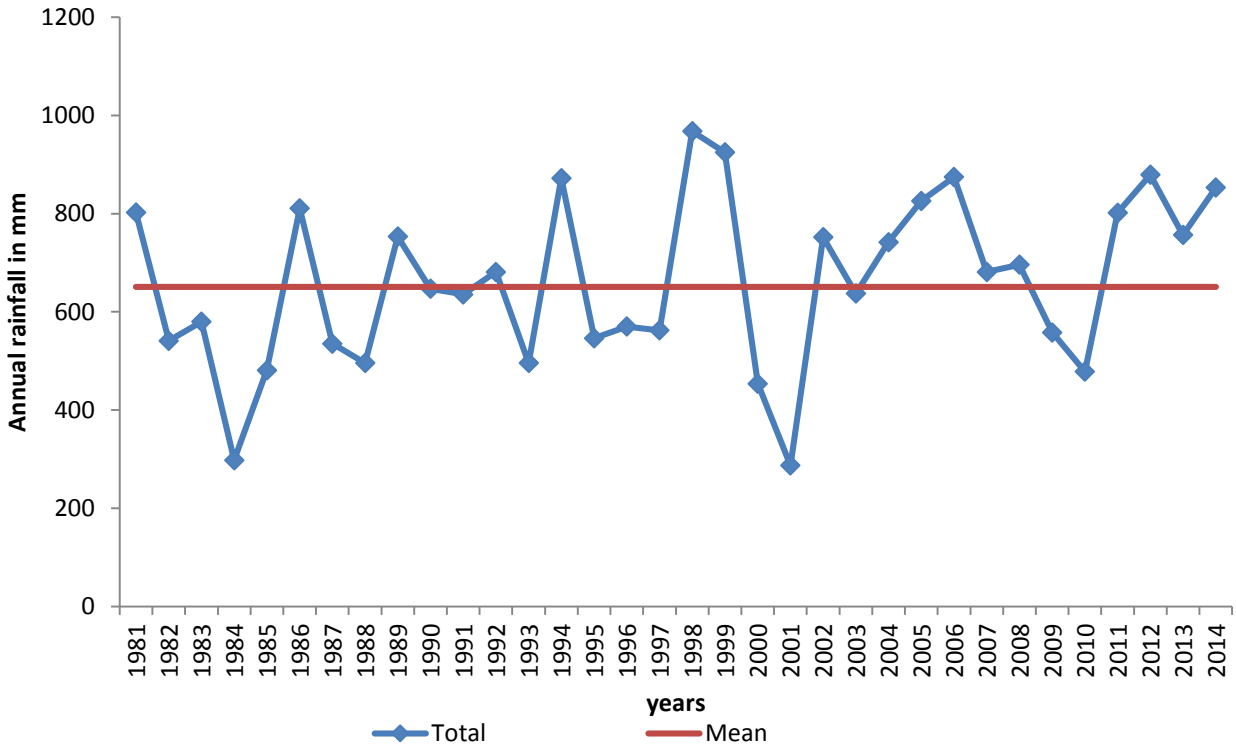

Figure 4.1: Annual and Mean Rainfall for the Period between 1981 and 2014 in Kieni East Sub County
Source: Kenya Meteorological Department, Nairobi

4.2 Effects of rainfall variability on tomato yields

The second objective analyzed the annual rainfall characteristic and correlated it with tomato production trends, yields and prices between 2009 and 2014 in Kieni East Sub County. From the study, it was evident that rainfall had some statistically significant negative relationship with tomato yields. This

means that an increase in rainfall caused a significant decrease in tomato yield with some confounding variables such as soil type, pests, disease, application of certified seeds, irrigation, tomato variety and regular weeding held constant. Hence this means that even though tomato needs water, excessive rainfall is detrimental to the tomato crop. High yields of the tomato resulted to low prices in line with law of demand and supply.

4.3 Farmers adaptation strategies to rainfall variability on tomato farming

The respondents applied different adaptation methods to check on the effects of rainfall variability on tomato farming. The results are represented on Table 4.1. It was observed that tomato farmers employed varieties of on-farm adaptation strategies; strategies that are practiced in the farm such as mulching, use of manures crop rotation, construction of greenhouses, irrigation and use of certified seeds as compared to the off-farm strategies like construction of water dams for irrigation.

These adaptation strategies practiced by the tomato farmers reinforces the relevance of the conceptual framework adapted for the study which explains farmers preparedness in employing adaptive strategies when their social and economic livelihoods are affected by the effects of rainfall variations. It was noted that a farmer could take more than one adaption strategy. Use of manure was applied by 32.3 percent of the respondents as compared to use greenhouses which was applied by 3.1 percent. Only 2.4 percent of respondent were able to access and do tomato in new pieces of earlier not cultivated (virgin lands), as the soil would have a high water retention capacity. Only 7.9 percent of the respondents were following agriculture officer advice which means the certified used seeds may not be the best for the specific farms or seasons hence limiting the production. Practicing rotation of crops was adapted by 7.1 percent of the respondents.

Table 4.1: Adaptations strategies adopted by tomato farmers

Adaption methods	N	Percent
Use of certified seeds	37	29.1%
Use of manure	41	32.3%
Use of green houses	4	3.1%
Follow advice from Agricultural Officers	10	7.9%
Mulching	12	9.4%
Virgin land farming	3	2.4%
Use of water irrigation/ Dam	11	8.7%
Practicing crop rotation	9	7.1%
Total	127	100.0%

Plate 2: Adaptation through Green House
Source: Field data (2014)

Many farmers in the area do practice mixed farming hence manure is cheaply and readily available. Use of certified seeds was also adopted by 29.1 percent, and this finding is consistent with the study of Tshiala and Olwoch (2010) who observed that the use of certified seeds are a good adaptation strategy that improves tomato yields. Use of greenhouse provides opportunities for year- round high production of tomato. Cultivation of tomato in new lands is cumbersome due to process of clearing bushes and such lands are not easily available and therefore farmers perceived it as an expensive venture. Therefore modern methods of farming are yet to be adopted in this area mainly due to lack of capital as only 24.5 percent of the respondent were able to access to finances from commercial banks and Saccos.

The adaptation strategies per ward are presented on Table 4.2. Use of manure and certified seeds is commonly adopted strategies by over 66.7 percent of the respondents in the Sub County. Use of dams to irrigate tomato was not applied in Kiamathaga/Narumoru and Gakwa wards. Use of

greenhouse was used by18.2 percent of the respondents in Kabaru ward. In Thegu River and Kabaru wards 50 percent and 27.3 percent of the respondents respectively adopted use of irrigation from rivers and dams.

Table 4.2: Adaptations strategies undertaken by tomato farmers per ward

	Ward				Total
	Kabaru	Thegu River	Nauromoru/ Kimathaga	Gakawa	
certified seeds	10	14	9	4	37
	90.9%	87.5%	81.8%	66.7%	
Use of manure	10	16	9	6	41
	90.9%	100.0%	81.8%	100.0%	
Use of green houses	2	1	1	0	4
	18.2%	6.2%	9.1%	0.0%	
Follow advice from Agricultural officers	5	1	2	2	10
	45.5%	6.2%	18.2%	33.3%	
Mulching	3	4	5	0	12
	27.3%	25.0%	45.5%	0.0%	
Virgin land farming	0	2	1	0	3
	0.0%	12.5%	9.1%	0.0%	
Irrigation/ dams	3	8	0	0	11
	27.3%	50.0%	0.0%	0.0%	
Crop rotation	2	4	1	2	9
	18.2%	25.0%	9.1%	33.3%	
Total	35	50	28	14	127

Plate 3: Adaptation by Applying Mulching.
Source: Field data (2014)

There are streams (Kandune, Lusoi) and rivers (Nairobi, Thegu) and therefore water is readily available, the volumes decreases considerably during periods of drought. Irrigation being an adaptive mechanism is seen as relevant particularly in the dry season as opined by Tshiala and Olwoch (2010) that identified irrigation as one of the major adaptive strategies that could improve the yield of tomato in the era of rainfall variability. New lands for cultivation are available along the rivers and stream sides in Thegu and Narumoru/ kiamathaga wards. The use of greenhouse technology is being adopted in Kenya, mainly for the purpose of high yields and production of high quality tomato throughout the year. Tomato pests and diseases are easily controlled in greenhouses. The use greenhouse is limited in the study area due to high cost involved in putting up; 120 square meter greenhouse costs Kshs 150 000 (Osure, 2010), taking into consideration that only 24.5 percent adapted.

Finally, the study revealed that farmers encounter numerous challenges in their bid to adapting to rainfall variability. Lack of access to weather information from the Kenya Meteorological department (KMD) and advice from Agricultural personnel was a major challenge

5. Conclusion

The main objective of the study was to find out the influence of rainfall variability on tomato production in Kieni East Sub County of Nyeri County. The study has made fairly significant contribution to previous methodologies regarding rainfall variability and tomato production. The study revealed that most farmers plant according to traditions and not according to seasonal weather forecast from KMD. The study has provided a framework for further research regarding rainfall variability effects and adaptation strategies relationships. Rainfall variation, insufficient of clean seeds, soil degeneration,

diseases and pests, high cost of farm inputs, inaccessible roads during wet seasons, interference of marketing by brokers, far markets and inadequate field officers are found to be the major challenges tomato production is facing. Clean seeds are either not available or when available they are very expensive to farmers. Agricultural field officers are few as compared to farmers and this has denied the farmers an opportunity to receive vital scientific knowledge necessary to increase their production.

6. Recommendations

Soil and water management practices should be enhanced to reduce loss of moisture from the soil and increase soil water retention capacity during dry seasons in Lusoi, Nyange and Githungo of the study area. In Kabaru, Kamburaini and Warazo Jet more trenches should be dug to reduce cases of water logging during heavy rain seasons. This water should be drained into earth dams to be utilized for irrigation during the dry seasons.

Since climate change may exacerbate rainfall variability, a close collaboration among the meteorological department and agricultural officers as well as the farmers to enable a more effective use of climate information. Farmers should be encouraged to enhance crop diversification to caution them from rainfall variability and to increase tomato production. Training of farmers on importance of timely planting should be intensified to utilize the available rains at their different stages of growth such as flowering and maturity, hence the KMD should avail relevant data information on weather predictions. The farmers' field day organized by KALRO officers should be organized more frequently to enable more farmers receive the appropriate information timely.

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