ANALYSIS OF FACTORS INFLUENCING TOMATO FARMERS' WILLINGNESS TO ADOPT INNOVATIVE TIMING APPROACHES FOR MANAGEMENT OF CLIMATE CHANGE EFFECTS IN TAITA TAVETA COUNTY, KENYA

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DECLARATION AND APPROVAL

Declaration

This thesis is my original work and has not been presented for the award of a degree in any other academic institution.

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DEDICATION

With lots of love, I dedicate this thesis to my father Abel, my late mother Maryloice, my siblings Emash, Nunu, Fay and Bhabha, my cousin Lilian and aunt Dorcas.

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ABSTRACT

Climate change poses serious economic challenges including low quality and yield of produce and high post-harvest losses leading to low incomes among smallholder tomato farmers. Recent literature shows possible ways of managing climate change, including innovatively altering the timing of farming operations to avoid adverse weather conditions and or taking advantage of favorable conditions. However, available literature on farmers' decision-making behaviour and the main factors that influence their willingness to adopt innovative management strategies is scanty. The current study addressed this knowledge gap by analyzing factors affecting smallholder tomato farmers' willingness to adopt innovative timing approaches to manage climate change effects in Taita Taveta County. Three innovative timing approaches, namely, off-season production, transportation of produce during cool periods of the day and processing of tomatoes to extend shelf life were identified at three nodes of the tomato value chain. A two-stage sampling technique was used to randomly select 196 smallholder tomato farmers who were interviewed using semi-structured questionnaires. Descriptive statistics and a Multinomial Logit (MNL) model were applied in data analysis. Results from the study show that farmers are coping with climate change through practices such as early preparation of land, changing planting dates, increasing the frequency and timeliness of weeding and using early maturing crop varieties. The MNL analysis showed that gender, access to credit, group membership, age and income are the main factors that determine farmers' willingness to adopt innovative timing approaches. These findings offer useful insights for improving the planning of investments in the tomato value chain, for enhanced stability of farm incomes among farmers. In particular, interventions that would help to boost farmers' uptake of off-season production include improving farmers' access to credit through lowering interest rates and simplifying application and disbursement procedures of financial service providers, as well as formation of farmer groups to enhance processing of their produce.

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List of Abbreviations and Acronyms

ANOVA	Analysis of Variance
CGIAR	Consultative Group for International Agricultural Research
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
IIA	Independence of Irrelevant Alternatives
IPCC	Intergovernmental Panel on Climate Change
KES	Kenya Shillings
KNBS	Kenya National Bureau of Statistics
MNL	Multinomial Logit
OECD	Organization for Economic Co-operation and Development
PNUTGRO	Peanut Crop Growth Simulation
SPSS	Statistical Package for Social Sciences

CHAPTER ONE

1. INTRODUCTION

1.1 Background Information

It is generally agreed among scientists that climate change is a reality the world over with the agricultural sector in the tropical regions experiencing adverse impacts (Kurukulasuriya & Rosenthal, 2003). Climate change is defined as "a change in the state of the climate that can be identified by changes in the mean and or the variability of its properties, and that persists for an extended period, typically decades or longer" (Intergovernmental Panel on Climate Change, 2007).

On the other hand, a closely related term 'climate variability' is defined as "variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes) of the climate on all temporal and spatial scales beyond that of individual weather events." (Intergovernmental Panel on Climate Change, 2001).

Kenya's horticultural sub-sector is the most important amongst all sub-sectors in the agricultural sector (Horticultural Crops Development Authority, 2013a). The sub-sector however faces a number of challenges with the effects of climate change becoming a concern (Kenya Development Learning Centre, 2010; Horticultural Crops Development Authority, 2013a). The Horticultural Crops Development Authority (2010) deems that the impact of climate change is already evident in the horticultural sub-sector with the decline in vegetable exports from 82,000 tons in 2008 to 72,000 tons in 2009. The decline has been attributed to unpredictable rainfall, which makes farm investment planning a challenge. Production of fruits and vegetables bears the brunt of weather-related risks as it is to a large extent practiced by smallholder farmers under rain-fed production systems (Minot & Ngigi, 2004).

If not abated, intra- and inter-seasonal climate variability could lead to major losses in the horticultural sub-sector. Since production is mainly weather-dependent, any changes in climatic and weather conditions will have an impact on the quality and quantity of produce with the resultant effect of decline in farmers' income and more volatile prices (OECD-FAO, 2010). As noted by Adiku *et al.* (1997), the erratic nature of rainfall negatively influences crop production in many semi-arid parts of Africa.

The unpredictability of weather conditions makes farmers unprepared as they do not know when to expect good or bad conditions (Jagtap & Chan, 2000). However, prompt provision of climate predictions can aid farmers in decision-making, reduce adverse impact and allow them to take advantage of, or prepare to effectively manage forecasted conditions (Bernardi, 2011). Furthermore, effective dissemination of climate information and advisory services can help a great deal in improving the management of climate-related risks and help farmers to adapt to change (Tall *et al*., 2014).

One of the important horticultural crops cultivated in Kenya is tomatoes. It is a high value crop and was recently ranked first in a prioritization workshop of vegetable crop value chains in the country (Kenya Agricultural Research Institute, 2012). Tomato enterprises offer great potential to create employment opportunities and increase incomes of actors involved in the tomato value chain through commercialization (Koenig *et al*., 2008). Slightly more than 30% of farmers grow tomatoes for either home consumption or for cash countrywide (Minot & Ngigi, 2004). The crop contributes 14% of all vegetable produce and about 7% of horticultural crops in the country (Republic of Kenya, 2012a). However, the crop is characterized by high perishability and is vulnerable to effects of climate change.

The main tomato varieties cultivated in the country include Riogrande, Moneymaker, Cal J, Roma and Onyx (Bob *et al*., 2005; Koenig *et al*., 2008). Cal J is preferred by the consumers owing to its long shelf life (Tschirley *et al*., 2004). Figure 1 shows the trends in production and productivity of tomatoes in Kenya. Although the area under production has been increasing over time, productivity has not kept pace with this trend. In fact, from 2009, productivity exhibited a downward trend (30.6 tons/Ha to 20.9 ton/Ha). This was partly due to the drought conditions experienced in 2008 which adversely affected crop production in the country.

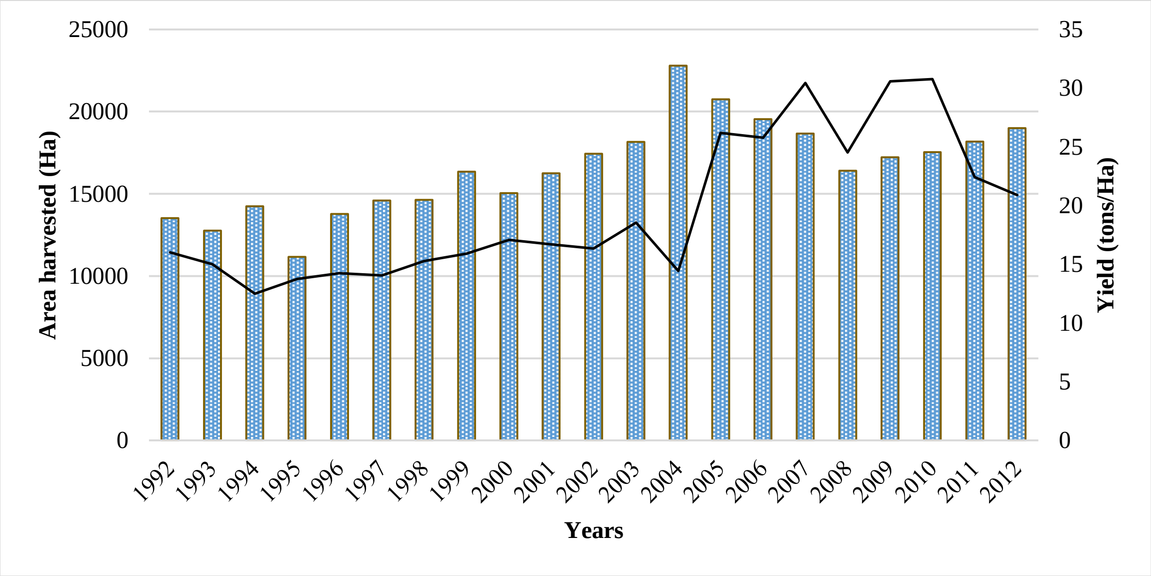

Figure 1: Trends in production of tomatoes in Kenya (1992-2012)

Source: FAO Statistics, 2016.

Koenig *et al*. (2008) noted that seasonality in production as influenced by weather conditions is responsible for the market price fluctuations of tomato produce in Kenya. A study conducted by Tschirley *et al*. (2004) showed tomato trade patterns between Kenya and its neighboring countries. The authors noted that Kenya experiences seasonal low production in the months of May-August and November-December. In order to supplement its low production during these periods, Kenya relies on tomatoes imports from Uganda and Tanzania (through Namanga, Lunga Lunga and Taveta borders) and Uganda (through Malaba, Busia and Isebania borders). Negligible volumes of tomatoes are exported into Tanzania.

Farmers in Africa are adapting to climate change using various strategies. Numerous studies, for example, Smit and Skinner (2002), Hassan and Nhemachena (2008), Ekpo and Nzegblue (2012) have identified various adaptation measures including irrigation, adoption of improved varieties, crop insurance, conservation tillage and livelihood diversification, depending on the nature of climate change and its effects. Indeed, adaptation has been recognized as the most efficient way for farmers to reduce the negative effects of a changing climate (Füssel & Klein, 2006).

Smallholder farmers can also be able to manage climate variability by altering the timing of their farming operations in such a way that they avoid adverse weather conditions and or take advantage of favorable conditions (Rosenzweig & Tubiello, 2007). This may involve year-to-year shifts in planting dates to better suit environmental changes. Some previous studies have suggested change in the timing of operations as a strategy to combat climate change (Kurukulasuriya & Rosenthal, 2003; Olesen *et al*., 2011). This adaptation measure is already being practiced in some parts of Africa where farmers routinely adjust planting dates in reaction to climate variability (Tadross *et al*., 2005; Maddison, 2007). Farmers stand to benefit by changing the timing of farming activities if climate change leads to “large shifts in the factors that determine optimal planting times” as Burke and Lobell (2010) observed. Thus, proper timing of activities such as planting, weeding and harvesting is important as these can help in mitigating the risks associated with climate change (Hassan & Nhemachena, 2008).

Despite the realities of climate change, there have been tomato producers who continue to do farming as has traditionally been passed down from previous generations. In the last decade, however, emerging evidence shows that some farmers are beginning to adjust the timing of their activities cognizant of the fact that climate change has led to shifts in seasons. For example, a study by Hassan and Nhemachena (2008) found that about 16% of African farmers have varied their planting dates as an adaptation strategy to climate change.

Prudent farmers take into account the status of the soil moisture in deciding the best time to cultivate, plant and apply fertilizers. This requires accurate and timely weather predictions to be disseminated to farmers in order to allow for planning and organizing of field activities so as to minimize adverse impacts and reap from favorable conditions (Jagtap & Chan, 2000).

Climate predictions help in decision-making such as what variety to grow and when, how much water to use for irrigation or when outbreaks of diseases are likely to occur (Bernardi, 2011). In Australia, Eastern and Southern Africa, some farmers have been reported to use seasonal forecasts to guide their agricultural decisions (O'Brien *et al*., 2000; Stone & Meinke, 2005).

Innovative timing involves farmers adjusting their operations in such a way that they are able to take advantage of, or minimize risks associated with climate change. Thus, innovative timing takes into consideration some key factors that determine optimal outcome. These factors could include, for instance, the availability of water, labor, expected temperature conditions (Hassan, 1996) and availability of good markets. In Kenya, however, available literature on the extent of use of innovative timing for agricultural value chain activities remains scanty.

1.2 Statement of the Research Problem

Approximately half of inter-annual variability of crop production is due to weather variability and between 5 and 10% of global agricultural production is lost yearly due to unfavorable weather conditions (Bernardi, 2011). In Kenya, it was estimated that the 2008-2011 drought alone caused 23% of crop losses nationally with the Coast province registering about 45% crop losses (Republic of Kenya, 2012c). Smallholder farmers in sub-Saharan Africa are vulnerable to climate change given that they are resource-poor and unable to afford adaptive measures that involve large capital outlays (Deressa *et al*., 2008).

In Taita Taveta County, the tomato value chain has been adversely affected as a result of changing climate with the yield per hectare (35 tons/Ha) being way below the potential level (50 tons/Ha). This has been due to crop losses associated with vagaries of weather (Republic of Kenya, 2013c). Further, due to seasonality in production, farmers face fluctuating prices which affect stability of their incomes.

Various studies on farmer adaptation to climate change (Maddison, 2007; Ogalleh *et al*., 2012; Kalungu *et al*., 2013) have largely focused on farmers' perceptions of climate change with little regard to timing aspects of farming activities as a potential adaptation measure. The few studies that have analyzed matters concerning timing of farm activities (Doering *et al*., 2002; Butt *et al*., 2005; Vassalos *et al*., 2013) have focused on how production timing decisions affect economic returns.

Climate change has resulted in adjustment of weather conditions and hence the need for altering the timing of agricultural activities. As a measure to adapt to climate change, farmers ought to change the timing of their operations accordingly. Failure to appropriately adapt may result in loss of income-earning opportunities, thereby hampering commercialization efforts.

Contrary to rational expectations, some farmers have not appropriately adjusted the timing of their operations and are practicing agriculture in the same way as in a no-climate change scenario. Currently, there is little empirical evidence to explain this disparity, more so in Kenya. There is paucity of knowledge as to what factors influence farmers' willingness to adopt them. This is the knowledge gap that the current study sought to address.

1.3 Objectives of the Study

The main objective of this study was to evaluate factors influencing tomato farmers' willingness to adopt innovative timing approaches to manage climate change effects in Taita Taveta County.

The specific objectives were:

i. To characterize timing approaches used by tomato farmers to manage climate change.

ii. To analyze factors affecting tomato farmers' willingness to adopt innovative timing approaches to manage climate change effects.

1.4 Research Hypotheses

i. HO_1: There is no statistically significant difference in the mean number of spoilage days for harvesting of tomatoes at mature green, half ripe and full ripe stages.

ii. HO_2: Socio-economic and institutional factors do not significantly influence farmers' willingness to adopt innovative timing approaches.

1.5 Justification of the Study

Climate change effects have prompted farmers to come up with ingenious ways of adapting in order to possibly reduce associated losses at various points along the tomato value chain. Some of these involve new timing approaches that have a high income-generating potential. In the production stage, considerable losses arise from poor timing of planting which results in crop failure due to excess rains or germination failure due to lack of water. At the marketing level, losses are usually incurred in the form of depressed produce prices obtained by farmers as a result of farming at the same time which lead to oversupply in the market. When transporting produce to the market some losses are incurred especially if it is done during hot periods of the day. Highly perishable commodities such as tomatoes, are very susceptible to high temperatures (Mugao, 2015).

Value addition through processing (that is, converting raw tomatoes into products such as paste and jam) helps extend shelf life thereby increasing its value (Sims *et al*., 2007). This study focused on three innovative timing approaches that can be applied within the value chain: off-season production (at the production level), transporting produce during cool periods of the day (distribution) and processing (marketing level). The national agribusiness strategy recognizes that opportunities for agricultural value addition are largely underexploited, hence the need to integrate smallholder farming into mainstream agricultural value chains (Republic of Kenya, 2012b). The results from this study are useful to various stakeholders. For instance, tomato farmers stand to gain valuable information on the timing approaches that are currently being used and also those which they can incorporate in their farming activities. The county government of Taita Taveta through its 2013-2017 development plan spells out its desire to establish a tomato processing plant in Taveta sub-county (Republic of Kenya, 2013d).

By knowing which factors affect the adoption of the timing approaches, the county government will be in a position to create a supportive environment and design appropriate programs in light of these timing approaches.

The results also provide insights on which factors to focus on so as to scale up the use of the timing approaches by tomato growing farmers. This is in line with the National Climate Change Action Plan that aims at enabling Kenyan farmers to cope with climate change and the Malabo declaration by African heads of state to enhance resilience of production systems to climate-related risks (Republic of Kenya, 2013b; African Union Commission, 2014).

1.6 Organization of the Thesis

This thesis is organized into five chapters. Chapter one has introduced the key concepts in climate change and stated the research problem, objectives and justification for the study. In the next chapter, the relevant literature is comprehensively reviewed. This is followed by the methodology chapter, which describes sampling and data collection procedures, data needs and sources used in the current study. Chapter three also elaborates the analytical framework used in data analysis. In chapter four, the results are presented and discussed. Important conclusions and suggestions for policy interventions are provided in chapter five.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 A Review of Timing Approaches for Managing Climate Change in Agriculture

Following the value chain approach (Kaplinsky & Morris, 2002)[1], some activities that farmers manipulate their timing so as to better adapt to climate change were considered. For instance, land preparation if done early when the sun is scorching has been shown to help kill pests that may be present in the soil, while minimizing disturbance to the soil structure (Beddington *et al*., 2012).

At the planting stage, farmers often shift planting dates so as to match rainfall availability with the growing season. Other farmers grow varieties that are early maturing in order to escape negative effects of droughts (Boko *et al*., 2007). According to Twomlow (1994), planting in a timely manner under rain-dependent cropping system is crucial in buffering against poor performance of crops in semi-arid environments.

In addition to these practices, weeding is considered an important activity as it helps reduce plant competition for resources such as water and nutrients in the soil (Swanton *et al*., 2015). Furthermore, timely and more frequent weeding by farmers also helps control pests (Recha *et al*., 2012b).

At the harvesting stage, the decision on when to pick tomatoes is important. The stage of development of the tomato fruit at which farmers harvest depends on whether they are to be subjected to immediate consumption or if they are to be consumed later. It follows that farmers should harvest the crop when they are already ripe if the intention is to consume immediately.

[1] The working definition of a value chain in this study is that given by Kaplinsky and Morris (2002, p.4). The value chain "describes the full range of activities which are required to bring a product or a service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use."

However, if they intend to sell later, harvesting should be scheduled in such a way that there is enough time to allow for transportation to the market so as to minimize post-harvest losses, considering the perishable nature of tomatoes and their susceptibility to bruises. Thus, farmers should harvest the tomatoes at the mature green stage for long distance marketing in order to ensure longer shelf life (Moneruzzaman *et al*., 2009).

In terms of timing of marketing activities, some farmers pursue tomato farming with little regard to details such as where and when to sell their produce. They fail to plan on how to satisfy the market when the demand for tomatoes is high. For some farmers, their harvesting time corresponds with the period when there is glut in the market hence their tomato output fetches low prices. Shepherd (1997) argues that this behaviour among farmers is explained by unavailability of reliable information on price, price trends and market demand conditions, which makes it difficult for farmers to adapt their production to market needs.

Vassalos *et al*. (2013) noted that income earned from fresh vegetable production is dependent on harvest timing decisions because price is influenced by supply. Fresh vegetables including tomatoes exhibit high inelasticity of supply due to limited storage opportunities as a consequence of their high perishability. As a result, producers usually have no choice but to accept the price offered during the harvesting period (Sexton & Zhang, 1996). In fact, an empirical study by Mishra and Kumar (2012) established that there was a negative relationship between wholesale price and quantity of market arrivals of vegetables in the hill region of Nepal.

Innovative timing involves thinking ahead and producing in such a way that the farmer is able to supply the market when prices are high. Indeed, Gebey *et al*. (2010) observed that early producers in a given season usually fetch higher prices because their output reaches the market when there is limited supply.

Innovative timing of market also involves the farmer deciding whether to sell presently or later after processing tomato into juice, paste and jam or any other products thus extending shelf life. According to Thornton and Lipper (2014), efficient harvesting and early processing of agricultural produce can considerably mitigate post-harvest losses and maintain product quality and nutritional value.

Other innovative timing approaches include off-season production and transportation of produce during cool periods of the day. Off-season production means that the farmer grows the crop at a time of the year when most other farmers are not; thus, producing out of sync with other farmers. As such, the farmer is able to capture good market returns during periods of scarcity. This practice also has the advantage of stabilizing prices in the market (Gebey *et al*., 2010). Commodity prices tend to stabilize because off-season production ensures a fairly consistent supply in the market throughout the year. Furthermore, the farmer may diversify into other farming activities in the meantime thereby earn more income. High price fluctuations due to seasonality in production are considered as a major marketing challenge in the tomato value chain in Kenya (Koenig *et al*., 2008; Sigei *et al*., 2014). Transporting produce during cool periods of the day (that is, early mornings, late evenings or overnight) can greatly help in reducing post-harvest losses that result from exposure of tomatoes to high levels of heat (Mugao, 2015).

Literature shows that the identified timing approaches have had varying degrees of success and failure depending on region-specific contexts. These are discussed further hereunder.

Using simulations from general circulation models, Doering *et al*. (2002) found that in Argentina and Midwest USA shifting planting dates allowed wheat, corn and soybean farmers to maintain their income levels under climate change scenarios.

In Cameroon, a simulation study by Tingem and Rivington (2009) showed that altering planting dates of sorghum was ineffective in reducing the negative effects of climate change due to a narrow rainfall band that dictates the timing of farm activities. However, the use of late-maturing and heat-tolerant varieties is highly effective in coping with increased temperatures. Butt *et al*. (2005) also found that adjusting sowing and harvesting dates were not effective ways for adapting to changing climate in Mali. Actually, early planting resulted in lower yields because planting schedules were primarily dictated by the onset of the rains.

In Tanzania, Ajuaye (2010) noted that early planting of crops did not yield expected results. There were cases where, due to inadequate weather forecast information, farmers did wrong timing and this resulted in loss of farming inputs. The case was different in the rain-fed semi-arid regions of the Indian peninsula, where Gadgil *et al*. (2002) were able to identify optimal timing of planting dates which maximize groundnut production in a variable climate. The authors relied on farmers' own experiences and a crop model (PNUTGRO) to simulate growth and yield of groundnuts. Unlike the Tanzanian farmers, farmers in India were able to utilize meteorological predictions to guide their farm-level decisions.

A study by Olaleye *et al*. (2009) used chi-square tests and Pearson correlation to show that off-season production helped reduce poverty among women farmers in Nigeria. The authors concluded that household size, highest level of education and tomato farming experience had positive influence on effect of dry season tomato production on poverty alleviation. A study in Ghana showed that farmers in Greater Accra who grew their tomatoes during the off-season reaped higher profits notwithstanding the extra costs they incurred in irrigating their crops (Robinson & Kolavalli, 2010a). This was so because there was less price variability during the off-season given that farmers in most of the other regions of the country planted according to the rains. Thus, farmers from the Greater Accra evaded competition from other tomato-producing regions and were able to cover their costs.

Off-season planting production technique has also been applied successfully among tomato farmers in Ethiopia (Gebey *et al.*, 2010). The authors showed that, in addition to increasing quantity of production, the practice also helped improve and stabilize tomato market prices. However, the same study also revealed that processing of tomatoes failed because of lack of awareness considering that tomato juice was new in the area and little promotion of the product was undertaken.

Adimabuno (2010) extensively discussed the ailing tomato processing industry in Ghana which was once thriving and remunerative as it initially enjoyed government support such as irrigation facilities, price control, input subsidies and market access. The author argued that the effect of trade liberalization, more so the reduction of import tariffs, led to an influx of cheap tomato paste products into the Ghanaian market, thereby outcompeting local factories' products. Moreover, mismanagement of processing factories coupled with technical inefficiencies led to closure of some of them. The use of rudimentary technologies and high overhead costs to undertake traditional processing methods such as drying and milling was also identified as a constraint to commercial expansion among tomato farmers.

Robinson and Kolavalli (2010b) also explored the reasons as to why tomato processing in Ghana has failed. The authors outlined that abolishment of import quotas, lack of technical knowhow, poor marketing, and wanting financial management capabilities as impediments. Other reasons include inadequate supply of varieties suitable for processing which escalate the costs incurred by Ghanaian factories hence making them less competitive than processing firms in European Union which enjoy government subsidies. Furthermore, the price of fresh tomatoes is usually too high for the domestic tomato paste production to compete with imports.

2.2 A Review of Empirical Studies and Methods Applied in the Analysis of Climate Change Adaptation and Timing Approaches

Various studies have investigated different aspects of climate change and timing of value chain activities. Hassan (1996) studied the determinants of maize farmers' planting regimes in Kenya using two-stage and three-stage probit models. The author found that agro-climatic diversity, population pressure, access to extension services, and time of onset of rains explain crop intensification and planting regimes. However, the author focused on the optimal time of planting only but did not extend the analysis to cover the timing of other value chain activities. The current study incorporated farmers' decisions regarding marketing of tomato produce as an important component of the value chain.

Deressa *et al.* (2008) analyzed the determinants of farmers' choice of climate change adaptation methods in Ethiopia. The authors used multinomial logit (MNL) model. The results of their study showed that income, level of education, access to credit, household size, temperature and precipitation significantly increases the likelihood of adjusting planting dates as an adaptation measure. The current study followed a similar approach of analysis but focused on farmers' willingness to adopt innovative timing approaches.

Komba and Muchapondwa (2012) applied the MNL model to examine factors influencing smallholder farmers' choice of adaptation methods to climate change in Tanzania. They observed that farmers adopted irrigation, short season crops, shifted sowing dates and engaged in planting of trees as measures to adapt to climate change. They also found that farm size, access to credit, agro-ecological zone, rainfall and temperature intensity, and distance from input market to the farm negatively influenced the likelihood of changing planting dates. Further, having experienced incidences of drought and receiving agricultural extension services increased their chances of using short season crops. The authors also reported that 24% of farmers undertaking adaptation planted short season crops and 11% changed planting dates.

In assessing farmers' adaptation to climate change effects in Kyuso District in Kenya, Ndambiri *et al*. (2012) used a probit model and found that the probability of farmers adapting to climate change can be explained by the age of the farmer, farm income, education, gender, access to climate information, household size, farming experience, access to credit, local agro-ecology, access to irrigation water, distance to market, temperature and rainfall. The use of probit model in analysis implicitly assumes that farmer's decision to use one adaptation strategy is uncorrelated with decision to use others, thus leading to inefficient estimates. Farmers often simultaneously adopt a number of adaptation options at a time (Tessema *et al*., 2013).

Pangapanga *et al.* (2012) analyzed factors influencing households' choice over drought and flood adaptation strategies in Southern Malawi using a multivariate probit model. Among lowland households, it was noted that gender and income significantly influenced shifting of planting dates, while for the highland farmers, gender and labor positively influenced their adaptation behaviours.

Al-Hassan *et al.* (2013) used the MNL regression to assess the determinants of choice of indigenous climate-related strategies by smallholder farmers in Northern Ghana. Their results showed that informal credit, farmer-to-farmer extension, noticing a decrease in rainfall and an increase in temperature were the main factors influencing the choices. Further, the descriptive results revealed that less than 1% of sampled farmers used short duration crops and 31% altered the planting dates appropriately.

Yegbemey *et al*. (2013) studied farmers' climate change adaptation decisions under various property rights in Benin using multivariate probit model and found that access to credit positively and significantly influenced farming calendar adjustments. Fatuase and Ajibefun (2013) in a study conducted in Nigeria examined the determinants of choices of adaptation measures practiced by crop farming households using the MNL model. They found that access to credit, years of formal education, access to information on climate change, farming experience and access to extension services positively influenced adjustment of planting date and growing of different varieties as adaptation measures.

Ajuaye (2010) noted that about 73% of farmers in Kilimanjaro, Tanzania used the strategy of timing farming operations to adapt to changing climate while 47% of the farmers used early maturing varieties. Moreover, Anyoha *et al*. (2013) in their study of crop farmers' adaptation to climate change in Nigeria found that about 73% of farmers cultivated early maturing crops whereas 45% changed planting and harvesting dates in response to perceived climate change.

Thus, from the foregoing literature review, farmers in various places adopt timing approaches to different degrees. Unlike the previous studies that focused on general adaptation strategies, the current study put more emphasis on timing aspects of adaptation to climate change, while examining institutional and socio-economic factors that explain farmers' willingness to adopt innovative timing approaches to manage climate change in Taita Taveta County. This is considered to be an important contribution to the literature. The next chapter describes the methodology applied in this study.

CHAPTER THREE

3. METHODOLOGY

3.1 Study Area

The study was done in Taita Taveta County which lies in Kenya’s coastal region (Figure 2).

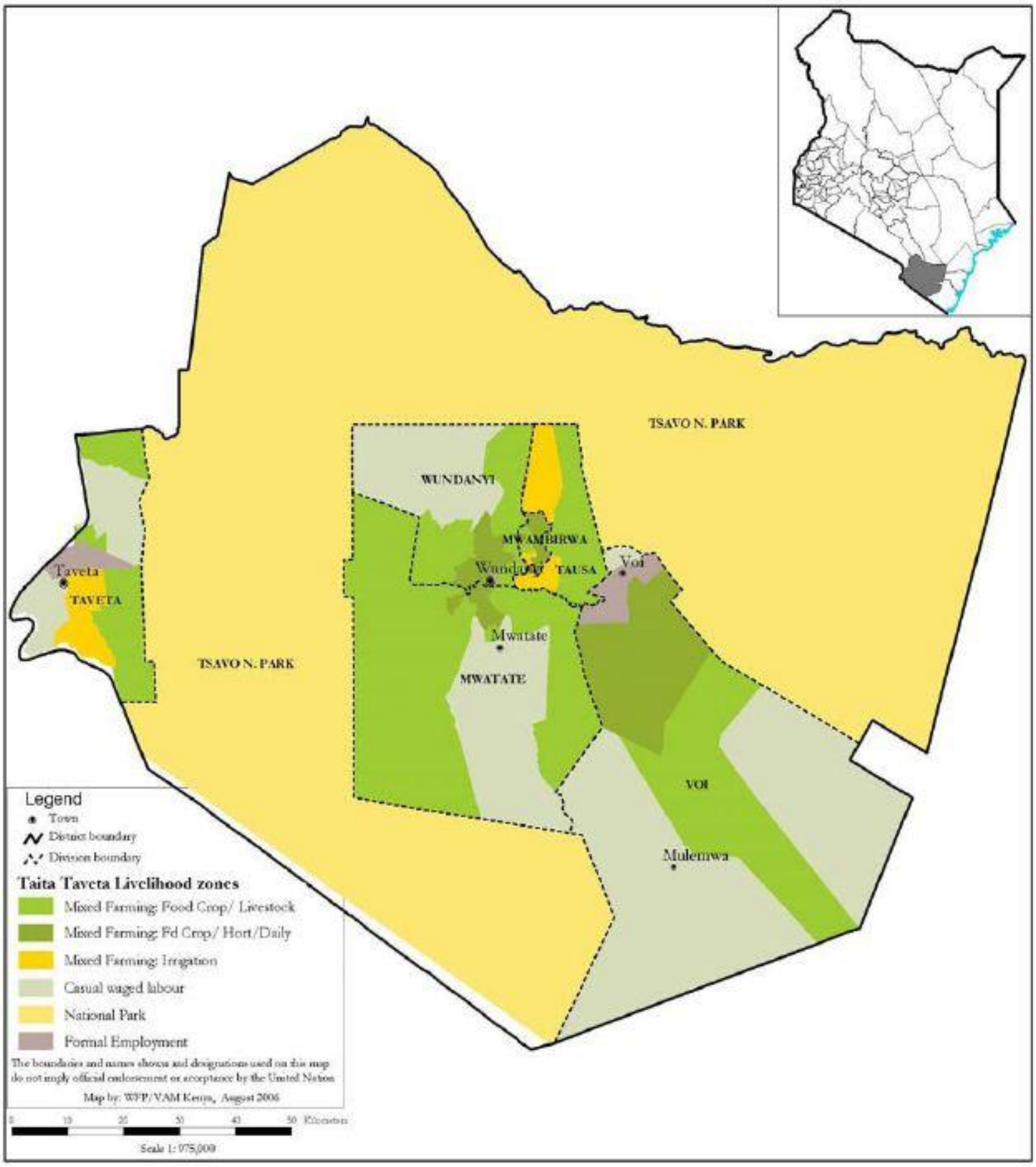

Figure 2: Geographic Distribution of Livelihood Activities in Taita Taveta County

Source: Ouma et al. (2013).

The County occupies a total area of 17,084.1 Km^2 with a population of 284,657 people (Kenya National Bureau of Statistics, 2009). This is a semi-humid to semi-arid region with annual mean rainfall of 650mm and average temperature of 23^0C. The area experiences bimodal rainfall with the short rains occurring between October and December while the long rains occur between March and June (Republic of Kenya, 2013a).

Taveta sub-county is in a low-lying plain with an average altitude of 300m above sea level and is prone to floods whereas Wundanyi is found in the Taita Hills which can rise up to 2200m above sea level. The annual rainfall in the hills can be as high as 1400mm whereas in the plains it ranges from 450 to 700mm (Wamwangi *et al.*, 2008).

Climate change effects are apparent in the County, with droughts and floods becoming a common occurrence. Moreover, there is frequent but unpredictable delay in the onset of the rains and rising temperature which is associated with high prevalence of pests and diseases that reduce crop yields (Republic of Kenya, 2013a).

It is a key supplier of fruits and vegetables to the urban consumers in Mombasa and other coastal towns of Kenya. Administratively, it has four sub-counties, namely; Voi, Wundanyi, Taveta and Mwatate (Republic of Kenya, 2013a). With regard to tomatoes, Wundanyi and Taveta sub-counties produce a larger share of tomato output and have the highest concentration of tomato growers. The main horticultural crops grown in the County are onions, cabbages and tomatoes under open-field production system. Specifically, tomato farming in the County is a significant horticultural enterprise contributing 7% of Kenya's annual production (Horticultural Crops Development Authority, 2013b) and it leads in terms of area under production (United States Agency for International Development, 2013).

3.2 Conceptual Framework

Climate change manifests itself in the form of low and unreliable rainfall patterns, high temperatures and droughts posing serious challenges to farmers (Herrero *et al.*, 2010; Nzioka, 2013). The effects of climate change and variability can lead to losses and damages such as crop failures, low quality produce and high post-harvest losses. However, farmers can innovatively adjust the timing of their operations to better manage these risks, thereby reduce losses and make higher profits (Vassalos *et al.*, 2013) and in this way address the problem of climate change. The decision to adopt these adaptation measures is influenced by factors such as age, access to credit and extension services, which differ across farmers' institutional, socio-demographic and resource contexts. Interventions that take into account the socio-economic characteristics of farmers to increase their adoption of the innovative timing approaches must be put in place to help achieve stable prices, reduce losses and ensure higher profits in the tomato value chain (Figure 3).

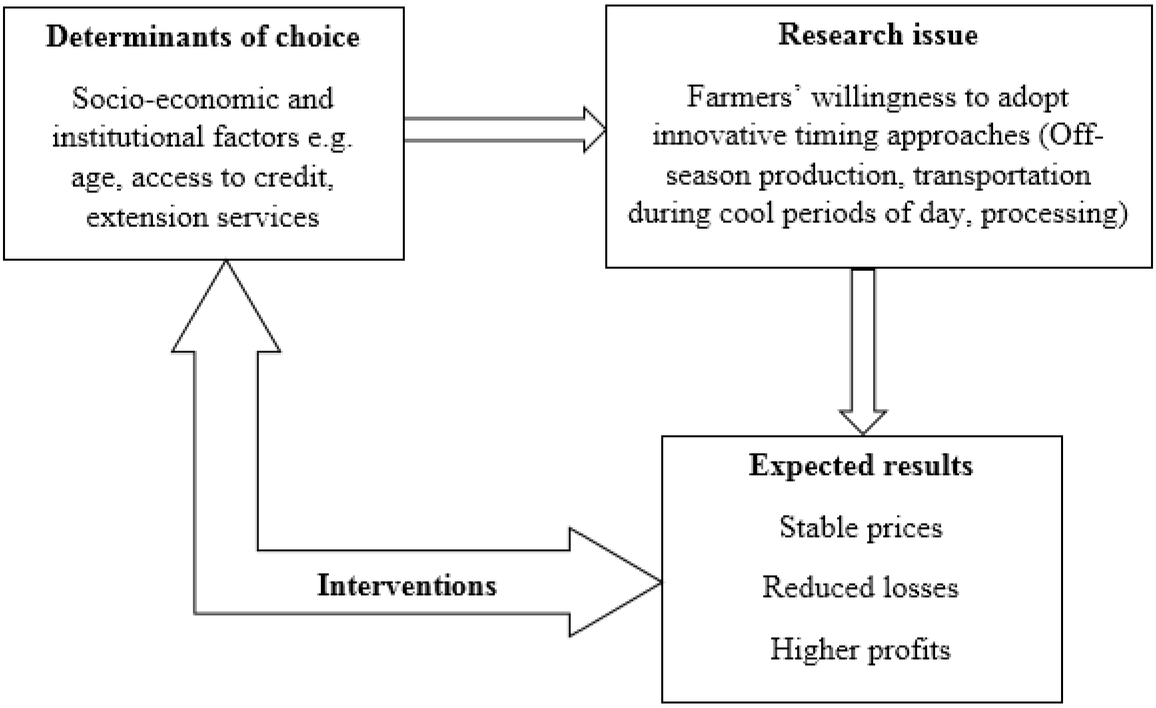

Figure 3: Conceptual Framework

Source: Author's Conceptualization.

3.3 Data Analysis Framework

The first objective of this study was to characterize farmers' timing approaches, and this was achieved through descriptive analysis using the Statistical Package for Social Sciences (SPSS 16.0) software. Such results were summarized by use of means (for continuous variables) and percentages (for categorical variables). These were presented in Tables, pie charts and bar graphs. For the second objective - analysis of determinants of farmers' willingness to adopt innovative timing approaches - the MNL regression was estimated using STATA 11.0 software and presented using Tables. The specific data analysis procedures and model estimation for each objective are discussed in detail below.

3.3.1 Characterization of Timing Approaches

The chi-square test (Field, 2009) was applied to ascertain whether there were any differences in use of timing approaches across the two sub-counties. Rejection of the null hypothesis leads to the conclusion that there is a statistically significant association between being in a sub-county and the likelihood of using a particular timing approach.

In line with the hypothesis tied to the first objective of this study, the One-Way Analysis of Variance (ANOVA) was used to test whether there was any significant difference between picking tomatoes at three different stages of harvesting and the number of days it takes for the tomatoes to spoil (Anderson *et al*., 2007).

3.3.2 Assessment of Factors Influencing Tomato Farmers' Willingness to Adopt Innovative Timing Approaches

The MNL model was applied in the analysis of farmers' willingness to adopt innovative timing approaches since the response variable had more than two outcomes (Greene, 2003).

The study analyzed three timing approaches[2]:

i. Off-season production

ii. Transportation of produce during cool periods of the day

iii. Processing tomatoes to extend shelf life

The MNL approach has been applied by Maddison (2006), Deressa *et al*. (2008), Gbetibouo (2009) and Komba and Muchapondwa (2012). The limitations of MNL include the restrictive Independence of Irrelevant Alternatives (IIA) and taste homogeneity assumptions (Bhat *et al*., 2008). Despite its drawbacks, the MNL method has the advantage of permitting analysis of multi-categorical decisions by predicting probabilities of choosing the different categories (Wooldridge, 2002). It is also computationally easy for calculating choice probabilities (Kennedy, 1998). The MNL model operates under the random utility framework (*ibid*.). The assumption here is that a farmer chooses the timing approach that maximizes his/her utility subject to a number of factors. It is assumed that the farmer derives higher utility from the choice s/he makes, given a choice set (Greene, 2003).

The model can be formally described as follows. Let Y_i represent the timing approach chosen by a farmer. Every farmer has a number of distinct and mutually exclusive alternatives that are assumed to be contingent upon a number of socio-economic and institutional attributes, X_i. The MNL model for the selection of a timing approach specifies the following relationship between the likelihood of choosing alternative Y_i (0, 1,…, J) and the set of exogenous variables X_i hypothesized to influence choice (Greene, 2003):

$$P(Y=j)|X_i = \frac{\exp\left(X_i\beta_j\right)}{\sum_{k=0}^{J}\exp(X_i\beta_k)} \tag{3}$$

[2] For brevity, the three timing approaches have been denoted as ‘off-season’, ‘transporting’ and ‘processing’ to respectively mean ‘off-season production’, ‘transportation of produce during cool periods of the day’, and ‘processing of tomatoes to extend shelf life’.

For j = 0, 1, 2

Equation 3 is normalized so as to ensure that probabilities add up to one (Cameron & Trivedi, 2005). This is done by assuming that the set of coefficients β_0 = 0, and thus the probability is estimated as

$$P(Y = j)|X_i = \frac{\exp(X_i\beta_j)}{1 + \sum_{k=1}^{J} \exp(X_i\beta_k)} \tag{4}$$

For j = 0, 1, 2; β_0 = 0

where β_j is a vector of coefficients of the exogenous variables X_i, β_k is the coefficient vector of outcome k, j denotes the possible unordered choices, and Y is the indicator variable of choices.

In the current study, there are three options, thus, j = 0 indicates that the farmer is willing to transport produce during cool periods of the day, j = 1 indicates that the farmer is willing to undertake off-season production and j = 2 indicates that the farmer is willing to process his/her tomato produce. The choice of an alternative to serve as the base or reference category is arbitrary (Cameron & Trivedi, 2009; Piquero & Weisburd, 2010). Taking ‘transporting’ as the base category effectively means that its coefficients β_0 is constrained to be equal to zero.

The J log-odds ratios for *equation 3* is given by:

$$\ln\left(\frac{P_{ij}}{P_{ik}}\right) = X_i\left(\beta_j - \beta_k\right) = \beta_j X_i \tag{5}$$

If k = 0, the dependent variable is thus expressed as the logarithm of one category relative to the base category.

According to Greene (2003), interpretation of the coefficients obtained from the MNL is difficult and somehow misleading. This necessitates derivation of marginal effects of explanatory variables in terms of probabilities as follows:

$$\frac{\partial P(Y=j|X)}{\partial X_i} = P(Y=j|X)\left(\beta_j - \sum_{k=0}^{J} P_k \beta_k\right) = P_j(\beta_j - \bar{\beta}) \qquad (6)$$

The MNL operates under the IIA assumption (Wooldridge, 2002) meaning that the odds of any two outcomes are not influenced by the remaining outcomes (Long & Freese, 2001). This might not always be the case in practical terms especially if choices are mutually similar. The *suest*-based Hausman test was done to verify that this assumption was not violated. If the IIA condition does not hold, one can use its alternative, which is the multinomial probit model since the later allows correlation of errors across choices (Bowen & Wiersema, 2003).

Based on the literature review on farmers' adaptation to climate change and the conceptual framework, the key independent variables included in the MNL model were identified and are shown in Table 1. MNL is appropriate for analysis because the regressors do not vary over alternatives (Cameron & Trivedi, 2005).

Table 1: Variables Included in the MNL Model Estimation

Variable	Description	Expected sign
Gender	Male = 1, Female = 0	+/-
Access to extension services	Has the farmer received training from an agricultural extension officer within the last 12 months (1= Yes, 0 = No)	+
Access to credit	Has the farmer obtained credit in the last five years (1= Yes, 0 = No)	+
Group membership	Is the farmer a member of a developmental group (1 = Yes, 0 = No)	+
Age	Number of years	+
Income	Average monthly household income in Kenya Shillings (KES)	+

The empirical model was specified as:

$$Innovtiming = \beta_0 + \beta_1 Gender + \beta_2 Extension + \beta_3 Credit + \beta_4 Groupmember + \beta_5 Age + \beta_6 Income + \varepsilon_i \quad (7)$$

where, *Innovtiming* is the innovative timing approach that a farmer is willing to adopt, $\beta_1 \ldots \beta_6$ are the coefficients associated with each independent variable and ε is the error term.

The effect of **gender** on adoption can either be positive or negative. On one hand, males have a higher access to information about new innovations than their female counterparts (Asfaw & Admassie, 2004) and this increases their adoption rates. On the other hand, females have a higher likelihood of implementing climate change adaptation measures because they do more farm activities and thus have more experience in farming and possible management practices (Nhemachena & Hassan, 2007).

Extension services increase farmers' awareness of climate change as well as provide information on adaptation methods (Maddison, 2006; Hassan & Nhemachena, 2008; Gbetibouo, 2009). Extension officers also guide farmers on what periods of the year are best for growing certain crops, in light of variations in weather conditions. Thus, the current study hypothesized a positive relationship between extension services and willingness to adopt innovative timing approaches.

Access to credit was expected to positively influence the likelihood of a farmer's adoption. Studies by Hassan and Nhemachena (2008) and Gbetibouo (2009) found a positive effect. This is because acquisition of financial resources enables farmers to purchase improved varieties that suit the changed climate and also avail money for hiring labor.

Farmer's **membership to a developmental group** was expected to have a positive and significant influence on willingness to adopt the timing approaches. Shiferaw *et al*. (2006) noted that organizational membership allow uptake of new innovations through mobilization of resources and information sharing.

Farmer's **age** was hypothesized to have a positive influence on the adoption of climate-related timing approaches. This is because older farmers have more farming experience and are in a better position to assess the attributes of an innovation than younger farmers (Gbetibouo, 2009). Older farmers also have more resources at their disposal and can easily try new technologies (Abdoulaye *et al*., 2014).

The higher the **income**, the higher the probability of adopting climate-related timing approaches. This is because the adoption of technologies requires considerable investment of financial resources (Knowler & Bradshaw, 2007).

Estimation of the MNL model was preceded by conducting heteroscedasticity, multicollinearity, goodness of fit and IIA tests. The Breusch-Pagan test for heteroscedasticity was used and gave a χ^2 of 0.25 and a *p* value of 0.62. This implied failure to reject the null hypothesis of constant variance and concluding that there was no problem of heteroscedasticity in the data.

Variance Inflation Factors (VIFs) were used to test for the presence of multicollinearity. As a rule of thumb, a VIF value greater than 10 reveals evidence of multicollinearity in the data (Gujarati, 2004). Appendix 1 indicates that multicollinearity was not a problem in the data. Individual VIF ranged from 1.04 to 1.32 with the mean VIF being 1.15. Hence, all explanatory variables were included in the multinomial logit regression.

The likelihood ratio test gave a chi-square (χ^2) value of 18.76 and a p value of 0.09, which means the model fitted the data well. The MNL model was significant at 10% indicating that all explanatory variables jointly influenced the response variable. The results are shown in Appendix 2.

The *suest*-based Hausman test was implemented to assess whether MNL model met the IIA assumption. This test is a modification of the standard Hausman test (Long & Freese, 2006).

Results indicated that the IIA assumption was not violated because the null hypothesis of independent alternatives could not be rejected (Appendix 3). This implied that the MNL was appropriate for the analysis.

3.4 Research Design

Mixed method research design was adopted for this study (Malina *et al*., 2010). Qualitative data was collected through conducting a Focus Group Discussion (FGD) whereas quantitative data was collected with the aid of a questionnaire. The main benefit of using both approaches is that it enables a researcher to draw from their respective strengths and gain a more comprehensive insight that can inform theory and practice (Johnson & Onwuegbuzie, 2004).

3.5 Sampling Procedure

The study used primary data collected from randomly sampled farmers who grow tomatoes in Taita Taveta County. A two-stage sampling procedure was applied to select the respondents. In the first stage, two sub-counties, namely Wundanyi and Taveta were purposively selected based on high concentration of tomato production. In the second stage, individual farmers were randomly chosen. This method was suitable as it guarantees representativeness of the population of interest and is cost-saving (Anderson *et al*., 2007).

Semi-structured questionnaires were administered to a total of 196 tomato farmers. Face-to-face interviews were conducted as they enable real-time clarification of questions (Doyle, 2005).

The sample size was determined following Anderson *et al*. (2007) as:

$$n = \frac{p\,(1-p)Z^2}{E^2} \tag{1}$$

where;

n is the sample size, p is the proportion of population having the major interest, Z is the confidence interval and E is the margin of error. Since the proportion of the population in the study site was unknown, p = 0.5 (assumed to be 0.50, as this would yield the maximum sample size), Z = 1.96 and E = 0.07.

Thus, the sample size was determined as:

$$n = \frac{0.5\ (1 - 0.5) 1.96^2}{0.07^2} = 196 \tag{2}$$

3.6 Data Needs and Data Collection Methods

Both primary and secondary data were used in this study. A preliminary FGD was conducted to gain insights on farming practices related to management of climate change and variability. The FGD was also useful for refining the survey questionnaires (Simon, 2006). The FGD participants comprised 14 tomato farmers distributed across a diversity of young and old, male and female participants. Subsequently, face-to-face household interviews were conducted to obtain primary data on farmers' socio-economic characteristics including experience, gender, education level, income and access to extension services. Other data captured in the questionnaire included awareness about climate change and sources of weather forecast information. Considering the potential non-response challenge in face-to-face mode of data collection, four repeat interviews were conducted to either complete some questionnaires or replace unwilling respondents so as to achieve the calculated sample size.

In order to validate the survey data, relevant secondary data were obtained from existing publications such as journal articles, government annual reports, and text books.

The key findings from the study are presented and discussed in chapter four.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1 Socio-economic Characteristics of Tomato Farmers

The results on socio-economic and institutional characteristics are presented in Table 2.

Table 2: Tomato Farmers' Socio-economic Profiles

Variable	n = 196
Gender (% of male farmers)	82.7
Access to credit (% of farmers)	42.3
Group membership (% of farmers)	56.6
Main occupation (% in farming)	89.2
Aware about climate change (% of farmers)	99.5
Receive weather forecast information (% of farmers)	98.0
Access to extension services (% of farmers)	64.8
Level of education - Secondary and above (% of farmers)	54.1
Average land size (Hectares)	0.8
Average area under tomato production (Hectares)	0.4
Mean age of farmer (Years)	43.6
Average education (Number of years of formal schooling completed)	10.0
Average extension service visits (Number of times farmer has received training from an agricultural extension officer within the last 12 months)	4.4
Experience (Mean number of years the farmer has practiced tomato farming)	11.4
Mean number of years as group member	5.2
Average household size (Number of persons)	5.2
Income (Average monthly household income in Kenya Shillings)*	18, 637.8

* On average, 1 US Dollar (US$) was equivalent to 93 Kenya shillings (KES) at the time of the survey.

Source: Survey data (2015).

Tomato farming in the County was predominantly undertaken by male farmers. This imbalance in gender could partly be explained by the economically lucrative[3] nature of the tomato enterprise (as compared to other farm enterprises) which tend to attract men into the business (World Bank, 2009). Tomato production also involves laborious activities such as pruning and

[3] Research Solutions Africa (2015).

spraying, which women find taxing. Wachira *et al.* (2014) in a study conducted in Nakuru also found that over 80% of tomato growers were males while the rest were females.

More than half of the respondents had secondary level of education and above while on average, the number of years of formal schooling completed was 10 years. Only 2% had no formal education as shown in Figure 4. This is a good indication that the literacy level among the farmers is high as compared to national figures. KNBS and ICF Macro (2010) reported that in Kenya, the median number of years of schooling for males and females was 6.0 and 5.2 years respectively.

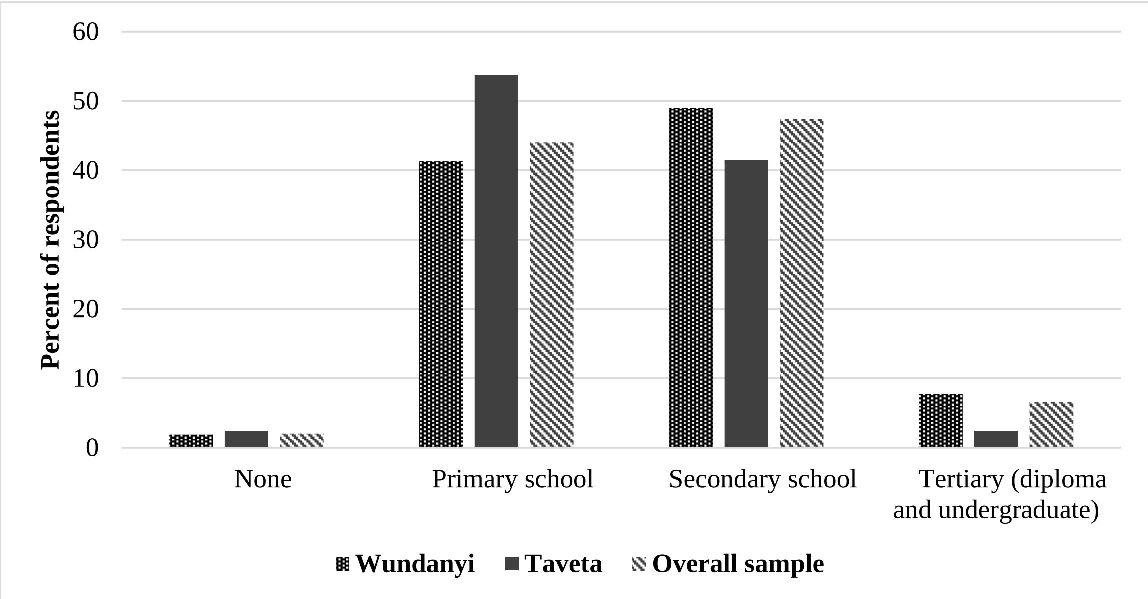

Figure 4: Distribution of Farmers in Terms of Highest Level of Formal Education

Source: Survey data (2015).

As noted by Anley *et al*. (2007), an educated farmer is expected to possess good decision-making ability and thus is able to take steps that address climate change (Ozor & Nnaji, 2010). Indeed, it has been argued in literature that achieving high educational levels increases farmers' chances of adopting improved practices (Agwu & Anyanwu, 1996).

The average land sizes of approximately one hectare points to the fact that most farmers in the County are smallholders. Pellikka *et al*. (2013) noted that high population growth in the area puts pressure on the land hence the small pieces of land. In the African culture, land size signifies resource endowment, therefore farmers with larger pieces of land are better placed to adapt to climate change (Tazeze *et al*., 2012).

The average age of the respondents in the study area was 44 years, implying that tomato farming was mainly practiced by the middle-aged farmers. This result is similar to the findings of Wachira *et al.* (2014) who observed that a high percentage of tomato farmers in Nakuru were within the 40 - 50 years age bracket. In this age bracket, farmers can enhance agricultural productivity as they are in their most productive stage of life (Urama & Ozor, 2011). Age positively correlates with farming experience, and therefore, the older a farmer is the more likely he is to adapt to climate change (Hassan & Nhemachena, 2008).

The mean number of years of tomato farming experience of about 11 years indicates that most producers in the County have been engaged in tomato production for a fairly long time. Farmers with more experience are in a better position to adapt to climate change as they have more knowledge about different interventions (Maddison, 2006). Ozor and Nnaji (2010) and Ofuoku (2011) also posited that the higher the number of years that farmers have been engaged in agriculture, the more likely it is that they are able to perceive or even anticipate changes in the climate based on the knowledge of their past interaction with the environment and therefore cushion themselves from its adverse effects.

The average household size was about 5 persons, which is higher than Kenya's national mean of 4 persons (KNBS & ICF Macro, 2010). The number of members of a household points to the availability of labor (Deressa *et al*., 2011). Larger household sizes make it easy for farmers to implement labor-intensive adaptation strategies (Nyangena, 2008).

The average monthly household income was about *KES* 19,000. Farmers with more income are better placed to invest in productivity-enhancing activities such as purchase of improved crop varieties (Tazeze *et al*., 2012).

4.2 Institutional Services

4.2.1 Access to Credit

About 40% of the respondents interviewed had accessed credit in the past five years. Of these, three-quarters had repaid over half of the amount that they had borrowed. The major source of credit was microfinance institutions (Figure 5). According to Atieno (2001), formal financial institutions especially banks are characterized by long application procedures, a factor which limits access to credit. Inability to access credit hinders farmers' adaptation to climate change as they lack capital to purchase inputs (O'Brien *et al*., 2000).

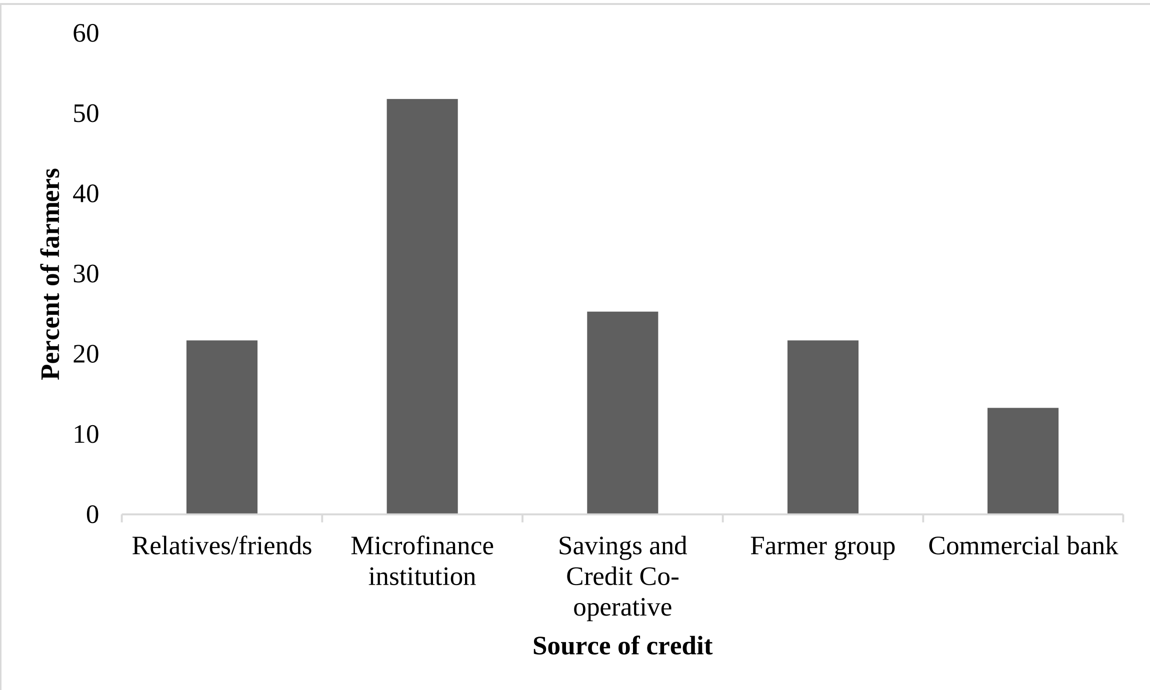

Figure 5: Various Sources of Credit

Source: Survey data (2015).

About two-thirds of the borrowers spent the loans on farm inputs such as seeds and fertilizers (Figure 6). Other uses of credit mentioned include buying livestock and water tanks. The buying of water tanks shows initiative on the part of the farmers as a water harvesting measure to cushion themselves from the ever-declining water quantity in the County.

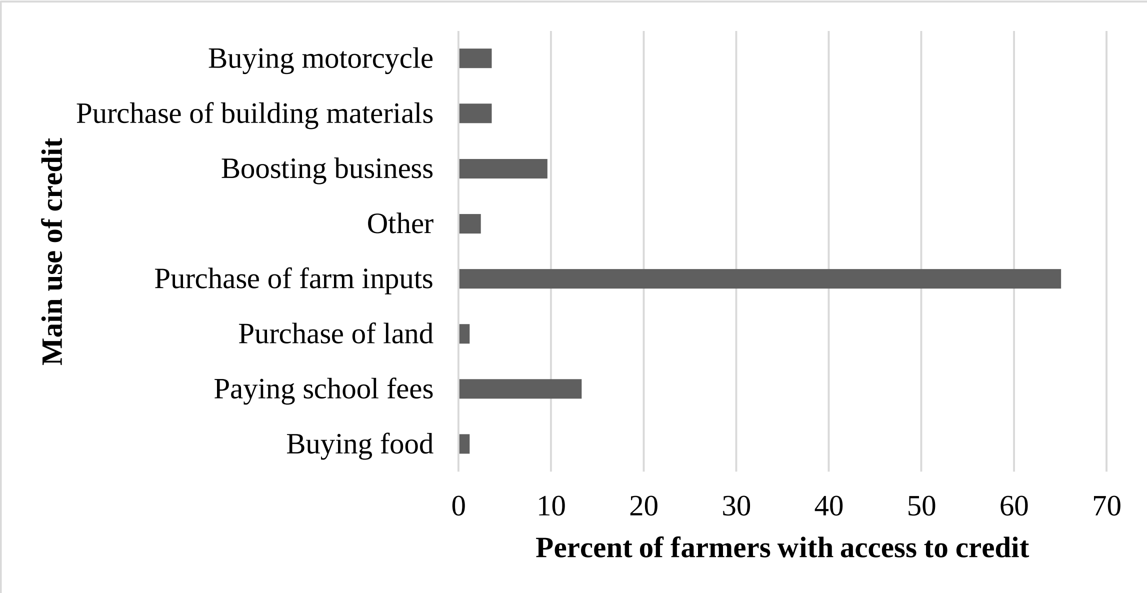

Figure 6: Main Use of Credit

Source: Survey data (2015).

For those who had not acquired any loan in the past five years, some of the reasons cited for not obtaining loans include lack of collateral, mistrust of lenders, lack of knowledge on application procedures, fear of non-repayment and high interest rates as shown in Figure 7.

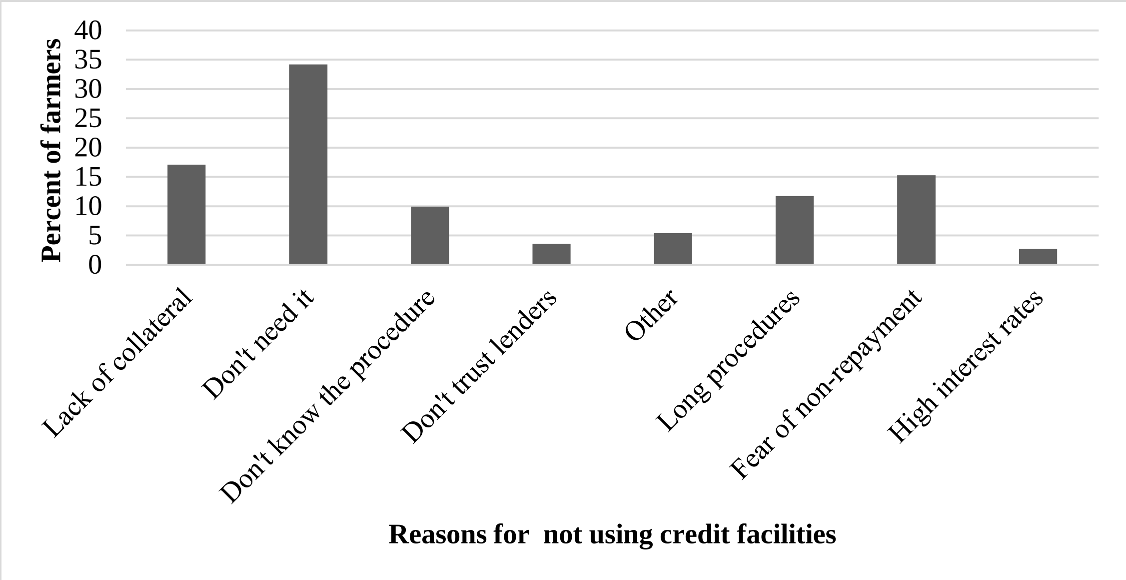

Figure 7: Reasons for Not Using Credit Facilities

Source: Survey data (2015).

An interesting observation is that the main reason cited by those who did not apply for any loan was that they considered it unnecessary as they had other means of raising money, for instance through their diversified sources of income. Generally, high loan interest rates, fear of defaulting, poor group cohesiveness among farmers and lack of collateral are the main challenges faced by Kenyan farmers in their bid to obtain credit (Republic of Kenya, 2013c). The fear of non-repayment emanates from the fact that farming is considered to have relatively high risks due to unpredictable environmental factors such as floods and droughts that often damage crops.

4.2.2 Group Membership

More than half of the respondents were members of a development group (Table 2). For those who were group members, the average duration of group membership was about 5 years. Figure 8 shows the major services that farmers obtain from the development groups they belong to.

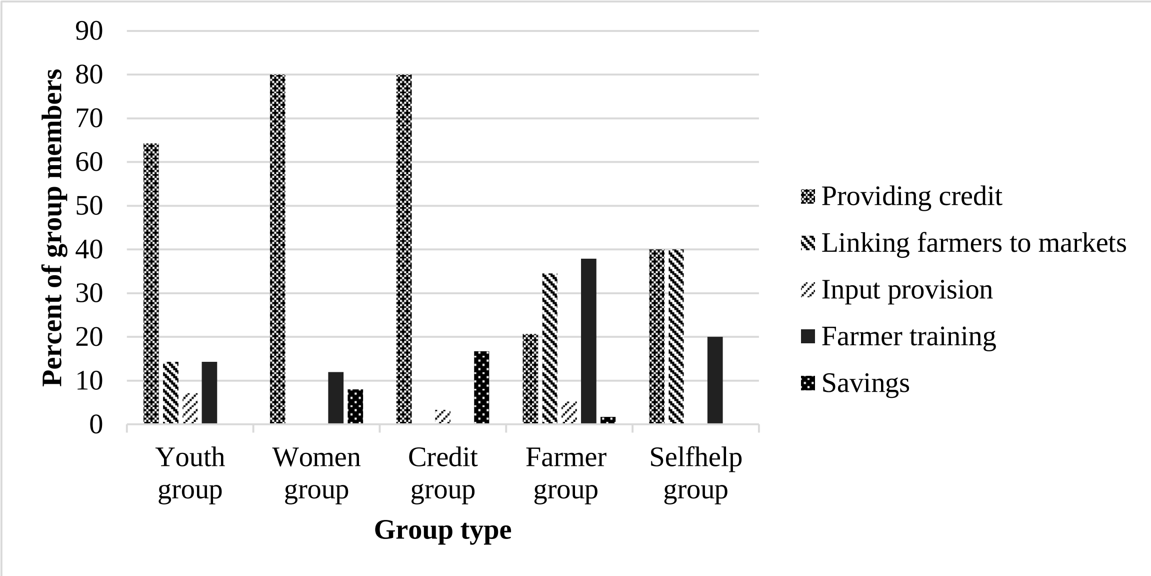

Figure 8: Main Services Offered by Various Development Group

Source: Survey data (2015).

The primary motivation for belonging to a group is that it offers farmers the opportunity to obtain credit. This is the case, especially nowadays as many financial institutions have evolved and require borrowers to be in groups in order to be given loans thereby enabling the lenders to reduce the problem of adverse selection (Atieno, 2001). Group membership also serves as a form of collateral by providing necessary peer-reference for lenders in ascertaining a borrower's credit-worthiness.

Working with farmer groups has various advantages such as aggregating produce to meet demand, forming a good platform for conducting trainings, allowing flow of information and mobilizing resources. Farmer groups are increasingly being used by agricultural extension providers to train a wider audience through Farmer Field School (FFS), an approach that has been shown to increase productivity and incomes (Davis *et al*., 2012). The participatory nature of FFS enables the farmers involved to acquire management skills and adopt self-tested and preferable technologies.

In a study conducted in Machakos District (Kenya), Odame *et al*. (2008) observed that farmers had formed groups for the purpose of processing tomato into tomato jam, tomato sauce and tomato paste, which helps in reducing losses and getting better prices for their produce.

4.2.3 Access to Extension Services

About two-thirds of the respondents had received an average of 4 extension visits within the last 12 months. The types of extension service providers accessed by the respondents are shown in Figure 9. Majority of respondents obtain training from government extension officers. Despite the government leading in terms of extension contact with farmers, the department is understaffed. Republic of Kenya (2013c) reports that in Taveta, there are 11 extension units with only 6 extension officers. The extension officer to farmer ratio is very low at 1:900 against the FAO-recommended ratio of 1:400 (Manfre & Nordehn, 2013). Such minimal extension contacts limits diffusion of knowledge to farmers, and this impedes agricultural productivity growth. According to Jones (2003), extension agents avail agricultural and climate information that help farmers to make timely decisions regarding crop management practices that address climate change.

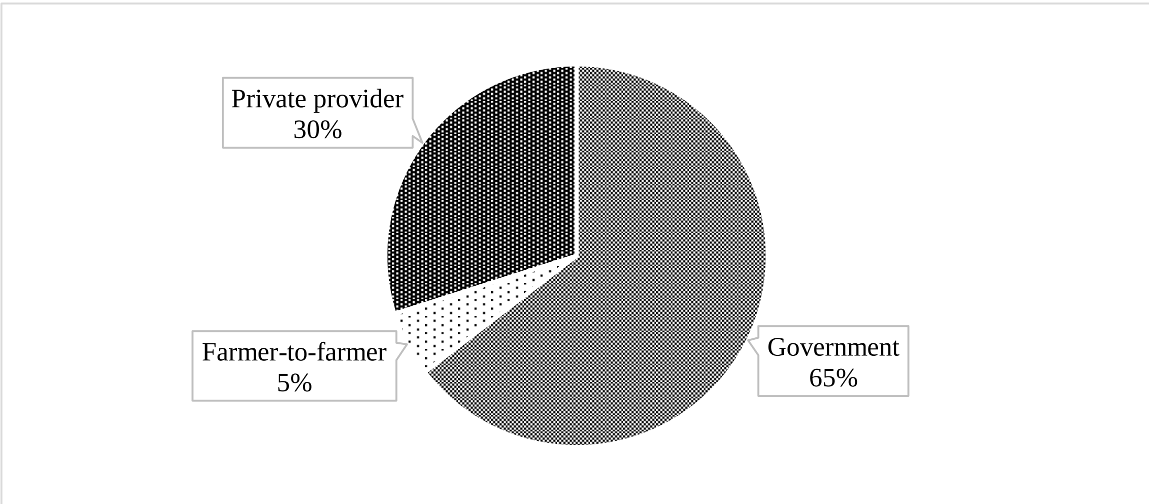

Figure 9: Distribution of Extension Service Providers

Source: Survey data (2015).

4.3 Climate Change Features

4.3.1 Farmers' Awareness and Perceptions on Climate Change

The respondents were asked whether they had observed any significant changes in rainfall and or temperature patterns over the past 20 to 30 years. Nearly all the respondents indicated that they were aware of climate change (Table 2). Generally, farmers had observed an increase in the average temperature and rainfall variability, and decline in mean amount of rainfall. Only a small fraction of farmers had not observed any changes in the environment (Table 3). It also emerged during the FGD that farmers have observed shift in seasons. In the past two decades, they were certain about the onset of the long rain which used to be in the month of February. But nowadays the rains start as late as April and are quite unpredictable. The short rains which used to start in August nowadays starts in November/December.

Table 3: Farmers' Perceptions on Observed Changes in Climate

	Percent of farmers reporting this scenario		
	Increase	**Decrease**	**No change**
Temperature mean	96.9	0.0	3.1
Rainfall mean	5.2	92.8	2.1
Rainfall variance	71.7	21.7	6.5

Source: Survey data (2015).

These results are consistent with what Sanga *et al*. (2013) found in Tanzania and Bryan *et al*. (2011) and Okumu (2013) in Kenya. Each of these previous studies reported high levels of awareness of climate change among respondents (over 85%). However, this is contrary to what Pelham (2009) reported, a rather low level of awareness in African countries. In the case of Kenya, there have been concerted efforts by various organizations to increase climate change awareness over time hence the increased public awareness (Ochieng, 2012).

4.3.2 Access to Weather Information

As noted earlier in Table 2, nearly all the farmers sampled in this study usually receive weather forecast information. Three-quarters of them normally make use of the weather forecast information to guide their farming decisions. Access to weather forecast information can greatly help to reduce uncertainties surrounding production decisions (Bernardi, 2011). Such weather forecast information can prepare the farmers well in terms of what crop to plant and when; during the short or long rainy season.

From the FGD, it was noted that Taita Taveta County relies on a weather station at Voi, which supplies weather forecast information yet Voi's agro-climatic conditions are different from those of both Taveta and Wundanyi sub-counties. Thus, most farmers who took part in this survey said that they often found this information misleading.

When probed further about their perception on the relative importance of the weather forecast information received, 38% of the respondents indicated that the information is very useful, 44% useful while the rest reported that the information provided is often irrelevant. This finding is not peculiar to Kenya. Ajuaye (2010) also made a similar observation that a large percentage of farmers in Tanzania are do not use weather forecast information in their crop and animal husbandry decisions because they consider the information unreliable.

In terms of the frequency with which farmers receive weather forecast information, three-quarters of the farmers reported that they receive the information daily, while others get it on weekly or monthly basis. The main channel of communication was radio followed by television and face-to-face verbal communication in that order as shown in Figure 10. Radio being readily accessible and preferable to most rural households in Kenya, makes it the popular media channel for smallholder farmers to receive information (Spurk *et al*., 2013). Furthermore, radios are cheap, portable and may not need electricity to work (Urama & Ozor, 2011).

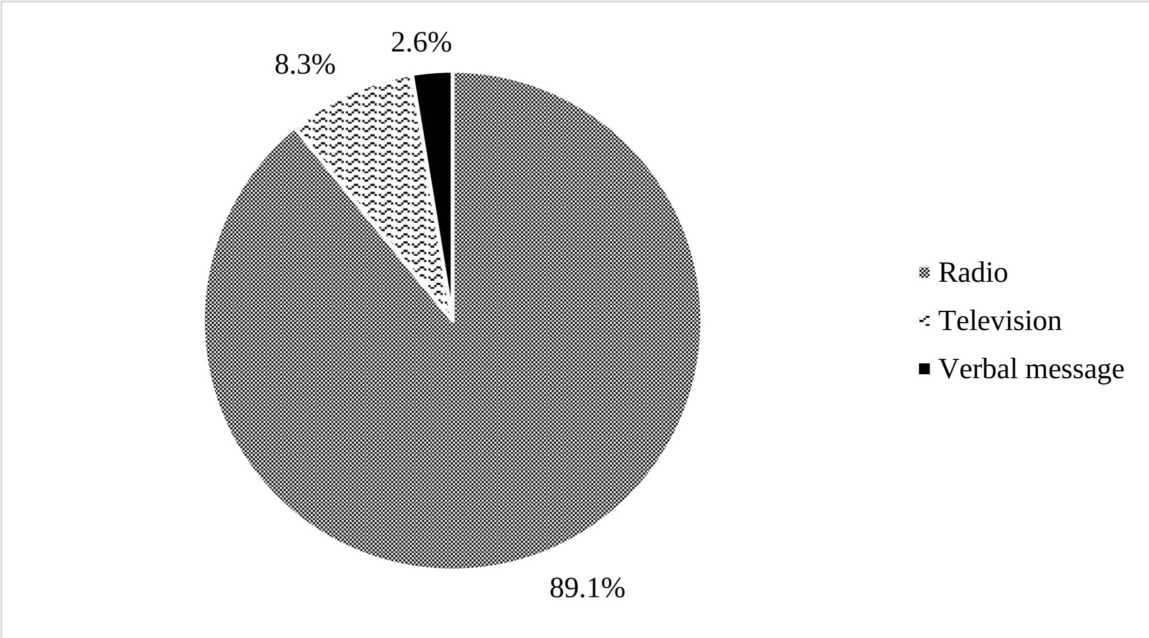

Figure 10: Main Channels of Communicating Weather Information

Source: Survey data (2015).

Three-quarters of the respondents considered that the information they needed was usually provided in a timely manner, while the rest did not. Bernardi (2011) reckons that timely provision of weather forecasts can prepare farmers well to manage climate variability.

When asked, '*what main kind of relevant information would you like to receive in future weather forecasts that is currently not provided or is inadequately provided'?*, most respondents suggested that more focus should be on the distribution of rainfall within seasons (Figure 11).

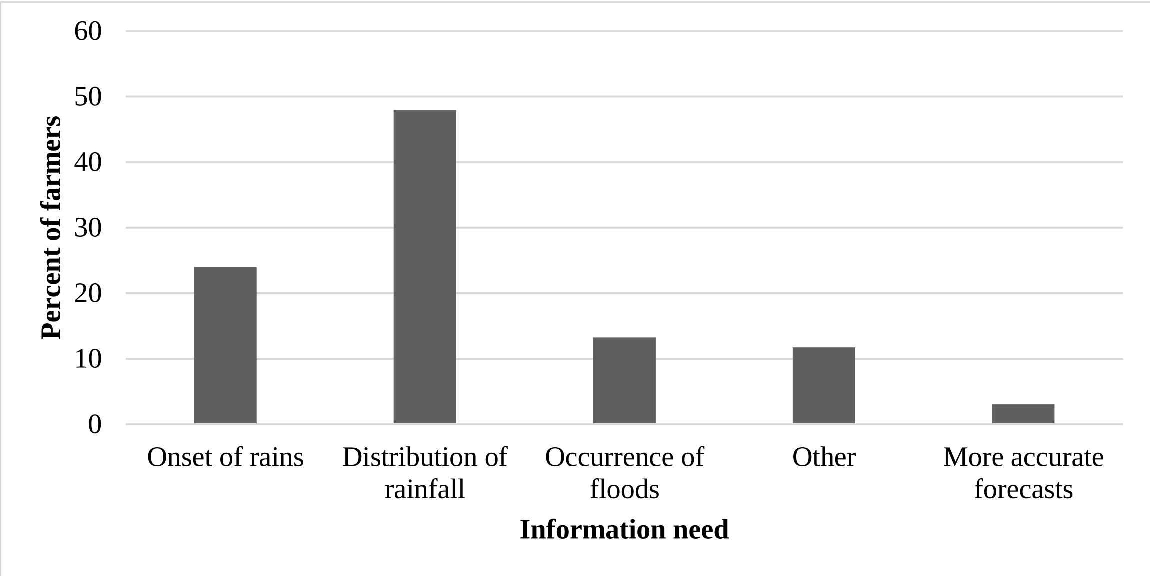

Figure 11: Main Type of Weather Information that Farmers Desire

Source: Survey data (2015).

4.4 Farmers' Adaptation Mechanisms to Climate Change

Cognizant of changes in climate, farmers had employed some coping measures. These are presented in Table 4.

Table 4: Current Adaptation Measures to Climate Change

Adaptation measure	Percent of farmers who are practicing it (n= 196)
Crop insurance	2.0
Irrigation	91.3
Diversification of source of income	59.2
Tree planting	78.1
Mulching	63.3
Use of varieties resistant to pests and diseases	74.0
Planting drought resistant varieties	63.8

Source: Survey data (2015).

Use of irrigation for production was the most common adaptation measure taken by farmers. Farmers in Taveta sub-county mostly produced in irrigation schemes whereas in Wundanyi, cultivation of horticultural crops was practiced near streams (Republic of Kenya, 2013c).

In Taveta, however, water rationing is very common due to erratic rains that cause low water availability in irrigation schemes. It takes about three-week intervals for irrigation water to be supplied into farmers' plots, which is a long time given the high temperature that causes high evaporation rates in the sub-county. These recurrent water shortages hamper production.

Planting of trees as a measure of coping with climate change was reported by over three-quarters of the farmers, due to their recognition of its economic and ecological benefits. Nair *et al*. (2009) views agroforestry as a means of enhancing carbon sequestration thereby mitigating climate change. Diversification of income was also mentioned as an important adaptation measure taken by the farmers. 59% of the respondents indicated that they depend on more than one income source to spread risks. For example, some grow a variety crops and keep livestock. Others engage themselves in off-farm employment activities such as trading and casual labor. These kind of income diversification options have also been reported in other countries such as South Africa (Thomas *et al*., 2007).

About two-thirds of the respondents practiced mulching. This is attributable to its role in improving soil fertility as a result of decomposition, conserving soil moisture, preventing soil erosion and reducing weeds (Montenegro *et al*., 2013; Patil *et al*., 2013). In Wundanyi, soil erosion is becoming more severe further exacerbating the effects of climate change. This is driven by high population growth, cultivation on steep slopes, intensive agriculture and, cutting down of trees (Boitt *et al*., 2015).

A negligible number of the respondents have adopted crop insurance. The main reason for the rather low uptake of crop insurance is lack of information among farmers. Njue *et al*. (2015) cited farmers' lack of understanding on how crop insurance works, unavailability of insurance services at the local level and unaffordable premiums as reasons for non-adoption of crop insurance in Kenya.

4.5 Climate-Related Timing Approaches

Based on reviewed literature, a number of climate change-related timing approaches were identified. Farmers were asked whether they practice various timing approaches and their responses are shown in Table 5.

Table 5: Adoption of Various Timing Approaches to Manage Effects of Climate Change

Climate-related timing approach	Percent of farmers practicing it (n = 196)
Early preparation of land	92.9
Change in planting dates	70.4
More frequent and timely weeding	79.1
Use of early maturing varieties	74.5
Use of greenhouses	0.5

Source: Survey data (2015).

Over 90% of the respondents prepare their land early in readiness for planting before the onset of rains as a measure to reduce the negative effects of climate change, particularly decimating pest population in addition to controlling weeds that have increased as a result of climate change. Land preparation a month or so before the onset of rains exposes soil-borne pests to the scorching sun that kills the pests and also improves soil aeration (Beddington *et al*., 2012). About one-third of the respondents reported that they had obtained higher yields as a result of preparing their farms early (Figure 12).

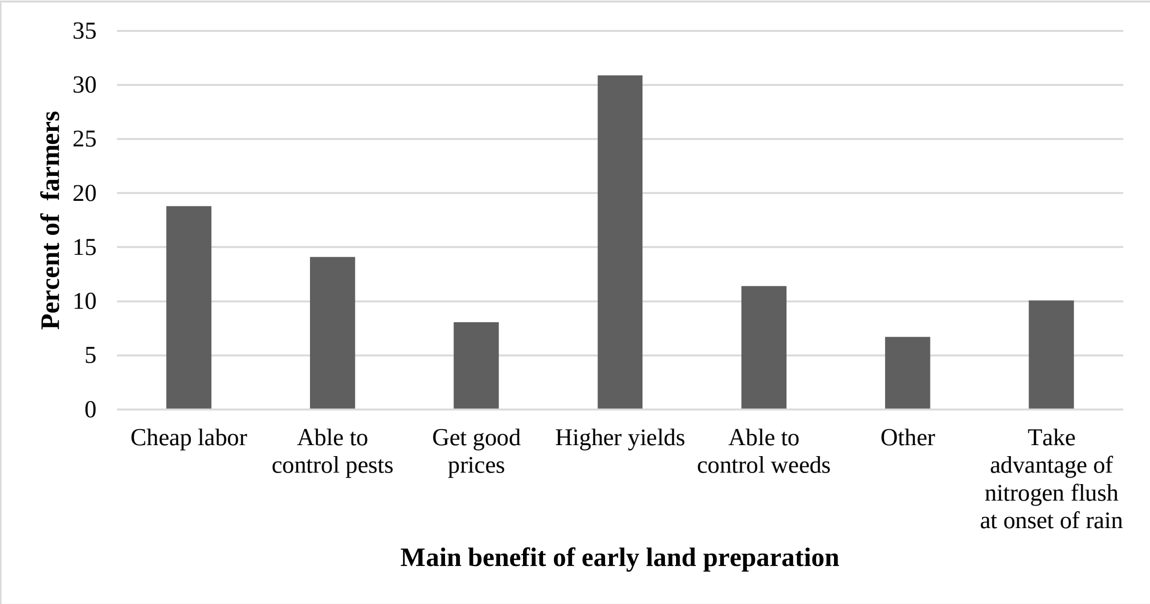

Figure 12: Benefits of Early Land Preparation

Source: Survey data (2015).

However the farmers cited lack of adequate weather forecast information and lack of funds as major challenges (Figure 13).

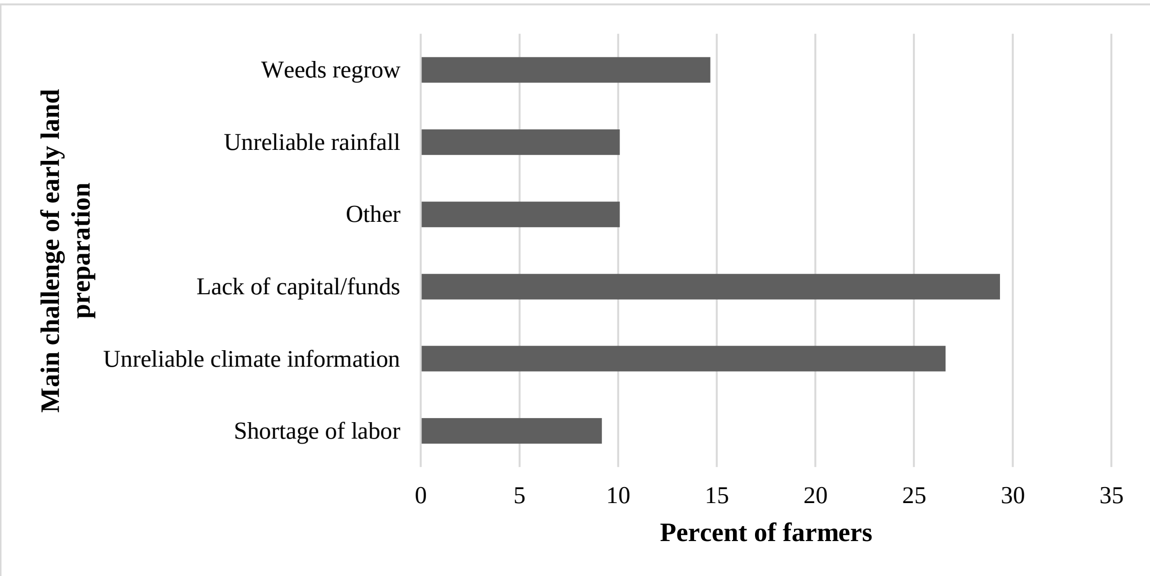

Figure 13: Constraints to Early Land Preparation

Source: Survey data (2015).

With weeds becoming more common and hard to control, more than three-quarters of tomato farmers had increased the frequency and timeliness of weeding. Weeds usually compete with the main crop for water and nutrients in the soil thereby reducing crop yields (Zimdahl, 2004). Farmers face the challenge of increased labor requirement and associated costs as an impediment to adopting this measure. In Nigeria, Ozor and Nnaji (2011) also reported that weeds escalate the costs of production through use of herbicides and wage payments.

Aware of the fact that seasons have shifted as a result of climate change, 71% of the tomato farmers reported that they had altered the planting dates in line with the new realities. They do this to match rainfall availability with the growing season (Recha *et al*., 2012a). The main benefits cited by farmers who practice this strategy include obtaining higher yields and good prices. Unreliable climate information was mentioned as one of the major challenges facing farmers in adopting this strategy. As noted by Ajuaye (2010), misleading weather forecasts can be very costly as it makes farmers to do wrong timing of planting decisions resulting in loss of their farm inputs.

Approximately three-quarters of the farmers interviewed had resorted to growing varieties that are early maturing. According to Twomlow (1994), planting in a timely manner under rain-dependent cropping systems is crucial in buffering against poor performance of crops in semi-arid environments. The challenges identified by farmers in undertaking this strategy include unavailability of improved seeds, lack of funds and lack of good markets for these cultivars (Figure 14).

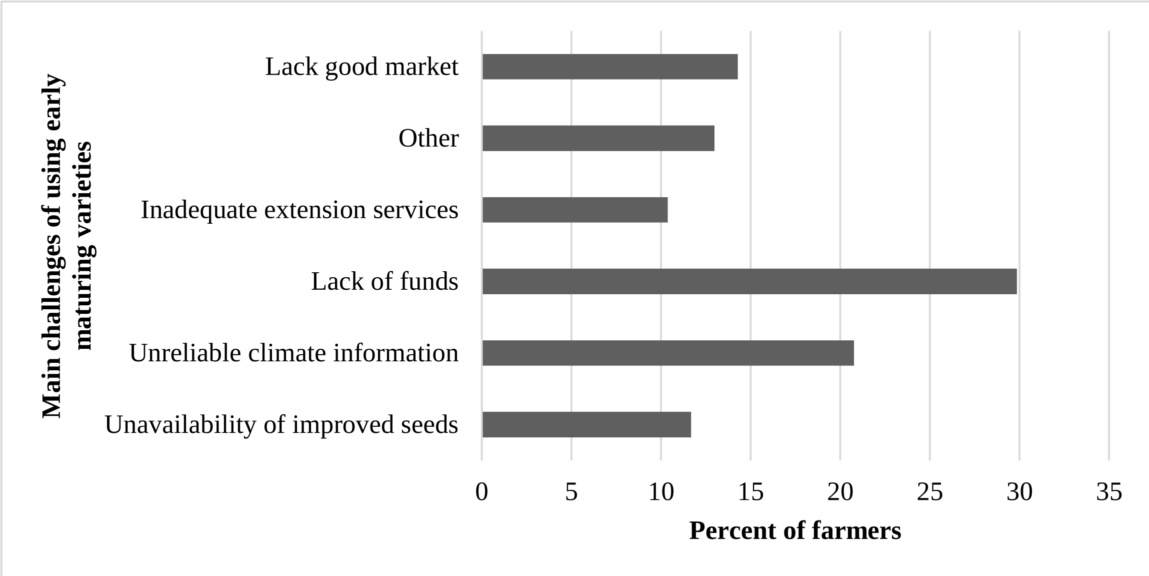

Figure 14: Challenges Experienced by Farmers in Using Early Maturing Varieties

Source: Survey data (2015).

In order to determine whether there was a significant difference in the practices adopted by farmers across the two sub-counties, a chi-square test was conducted and the results are shown in Table 6.

Table 6: Distribution of Timing Approaches Used by Farmers across Sub-counties

Strategy	Taveta (% of farmers)	Wundanyi (% of farmers)	χ^2 p-value
Early preparation of land	90.2	93.5	0.497
Change in planting dates	75.6	69.0	0.449
More frequent and timely weeding	95.1	74.8	0.004
Use of early maturing varieties	82.9	72.3	0.226
Use of greenhouses	0.0	0.6	1.000

Source: Survey data (2015).

From Table 6, it can be deduced that there is statistically significant difference between farmers in Taveta and Wundanyi in terms of adoption of more frequent and timely weeding ($p < 0.01$). Nearly all farmers in Taveta sub-county and three-quarter of the farmers in Wundanyi use the practice.

This implies that farmers in Taveta are more likely to engage in more frequent and timely weeding than those in Wundanyi. Farmers in Taveta do weeding more frequently as their plots are more exposed to weeds that are dispersed by the furrow irrigation water that collects weeds as the water flows downslope by gravity. However, there is no significant difference between farmers in Taveta and farmers in Wundanyi in terms of adoption of early land preparation, change in planting dates, use of early maturing varieties and greenhouses.

The decision on when to pick tomato produce is an important one. Timing of harvesting dictates the shelf life of the tomatoes. Table 7 shows results of the various stages of tomato development at which farmers normally harvest and the associated reasons for doing so. At the *mature green* stage, the tomato is ready for harvest but still green in color, *half ripe* stage is the breaker stage when the fruit turns to red and the *full ripe* stage is characterized by red and soft fruit and is the edible stage of the fruit (Moneruzzaman *et al*., 2009). Two-thirds of the farmers usually harvest their produce at the half ripe stage and it takes an average of 12 days to spoil.

Table 7: Tomato Harvesting Stages

Harvesting stage	**Percentage of farmers (n=196)**	**Average number of days before spoilage**	**Main reason why farmers harvest at that stage**
Mature green	3.1	14.2	Longer storage duration
Half ripe	62.8	11.8	Longer storage duration
Full ripe	34.2	7.9	Immediate consumption

Source: Survey data (2015).

Other reasons pointed out by the respondents as to why they normally harvest at the mature green and half ripe stages is that it helps reduce losses due to pest attack in the field and transportation is made easy. For the farmers who normally harvest at full ripe stage, they mentioned high demand in the market which attracts higher prices as the major reason. This is because fully ripe tomatoes are usually directly taken to hotels and restaurants for immediate consumption. According to the farmers, buyers prefer them because they are easy to peel.

In order to test if there was any significant difference between picking tomatoes at the three developmental stages of harvesting and the number of days it takes for the tomatoes to spoil, One-Way Analysis of Variance (ANOVA) was used. The results are presented in Table 8.

Table 8: One-Way ANOVA Results for Tomato Spoilage Duration

	Sum of Squares	Degree of freedom	Mean Square	*F*	*P*-value
Between Groups	731.208	2	365.604	11.198	0.000
Within Groups	6301.379	193	32.650		
Total	7032.587	195			

Source: Survey data (2015).

From the results, the null hypothesis that there is no difference between harvesting of tomatoes at mature green, half ripe and full ripe stages and the average number of days it takes before spoilage is rejected (F = 11.198, p < 0.001). Thus, this leads to the conclusion that indeed the mean number of days it takes for the tomatoes harvested at the different developmental stages to spoil is not equal.

Hochberg's GT2 post hoc tests[4] revealed that tomatoes harvested at mature green stage take significantly longer time before spoilage as compared to if they are harvested at full ripe stage. Moreover, tomatoes harvested at half ripe stage have longer shelf life than if they are harvested at full ripe stage. However, there is no significant difference in the number of days it takes for tomatoes to spoil if harvested at either the mature green or half ripe stages. The implication of this finding is that in order for farmers to ensure longer shelf life of their tomato produce, they should harvest at mature green and half ripe stages.

[4] According to Field (2009) the *Hochberg's GT2 post hoc* test is appropriate when the *Levene's* test of homogeneity of variance shows equality of variance and sample sizes are very different. In this study, *Levene's* test revealed equal variances of number of days before spoilage of tomatoes across the three harvesting stages (p > .05).

4.6 Innovative Timing Approaches

Three innovative timing approaches namely **off-season** production, **transportation** of produce during cool periods of the day and **processing** were identified at three nodes of the value chain. The adoption of these timing approaches is meant to reduce losses and or increase profits of tomato farmers.

Figure 15 shows the distribution of farmers who expressed their willingness to adopt these innovative timing approaches. Processing takes the largest proportion with more than half of the respondents willing to process as a strategy to reduce weather-related losses in the tomato industry. About one-third of the respondents were willing to undertake off-season production while the rest were willing to transport their produce during cool periods of the day.

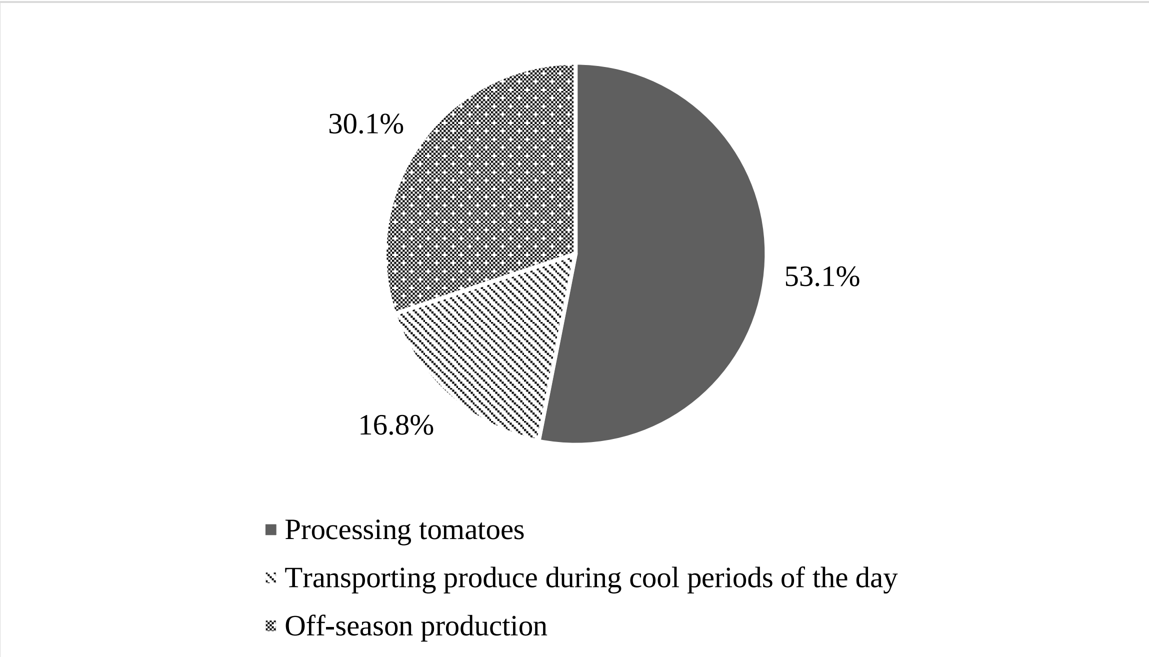

Figure 15: Percent of Farmers Willing to Adopt Innovative Timing Approaches

Source: Survey data (2015)

Respondents were further asked to point out the factors that they would consider as important in enabling them to take up the strategies that they were willing to adopt. These are illustrated in Figures 16, 17, and 18.

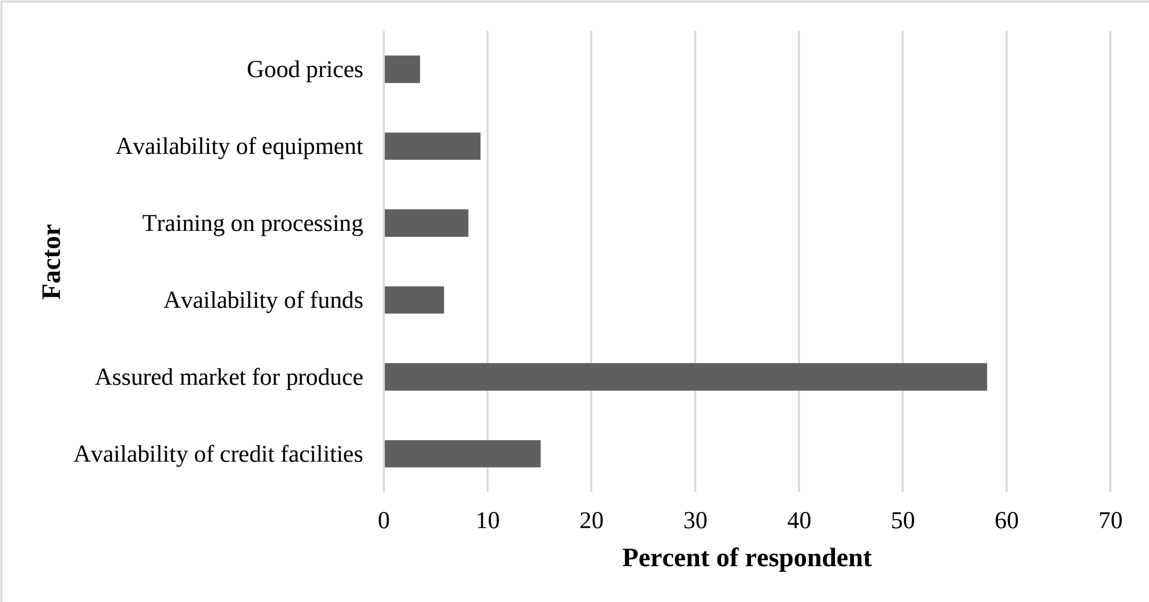

Figure 16: Considerations for Adoption of Processing of Tomatoes

Source: Survey data (2015).

Finding an assured market for processed products was the primary consideration that most farmers mentioned should be in place to enable them to process their tomato. Other factors included availability of equipment, training and credit facilities.

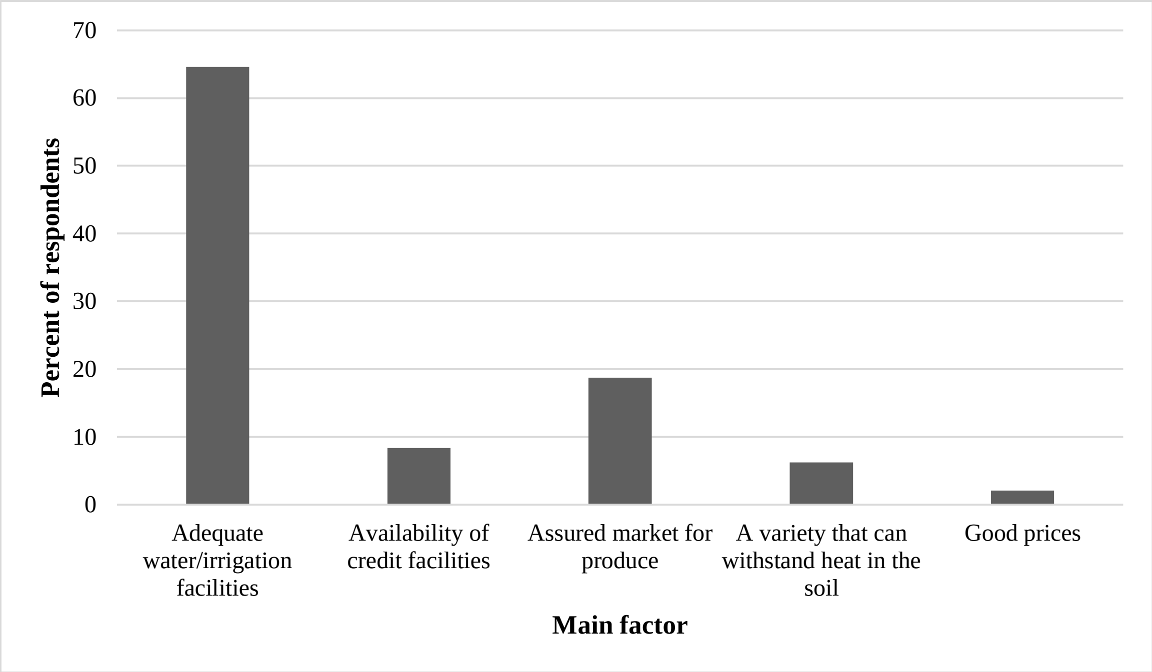

Figure 17: Considerations for Adopting Off-season Production

Source: Survey data (2015).

Irrigation facilities, assured market for produce and availability of a variety that can withstand heat in the soil were the main considerations that farmers would like to be in place to allow them practice off-season production.

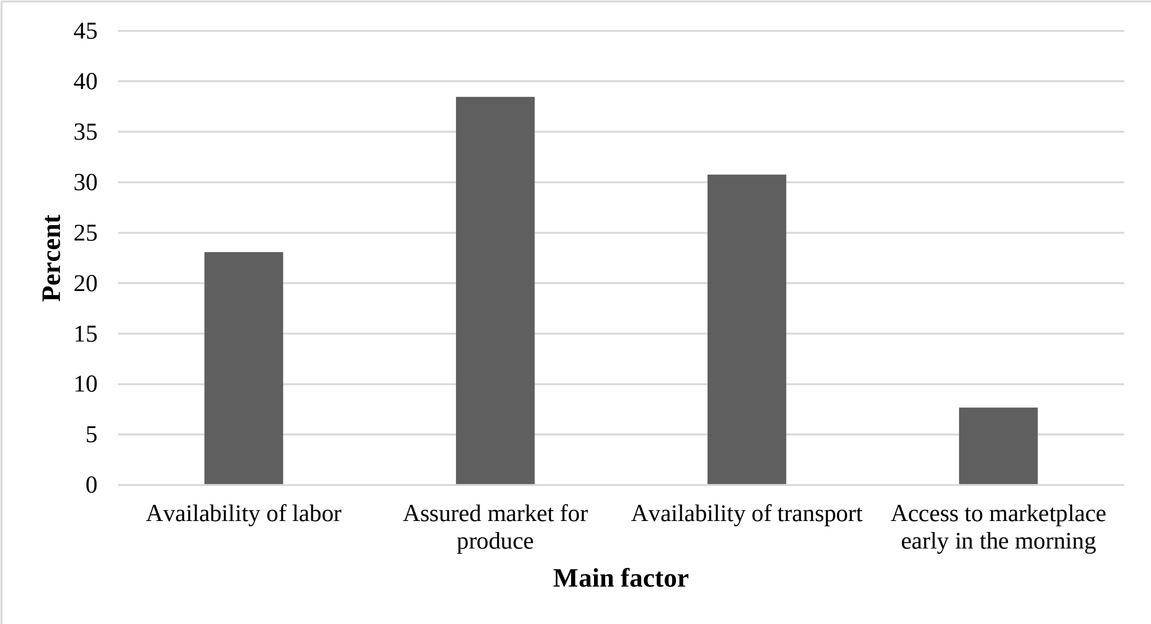

Figure 18: Considerations for Transporting Produce during Cool Periods of the Day

Source: Survey data (2015).

Availability of labor, transport means and assured market for produce are the main factors that farmers view as necessary in enabling them to transport their produce during cool periods of the day. The road networks in the County are in a sorry state and become impassible during the rainy seasons (Republic of Kenya, 2013d). This makes transportation of produce to the market cumbersome.

4.7 Factors Influencing Tomato Farmers' Willingness to Adopt Innovative Timing Approaches

As discussed in sections 3.3.2 and 4.6 three innovative timing approaches were analyzed namely off-season production, transportation of produce during cool hours of the day, and processing of tomatoes to extend shelf life. The sign of the MNL parameter estimates cannot be used to ascertain the direction and magnitude of the relationship between an explanatory variable and the probability of a specific choice (Bowen and Wiersema, 2003). This therefore calls for the computation of marginal effects, which give the probability that a particular choice will be made if an explanatory variable changes by one more unit (Cameron and Trivedi, 2009). The marginal effects are shown in Table 9.

Table 9: Marginal Effects on the Determinants of Farmers' Willingness to Adopt Innovative Timing Approaches

	Processing		**Off-season**	
Variable	**dy/dx**	**p>|z|**	**dy/dx**	**p>|z|**
Gender	0.165*	0.078	-0.090	0.279
Extension service	-0.068	0.372	-0.007	0.921
Credit	-0.133*	0.094	0.179**	0.013
Group membership	0.161**	0.038	-0.147**	0.046
Age	0.005	0.114	-0.005*	0.086
Income	-0.004**	0.047	0.003	0.203

**, *statistical significance at 5% and 10% levels, respectively; dy/dx for dummy variables is the discrete change from 0 to 1.

Source: Survey data (2015).

The results in Table 9 show that the gender of a farmer had an influence on their willingness to adopt processing at 10% significance level. Male farmers showed more willingness to process their produce as compared to female farmers. This finding resonates well with the observations by Asfaw and Admassie (2004), considering that men tend to have a higher access to information about new innovations than their female counterparts (Wilson & Getnet, 2011).

Having access to credit significantly predicted whether a farmer was willing to adopt processing. The negative sign is a pointer to the observation that farmers view investment in processing as being a risky venture since they are not assured of markets for the processed products. As it was discussed earlier (see Figure 16), most farmers cited 'assured market for produce' as the main consideration they would take in order to successfully engage in processing.

Holding other factors constant, access to credit had a positive impact on the likelihood of adopting off-season production. Farmers who had access to credit were about 18% more likely to undertake off-season production as compared to transporting their produce during cool hours of the day. The implication is that there is need to increase efforts in provision of financial resources directed at promotion of this practice in a bid to reduce negative effects of climate change. Hassan and Nhemachena (2008) and Gbetibouo (2009) also observed that access to credit was a very important determinant of adaptation to climate change.

Being a member of a development group increased the probability of a farmer's willingness to adopt processing by up to 16%. This finding is consistent with the argument advanced by Shiferaw *et al*. (2006), that organizational membership enhances the uptake of technological innovations through mobilization of resources and information sharing. Already, farmers in Kenya have formed groups in order to enable them to process their tomato produce. For instance, a study by Odame *et al*. (2008) indicated that this is taking place in Machakos.

However, membership to a development group decreased the probability of a farmer's willingness to adopt off-season production by about 15%. This can be explained by the view that practicing off-season production is an individual's choice and does not necessarily depend on collective decision-making. Based on an individual farmer's observation on the environment and market conditions, a farmer has the sole discretion to choose what kind of crop to plant and when to do it so as to maximize his or her returns.

Results also show that a one year increase in age of a farmer was associated with a 0.5% decrease in their willingness to adopt off-season production. A plausible explanation for this is that the aged are more risk averse than younger farmers and therefore tend to be more conservative in their approach to innovations (Langyintuo & Mulugeta, 2005). However, this result is contrary to the findings of Maddison (2006), who noted that as farmers grow older they gain more experience in farming and are thus expected to adopt new technologies.

The level of income was significantly associated with a lower probability of choosing processing. The probability of choosing processing decreases by 0.4% for every KES 1,000 increase in the monthly household income. Access to extension services did not significantly predict whether a farmer was willing to adopt any of the innovative timing approaches. This could be because extension messages disseminated to the farmers were not tailored to address the challenge of climate change.

In summary, the results presented in this chapter shows that there is high level of awareness about climate change among farmers in Taita Taveta County. Consequently, farmers have adopted some coping strategies on their farms such as irrigation, mulching, and doing more frequent and timely weeding. It was also clear that tomatoes harvested at mature green stage take significantly more time before spoiling as compared to those harvested at full ripe stage.

The MNL analysis revealed that five out of the six variables hypothesized to influence farmers' willingness to adopt innovative timing approaches were statistically significant. These were gender, credit, group membership, age and income. In the next chapter, the summary, conclusions and recommendations are presented.

CHAPTER FIVE

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The purpose of this study was to evaluate the determinants of farmers' willingness to adopt innovative timing approaches to manage climate change in Taita Taveta County. A two-stage sampling procedure was used to select 196 smallholder tomato farmers in the County who were interviewed using semi-structured questionnaires. Results from the study revealed that farmers were employing various adaptation strategies on their farms. These were irrigation, tree planting, use of varieties that are resistant to pests and diseases, early preparation of land, changing planting dates, more frequent and timely weeding and using early maturing crop varieties.

The farmers also reported benefits and constraints of various timing approaches that they have used on their farms. The main benefits are higher yields, ability to control pests and weeds, taking advantage of nitrogen flush at the onset of rains, and obtaining better prices due to improved quality of their produce. The key constraints identified include inadequate and unreliable weather forecast information, limited funds, increased labor costs and unavailability of improved varieties.

It was empirically tested and determined that the tomato harvesting stage had influence on the shelf life of tomatoes. Harvesting at mature green stage and half ripe stages are associated with longer storage duration and allow easy transportation of produce to the marketplace. About two-thirds of the farmers interviewed normally harvest at half ripe stage.

The MNL analysis showed that the main determinants of farmers' willingness to adopt innovative timing approaches to manage climate change in Taita Taveta County are access to credit, group membership, gender, age and income.

5.2 Conclusions

An overwhelming majority of farmers are aware that climate change is taking place with most of them observing that temperatures have considerably increased and rainfall reduced in the last two to three decades. Although most farmers receive weather forecast information some find it inadequate and unreliable.

The stage of development at which tomatoes are harvested determines the shelf life of the produce. Access to credit, group membership, gender, age and income were the main factors affecting farmers' willingness to adopt innovative timing approaches to manage climate change in Taita Taveta County.

5.3 Recommendations for Policy Action

Based on the findings from this study, it is suggested that more efforts and resources should be directed towards enabling adaptation to climate change besides creating awareness. In addition, prompt provision of accurate weather forecast information should be made a priority by the meteorological department and any other organizations engaged in availing such information. This will enable farmers to reduce uncertainties and make information-guided decisions to better manage the negative effects of climate change.

In order to get more accurate predictions, additional weather stations should be set up as the current ones are very few and do not cover a wide geographical area. As a starting point, one weather station should be set up at Wundanyi and another at Taveta as these two areas which rely on Voi weather station are in different agro-ecological zones. Utilization of radio as a channel of choice to reach out to farmers with weather forecast information should also be promoted as it is the main medium of communication accessible to and used by majority of the farmers.

Resources should also be directed by the national government (through the Kenya Agricultural and Livestock Research Organization) towards breeding of new varieties that are fast maturing, tolerant to high temperatures, disease resistant in addition to containing attributes that are attractive to buyers. The seeds should be made available to farmers at affordable prices. Additionally, the government should work towards reducing water losses in irrigation schemes by for example increasing canal linings and construction of more water harvesting structures. It is commendable that the government is moving in this direction but more needs to be done to improve farmers' access to irrigation.

Lending institutions such as commercial banks and micro-finance institutions should work towards availing affordable credit to farmers in order to improve their ability to cover costs associated with practicing off-season production. These costs could arise from irrigation facilities that must be put in place when drought conditions are present. Lowering of interest rates and simplifying application and disbursement procedures of loans should be prioritized. Farmer-driven efforts to facilitate credit availability amongst themselves such as table banking should also be encouraged.

Organizations involved in value addition activities such as processing should work closely with farmer groups to exploit the spirit of collective action. However, for them to be functional, group cohesiveness and unity of purpose must be the guiding principles.

5.4 Contributions to Knowledge and Suggestions for Further Research

The study was able to point out the factors influencing the adoption of timing approaches in a bid to address climate change effects in Taita Taveta County. Among others, these included inadequate and unreliable weather forecast information, lack of funds and unavailability of improved varieties that are both adaptable to the environment and acceptable to the consumers. However, a key limitation of the current study is that it only focused on farmers' perspectives without incorporating the views of other actors in the tomato value chain. Future research should take this into account.

Access to weather forecast information was a resounding constraint to planning of farming activities on the part of the farmers. There is therefore need to know how to package this information to be useful for decision making. Coming up with a more tailored weather forecast information than is currently provided has cost implications. Are the farmers willing to pay for the value added weather forecast information? This can form a basis for new studies.

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APPENDICES

Appendix 1: Variance Inflation Factors

Variable (X_j)	**VIF**	**Tolerance = 1/VIF = (1 – R_j^2)**
Gender	1.12	0.89
Extension service	1.10	0.91
Credit	1.32	0.76
Group member	1.29	0.77
Age	1.02	0.98
Income	1.04	0.96
Mean VIF	1.15	

All VIF < 10, hence there is no multicollinearity (Gujarati, 2004). Tolerance is also used for testing multicollinearity and the closer it is to 1, the greater the evidence that X_j is not collinear with other independent variables (*ibid*.).

Appendix 2: Measures of Goodness of Fit for Multinomial Logit Model

Log-likelihood intercept only	-195.53
Log-likelihood full model	-186.16
LR (12)	18.76
Prob > chi^2	0.0946

The model fitted well with prob>LR of 0.0946

Appendix 3: Results of *suest*-based Hausman test for IIA Assumption

Omitted	**Chi^2**	**Degree of freedom**	**P>chi^2**	**Evidence**
Transporting	6.00	14	0.9664	For H_0
Off-season	5.69	14	0.9738	For H_0
Processing	6.39	14	0.9556	For H_0

Ho: Odds (Outcome-J vs Outcome-K) are independent of other alternatives.

Thus the test confirmed the validity of IIA assumption.

Appendix 4: Focus Group Discussion Checklist

Date……………………..……….. Starting time……………………….…………………..

Ending time……….………….. Number of participants (Male...……..…. Female…………..)

Location of the meeting…………………………………………………………………………

1.) Are you aware of/perceive climate change? How has the rainfall and temperature patterns changed over the past 30 years or so? Please give specific examples.

2.) Which date and month of the year was considered the onset of: a) short rains b) long rains 30 years ago? Which date and month of the year is considered the onset of: a) short rains b) long rains nowadays?

3.) How does this change in climate affect you and your community?

4.) What do you do to cope or adapt to the impacts of climate change?

5.) Have you changed the timing of your farm operations? Why/why not?

6.) Do you recognize the importance of timing farming operations to better suit the changed environmental conditions?

7.) Do you face any challenge or constraints when undertaking the adaptive strategies or coping mechanisms to deal with the effects of climate change?

8.) What challenges do you face in trying to alter the timing of farming operations accordingly?

9.) Has weather forecast information been useful in helping you make day-to-day farming decisions? What kind of information do you really need?

Thank you!

Appendix 5: Questionnaire Used for Data Collection

ANALYSIS OF FACTORS INFLUENCING TOMATO FARMERS' WILLINGNESS TO ADOPT INNOVATIVE TIMING APPROACHES FOR MANAGEMENT OF CLIMATE CHANGE IN TAITA TAVETA, KENYA

INTRODUCTION **APRIL 2015**

This research survey is being undertaken by the Department of Agricultural Economics, University of Nairobi. The purpose of the survey is to obtain views, experiences and suggestions of farmers on determinants of tomato farmers' willingness to adopt innovative timing approaches for climate change management in Taita Taveta County. Respondents of this survey shall be tomato farmers who must be at least 18 years old. You have been randomly selected from Taita Taveta County and your participation in this survey is voluntary. About 200 respondents will be interviewed in this survey. The findings will provide insights for improving farmers' adoption of innovative timing approaches in managing climate change effects in tomato enterprises. Information obtained in this survey will be confidential and will strictly be used for academic and research purposes. The survey interview will require about 45 minutes to complete. I now request your permission to begin the interview.

Respondent screening question

Are you a tomato farmer? (1- Yes, 2- No)

If the question above is yes proceed to the next section if no end the survey and thank the respondent for his/her time

IDENTIFICATION

Interviewer's code.........................…………… Date of interview...................................

Village... Sub-location..… Location...

District... Division………………………………... Sub-County......................................

Point of interview: (1- Home/ Residential area, 2- Market, 3- Roadside, 4- Farm, 5- Other [Specify..])

SECTION A: Farm and Farming Characteristics

A1.) What is the size of your farm under tomato production (in acres)? ....…

A2.) What is the total size of land that you possess (in acres)? ……………………………

A3.) What is the **main** variety of tomatoes that you grow on your farm? ....

A4.) What other **major** crop do you grow apart from tomatoes? (1- Maize, 2- Beans, 3- Cabbages, 4- Onions, 5- Bananas, 6- Snow peas, 7- Other [Specify…………………………………………………..….])

A5.) For how many years have you practiced tomato farming? ....…………….

SECTION B: Institutional Services

B1.) For the last 12 months have you had access to extension services? (1- Yes, 2- No)

B2.) **If yes,** how many times in the last 12 months have you received training from an agricultural extension officer? …………………….…….

B3.) What type of extension services did you access? (1- Government to farmer, 2- Farmer to farmer, 3- Private provider to farmer)

B4.) Please indicate in the table below, your membership to various development groups in the last 12 months.

Type of group	**Member to a group (1- Yes, 2- No)**	**If yes, duration of membership (years)**	**If yes, ONE major service offered by the group** (1- Providing credit, 2- Sharing market information, 3- Seeking markets and linking you to buyers, 4- Input provision, 5- Farmer training, 6- Other [Specify……………………………….…………………………...])
Youth group			
Women group			
Credit group			
Farmer group			
Other (Specify………………………….)			

B5.) Have you obtained credit in the past five years? (1- Yes, 2- No).

B6.) **If yes**, please provide details in the following table.

Source of credit	**Did you get? (1- Yes, 2- No)**	**If yes, what proportion of the amount applied did you get?** (a - ¼, b - ½, c - ¾, d - All)	**MAIN use of credit** (1- Food, 2- School fees, 3- Purchase of land, 4- Farm inputs, 5- Household items, 6- Boost business, 7- Others [Specify…………………….………...])	**What proportion have you repaid?** (a - ¼, b - ½, c - ¾, d - All)
Relatives/Friends				
Micro-finance institution				
Commercial bank				
Savings and Credit Co-operative				
Farmer group				
Other (Specify…………………)				

B7.) If you **did not** apply for credit, what was the **main** reason that made you not apply for it? (1- Not aware, 2- Lack of collateral, 3- Don't need it, 4- Don't know the procedure, 5- Don't trust lenders, 6- Others [Specify…………………………...……………………………...])

SECTION C: Climate Change Awareness and Access to Weather Forecast Information

C1.) Have you observed any significant changes in rainfall and or temperature over the last 20 to 30 years? (1- Yes, 2-No).

C2.) **If yes**, has the mean and or variance increased or decreased?

		Increased	**Decreased**	**No change**
Temperature	Mean			
Rainfall	Mean (Amount)			
	Variance (Variability)			

C3.) Do you receive any information on predicted weather conditions? (1-Yes, 2- No)

If yes, proceed to question C4. If no, proceed to question C9.

C4.) Do you normally make use of the weather forecast information to guide your farming decisions? (1- Yes, 2- No)

C5.) How often do you receive this kind of information? (1- Daily, 2- Weekly, 3- Monthly)

C6.) What is your perception on the relative importance of this information? (1- Very useful, 2- Useful, 3- Not useful)

C7.) What is the **main** means of obtaining weather forecast information? (1- Radio, 2- Television, 3- Verbal message, 4- Mobile phone, 5- Internet [email, website], 6- Print media e.g. newspapers, 7- Others [Specify…………………………………………………………………..])

C8.) Is the information provided timely? (1- Yes, 2- No)

C9.) What **main** kind of relevant information would you like to receive in future weather forecasts that is currently not provided or is inadequately provided?

Type of information	**Tick ONE main type**
Onset of rains	
End of rainy seasons	
Distribution of rainfall within seasons	
Occurrence of floods	
Other (Specify…………………….……………………………………………………….)	

SECTION D: Farmers' Adaptation to Climate Change

D1.) Have you practiced any of the following measures to reduce the negative effects of climate change?

Adaptation strategy	**(1-Yes, 2- No)**
Taking up crop insurance	
Irrigation	
Diversify source of income	
Tree planting	
Mulching	
Use varieties resistant to pests and diseases	
Plant drought resistant varieties	
Other (Specify……………………………………………………………………………………..)	

D2.) Apart from the measures highlighted above, have you applied the following climate-related timing approaches?

Climate-related timing approach	**(1- Yes, 2- No)**	**MAIN benefit** (1- Cheap labor, 2- Able to control pests, 3- Get good prices, 4- Higher yields, 5- Reduce losses, 6- Able to control weeds, 7- Others [Specify……….…………..])	**MAIN challenge faced in implementing** (1- Unavailability of improved seeds, 2- Shortage of labor, 3- Unreliable climate information, 4- Lack of funds, 5- Inadequate extension services, 6- Others [Specify……………………………………………..])
Early preparation of land			
Change in planting dates			
More frequent and timely weeding			
Use of early maturing variety			
Greenhouses			

D3.) At what stage of tomato development do you **normally** harvest?

Stage of harvesting	**Reason for harvesting at that stage** (1- Longer storage duration, 2- Immediate consumption, 3- Others [Specify……………………………………………])	**For how long can you keep the produce before it spoils (in days)?**
Mature green (Mature but green in color)		
Half ripe (Breaker stage when fruit turns to red)		
Full ripe (Red and soft, edible stage)		

D4.) There are new timing approaches that are being used by farmers in their farming enterprises to reduce losses associated with change in climate, some of which are listed in the table below.

Innovative timing approach	**Are you aware?** (1-Yes, 2- No)	**Do you currently practice it?** (1- Yes, 2- No)	**If you currently practice, which ONE of these do consider as best in addressing climate change? (**Tick one**)**	**If not practicing, which ONE would you be willing to adopt as your main strategy?** (Tick one)	**What MAIN factor would you consider as important to you before adopting such timing approaches** (1- Availability of labor, 2- Adequate water/irrigation facilities, 3- Availability of credit facilities, 4- Assured markets for produce, 5- Other [Specify…………………………………….………..])
Off-season production					
Transporting your produce during cool periods of the day (e.g. early mornings and late evenings)					
Processing tomatoes into paste and jam to extend shelf life					

SECTION E: Socio-demographic Characteristics

E1.) Age of respondent in years ……………………….……….

E2.) Gender of respondent (1- Male, 2 - Female)

E3.) Number of members in the household ……………..…….………………….

E5.) **Main** occupation of the respondent (1- Farmer, 2- *Bodaboda* operator, 3- Trader, 4- Teacher, 5- Civil servant, 6- Driver, 7- Tailor 8- Other [Specify…………………………………………………..])

E6.) Formal education level of respondent

HIGHEST level of formal education (1- None, 2- Primary, 3- Secondary, 4- Tertiary certificate, 5- Diploma, 6- Undergraduate degree, 7- Masters, 8- PhD)	**Number of years of formal schooling completed**

E7.) What is the average household monthly income?

Income category	**Tick ONE category**	**Indicate average amount in Kenya Shillings**
Below KES 5, 000		
KES 5, 001 – 10, 000		
KES 10, 001 – 15, 000		
KES 15, 001 – 20, 000		
Above KES 20,000		

Thank you for your participation