

**ECONOMIC IMPORTANCE OF CROP DIVERSIFICATION AMONG
SMALLHOLDER FARMERS IN MATHIRA EAST DISTRICT, KENYA**

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**A Thesis Submitted to Graduate School in Fulfillment of the Requirements of the
Award of Master of Science Degree in Agricultural and Applied Economics (CMAAE)
of Egerton University**

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DEDICATION

To my wife, Eunice and my mother, Jane: they stood by my side while I laboured on this work.

ACKNOWLEDGMENT

I wish to acknowledge the entire staff of the Department of Agricultural Economics and Business Management, Egerton University for their sincere and honest support since I enrolled for my studies. Special thanks go to my University supervisors Prof. J.K. Lagat and Dr. H.K. Bett for their tireless and invaluable effort in guiding and supporting me during the entire study and research period. I would like to extend my sincere gratitude to AERC through the CMAAE programme for great support with research grants. My appreciation also goes to my fellow colleagues for sharing with me useful ideas during entire period of study and research. Above all, I thank the Almighty God for his mercy, care, strength and guidance during the entire period of study.

ABSTRACT

Agriculture is the most important sector in Kenya. The main economic importance of crop diversification is contribution to living standards and risk management. Crop farming in Mathira East District is characterized by different forms of diversification. However, there is little knowledge on economic importance of diversification. The main objective of this study was to contribute to the understanding of the importance of crop diversification in meeting the household's goal of improved standards of living and risk reduction. The mean-variance (E-V) approach and random utility theories were used to guide the study. Data was collected from 150 smallholder farmers using a structured questionnaire. A Tobit regression model was used to identify the determinants of duration and distribution diversification. Ordered probit model was used to determine the influence of crop diversification on standard of living while Two-Stage Least Square (2SLS) regression was used to determine the relationship between diversification and production risk. This study arrived at the finding that smallholder crop farming in the study area is characterized by distribution and duration-based diversification. Production risk is an important factor that influences farmers' decision to diversify in crop production with respect to their distribution and the duration of cropping seasons. The household standard of living was found to be influenced by distribution and duration-based diversification. Duration and distribution based diversification has a significant negative and positive influence from crop production risk at 1% and 5% level respectively. This study recommends that the government should endeavour to enlighten more farmers about the reality of production risks that may affect their crop production activities. In order for farmers to improve their standards of living through farming, diversification should be undertaken in such a way that there is more emphasis to at least one particular crop which the farmer has competitive advantage in its production as well as failure to neglect short season crops such as most horticultural crops. The government should provide a conducive environment for farmers to improve their levels of education and household average income per month since these factors may help to boost diversified agriculture that lead to improved standard of living. Farmers should be supported on how to take advantage of diversification in improving their standards of living. This may be achieved if necessary infrastructure (irrigation, credit access, improved information access and good road network) can be put in place.

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LIST OF ABBREVIATIONS

2SLS	Two Stage Least Square Regression
ASDS	Agricultural Sector Development Strategy
FA	Factor Analysis
FAO	United Nations Food and Agriculture Organization
GCA	Gross Cropped Area
GDP	Gross domestic product
GoK	Government of Kenya
IFAD	International Fund for Agricultural Development
ML	Maximum Likelihood
OLS	Ordinary Least Squares
PERT	Program Evaluation and Review Technique
SPSS	Statistical Package for the Social Sciences
SUR	Seemingly Unrelated Regression
UNFCC	United Nations Framework Convention on Climate Change
VIF	Variance Inflation Factor

CHAPTER ONE

INTRODUCTION

1.1 Background Information

A number of research studies have successfully identified the potential of diversification to contribute to better performance in agriculture by smallholder farmers in Kenya. Kimura *et al.* (2010) noted that risk management strategies through properly managed diversification can help boost agriculture and hence uplift farmers' standards of living. Additionally, due to limited availability of high potential land, it has been envisaged that increasing agricultural production will have to come from diversification (FAO, 2013). Promoting and supporting diversification opportunities is an integral part of most agricultural strategies in Kenya. The Government of Kenya, in collaboration with development partners, has over the years developed policies and strategies to enhance agricultural growth and improve household incomes through diversification.

In 2008, Kenya launched Vision 2030 as the country's long-term economic blueprint to guide the development process. Vision 2030's objective is to transform Kenya into a middle income country providing a high quality of life to all its citizens by 2030. Based on Vision 2030, the agricultural sector has developed the Agricultural Sector Development Strategy (ASDS) that envisages a food-secure and prosperous nation. The overall objective of the ASDS is to achieve an agricultural growth rate of 7 per cent per year over the next 5 years through various means, among them being promotion and support of diversification opportunities. The United Nations Food and Agriculture Organization (FAO) is Kenyan development partner that has been on the forefront in promoting diversification opportunities among smallholder farmers (FAO, 2013).

There are well-known gains associated with specialization. However, rural households in developing countries still adopt diversification strategies due to a number of reasons. Changing consumer demand following welfare advancement drives households to diversify in order to satisfy their demand for different types of food and non-food goods (Singh *et al.*, 1986; Omamo, 1998). The carrying out multiple activities on the same farm reduces costs or increases output (positive externalities between activities) leading to economies of scope. On the other hand, the

intense land subdivision place pressure on land resources causing farmers to generate greater income only by diversifying.

Since agriculture is rampant with risk, farmers in most parts of the country choose to diversify. This makes households with multiple income sources to experience less variability in total income than a specialized household. Consequently, risk management in crop farming involves choosing among alternative cropping strategies that reduce the effects of risks.

Mathira East District has a variety of crops grown, ranging from food to cash crops. These crops have varying durations of maturity. The most important food crops grown in the district include maize, beans, peas, potatoes, sweet potatoes, sorghum, millet and barley. Distributive diversification (balance between crops) and crops duration diversification (spread/balance in expected crop durations) are very common. Many researchers have argued that the main economic goals behind diversification relate to income enhancement and hence improved standards of living (Nickerson *et al.*, 2001; McGehee and Kim, 2004; Turner *et al.*, 2006) and reduction of risk (Kimura *et al.*, 2010). The decision of diversification by a farmer is considered to be one of the major economic decisions that have strong bearing on his welfare (Rearden and Timmer, 2012).

A broad range of economic and non-economic related factors influence the decisions to diversify (Barbieri and Mahoney, 2008). However, in Mathira East District, the factors leading farmers to engage in different forms of diversification is not clear. It is therefore, important to know the specific drivers of diversification as well as its contribution to standard of living and risk reduction.

1.2 Statement of the Problem

In the recent past, despite the widespread campaign meant to encourage smallholder farmers into specialized and commercial farming, evidence shows that most farmers in Mathira East District continue to be diversified. Though the overall goal of diversification is improvement of the standards of living and risk reduction, there is little knowledge on factors that determine the different forms of crop diversification strategies. Additionally, although farmers in Mathira East

District have adopted diversified crop strategies, the choice may not be guided by economic but other considerations. Consequently, it is not known if their involvement in crop diversification enables them to improve their living standards and reduce crop production risks. None of the key strategies has been evaluated to pinpoint their ability to improve living standards and reduce crop production risks to the household and yet they are used repeatedly.

1.3 Objectives

General Objective

To contribute to the understanding of the importance of crop diversification in meeting the household's goal of improved standards of living and risk reduction in Mathira East District.

Specific Objectives

- a) To characterize the crop farming strategies with respect to distribution and duration-based diversification.
- b) To determine the major drivers distribution and duration-based crop diversification
- c) To evaluate the influence of distribution and duration-based crop diversification strategies on household living standards.
- d) To determine the influence of distribution and duration-based crop diversification strategies on production risk.

1.4 Research Questions

- a) What are the characteristics of the crop farming strategies in the study area with respect to distribution and duration-based diversification?
- b) What are the major drivers of distribution and duration-based crop diversification?
- c) What is the influence of distribution and duration-based crop diversification strategies on household living standards?
- d) What is the influence of distribution and duration-based crop diversification strategies on production risk?

1.5 Justification of the study

Results of this study would contribute to better understanding of the drivers of crop diversification strategies, contribution of diversification to households' standards of living and influence of diversification on production risk. It would provide a good starting point in the process of comprehending the best agricultural policy reform suited to the area. The findings would also be useful as reference material for future research with regard to distribution and duration based diversification; concepts of agriculture that are not commonly researched. Farmers may benefit by knowing whether diversification is appropriate in their goals to improve their standards of living and reduce production risks inherent in their crop farming. The government and agricultural policy makers may get a fine understanding of the diversification concept and how it affects the well-being of smallholder farmers.

1.6 The scope of the study

Although many forms of crop diversification exist in Mathira East District, it was not possible to cover all of them. This study focused on only two forms of on-farm crop diversification (distributive and duration-based diversification). The study was conducted amongst the smallholder crop farmers because they are common users of diversification strategies.

1.7 Limitations of the study

The study was limited by the fact that it was mainly cross-sectional, this implies that it was a challenge having to collect data about what had already taken place in the household farming system before the study commenced. However, the research instruments were prepared in such a manner that respondents were expected to recall the changes in certain variables over a specified period of time. This eventually made it possible to cover up the weaknesses inherent in the cross-sectional type of research design.

A variety of issues that were studied were viewed as personal by some people in the study area and hence some people were hesitant to give answers as expected. Some of these issues were household income and number of people in the family. However, there was caution on the framing of such types of questions in the questionnaire schedule in order to obtain unbiased and true responses. Necessary measures to ensure that clear communication was made on the purpose

of the study and assuring confidentiality to the respondents about the use of information provided was done.

1.8 Definition of Terms

Distribution-based diversification – Strategy concerned with the balance among different crops. Minimum diversification entails a single crop and maximum diversification as equal distribution of land to all crops.

Diversification – A management technique that mixes a wide variety of activities/practices within a portfolio. It involves the re-allocation of some of a farm's resources such as land, capital, farm equipment and paid labour to within and off the farm.

Duration-based diversification - Strategy concerned with the decision to grow crops based on the expected production duration. Minimum diversification entails growing crops with fewer cropping cycles per year while maximum diversification entails crop with several cropping cycles per year.

Household - A group of people related by blood, living together under one roof and/or one homestead and sharing resources within one land holding. Members of a homestead have one head.

Production risks - It is the possibility of adversity or loss of yield

Specialization - An arrangement in which an individual choose to undertake only the most suited activities by virtue of technical skills, location, or other qualifications.

Standard of living – This is defined as the level of welfare available to a household. This study constructed arbitrary index as the average of indicator or dummy variables for whether a household possesses certain assets, kind of building materials used for the dwelling structure, availability of drinking water, sanitation and the type of energy used. The index was then translated into meaningful ordered categories (extremely worse, worse, average, good and very good).

CHAPTER TWO

LITERATURE REVIEW

Several studies have been conducted on agricultural crop diversification. This chapter presents a literature review on overview of on-farm crop diversification, drivers of diversification, studies related to diversification, benefits and challenges of diversification. A discussion on theoretical and conceptual framework has also been presented.

2.1 On-Farm Crop Diversification

Agricultural diversification in smallholder farming results because of farmers' planning of activities. On one hand, a farmer as a decision maker would have to choose a portfolio of farm and non-farm enterprise mix that optimizes aggregate income and on the other hand, choose a portfolio of within-farm activities that optimizes income. The later decision is made during farm planning where a farmer makes three main decisions; what to produce, how to produce and how much to produce (Van and Keller, 2006). These three questions are different but inter-related. This implies that a farmer has to choose which crops to produce and to what extent to specialize, or alternatively diversify. A rational farmer is expected to make a choice that optimizes the aggregate output at the farm.

Diversification is a major determinant of farm income. It influences the output through its impact on cost, income and risk (Grimes, 1929). In a broad manner, diversification is seen as having two main properties; it expands the production possibility set or area allocation frontier, thereby increasing opportunities for income generation and employment creation. It also reduces the risk of having all of one's eggs in a basket with a few crops with potentially high covariance risk (Samuelson, 1967).

There are several sub-components of diversification that include both the spatial and temporal aspects that are relevant to smallholder crop farmers. These are decisions taken by farmers, together, and not in isolation, which eventually affect their welfare in terms of income and risk outcomes (Hearn *et al.*, 1996).

The first decision is about the level of participation between farm and off-farm activities. This is influenced by opportunities and threats available in the two enterprises (risks, taxation, unemployment, government policies) as well as farmer's characteristics as defined by strengths and weaknesses such as level of education, capital endowment and land ownership. This kind of diversification is typically referred as livelihood diversification.

Secondly, a choice on how to balance the involvement in livestock and crop production at the farm level has to be done. This is influenced by resource (land, labour, capital and management) availability and farmer's experience. This kind of diversification is typically referred as enterprise diversification.

Thirdly, a choice of number of crops is made. Within the area allocation or on the production possibility frontier, a farmer decides about the number of crops that could be produced. Some farmers prefer to produce more number of crops than others within a homogenous climatic and land quality. This system of diversification is related purely to the diversity aspect, where diversification is only related to the number of crops produced. This kind of diversification is typically referred as crop diversification.

Fourthly, when a farmer decides about the number of crops, it influences the aggregate level of spread or concentration in the cropping pattern; this determines the extent of specialization at the crop level. In this context, diversification is seen in terms of the balance among different crops. This type of diversification is referred as distributive diversification. The concept can be explained by considering minimum diversification as the practice of having a single crop and maximum diversification as equal distribution of land to all crops (Grosskopf *et al.*, 1992). In this case, a household producing two crops, each contributing equally to the total, would be more diversified than a household with two crops, of which one crop covers more of the total area under cultivation (Minot *et al.*, 2006). Here, higher spread is synonymous to higher level of diversification. Higher spread in cropping pattern is expected to help farmers in a fuller or better utilization of resources, in realizing regular and quick results and reducing risks out of crop or market failures. This type of crop diversification can be measured by the changes in cropping pattern in terms of substitution and expansion effects on crop area. Substitution effect is the

relative decline in area under some crops and the corresponding increase in area under other alternative crops for a given gross cropped area. Expansion effect is the effect of increase in gross cropped area (Venkataramanan and Prahladachar, 1980).

Fifthly, as a farmer in deciding on how to spread the chosen number of crops, a decision on the expected production period/duration is made. In this context, diversification is seen in terms of the spread/balance in expected crop durations. The main reasoning is considering how many cropping seasons that can be supported by the chosen number of crops per year. The maximum diversification in this case is considered as when the crop(s) chosen is/are ready for harvesting within short durations; the possibility of having several cropping seasons per year and minimum diversification as when a farmer specializes on crops with long durations to maturity; the possibility of having fewer cropping seasons per year. This form of diversification has been affected by technological changes over time (development of new fast maturing crop breeds through genetic modification) that alter the cropping pattern and thus pattern of diversification

Lastly, while taking decision on number of crops and level of spread in the cropping pattern, farmers also take another critical decision on, which of the different combinations of low versus high value crops or mix of subsistence and commercial crops to take. The value of crops is determined on the basis of their capacity to generate economic returns per unit of land or labour (Minot *et al.*, 2006). It is important to note that diversification from staple crop production into high-value crops need not imply greater diversity in crops. For example, if a mixed potato and maize grower decides to specialize in maize production (assuming that maize generate more economic returns per unit of land or labour as compared to potatoes); this would represent diversification into a high-value crop, but not diversification in the sense of multiple cropping. Here, diversification is seen also from the angle of commercialization. This is called commercial or high value crop diversification and can be measured by analyzing the share of area or income from high-value crops

Most studies have concentrated in livelihood, enterprise and crop number diversification (Grimes, 1929; Alagh and Sharma, 1980; Pingali and Rosegrant, 1995; Delgado and Siamwalla, 1997; Barrett and Reardon, 2000; Acharya, 2003; Agarwal, 2004; Minot *et al.*, 2006; Mehta,

2010). This implies that there are few studies that deal with other forms of diversification, especially, distribution and duration-based diversification. This has in turn sometimes not yielded quality results for policy making with regard to diversification strategies by farmers.

2.2 Drivers of Crop Diversification

According to BIRTHAL *et al.* (2007), diversification can be a response to both opportunities and threats. There are well-known gains associated with specialization. However, rural households in developing countries still adopt multiple income-generating activities. There are many factors that propel this move by farmers.

Following welfare advancement, consumers move away from a diet based on staples to one with more contents of animal products (meat, eggs and dairy) and fruits and vegetables. Diverse economic activities may be motivated by the combination of diverse consumption needs and high transaction costs in purchasing consumer goods. In economic terms, high transaction costs imply that production and consumption decisions are not separable, so that consumption needs affect production decisions. For example, if a household lives far from roads and markets, the cost of buying and selling goods will be high, forcing it to diversify in order to satisfy its own demand for different types of food and non-food goods (Singh, Squire and Strauss 1986; Omamo, 1998).

Risk reduction is a major driver of crop diversification. Since the type of crop that can be grown in an area is affected by changes in temperatures and the length of the growing season, farmers in several countries have already initiated diversification as a response to climate change (UNFCCC, 2007). If each source of income fluctuates from year to year as a result of weather or other factors and the correlations in variations in income are not perfectly positively across sources, then a household with multiple income sources will experience less variability in total income than a specialized household. Quiroz and Valdez (1995) argued that crop diversification is unlikely to reduce production risk because the yields of different crops are closely correlated, but if drought-resistant crops such as cassava are included in the crop mix; weather-related risks may be reduced. When diversification is motivated by risk management, the household generally has to sacrifice in terms of average income. Thus, diversification is expected to occur when income

sources are highly variable and when households are particularly risk averse. This is consistent with empirical research that shows that poor rural households practicing rain-fed agriculture in low-potential areas are more likely to have diverse income sources than richer households in areas with greater agro-ecological potential (Barrett *et al.*, 2001; Block and Webb 2001; Joshi *et al.*, 2002). Farmers face risk from bad weather and from fluctuating prices and diversification is a logical response to both.

Changing demographics such as rapid urbanization require adaptation to new farming methods to meet the growing products demand. Diversifying into crops that can meet export market demand can result to agricultural success. The new patterns witnessed in most countries where consumers devote less and less time to food preparation provides an opportunity for farmers to diversify into crops that are highly compatible with value addition. Government policies that control the way in which farmers can link to markets can open up new diversification possibilities (Birthal *et al.*, 2007). Diversifying from the monoculture of traditional staples can have important nutritional benefits for farmers in developing countries.

Multiple income sources may be useful as an adaptation to missing or poorly functioning markets as a household attempt to produce what it is expected to consume. For example, if a household lives far from roads and markets, the cost of buying and selling goods will be high, forcing it to diversify in order to satisfy its own demand for different types of food crops (Finocchio and Esposti, 2008; Bowman and Zilberman, 2013).

Considering that the geographical situation in the study area may be unique and that the farmers may be faced with unique opportunities, it is therefore necessary to conduct a study aimed at identifying the specific drivers of diversification.

2.3 Studies on On-Farm Crop Diversification

Delgado and Siamwalla (1997) examined broad patterns of crop diversification in Asia and Africa. They noted that African farmers often have highly diversified crop mixes as a strategy to reduce risks associated with weather. In contrast, crop diversity in Asia is associated with

farmers diversifying away from rice into higher-value crops and activities, such as horticulture, and aquaculture.

Ersado (2003) examined the relationship between diversification and household welfare in Zimbabwe. The finding was that in rural areas, richer households were more diversified due to highly variable rainfall, which is consistent with the idea of diversity as a risk management strategy.

Using area and production statistics, Joshi *et al.* (2004) examined the trends in diversification in South Asia over recent decades. They showed that the diversity of crop production has increased since 1980 in most South Asian countries. In India, the southern and western regions are diversifying away from grains toward pulses, oil seeds, fruits, and vegetables. In the northern region, farmers are turning from coarse grains to commercial production of rice, wheat, and (to a lesser degree) non-grain crops. They concluded that diversification from coarse grains to high-yielding rice and wheat has had positive effects on household standards of living, while diversification toward cash crops has boosted employment per hectare and agricultural exports.

Reardon, Matlon and Delgado (1988) found that rural households in an arid village in Burkina Faso were more diversified. In contrast, another village with better agro climatic conditions earned about half of their income from crop production due to less diversification but were actually more vulnerable to droughts than households in the drier zone. Studies that focus on on-farm crop diversification in terms of distribution and duration to maturity are relatively rare compared to studies using other definitions.

2.4 Benefits of Diversification

Diversification adaptive strategies impact differently on farmers' welfare. Boris *et al.* (2005) noted a positive impact of diversification between subsistent crops and cash crops but observed a negative impact among cash crops. Likewise, Coelli (2004) observed that diversification economies existed between subsistence food production and the production of either coffee or cash food items, while diversification diseconomies were found between coffee and cash food production.

Diversified farmers find an array of benefits. Fleming and Hardaker (1994) observed that farmers have had most success in commercializing their operations through adaptive strategies of combining cash cropping with subsistence production and further noted that increased productivity occurs with diversification from subsistence food production into cash cropping activities while still retaining a significant subsistence base, given that most farming systems continue to rely heavily on the farm inputs of household labour, management and land resources. When a smallholding diversifies into cash production, the farmer has the opportunity to select those activities that complement each other given the seasonal nature of their labour demands to utilize family labour resources fully throughout the year. It is largely for this reason that the implementation of an adaptive growth strategy by smallholders has been so pervasive.

Gary *et al.* (1995) noted that crop diversification helps in establishing a year-round or extended season employment system. While climate and soil conditions limit farming activities in many regions, diversified farm enterprises can extend work during the offseason in any region. This helps to achieve year-round or extended season employment. Developing a diversified enterprise is sometimes a challenge for farmers. Often different management skills are needed. There are, however, many examples of successful diversification strategies practiced in Kenya.

2.5 Challenges of Diversification

According to Ellis (2000), diversification may be inhibited by lack of liquidity and lack of access to credit. This constraint is particularly applicable in the case of fruit and other tree crops that require several years to mature. Lack of information about production methods and markets is another challenge whose constraint is particularly relevant for new and specialty crops, aquaculture, fruits and vegetables, and other perishable commodities. Lack of education or language skills necessary to acquire needed information related to diversification affects ethnic minorities in many countries and may be an issue for female-headed households in some areas. Poor infrastructure which reduces the farm-gate price of crops and raises the farm-gate cost of purchased inputs is a more binding for households in remote locations and for crops that are either perishable or have a low value-bulk ratio. Insufficient land or labor to diversify into non-food crops makes poor farmers to be reluctant to depend on the market for their food, so they often prefer to supplement food production with high-value crops rather than reallocate a large

portion of land to high-value crop production. This constraint affects areas where the population density is high relative to the agro-ecological potential of the land. Lack of social capital (the network of friends and business associates with which a person has some level of mutual trust) in the agricultural sector may impede involvement in high value crop production.

2.6 Theoretical Framework

2.6.1 Random Utility Theory

According to Train (2003), random utility theory could be used to guide a study in the empirical estimation of responses that can be taken with varying consequences. The random utility model was used to guide the empirical estimation of the farmers' response to production risk through on-farm crop diversification. A decision maker i who must choose from a set of mutually exclusive alternatives, $n=1 \dots, n$ was assumed.

The decision maker i was assumed to obtain utility U_{in} from each choice made. In general, given a set of alternatives, a rational individual was assumed to choose an alternative that provides the highest utility. The utility is not directly observed, but instead only attributes of the available alternatives are observed. Thus, the random utility function may be expressed as follows:

$$U_{in} = V_{in} + \varepsilon_{in} \quad \forall n \quad \text{-----}(1)$$

Where; V_{in} is the deterministic component which can be calculated based on observed characteristics and ε_{in} is the unobserved random or stochastic error component. The error component is never observed which makes it difficult to have enough information that would allow prediction of a specific individual's choice at each occasion.

Regression analysis was used to make predictions about the patterns of choices over many individuals and many choice occasions. The probability of a decision maker i choosing alternative k among n alternatives is expressed as follows;

$$\begin{aligned} P_{ik} &= Pr(U_{ik} > U_{in} \forall n \neq k) \\ &= Pr(V_{ik} + \varepsilon_{in} > V_{in} + \varepsilon_{in} \forall n \neq k) \quad \text{-----}(2) \end{aligned}$$

The utility specified above under a random utility modeling framework can be extended as follows:

$$V_{ik} + \varepsilon_{ik} = \chi_{ik} \beta + \varepsilon_{ik} \text{ ----- (3)}$$

Where; χ_{ik} is a vector of characteristics which influence the on-farm crop strategy, β is the coefficient vector and ε_{ik} is the term for random disturbances with an extreme value distribution.

2.6.2 The E-V rule/approach

An extension of utility theory called expected mean-variance (E-V) approach was also applied in this study. This approach was developed by Mackowitz (1952, 1959) and assumes that decision makers have quadratic utility functions, or that their utility functions are consistent with the von Neumann-Morgenstern expected utility maximization. In this approach, farmers preference ordering depends only on mean and variance of returns, (Hisham *et al.*, 2002). A farmer would choose a particular form of diversification if the utility to be derived (U_d) is greater than the utility that would have otherwise resulted if the choice was not made (U_{d0}).

$$\text{Max } U_i = f(U_d, U_{d0}) \text{ ----- (4)}$$

Subject to resource constraints and

$$U_d - U_{d0} > 0 \text{ ----- (5)}$$

Where U_i is household i utility function, U_d is total utility derived by the household after a diversification choice and U_{d0} is the utility that would have otherwise resulted if the choice was not made.

2.7 Conceptual Framework

The conceptual framework that informed this study in explaining the relationship between determinants/drivers of on-farm crop diversification, agricultural production risks and household standards of living is presented in Figure 1.

It is conceptualized that the type and extent of crop diversification is influenced by a set of drivers/determinants. On-farm crop diversification has a direct influence on household standards of living and production risk. Crop production risk and diversification are two variables that simultaneously determine each other. Additionally, the type of crop diversification may be

influenced by intervening variables and eventually influence the household standards of living and overall production risks.

Independent variables

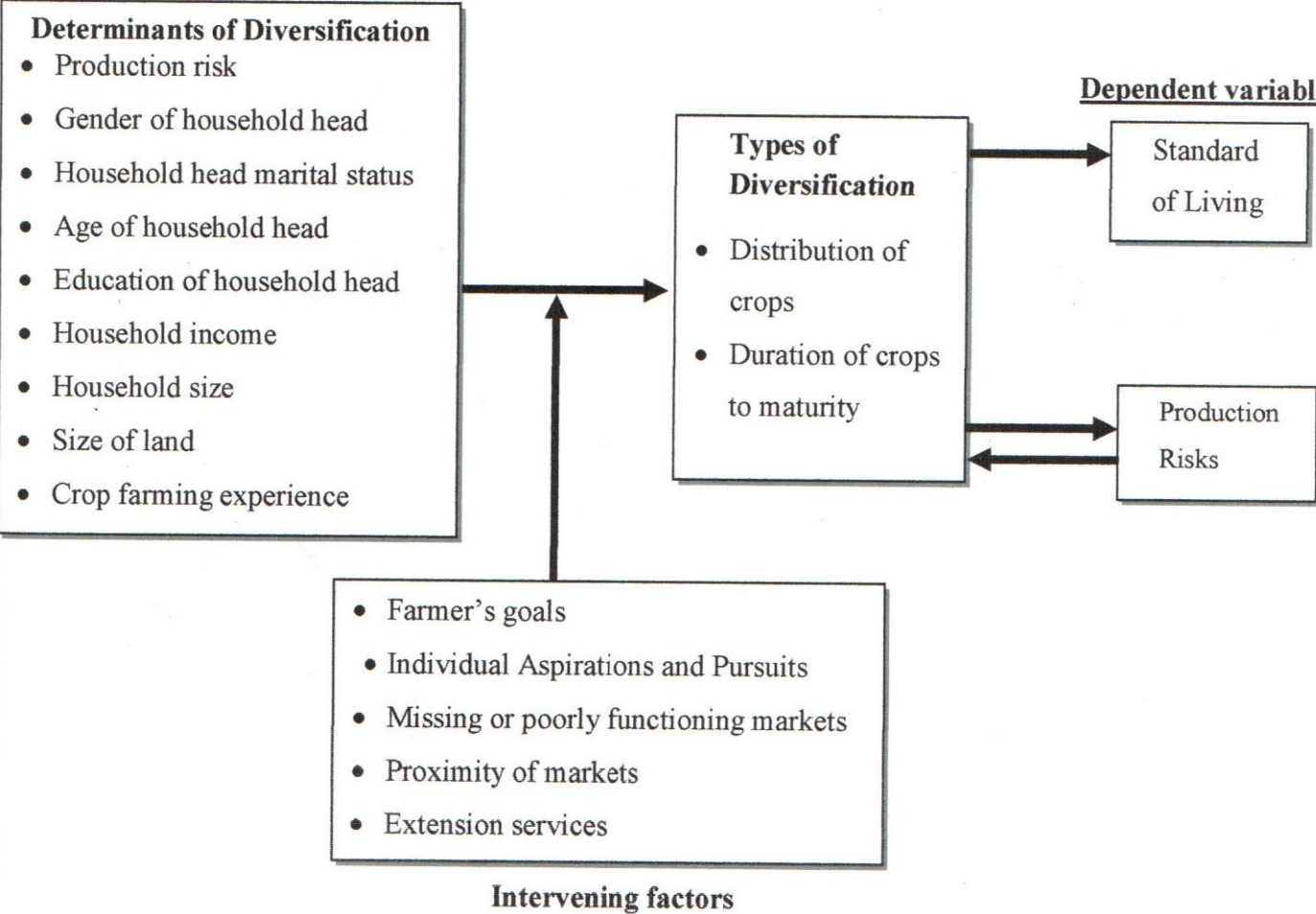


Figure 1: Conceptual Framework

Source: Own Conceptualization

Figure 1 shows the relationship of factors that were considered to have various directions of influence on production risk and standards of living of smallholder farmers. The determinants/drivers of crop diversification have a direct influence by farmers' adoption of particular cropping strategy with regard to diversification. The adoption of different forms of diversification consequently influences the production risk and the households' standards of living in a direct manner. The increased adoption of distribution based diversification reduces

production risks but contribute to low standards of living among farmers. On the other hand increased adoption of duration based diversification increases the production risks but contribute to higher standards of living. Farmer's goals, individual aspirations and pursuits, missing or poorly functioning markets, proximity of markets and access to extension services are some of the intervening variables that may influence the choice of particular crop diversification strategies. Crop diversification strategies have a direct influence on production risk and the households' standards of living. It is also conceptualized that, on one hand, diversification is as a result of farmers' response to risk inherent in their farming while on the other hand, the extent in which a farmer may choose to diversify his crop production may influence the levels of risk faced in crop farming.

CHAPTER THREE

METHODOLOGY

3.1 Study Area

The study area, the Mathira East District, is in Nyeri County where many farmers are diversified. Due to intense land subdivision, distribution and duration based crop diversification are farming strategies commonly practiced in the area. It has an area of about 129 Square Kilometres (GoK, 2005). It is located on Latitude $0^{\circ} 25' 0''$ S and longitude of $36^{\circ} 57' 0''$ E. The district mainly has red volcanic soils suitable for food crops such as maize, beans, peas, sorghum and potatoes. The district has a population of 81,126 persons. The district has some sizeable portions of areas that are vulnerable to drought. The rainfall pattern in the District is bimodal. The main physical feature in the district is Mt. Kenya (5199 meters above the sea level) to the east. These features determine relief, climate and soils, and consequently, the agricultural potential of the area. The district has a population density of 388 persons per square kilometres according to the Population and Housing Census of 2009.

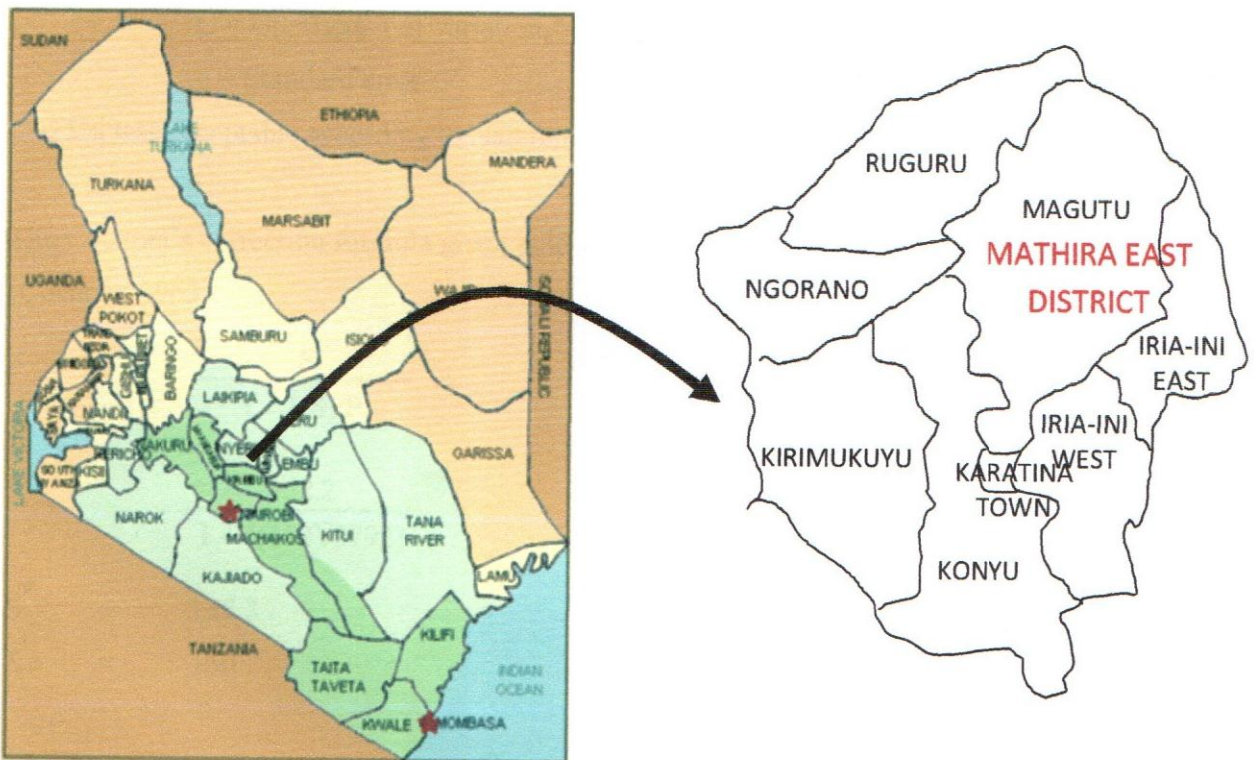


Figure 2: Map of the Study Area

Source: Nyeri District Strategic Plan 2005-2010 (Page 4)

3.2 Determination of the Sample Size

Ideally, it was preferable to collect data from all the 5,792 smallholder crop farmers in the four administrative divisions of Mathira East District (Magutu, Konyu, Iriani East and Iriani West). However, due to time and finance constraints, sampling was inevitable. A systematic random sampling technique was used to select the respondents. The target population was the smallholder crop farmers in the district.

The following formula was used to come up an appropriate sample for the study as per Nassiuma, (2000).

$$n = \frac{NC^2}{C^2 + (N - 1)e^2}$$

Where: n = Sample size,

N = Population,

C = Coefficient of variation,

e = Standard error.

C=25% was acceptable according to Nassiuma (2000), e = 0.02 and N=5,792

The Cochran's correction formula given below was used to calculate the final sample size (Cochran, 1963).

$$s = \frac{S}{1 + [(S)/P]}$$

$$s = \frac{152.2}{1 + [(152)/5792]}$$

$$S = 148.3$$

$$S \approx 150$$

Therefore, only 150 smallholder crop farmers were sampled for the study. Proportionate sampling in each of the four divisions of the district was as tabulated below:

Table 1: Distribution of the Sampled Respondents per Division

Locations	Total Number of farmers	Percentage (%)	Number of farmers sampled
Magutu	1614	27.9%	42
Konyu	1404	24.2%	36
Iriani East	1341	23.2%	35
Iriani West	1433	24.7%	37
TOTAL	5792	100.0%	150

3.3 Data Collection Instruments

The main data collection instrument was a household questionnaire directed at households' heads. An important aspect of the household questionnaires was its ambition to capture information on demographic and socio-economic characteristics as well as engagement in on-farm crop diversification. There were questions related to distribution and duration to maturity of crops grown. Generally, questions were few and not unduly time consuming. The study further used secondary data where necessary while reviewing the literature and discussing results.

3.4 Data Analysis

Data from the pre-coded questionnaires was entered in the Statistical Package for Social Scientists (SPSS) version 16.0. The data was then cleaned and organized. SPSS enabled easy manipulation of the data to obtain descriptive statistics, which provided a general description of diversification strategies used by farmers in the study area. STATA software was employed in the analysis of research questions. The @Risk software was employed in performing quantitative (stochastic) risk analysis using Monte Carlo simulation using minimal data such as the minimum, most likely, and maximum values of certain incidences.

3.5 Empirical Models

The objectives in this study were analyzed as follows:

Objective 1: To characterize crop farming strategies with respect to diversification

The objective was addressed using descriptive statistics.

Objective 2: To identify the major drivers of diversification: Tobit regression model

On-farm crop diversification was examined in terms of distribution (balance among different crops) and cropping durations (number of months taken for a crop to mature).

The method used to measure crop distribution and duration based diversification was a modification of the Entropy index that lies strictly between zero and one as proposed by Culas and Mahendrarajah (2005). The entropy index is given by $\sum(P_i) \cdot [\log(1/P_i)]$. This index is a weighted sum of proportions [weights being $\log(1/P_i)$]. It attains 0 with complete specialization and $\log(N)$ with perfect diversification. This is good for capturing the 'diversity' aspect of diversification as N varies. Thus, it shows how diversified is a distribution.

The entropy diversity index was censored because some of its values clustered at the limit (0 for complete specialization and 1 for perfect diversification). Standard ordinary least squares (OLS) or seemingly unrelated regression (SUR) of the diversity index would have yielded biased and inconsistent estimates in this situation and it was not appropriate to use them.

Censored regression model was employed to ascertain the determinants of on-farm crop diversification among smallholder crop farming households. Censored model assumes that all zeros are attributable to standard corner solutions. As such, zero observations are accounted for and the censored regression provides a more accurate estimation (Wooldridge, 2002). The model was used to analyze covariates of on-farm crop diversification and its intensity.

In censored regression models, the dependent variable is observed only if it is above or below some cut off level. The Tobit model is a special case of censored regression models that arise when the dependent variable is limited (or censored) from above and/or below. It is a non-linear model which employs maximum likelihood estimation technique to estimate the likelihood of a

diversification strategy and its intensity. This model is appropriate since the dependent variable is an index which takes values between 0 and 1 inclusive. The dependent variable of the model can be either left-censored, right-censored, or both left-censored and right-censored, where the lower and/or upper limit of the dependent variable can be any number.

The two-limit Tobit model can be specified as:

$$y_i^* = \beta X_i + \varepsilon_i \text{-----}(4)$$

Where y_i^* is a latent variable (unobserved for values smaller than 0 and greater than 1) representing specialization or diversification index; x_i is a vector of explanatory variables; β' is a vector of unknown parameters; and ε_i is a disturbance term.

Denoting y_i (diversification index) as the observed dependent variable the two limit Tobit model can be specified as:

$$y_i = \begin{cases} 0 & \text{if } y_i^* \leq 0 \\ y_i^* & \text{if } 0 < y_i^* < 1 \\ 1 & \text{if } y_i^* > 1 \end{cases} \text{-----}(5)$$

In principle, a maximum likelihood approach may be employed to address the censoring (Tobit model) and account for correlations in error terms across equations by specifying a multivariate density function for the error terms (Benin *et al.*, 2004). Censored regression models (including the standard Tobit model) are usually estimated by the Maximum Likelihood (ML) method. The log likelihood function is specified with an assumption that the disturbance term ε follows a normal distribution with mean 0 and variance σ^2 . The variables employed in the Tobit Regression Model are defined in Table 2.

Table 2: Description of the Variables used in the Tobit Model

Variable	Description	Expected sign
DISDIVER	Extent of distribution-based diversification practiced (the measure ranges from 0 and log (N))	---
DURDIVER	Extent of duration-based diversification practiced (the measure ranges from 0 and log (N))	----
RISK	Production risk (Measured as an index that range between 0 and 1)	+
GENDER	Gender of head of household (value 1 if male; 0 if female)	+/-
MARITAL	Marital status of the household head (value 1 if married; 0 if otherwise)	+
HHAGE	Age of head of household in years	+
EDUC	Highest level of education of the household head (measured in number of years of formal education)	+
INCOMEPM	Household income realized per month (in Kshs.)	+
LANDSIZE	Total size of land (value measured in acres)	+
HHSIZE	Household size	+
EXPER	Crop farming experience (in years)	

Objective 3: To evaluate the influence of distributive and duration-based crop diversification strategies on household living standards

Ordered probit model was used to analyze the influence of distributive and duration-based crop diversification strategies on household standard of living. The model was preferred since the dependent variable is multiple and ordered. According to Greene (2003), in the formulation of the ordered probit model, the observed responses are represented by a variable Y_i which denotes the perceived standard of living as a result of crop diversification given by farmer i and takes on j different values which are naturally ordered, in this case 5 values ($j = 0, 1, 2, 3, 4$).

However, these observed values are assumed to be derived from some unobservable latent variable.

$$Y_i^* = X_i\beta + \varepsilon_i \text{-----}(6)$$

where X_i represents the observable individual specific factors on which data will be collected, β is a vector of parameters to be estimated and ε_i is the stochastic disturbance term whose distribution is estimated to be normal. The values for observed choice outcome Y_i are assumed to be related to the latent variable Y_i^* as follows:

$$\begin{aligned} Y &= 0 \text{ (Extremely worse) if } Y^* \leq \mu_0 \\ Y &= 1 \text{ (Worse) if } \mu_0 < Y^* \leq \mu_1 \\ Y &= 2 \text{ (Average) if } \mu_1 < Y^* \leq \mu_2 \\ Y &= 3 \text{ (Good) if } \mu_2 < Y^* \leq \mu_3 \\ Y &= 4 \text{ (Very good) if } \mu_3 < Y^* \leq \mu_4 \end{aligned} \quad \text{-----} \quad (7)$$

Where μ_i is unknown threshold parameter to be estimated for outcome i that separates the adjacent boundary values and is estimated together with the β s. The estimated μ follows the order $\mu_0 < \mu_1 < \mu_2 < \mu_3 < \mu_4$.

The probability of each observed outcome falling in a given category is given as:

$$\text{Prob } [y = 0 \text{ or Extremely worse}] = \varphi(-\beta'X) \text{-----} (8)$$

$$\text{Prob } [y = 1 \text{ or Worse}] = \varphi[\mu_1 - \beta'X] - \varphi(-\beta'X) \text{-----} (9)$$

$$\text{Prob } [y = 2 \text{ or Average}] = \varphi[\mu_2 - \beta'X] - \varphi(\mu_1 - \beta'X) \text{-----} (10)$$

$$\text{Prob } [y = 3 \text{ or Good}] = \varphi[\mu_3 - \beta'X] - \varphi(\mu_2 - \beta'X) \text{-----} (11)$$

$$\text{Prob } [y = 4 \text{ or Very good}] = 1 - \varphi(\mu_3 - \beta'X) \text{-----} (12)$$

Where φ is the cumulative density function of μ_i . Using maximum likelihood estimates technique, the values for the parameters β s will be estimated.

The explanatory variables employed in the Ordered Probit Regression Model are defined in Table 3.

Table 3: Description of the Variables Used in the Ordered Probit Model

Variable	Description	Expected sign
STD LIV	A measure of standards of living (Extremely worse, Worse, Average, Good, Very good)	+
DIS DIVER	Extent of distribution-based diversification practiced (the measure ranges from 0 and log (N))	
DUR DIVER	Extent of duration-based diversification practiced (the measure ranges from 0 and log (N))	+
GENDER	Gender of head of household (value 1 if male; 0 if female)	+/-
MARITAL	Marital status of the household head (value 1 if married; 0 if otherwise)	+
HHAGE	Age of head of household in years	+
EDUC	Highest level of education of the household head (measured in number of years of formal education)	+
INCOMEPM	Household income realized per month (in Kshs.)	+
LANDSIZE	Total size of land (value measured in acres)	
HHSIZE	Household size	+
EXPER	Crop farming experience (in years)	+

Objective 4: To Determine the Influence of Distributive and Duration-Based Crop Diversification Strategies on Production Risk.

Crop production risk and diversification are two variables that simultaneously determine each other. Production risk is a function of diversification and simultaneously, diversification is a function of production risk. According to Bollen and Biesanz (2002) and Kelejian (1971), OLS could not be used to estimate these models, because the relationship specified by the equations violates the OLS assumption of zero covariance between the disturbance term and the independent variables. A Two-Stage (2SLS) regression was used in determining the relationship. This is given in the equations 13 and 14.

$$Y_1^* = Y_1 Y_2^* + \beta'_1 X_1 + \varepsilon_1 \text{ -----(13)}$$

$$Y_2^* = Y_2 Y_1^* + \beta'_2 X_2 + \varepsilon_2 \text{ -----(14)}$$

In the first stage of 2SLS, the endogenous variable would be regressed on all the exogenous variables and the predicted value of this regression obtained. In the second stage, the predicted values would replace the original endogenous variables in the equation.

It is assumed that Y_1^* and Y_2^* are fully observed, that is, $Y_1 = Y_1^*$ and $Y_2 = Y_2^*$.

The first stage in 2SLS would estimate the following equations, via OLS, since Y_1^* and Y_2^* are fully observed:

$$Y_1^* = \beta'_1 X_1 + \beta'_2 X_2 + v_1 \text{ -----(15)}$$

$$= G_1 X + v_1$$

$$Y_2^* = \beta'_1 X_1 + \beta'_2 X_2 + v_1 \text{ -----(16)}$$

$$= G_2 X + v_2$$

Where X is a matrix containing all the exogenous variables in (13) and (14). From (15) and (16), equations 17 and 18 would be obtained.

$$\hat{Y}'_1 = \hat{G}_1 X \text{ ----- (17)}$$

$$\hat{Y}'_2 = \hat{G}_2 X \text{ -----(18)}$$

This completes the first stage of 2SLS. In the second stage, Y_1^* and Y_2^* in (13) and (14) are replaced with $\hat{Y}_1^*$ and $\hat{Y}_2^*$, respectively, and estimate the equations (13) and (14) with OLS. That is, equations 19 and 20 would be estimated:

$$Y_1^* = Y_1 \hat{Y}_2^* + \beta'_1 X_1 + \varepsilon_1 \text{ -----(19)}$$

$$Y_2^* = Y_2 \hat{Y}_1^* + \beta'_2 X_2 + \varepsilon_2 \text{ ----- (20)}$$

The resulting coefficients estimates will be consistent. However, this does not preclude the possibility of collinearity between the exogenous variables. Hausman Test was used to determine the appropriateness of 2SLS estimates over OLS.

In quantifying risk, two approaches would be employed; stochastic risk analysis using Monte Carlo's simulation approach and computation of level of risk. In these approaches, two elements would be considered; frequency of the risk occurring and the economic consequences of its occurrence. To capture the frequency of risk to be included in Monte Carlo's simulation, farmers were requested to indicate the most likely amount of yield they expect to realize as well as the possible minimum and maximum for each of the crops grown. This would facilitate the use of triangular probability distribution in measuring production risks. Farmers were asked to indicate the likelihood (probability) and consequences (severity) of production risks occurrence and consequently level of risk computed as a product of consequence and likelihood. The dependent and explanatory variables employed in the 2SLS Regression Model are defined in Table 4.

Table 4: Description of the Variables Used in the 2SLS Regression Model

Variable	Description	Expected sign
DISDIVER	Extent of distribution-based diversification practiced (the measure ranges from 0 and log (N))	+/-
DURDIVER	Extent of duration-based diversification practiced (the measure ranges from 0 and log (N))	+/-
FERISK	Farm environment risk (instrumental variable for production risk). This is measured as an index that range between 0 and 1 and relate to how production figures differs. Make use of minimum, maximum and most likely values of production.	+/-
PRDRISK	Production risk (Measured as an index that range between 0 and 1)	+
HGENDER	Gender of head of household (value 1 if male; 0 if female)	+/-
MARITAL	Marital status of the household head (value 1 if married; 0 if otherwise)	+
HHAGE	Age of head of household in years	+
HEDUC	Highest level of education of the household head (measured in number of years of formal education)	+
MINCOME	Household income realized per month (in Kshs.)	+
LANDSIZE	Total size of land (value measured in acres)	+
HHSIZE	Household size	+
EXPER	Crop farming experience (in years)	

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the results from the descriptive and econometric analyses. The descriptive analysis made use of tools such as mean, frequencies, percentages and standard deviation. Econometric analysis was carried out to determine the major drivers of distributive and duration-based crop diversification, to evaluate the influence of distributive and duration-based crop diversification on household living standards and to determine the influence of distributive and duration-based crop diversification strategies on production risk.

4.1 Farmer characteristics

This study assessed the farmer characteristics in order to elaborate the farmer conditions? What conditions. The result is presented in Table 5. The majority (72%) of the respondents were male as compared to 28% who were female. This implies that most farming related decisions such as what to grow and how to grow the chosen crops is dominated by male.

In terms of education, most of the household heads had less than tertiary level of education. Majority (38.7%) of them had primary level of education, 33.3% had secondary level of education while 18.7% had no formal education. It was only 6.7% and 2.7% of the household heads that had tertiary and university level of education respectively. This implies that majority of the crop farmers may lack adequate technical education which is a prerequisite to better modern crop farming. The level of education of the household head can influence the kind of decision that may be made on behalf of the entire household with regard to crop farming prospects. More educated household heads are likely to make decisions that are informed by economic considerations as compared to their less educated counterparts. Most short-season crops normally require a higher level of technology in their production which is best supported by higher level of education (Dinh, 2006).

The household heads that were sampled to participate in this study were of varying age brackets. About 40.7% of household heads were between the ages of 46 and 55 while 22.0% were between the ages of 56 and 65. About 19.3% and 12.7% of the household heads, respectively, fell into the

Table 4: Farmers' Characteristics

Variable	Frequency	Percent
Gender		
Male	108	72.0%
Female	42	28.0%
Level of Education		
No formal education	28	18.7%
Primary	58	38.7%
Secondary	50	33.3%
Tertiary	10	6.7%
University	4	2.7%
Age		
Less than 26 years	0	0.0%
26 - 35 years	8	5.3%
36 - 45 years	29	19.3%
46 - 55 years	61	40.7%
56 - 65 years	33	22.0%
Above 65 years	19	12.7%
Marital Status		
Married	115	76.7%
Single	21	14.0%
Divorced	3	2.0%
Separated	5	3.3%
Widowed	6	4.0%
Household size		
01-May	49	32.7%
06-Oct	93	62.0%
Nov-15	8	5.3%
Years of farming experience		
1 – 5 years	17	11.3%
6 – 10 years	43	28.7%
11 – 15 years	56	37.3%
16 years and above	34	22.7%
Income per Month		
Above Kshs. 50000	2	1.3%
Between Kshs. 30000 and 50000	7	4.7%
Between Kshs. 10000 and 30000	19	12.7%
Between Kshs. 5000 and 10000	97	64.8%
Less than Kshs. 50000	25	16.6%

age categories of 36-45 years, and above 65 years. There were very few household heads who were young in age and as a result, only 5.3% of the total household heads were aged between 26– 35 years and none of them was aged below 26 years. Age of the household head has an implication on the choice of farming strategies and consequently, the type of crops grown. This may be attributed to the preference of the older farmers for less labour intensive crops such as most staple crops (maize, beans, potatoes) while young farmers may comfortably grow crops that require more labour inputs such as most horticultural crops (tomatoes, cabbages, kales, French beans) (Nwaru *et al.*, 2004).

Majority (76.7%) of the households were headed by individuals who were married. The other categories of marital status were single (14.0%), widowed (4.0%), separated (3.3%) and divorced (2.0%). This implies that it is expected that in majority of the households have decision making responsibilities shared between male and female household heads.

The number of household members varied as shown in table 5. About 32.7%, 62.0% and 5.3% of the households had a size of 1-5 persons, 6 -10 persons and 11 persons and above respectively. Household size can give an indication of the extent of pressure that could be exerted on the household resources. On the other hand it can also be an indication of the available family labour (Obinne, 1989). Most crops that are grown in the area require labour intensive activities; therefore a large household size might be an advantage for households that grow such crops.

Farmers had vast experience in farming. About 11.3%, 28.7%, 37.3% and 27.7% of the households studied had years of crop farming experience of 1-5 years, 6-10 years, 11-15 years and 16 years and above respectively. This suggests that majority of the farmers had the necessary experience in crop production and its associated risk management. The higher the farming experience the more the farmer would have gained knowledge and technical ideas on how to undertake farming in a prudent manner and the better would be the response towards production risks (Nwaru *et al.*, 2004).

Majority of the respondents had monthly income that ranged from Kshs. 5000 to 10,000 as represented by 64.7%. This is closely followed by farmers with monthly incomes of less than

Kshs. 5,000 (16.7%) and between Kshs. 10,000 and 30,000. Other categories of households' monthly incomes were between Kshs. 30,000 and 50,000 and above Kshs. 50,000 with a representation of 4.7% and 1.3% respectively. Household's income plays a very important role in agriculture. In most cases, it can determine the extent in which farming may be done through its control of available inputs. Specialized and commercial farming often require greater capital which can be supported best by higher family incomes.

4.2 Characterization of Crop Farming Strategies with Respect to Distribution and Duration-Based Diversification

There were different types of crops grown as shown in Figure 3. However, this study concentrated itself on food crops (maize, potatoes, beans, sweet potatoes and cassava) and a few cash crops (tomatoes, cabbages, Kales (*Sukumawiki*), French beans and flowers).

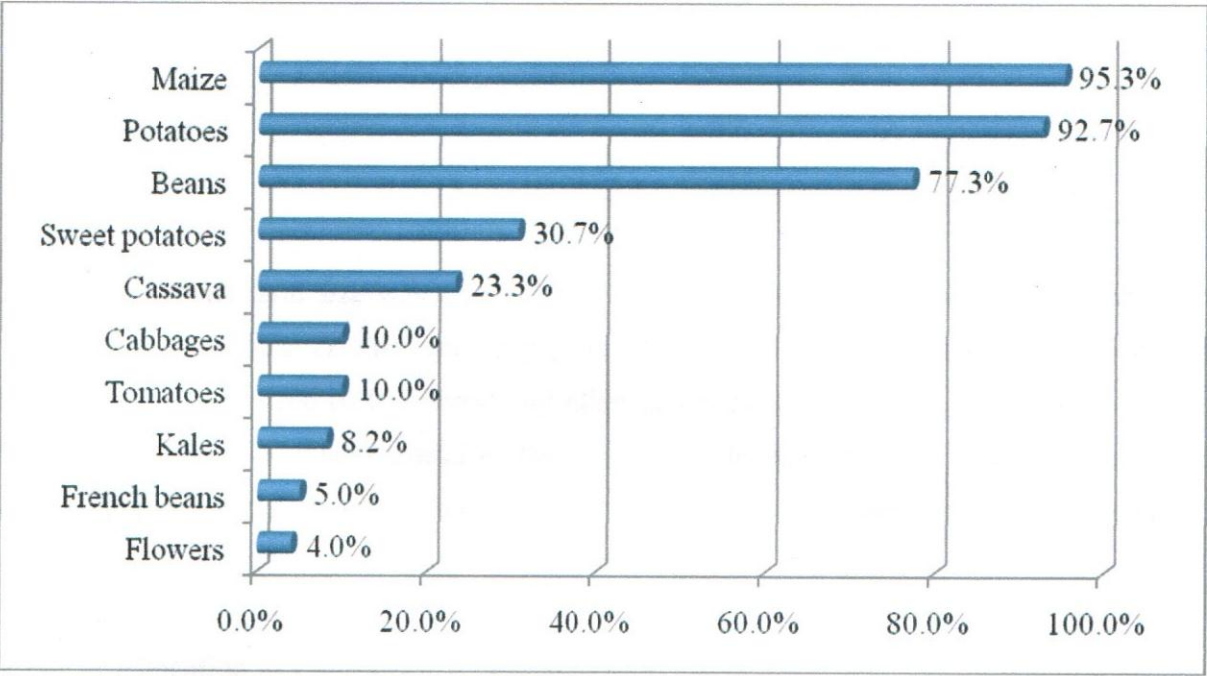


Figure 3: Types of Crops Grown

Figure 3 shows that the most common crop was maize and grown by 95.3% of the households. This was closely followed by potatoes (92.7%) and beans (77.3%). Other crops grown included sweet potatoes (30.7%), cassava (23.3%), tomatoes (10.0%), cabbages (10.0%), Kales (8.2%), French beans (5.0%) and flowers (4.0%). The dominance of staple food crops such as maize,

beans and potatoes reflects the subsistence nature of the households. Their main concern is to produce basically for home consumption.

Land ownership varied in size and the distribution is presented in Table 6. It is shown that more than 70 percent of the households owned less than 5 acres. This has an implication on the types and magnitude of the farm enterprises. Indeed Table 7 shows the different enterprises commonly engaged.

Table 5: Size of Land Owned

Land size	Frequency	Percentage	Cumulative Percentage
Less than 0.5 acres	11	7.3%	7.3%
Between 0.5 acres to 1 acres	17	11.3%	18.7%
Between 1 acres to 5 acres	78	52.0%	70.7%
Between 5 acres to 10 acres	38	25.3%	96.0%
Above 10 acres	6	4.0%	100.0%
Totals	150	100.0%	

Whereas the mean farm size was 4.653 acres, the size of land that was under crop production was 2.384 acres (Table 7). The remaining piece of land was utilized through dairy production (1.132 acres), homestead (0.165 acres) and other activities (0.971 acres). According to Obasi, (2007), small land holdings invariably lead to more intensive land use systems. This is so because population growth forces farmers to shorten fallow periods, increase investment on land, manage soil fertility through the addition of manure.

Table 6: Allocation of Land to Different Activities

Allocation of land	Minimum	Maximum	Mean	Std. Deviation
Total size of land (acres)	0.44	13.25	4.653	3.132
Land occupied by dairy production	0.00	4.00	1.132	1.169
Land occupied with homestead	0.05	1.00	0.165	0.203
Land occupied with other activities	0.00	5.25	0.971	1.192
Land occupied by crops	0.45	6.00	2.384	1.435

Table 7: Area Allocated to Different Crops

Major crops grown	N	Area covered by the crops			
		Minimum	Maximum	Mean	Std. Deviation
Maize	143	0.05	4.50	2.34	0.14
Potatoes	139	0.10	3.00	2.12	0.87
Beans	116	0.05	3.00	1.82	0.12
Tomatoes	15	0.30	2.00	1.65	1.42
French beans	8	0.50	1.50	0.75	0.47
Kales (<i>Sukuma wiki</i>)	12	0.30	1.40	0.35	0.05
Flowers	6	0.10	0.50	0.30	0.21
Cabbages	15	0.10	2.30	0.20	0.11
Cassava	35	0.05	0.30	0.15	0.09
Sweet potatoes	46	0.05	0.20	0.10	0.06

Results in Table 8 show that farmers were growing staple food crops (maize, potatoes, beans, cassava and sweet potatoes) and horticultural crops (tomatoes, French beans, Kales, flowers, cabbages). The mean area planted was maize (2.34 acres), potatoes (2.12 acres) and beans (1.82 acres). Other crops grown along with the area in acres were: sweet potatoes (0.10), cassava (0.15), cabbages (0.20), flowers (0.30), tomatoes (1.65), Kales (0.35) and French beans (0.75). This shows that most farmers were planting different types of crops while distributing them in a manner that staple crops (maize, potatoes and beans) had the highest land allocation as compared to other crops.

Farmers were growing crops with different maturity durations as shown in table 9. Cassava, sweet potatoes and maize had the longest duration to maturity with a mean of 7.0, 6.0 and 5.1 months respectively. The length of duration of the other crops (in months) was as follows: beans (3.0), cabbages (3.0), potatoes (3.0), Kales (3.0), tomatoes (3.0), flowers (2.5) and French beans (1.6). This may imply that most farmers prefer to grow short season crops (being diversified) except with regard to staple and traditional crops.

Table 8: Duration to Maturity of the Different Crops

Crop name	N	Duration to maturity in months			
		Minimum	Maximum	Mean	Std. Deviation
Cassava	35	6.0	7.0	7.0	0.37
Sweet potatoes	46	5.0	6.0	6.0	0.33
Maize	143	4.5	5.5	5.1	0.19
Beans	116	2.5	3.0	3.0	0.51
Cabbages	15	2.5	3.0	3.0	0.46
Potatoes	139	3.0	3.5	3.0	0.38
Kales (<i>Sukuma wiki</i>)	12	2.0	3.0	3.0	0.32
Tomatoes	15	2.5	3.0	3.0	0.35
Flowers	6	2.0	3.0	2.5	0.53
French beans	8	2.0	3.0	1.6	0.43

The different crops grown by farmers have varying risk implication on them. The average production risk in crop yields for each crop was noted to differ with most risk associated with horticultural crops and the staple crops showing the least level of risk. Table 10 shows the stochastic simulation results for the expected production of the major crops per one acre of land with the production figures given in kilograms.

Table 9: Expected production (kgs/acre) statistics of the major crops grown

Crop name	5% Percentile	95% Percentile	Minimum	Maximum	Mean	Standard deviation
Cassava	115.6	129.91	113.89	132.06	122.56	4.28
Sweet potatoes	217.15	237.04	215.01	240.28	227.1	5.85
Beans	98.3	227	81.19	250.98	165.45	38.94
Potatoes	228.7	371.2	211.94	400.55	292.41	44.17
Maize	344.7	518.3	307.56	552.38	435.12	52.33
Fruits	164.9	357.4	121.29	390.12	265.74	58.18
Flowers	80.8	330.4	56.15	257.42	267.85	65.13
French beans	105.9	327.8	64.96	357.28	236.67	67.68
Sukuma wiki	229	633	151.35	701.7	436.72	121.17
Cabbages	430	1173	268.85	1256.82	844.79	225.6
Tomatoes	462	1695	270.95	1855.23	1154.03	371.21
Sampling type:		Latin Hypercube				
Number of iterations:		10000				

Table 10 shows that tomatoes (standard deviation = 371.21) is the crop with the greatest production risk among the major crops grown. This is closely followed by cabbages (standard deviation = 225.6), kales (standard deviation = 121.17), French beans (standard deviation = 67.68), flowers (standard deviation = 65.13), fruits (standard deviation = 58.18), maize (standard deviation = 52.33), potatoes (standard deviation = 44.17), beans (standard deviation = 38.94), sweet potatoes (standard deviation = 5.85) and cassava (standard deviation = 4.28). This imply that majority of the horticultural crops have more production risk attached to them as compared to staple crops.

4.3 Drivers of Distribution and Duration-Based Crop Diversification

To determine the major determinants of distribution and duration diversification, diagnostic tests were first conducted to check the problem of multicollinearity and heteroscedasticity. The presence of multicollinearity was tested by use of Variance Inflation Factor (VIF) (Gujarati, 2004). The problem of multicollinearity increases with larger values of VIF. Generally, if a VIF

of a variable exceeds 10, the variable is said to be highly collinear. In this study, VIF values for all continuous variables ranged between 2.39 and 3.06. On the other hand, the values of mean of the factors ($1/VIF$) were between 0.23 and 0.79 inclusive. This means that multicollinearity was not a problem among the continuous variables. On the other hand, the problem of heteroscedasticity was detected using White Test. Heteroscedasticity exists when the variances of all observations are not the same, leading to consistent but inefficient parameter estimates. In such a situation, the estimated standard errors may lead to invalid inferences (White, 1980). In this test the regression was run and standard errors obtained. The squares of the errors were regressed on the constant and all other explanatory variables. The null hypothesis was then tested as likelihood. Since the p-value for the chi-square was not significant ($P\text{-value}=0.32$) at 5% level, then the null hypothesis of homoscedasticity between the variance of the errors and the independent variable was not rejected. Consequently, all the explanatory variables were entered and the equation fitting the Tobit Regression Model was estimated.

To evaluate the determinants of distribution and duration-based diversification, Tobit regression model was used. The distribution-based diversification was computed using Entropy index. The variable was zero in the case of complete specialization and was equal to $\log(N)$ in the case of complete diversification. Sample means of dependent and explanatory variables used in Tobit regression are presented in Table 11.

Table 10: Sample Means of Dependent and Explanatory Variables used in Tobit Model

Variable	Mean	Std. Deviation
Dependent		
Distribution-based diversification	0.369	0.003
Duration-based diversification	0.187	0.010
Independent		
Production risk (RISK)	0.619	0.013
Gender of household head (GENDER)	0.680	0.451
Marital status of household head (MARIT)	0.740	0.986
Age of household head (AGE)	54.173	9.054
Education of household head (EDUC)	9.360	2.950
Household income (INCOM)	8170.30	1775.00
Household size (HHSIZE)	6.460	2.242
Size of land (LAND)	4.653	3.132
Crop farming experience (EXPER)	17.800	3.668

4.3.1 Determinants of Distribution-Based Diversification

In analyzing the determinants of distribution based diversification, the variables relating to production risk (RISK), level of education (EDUC), household average income per month (INCOME) and farm size (LAND) were found to be significant at 1% and 10% level implying that these variables are the important factors that influence farmers' decision to diversify in crop production with respect to their distribution. These results are presented in Table 12.

Table 11: Tobit Estimates of Variables Influencing Distribution Diversification

Explanatory variables	Coefficient	Std. Err.	T-values	P> t
Production risk (RISK)	0.001***	0.001	3.37	0.001
Gender of household head (GENDER)	0.005	0.004	1.34	0.182
Marital status of household head (MARIT)	0.005	0.020	0.27	0.786
Age of household head (AGE)	0.001	0.001	0.62	0.540
Education of household head (EDUC)	-0.110***	0.013	-8.83	0.001
Household income (INCOM)	-0.058*	0.031	-1.88	0.063
Household size (HHSIZE)	0.017	0.010	1.64	0.285
Size of land (LAND)	-0.038*	0.022	-1.74	0.084
Crop farming experience (EXPER)	0.022	.0261	0.85	0.395
Constant	0.649	0.243	2.67	0.009
/Sigma	5.671	0.366		
LR chi-square (8 degrees of freedom)	161.96			
Prob > chi2	0.001			
Sample size	150			
Log likelihood	-19.871			
Pseudo R ²	0.794			

Threshold values for the model: Lower = 0, Upper = 1

***, ** and * represent level of significance at 1%, 5% and 10% respectively

The coefficient for age (AGE), gender (GENDER), marital status of the household head (MARIT), crop farming experience (EXPER) and household size (HHSIZE) were not significant indicating that were not important factors in influencing farmers' decision to diversify with respect to distribution of crops.

The coefficient of production risk (RISK) was positive and significant at 1% level, implying that increases in the production risks would lead to increases in distribution diversification of crops. This situation is especially true to the smallholder farmers who are risk averse. The idea of diversification is to reduce the dispersion of the overall return by selecting a mixture of activities

that have net returns with low or negative correlations. Diversification may be managed to result to a risk-efficient combination of farm activities (Hardaker *et al.*, 2004).

The coefficient of level of education (EDUC) was negative and significant at 1% level, suggesting that farmers with higher education were less diversified. This could be attributed to the fact that higher education enables the farmer to know the benefits of specialization in crop production. They are likely to be engaged off farm and have less time to concentrate on diversification which requires close attention. These results are similar to Barrett *et al.*, (2001) which revealed that educational attainment was one of the most important determinants of non-farm earnings, especially in more remunerative salaried and skilled employment. The few farmers who chose to grow crops did it with less distribution diversification and more specialization. These results disagree with Mehta (2010) who found that in diversification of horticultural crops in Himachal Pradesh in India educated farmers were concerned about the risk from production and hence preferred to have higher level of diversity in their cropping pattern than being fully specialized in one crop.

The coefficient of farm size (LAND) was negative and significant at 10% level, indicating that farmers with larger farm size were less diversified (more specialized) than farmers with small farm size. This is probably because large sized farms are better suited for commercialized farming. Most farmers with large farms are often more wealthier. Consequently according to Hardaker *et al.*, (2004), farmers with large size of farms are more risk takers and may afford to grow fewer crops (less diversification).

The coefficient of monthly household income (INCOME) was negative and significant at 10% level, indicating that farmers with more family incomes were less diversified (more specialized). This may be attributed to the fact that wealthier families are more likely to withstand more production risks and thereby able to be less diversified (Hardaker *et al.*, 2004).

4.3.2 Determinants of Duration-Based Diversification

In analyzing the determinants of duration-based diversification, the variables relating to production risk (RISK), level of education (EDUC) and household average income per month

(INCOME) were found to be significant at 1%, 5% and 10% levels respectively. These variables are the important factors that influence farmers' decision to diversify in crop production with respect to the duration of cropping seasons. The results are shown in table 13.

Table 12: Tobit Estimates of Variables Influencing Duration Diversification.

Explanatory variables	Coefficients	Std. Err.	T- values	P> t
Production risk	-0.001***	.001	-4.32	0.001
Gender of household head (GENDER)	0.001	.002	0.12	0.905
Marital status of household head (MARIT)	0.001	.001	0.02	0.980
Age of household head (AGE)	0.001	.001	0.62	0.540
Education of household head (EDUC)	0.002**	.001	2.04	0.044
Household income (INCOM)	0.002*	.001	1.77	0.079
Household size (HHSIZE)	0.001	.001	0.18	0.860
Size of land (LAND)	-0.001	.001	-0.24	0.814
Crop farming experience (EXPER)	0.005	.020	0.27	0.786
Constant	0.206	.008	26.67	0.000
/Sigma	3.843	.120		
LR chi-square (8 degrees of freedom)	56.12			
Prob > chi2	0.001			
Sample size	150			
Log likelihood	107.065			
Pseudo R ²	0.81			

Threshold values for the model: Lower= 0, Upper= 1

***, ** and * represent level of significance at 1%, 5% and 10% respectively

The coefficient for gender (GENDER), age (AGE), marital status of the household head (MARIT), land size (LAND), household size (HHSIZE) and crop farming experience (EXPER) were not significant and thus not important factors influencing farmers' decision on crop duration diversification

The coefficient of production risk (RISK) was negative and significant at 1% level, implying that increases in the production risks would lead to decreases in duration diversification of crops. This means that households that want to reduce production risks would grow crops with long duration (such as most traditional crops and staple crops) as opposed to growing short duration crops. Households would consider long maturing crops as a risk reducing strategy because agricultural risks are more likely to wear out with time. Short season crops may not escape such risks. This is consistent with the findings of Mehta (2010) who noted that horticultural crops that last shorter in the field are riskier than those that take a longer period.

The coefficient of level of education (EDUC) was positive and significant at 5% level, suggesting that farmers with higher education were more diversified as far as the duration of crops was concerned. This could be attributed to the fact that higher education enables the farmer to be in a position to grow short season crops requiring more skills. These results are consistent with Mehta (2010) who observed that horticultural crops are avoided by some farmers because of their high requirements of technology.

The coefficient of household average monthly income (INCOME) was positive and significant at 10% level, suggesting that farmers with higher incomes are more diversified as far as the duration of crops is concerned and thus can afford to grow short season crops that require a huge capital investments (in irrigation facilities), more inputs (hired labour, fertilizer and pesticides). This may be attributed to the fact that wealthier families are more likely to withstand more production risks. Farmers with more income per month are able to grow short season crops and thereby depict greater crop duration diversification (Hardaker *et al.*, 2004).

4.4 Influence of Distributive and Duration-Based Crop Diversification Strategies on Household Living Standards

This section presents results of Ordered Probit Regression Model, which show the influence of distributive and duration-based crop diversification strategies on household living standards. Arbitrary indices to proxy living standards were used. The final index was constructed as the average of indicator variables for whether a household possessed certain assets, kind of building materials used in the dwelling structure, availability of drinking water, sanitation and the type of

energy used. The index was then translated into meaningful ordered categories (extremely worse, worse, average, good and very good). Asset ownership was views in terms of livestock, land, businesses, transportation tools and other assets. The kind of building materials used for the dwelling structure was assessed in terms of type of roofing, walls and floor. Sanitation was viewed in terms of toilet facilities and main method of garbage disposal in the household while the type of energy used considered the cooking and lighting fuels. The results on various indicators used as proxies for the standards of living are shown in Appendix 1. The figure below shows a summary of respondents' standards of living.

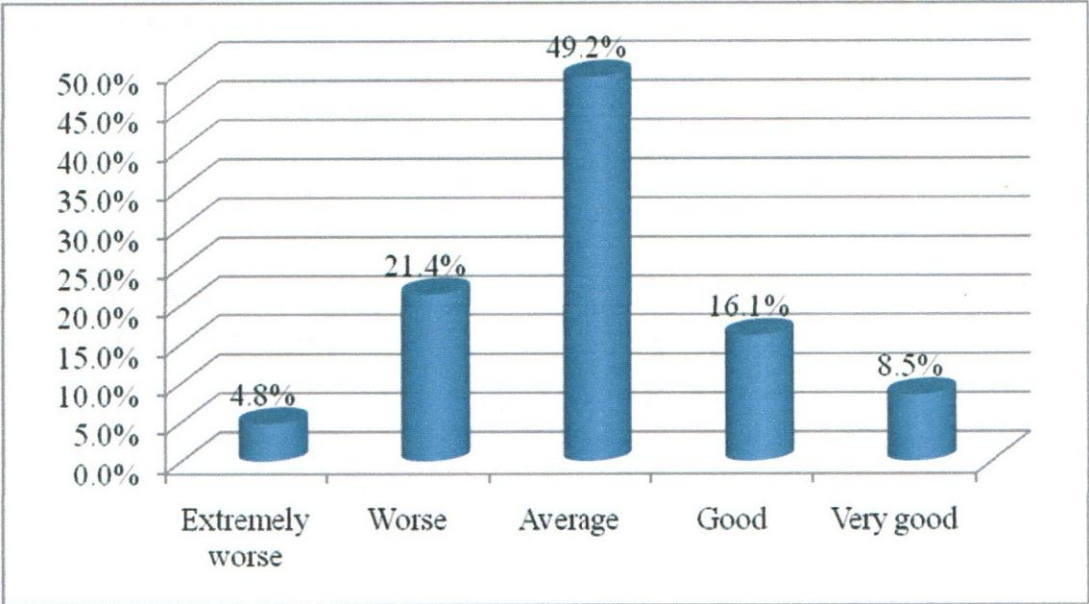


Figure 4: Respondents' Standards of Living

Majority of the households had average standard of living as represented by 49.2% of the total responses. About 21.4% of the households had worse standard of living. Other households had good (16.1%), very good (8.5%) and extremely worse (4.8%) standards of living. The ordered probit model was used because the dependent variable and the values of each category have a meaningful sequential order.

The households' standard of living depends on a number of factors. Table 14 shows the maximum likelihood estimates of the parameters of Ordered Probit regression model characterizing the relationship between households' standards of living and independent

variables. From the model, five variables were found to be statistically significant. These are distribution-based diversification (with negative sign), duration-based diversification (with positive sign), household head education (with positive sign) and land size (with positive sign).

Table 13: The Maximum Likelihood Estimates of the Ordered Probit Model

Variable	Coefficient estimates	Standard Error	Z-value	P> z
Distribution-based diversification (DISDIVER)	-0.292**	0.121	-2.42	0.016
Duration-based diversification (DURDIVER)	0.092**	0.042	2.17	0.030
Gender of the household head (GENDER)	0.088	0.211	0.42	0.675
Marital status of the household head (MARITAL)	0.140	0.093	1.51	0.131
Age (AGE)	0.043	0.087	0.49	0.623
Education (EDUC)	0.367***	0.099	3.69	0.001
Household income (per month) (INCOME)	0.277***	0.087	3.18	0.001
Land size (LAND)	0.095**	0.042	2.26	0.024
Household size (HHSIZE)	0.051	0.087	0.59	0.555
/cut1	0.525	0.046		
/cut2	0.531	0.068		
/cut3	0.645	0.066		
/cut4	0.843	0.086		

Log likelihood = -143.015; LR Chi2 (9) = 176.25; Prob> χ^2 = 0.000, Pseudo R² = 0.381; N = 150

*** Sig at P<0.10, ** Sig at P<0.05, * Sig at P<0.01

Results in Table 14 reveal that two coefficients were significant at 1% and three coefficients significant at 5%. The log likelihood for the fitted model was -143.01 and the log likelihood chi-squared value of 176.25 indicating that all parameters are jointly significant at 5%. Pseudo R² of 0.38 was also above the statistical threshold of 20% confirming that the household's standard of living was well attributed to the independent variables considered in the model.

Distributive-based diversification was observed to have a significant and negative relationship with the level of standards of living at 5% level. The negative signs on distributive-based

diversification (DISDIVER) variables imply that the standards of living decrease when that strategy is used. This therefore suggests that the manner in which farmers distribute their land to the crops grown is an important variable influencing the standards of living of the household. The lack of more emphasis to at least one particular crop which the farmer has competitive advantage in its production only encourages subsistence farming, reduced commercialization and eventually greater possibilities of encouraging family poverty.

Duration-based diversification has a significant relationship with the level of standards of living at 5% level. The positive signs on duration-based diversification (DURDIVER) variables imply that the standards of living increase with increase with this strategy. This situation is attributed to the fact that growing short-season crops (and often, high value crops) increase the farmers likelihood of benefiting from agriculture. This implies that farmers who have the means (irrigation facilities, capital and adequate land) and know-how of conducting commercial agriculture involving short season crops should do so as this may earn them more profits. This is consistent with Mehta (2010) who noted that most horticultural crops are high value crops and shift from staple crops to horticultural crops was seen as commercial diversification in Bangalore, India.

Education was observed to have a significant and positive relationship with the level of standards of living at 1% level. The positive sign on the level of education (EDUC) variable might be attributed to the high level of knowledge and experience on improved farm practices acquired by the educated household heads that enables them to benefit most from agriculture. This helps them to engage in various crop diversification strategies in a more profitable way and thereby raising the standards of living of their households. This observation is consistent to Dinh (2006) who noted that a household head's education positively affects the participation of farm households in the adoption and transfer of advanced technologies and eventually improving the household standards of living through farming.

Household income per month (INCOME) has a significant and positive relationship with the level of living standards. The variable is significant at 1% level. The surplus income may be reinvested in agriculture thereby providing reliable capital that may significantly boost their

farming activities, especially through better management of distribution and duration-based diversification strategies. This may eventually improve their living standards. Furthermore, households with more income per month may easily afford to grow short season crops such as horticultural crops that require a huge capital investments (in irrigation facilities), more inputs (hired labour, fertilizer and pesticides), which may be expensive for farmers with low incomes.

The coefficient of farm size (LAND) was positive and significant at 5% level, indicating that farmers with larger farm size had higher living standards as compared to farmers with small farm size. This can be due to the fact that large farms expand the farmers production possibility curves and thus making them able to carry out several economic activities at profitable levels and eventually raising their standards of living. Additionally, farmers with more land are highly likely to be less risk averse. This implies that they can afford to be more specialized towards one profit making type of crop (less distribution diversification) even if it is could be a short-season crop (greater duration based diversification). This agrees with Mehta (2010) finding that higher allocation of land in favour of high value crops like fruits and vegetables is desirable from the point of view of not only raising the farm income and productivity of the farmers but also to create high employment. .

4.5 Influence of Distributive and Duration-Based Crop Diversification Strategies on

Production Risk

Before conducting a 2-stage regression analysis for the influence of distribution and duration-based crop diversification strategies on production risk, farm environment risk (FERISK) was identified as an appropriate instrumental variable for the production risk. Crop farming is characterized by high variability of production outcomes. Monte Carlo simulation is a risk analysis method in which uncertain inputs in a model are represented using ranges of possible values known as probability distributions. In this study, Monte Carlo simulation was done using @RISK software. Triangular probability distribution was used in measuring agricultural farm environment risk. In triangular distribution, the minimum, most likely, and maximum values of production figures was considered.

Table 15 shows the OLS and 2SLS model estimates. The Breusch–Pagan test was used to check for heteroscedasticity and in both cases (2SLS and OLS); the null hypothesis of

homoscedasticity was not rejected at the 1% level of significance. The calculated chi square (3.57) at 8 degrees of freedom was small, indicating heteroskedasticity was probably not a problem (or at least that if it was a problem, it was not a multiplicative function of the predicted values).

Table 14: Instrumental Variable Estimates of Diversification and Production Risk

	Dependent variable: Production Risk		Dependent variable: Farm Crop Diversification		
			Duration based	Distribution based	
	OLS (1 st Stage)(I)	OLS (II)	IV 2SLS (2 nd stage)(III)	OLS (IV)	IV 2SLS (2 nd stage) (V)
Intercept	6.94(13.26)	38.37(2.22)	1.12(0.32)	0.25(0.58)	42.46(2.23)
FERISK	1.98*** (0.13)	-0.06** (0.03)		0.01** (0.01)	
PRDRISK		-0.04** (0.06)	- 0.01*** (0.01)	0.01** (0.01)	0.23** (0.05)
DURDIVER	1.06*** (1.93)	---	----	---	----
DISDIVER	0.72** (0.28)	---	----	---	----
HGENDER	2.44(1.69)	0.08(0.51)	-0.09(0.08)	-0.09(0.08)	0.06(0.53)
HHAGE	-3.22(0.63)	-0.29 (0.20)	0.03(0.03)	0.03(0.03)	0.13(0.20)
HHEDUC	-0.60(0.70)	0.03** (0.21)	0.03** (0.03)	-0.03** (0.03)	-0.06** (0.22)
MINCOME	-5.76(0.92)	0.52(0.31)	0.04(0.04)	-0.02(0.05)	-0.04(0.29)
HHSIZE	.78(0.30)	0.07(0.09)	0.01(0.01)	0.01(0.01)	0.05(0.09)
LANDSIZE	.17(0.41)	0.05(0.12)	0.17(0.01)	-0.17** (0.01)	-0.27** (0.08)
EXPER	6.47(1.12)	0.90 (0.36)	0.14 (0.05)	0.16(0.05)	0.13(0.35)
R-squared	0.77	0.77	0.69	0.58	.52
Observations	150	150	150	150	150

Significance level: * = 0.10, ** = 0.05, *** = 0.01.

Figures in brackets are standard errors.

The factors forming the independent variables are: farm environment risk (FERISK), production risk (PRDRISK), crop duration diversification (DURDIVER.), crop distribution diversification (DISDIVER), gender of household head (HGENDER), age of the household head (HHAGE),

education of the household head (HHEDUC), household monthly income (MINCOME), household size (HHSIZE), size of land (LANDSIZE) and experience in crop farming (EXPER).

The Hausman specification test was used to test for simultaneity between diversification and production risk (Hausman, 1978). The null hypothesis (H_0 : the efficient estimator (OLS) is consistent) was rejected. This is because the calculated chi-square of 12.86 was significant at 5% level ($P\text{-value} = 0.023 < .05$). This test revealed that contemporaneous correlation between the proposed endogenous variables and the error term in the diversification equation does exist at the 5% significance level. This result confirms the simultaneity assumption made in the empirical model, indicating that 2SLS is preferred over OLS. Consequently, the results to be presented are based on the 2SLS approach.

Table 15 shows (in column I; First stage OLS regression) that farm production risk is significantly and positively associated with farm environmental risks at 1% level; hence the suitability of the latter to act as an instrumental variable for the former. Farm crop production risk is further noted to have significant positive relationship with crop distribution and duration diversification at 5% and 1% levels respectively. This implies that the more the production risks, the more farmers would distribute their crops evenly and grow crops that mature with a longer period.

4.5.1 Relationship between Duration Based Diversification and Production Risk

The 2SLS regression analysis results for the duration based diversification equation shows that, 2 out of a total of 9 coefficients used in determining the relationship between distribution-based diversification and production risk among other independent variables were statistically significant at the 1% and 5% levels respectively. Moreover, the R-square indicates that the variables included in the model account for 69.0% of the variation in duration based diversification.

It can be noted in table 11(column III; Second stage IV 2SLS regression with duration diversification as the dependent variable) that duration based diversification suffers a negative and significant influence from with farm production risk at 1% level. The higher the risk, the

lower the farmers levels of duration diversification (implying a greater preference for crops that grow in long duration).

The education level of the household head was also found to have a significant and positive relationship with duration based diversification at 5% level. This implies that most short season crops are grown by more educated farmers. Short season crops such as kales, tomatoes, flowers and French beans are popular with educated farmers since they require greater use of modern technology.

4.5.2 Relationship between Distribution Based Diversification and Production Risk

The 2SLS regression analysis results for the distribution based diversification equation shows that, 3 of a total of 9 coefficients used in determining the relationship between distribution-based diversification and production risk among other independent variables are statistically significant at least at 5% significance levels. Moreover, the R-square indicates that the variables included in the model account for 52.0% of the variation in distribution based diversification.

In Table 16 (column V; Second stage, IV 2SLS regression with distribution diversification as the dependent variable) shows that distribution based diversification is positively and significantly influenced by farm level crop production risk at 5% level. The higher the risk, the higher the farmers levels of distribution diversification (implying that the more they uniformly distribute their crops in their field). This implies that most farmers are risk-averse and when facing more crop production risk, tend to use diversification strategy meant to trap possible gains from more than one crop. This agrees with Minot *et al.* (2006) who noted that indeed, risk management motivates diversification, although it lowers their average income as evident from the observation that poor rural households practicing rain-fed agriculture in low-potential areas were more likely to have diverse cropping pattern than richer households in areas with greater agro-ecological potential.

The education level of the household head was also found to have a significant and negative relationship with distribution based diversification at 5% level. This implies that more educated farmers preferred to undertake cropping strategies aimed at having a greater concentration on

more profitable crops. This disagrees with Mehta (2010) who observed that in Himachal Pradesh in India, educated farmers were concerned also about risk from the production of crop, and hence preferred to have higher level of diversity in their cropping pattern than being fully specialized in one crop. In other words, they were found to have more awareness about the trade-off between risk and income, whereas uneducated farmers concentrate more on income optimization than worry about the risk situation.

The coefficient of farm size (LAND) was negative and significant at 10% level, indicating that farmers with larger farm size were less diversified (more specialized) than farmers with small farm size. Farmers with large tracts of land prefer to practice commercialized farming which favours less diversification (more specialization). According to Mule (2010), one of the major hindrances to commercial agriculture is land sub-division. It is therefore not a surprise to note that most farmers who are specialized are the ones with more land.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECCOMENDATIONS

This chapter presents a summary of the main findings, conclusions and recommendations of the study. It also highlights the suggestions for further studies.

5.1 Summary of Findings

The following were the salient findings of this study:

Farmers were growing different types of crops distributed in different manner. The most dominant crops were staple food crops (maize, potatoes and beans) while the least were horticultural crops (cabbages, sukumawiki, tomatoes, flowers and French beans). Crops with the longest durations to maturity were cassava, sweet potatoes and maize.

The key determinants of distribution based diversification are production risk, level of education, household average income per month and farm size. On the other hand, production risk, level of education and household average income per month were found to be important factors that influence farmers' decision to diversify in crop production with respect to the duration of cropping seasons.

The variables responsible for influencing standards of living were distribution-based diversification, duration-based diversification, household head education and land size.

This study noted that the higher the risk, the greater preference for crops that grow in several months and the more the farmers uniformly distribute their crops in their field

5.2 Conclusions

Production risk was a major determinant of crop duration and distribution diversification. An increase in production risks prompted farmers to be diversified in their cropping activities.

The households' standard of living was influenced by distribution-based diversification but more diversification was associated with less living standards. Duration-based diversification improved the level of living standards since it implies a shift to high value crops.

Agricultural crop production risks influence crop diversification and simultaneously, diversification influence crop production risk. Crop production risk was mitigated through distribution and duration-based diversification while diversification was responsible for the different levels of crop production risk.

5.3 Recommendations

Based on the findings of the study, the following recommendations are suggested.

The stakeholders should endeavour to enlighten farmers on possibilities of commercializing their agricultural activities. Most farmers were observed to be engaged in subsistence farming that eventually leads to low farming incomes. Necessary training should be given to farmers to help them undertake the growing of different types of crops that can be well grown and marketed in the area.

Farmers should be adequately educated on how to deal with production risks in agriculture. This may be implemented through the media, seminars and barazas. This is because successful farming greatly depends on how well the risk aspect is handled. Likewise the government should provide a conducive environment for farmers to improve their levels of education and household average income per month since these factors may help to boost diversified agriculture that lead to improved standard of living.

In order for farmers to improve their standards of living through farming, diversification (distribution-based and duration-based) should be undertaken in a careful manner in such a way that there is more emphasis to at least one particular crop which the farmer has competitive advantage in its production as well as failure to neglect short season crops such as most horticultural crops.

The government should support farmers on how to take advantage of diversification in improving their standards of living. This may be achieved if necessary infrastructure (irrigation, credit access, improved information access and good road network) can be put in place.

5.4 Suggestions for Further Research

The findings of this study would act as a base for more research on importance of diversification in the study area. However, the study was not exhaustive and the researcher suggests the following areas of future research:

- i) A comparative analysis of the profitability of diversified and specialized cropping strategies in the study area.
- ii) The contribution of on-farm risk management strategies among smallholder crop farmers in the study area.

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APPENDICES

Appendix 1: Results on Standards of Living Measurement Parameters

Variable	Categories	Frequency	Percent
Building materials used for the dwelling structure	Roofing		
	Iron sheets	129	86.0%
	Grass thatched	2	1.3%
	Asbestos sheets	11	7.3%
	Asbestos tiles	8	5.3%
	Floor		
	Concrete only	23	15.3%
	Covered concrete	65	43.3%
	Mud	58	38.7%
	Wooden	4	2.7%
	Wall		
	Mud	34	22.7%
	Stones	16	10.7%
	Concrete bricks	6	4.0%
	Mud bricks	1	0.7%
	Wood	88	58.7%
	Iron sheets	5	3.3%
Availability of drinking water	Type of drinking water		
	River water	106	70.7%
	Public Tap	1	0.7%
	Own tap	38	25.3%
	Rain water	5	3.3%
	Distance of drinking water source		
	Wet season		
	Distance < 5km	150	100.0%
	Distance >= 5km	0	0.0%
	Dry season		
	Distance < 5km	150	100.0%
	Distance >= 5km	0	0.0%
Sanitation	Main toilet facility		
	Flush toilet	12	8.0%
	Pit latrine	137	91.3%
	Neighbour's/another household's pit latrine	1	0.7%

	Main method of garbage disposal		
	Pit	111	74.0%
	Dumping	39	26.0%
Type of energy used	Cooking fuel		
	Firewood	113	75.3%
	Electricity	1	0.7%
	Kerosene	3	2.0%
	Gas	2	1.3%
	Charcoal	31	20.7%
	Lighting fuel		
	Firewood	2	1.3%
	Electricity	24	16.0%
	Gas	1	0.7%
	Kerosene/paraffin	118	78.7%
	Candle	1	0.7%
	Torch	1	0.7%
	Diesel	3	2.0%
Asset ownership	Land		
	Size in acres		
	Less than 0.5 acres	11	7.3%
	Between 0.5 acres to 1 acres	17	11.3%
	Between 1 acres to 5 acres	78	52.0%
	Between 5 acres to 10 acres	38	25.3%
	Above 10 acres	6	4.0%
	Livestock		
	Cows	129	29.5%
	Goats	64	14.6%
	Sheep	97	22.1%
	Chicken	141	32.2%
	Pigs	7	1.6%
	Business		
	Shop	24	49.0%
	Butchery	3	6.1%
	Hotel	5	10.2%
	MPesa	2	4.1%
	Agrovet	1	2.0%
	Bar/restaurant	2	4.1%

Bicycle repair	1	2.0%
Green grocery	9	18.4%
Barber shop	2	4.1%
Transportation tools		
Car	3	5.8%
Lorry	2	3.8%
Motor bike	17	32.7%
Bicycle	29	55.8%
Animal drawn cart	1	1.9%
Other assets		
Sewing machine	3	1.7%
Refrigerator	1	0.6%
TV	24	13.3%
Radio	140	77.3%
Clock	13	7.2%

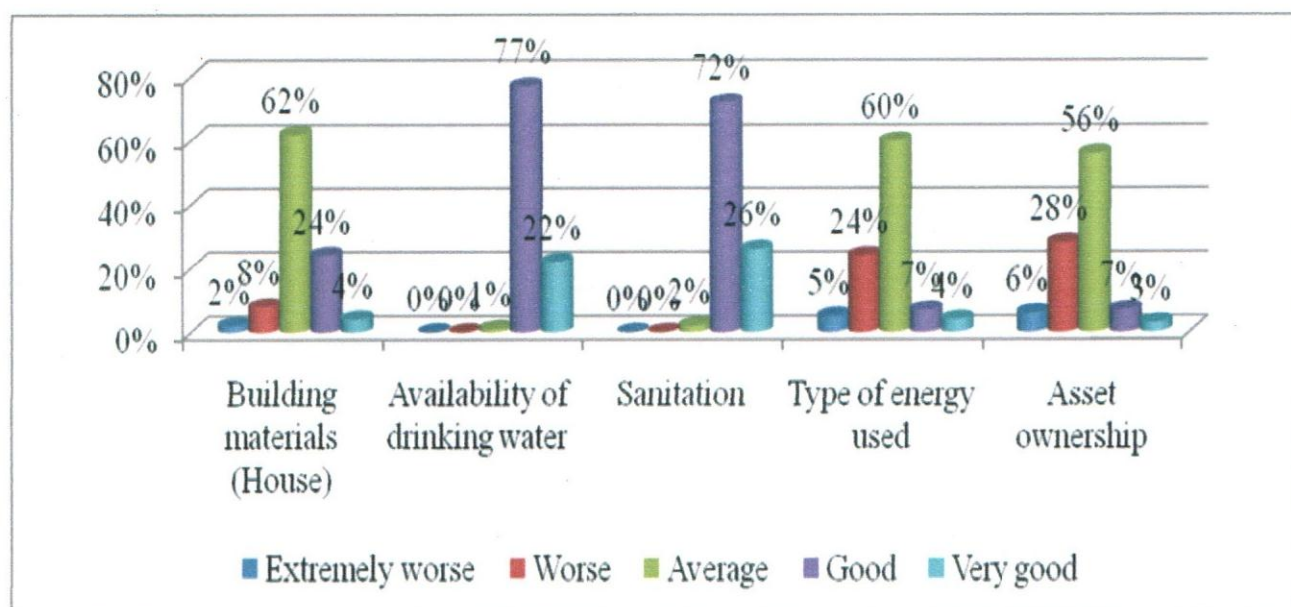


Figure: Respondents Standards of Living on Different Arbitrary Indicators

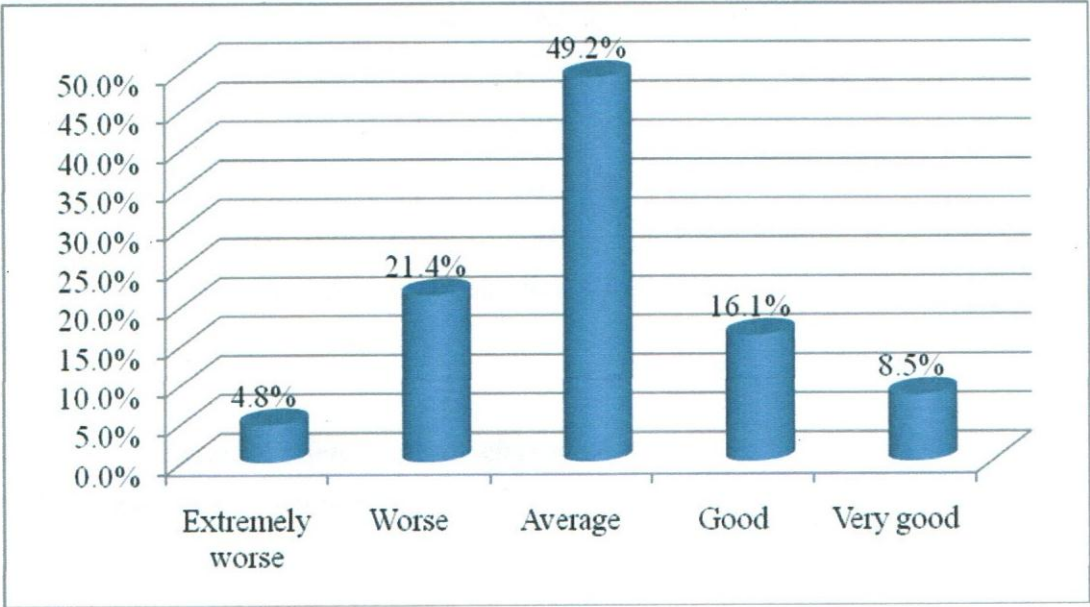


Figure: Respondents Average Standards of Living

Appendix 2: Research Questionnaire

The purpose of this study is to contribute to the understanding of the importance of crop diversification in meeting the household's goal of improved standards of living and risk reduction in Mathira East District, Kenya. You have been identified as a useful informant to assist us in this study. Your participation is voluntary and you are assured that the information you provide will be treated with confidentiality and used for the sole purpose of research. Kindly respond to the queries below.

Section A: Household demographic characteristics

A 1 Name of the respondent (optional).....

Division..... Location.....

A 2 Relationship with the household head

- a) Head []
- b) Spouse []
- c) Sibling []
- d) Other (specify)

A 3 Gender of head of household Male [] Female []

A 4 Marital status of the household head

- a) Married []
- b) Single []
- c) Divorced []
- d) Separated []
- e) Others []

A 5 Age of head of household: Actual age in years _____

- a) Age less than 26 years []
- b) Age between 26 to 35years []
- c) Age between 36 to 45years []
- d) Age between 46 to 55years []
- e) Age between 56 to 65years []
- f) Age more than 65 years []

A 6 Highest level of education of the household head

- a) No formal education []
- b) Primary []
- c) Secondary []
- d) Tertiary []
- e) University []

Number of years of education _____

A 7 How much household income do you realize per month? Income in Kshs _____

- a) Income less than 5,000 per month []
- b) Income from Kshs. 5,000 to Kshs. 10,000 per month []
- c) Income from Kshs. 10,000 to Kshs. 30,000 per month []
- d) Income above Kshs. 30,000 per month []

A 8 Household size (number of people living together in one homestead).....

A 9 How many members aged above 12 years are there in the household?.....

A 10 How many members aged 12 years and below are there in the household?.....

A 11 Indicate the type of land tenure that suite your condition

- a) Individual []
- b) Leasehold []
- c) Communal []
- d) Other (Specify)

A 12 Tenure status of the household land

- a) Own with title []
- b) Own w/o title []
- c) Rent/borrow []

A 13 How much land do you have?: Actual land in acres _____

- a) Land size less than 0.5 acres []
- b) Land size between 0.5 acres to 1 acres []
- c) Land size between 1 acres to 5 acres []
- d) Land size between 5 acres to 10 acres []
- e) Land size above 10 acres []

A 14 How much land (in acres) is under the following?

- a) Crops.....
- b) Dairy.....
- c) Homestead.....
- d) Other enterprises (specify).....

A 15 What experience do you have in crop farming? Experience in years _____

- a) Farming experience less than 5 years []
- b) Farming experience between 6and 10 years []
- c) Farming experience between 11 and 15 years []
- d) Farming experience of more than 15 years []

Section B: Drivers of Diversification

B 1. Indicate how the following factors have contributed to the way you distribute the crops in your field

	Very little effect	Little effect	Average effect	High effect	Very high effect
1. Need to benefit from changing consumer demand.					
2. Need to benefit from changing demographics (Rapid urbanization).					
3. Intension to enhance revenue					
4. Opportunities created by improved technology of adding value.					
5. Improved marketing opportunities for the crops grown					
6. Intension of improving nutrition through variety of crops					
7. Enhanced financial condition					
8. Individual aspirations and pursuits					

9. Your education level					
10. Type of land tenure (individually owned, communally owned, leased)					
11. Tenure status of the household land (owing and not owning title deeds)					
12. Availability of land					
13. Farming experience					
14. Reduction of family labour					
15. High transaction costs in purchasing consumer goods					
16. Adaptation to missing or poorly functioning markets					
17. Proximity of markets					
18. Intension to manage production risks and uncertainties (drought, excess rain, pests and diseases)					
19. Intension to manage price risks (high prices, volatile prices)					
20. Availability of irrigation water for production					

B 2. Indicate how the following factors contribute to the way you choose crops with varying durations to maturity.

	Very little effect	Little effect	Average effect	High effect	Very high effect
1. Need to benefit from changing consumer demand.					
2. Need to benefit from changing demographics (Rapid urbanization).					
3. Intension to enhance revenue					
4. Opportunities created by improved technology of adding value.					
5. Improved marketing opportunities for the crops grown					
6. Intension of improving nutrition through variety of crops					
7. Enhanced financial condition					
8. Individual aspirations and pursuits					
9. Your education level					
10. Type of land tenure (individually owned, communally owned, leased)					
11. Tenure status of the household land (owing and not owning title deeds)					
12. Availability of land					
13. Farming experience					
14. Reduction of family labour					
15. High transaction costs in purchasing consumer goods					
16. Adaptation to missing or poorly functioning markets					

17. Proximity of markets					
18. Intension to manage production risks and uncertainties (drought, excess rain, pests and diseases)					
19. Intension to manage price risks (high prices, volatile prices)					
20. Availability of irrigation water for production					

Section C: Standard of Living Information

- C 1. How many months are covered by own food production in the household?.....
- C 2. State the standard of living of the household in comparison to others in village
- a) Extremely worse []
 - b) Worse []
 - c) Average []
 - d) Good []
 - e) Very good []
- C 3. On what basis does your household occupy the dwelling now?
- a) Rented house []
 - b) Own house []
- C 4. How many rooms are occupied by this household (excluding bathrooms and toilets)-----
- C 5. Asset ownership
- a) Livestock
- | Name of livestock | Number of animals owned |
|-----------------------|-------------------------|
| Cows | _____ |
| Goats | _____ |
| Sheep | _____ |
| Chicken | _____ |
| Pigs | _____ |
| Others (Specify)_____ | _____ |
| _____ | _____ |

- b) Land: Size of in acres -----
- c) Business e.g. shop, butcheries, hotel (Indicate the value of stock -----)
- d) Transportation tools
- i. Car []
 - ii. Lorry []
 - iii. Motor bike []
 - iv. Tractor or similar machinery []
 - v. Animal drawn cart []
- e) Other assets
- i. Sewing machine []
 - ii. Refrigerator []
 - iii. TV []
 - iv. Radio []
 - v. Clock []
 - vi. Fan []
 - vii. Others (specify).....

C 6. Do you get assistance from the following sources?

- a) Social welfare assistance Yes [] No []
- b) Assistance from NGOs Yes [] No []
- c) Assistance from government Yes [] No []
- d) Assistance from relatives Yes [] No []

C 7. What kind of building materials is/are the dwelling structure of the household?

a) Type of roofing in the household house

- i. Iron sheets []
- ii. Grass thatched []
- iii. Asbestos sheets []
- iv. Asbestos tiles []

b) Types of walls in the household house

- i. Mud []
- ii. Stones []
- iii. Concrete bricks []

- iv. Mud bricks []
- v. Grass/straw []
- vi. Hardboard []
- vii. Wood []
- viii. Iron sheets []
- ix. Others (Specify)-----

c) Types of Floor in the household house

- i. Concrete only []
- ii. Covered concrete []
- iii. Mud []
- iv. Wooden []
- v. Others (Specify)-----

C 8. Availability of drinking water

a) Type of drinking water

- i. River water []
- ii. Public Tap []
- iii. Own tap []
- iv. Rain water []
- v. Water sold by vendors []

b) How far is this source of drinking water during the wet season and dry season?

- i. Wet season []
- ii. Dry season []

C 9. Type of sanitation

a) What is the main toilet facility for this household?

- i. Flush toilet []
- ii. Pit latrine []
- iii. Neighbour's/another household's pit latrine []
- iv. Bucket []
- v. Other (specify).....

b) What is the main method of garbage disposal that this household uses?

- i. Refuse collected []
- ii. Pit []
- iii. Dumping []
- iv. Other (specify).....

C 10. Type of energy used

a) Cooking fuel

- i. Firewood []
- ii. Electricity []
- iii. Kerosene []
- iv. Gas []
- v. Biogas []

b) Lighting fuel

- i. Firewood []
- ii. Electricity []
- iii. Gas []
- iv. Biogas []
- v. Kerosene/paraffin []
- vi. Candle []
- vii. Open fire []
- viii. Torch []
- ix. Diesel []
- x. None []
- xi. Other (specify).....

Section D: Diversification Information

D 1. How much land do you allocate for each of the major crop(s) you grow?

No.	Crop name	Amount of land in acres
Crop 1		
Crop 2		
Crop 3		
Crop 4		
Crop 5		
	Totals	

D 2. Rank the households three most important sources of income and list any others.

- a) Maize []
- b) Sweet potato []
- c) Potato []
- d) Cassava []
- e) Beans []
- f) Other legumes []
- g) Vegetables []
- h) Fruit []
- i) Sugarcane []

D 3. Why did you decided to distribute the above crops in the above manner?

.....
.....

D 4. Do you think that there exist particular forms of crop distribution that can reduce crop production risks? Yes [] No []

If yes, what kind of distribution?.....
.....

D 5. Do you encounter any challenge in striking a balance in the distribution of the crops that you grow? Yes [] No []

If yes, which challenges do you encounter?

- a)
- b)
- c)

D 6. Indicate the duration taken before harvesting by the major crops that you grow in your farm in the table below

No.	Crop name	Duration taken before maturity/harvesting (months)
Crop 1		
Crop 2		
Crop 3		
Crop 4		
Crop 5		
Totals		

D 7. What are the main reasons why you chose to grow the above crops?

- a) They have a shorter cropping season []
- b) Their market value is high (due to high prices) []
- c) There is a ready market for them []
- d) I possess adequate knowledge on how to grow them []
- e) Other reasons (specify).....

D 8. Do you think growing of crops with shorter seasons has a significant contribution to production risk reduction? Yes [] No []

If yes, explain how.....
.....
.....

Section E: Production Risk

E 1. Within the last five years, how many times have your crops been affected by the following production risks?

Production risks	Frequency				
	None	Once	Twice	Thrice	More than thrice
Severe pest or/and diseases outbreak					
Draught					
Excess rain					
Others (Specify)					

E 2. For up to five major crops that you grow, indicate the most likely, the possible minimum and the possible maximum amount of yield in bags per year that you expect to realize.

No.	Crop names	Most likely	Possible minimum	Possible maximum
1				
2				
3				
4				
5				

E 3. Indicate the likelihood (chances) of occurrence of the following production risks using a likert scale of 5 as follows: 1 = Very rare occurrence, 2 = Rare occurrence, 3 = Neither rare nor frequent occurrence, 4 = Frequent occurrence and 5 = Almost certain occurrence

Production risks	Frequency of risk
Severe pest or/and diseases outbreak	
Severe Draught	
Excess rain	
Others (Specify).....	

E 4. Indicate the potential impact (consequences) of the following production risks using a likert scale of 5 guided by the below key: 1 = very low or minor impact, 2 = low impact 3 = Neither low nor high impact, 4 = High impact and 5 = Very Significant or severe impact.

Production risks	Impact of risk
Severe pest or/and diseases outbreak	
Severe Draught	
Excess rain	
Others (Specify).....	

Thank you for your genuine responses

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