THE ROLE OF EXTRANEOUS INCENTIVES AND DRIVERS IN FARM ENTERPRISE DIVERSIFICATION: A STUDY OF PASSION-FRUIT (*Passiflora edulis*) UPTAKE IN UASIN-GISHU COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

DECLARATION

I declare that this is my original work and has not been presented in this or any other University for the award of a degree.

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RECOMMENDATION

This work has been submitted with our approval as University supervisors.

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DEDICATION

I dedicate this work to my parents, brothers and sisters for their support.

ABSTRACT

Despite the continued production and overdependence of traditional crops mainly maize and wheat as main source of income in the Uasin-Gishu County, poverty among farmers has been increasing. To mitigate the poverty effects, farmers have tended to substitute land under the traditional crops for high yielding and high value crops passion fruit inclusive. However, the uptake of passion fruit has been achieved with partial success. This study examined factors affecting passion fruit adoption and the extent of adoption. It further investigated the comparative profitability of passion fruit crop *vis-à-vis* other farm enterprises contingent on available farm resources. Cross-sectional data from 100 randomly selected farmers were collected and subjected to Heckman two-step regression analysis to determine factors affecting passion fruit adoption as well as the extent of adoption. Gross Margin Analysis and Data Envelopment Analysis methods were used to assess the comparative profitability of passion fruit crop. The results showed that availability of water for irrigation, title deeds and farming as main occupation significantly and positively affected the adoption of passion fruit while age was significant with negative effect. Private land ownership and access to extension services significantly and positively influenced the extent of adoption while age had significant negative effect. Further, this study revealed that passion fruit production was the more profitable farm enterprise than other comparable farm enterprises. The results mean more incentives and innovative drivers are necessary for crop diversification and substitution in Kenya and not sufficient for adoption of the new crops. Government and other stakeholders should formulate and implement effective policies related to promotion of adoption, production and marketing of new agricultural technologies.

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ABBREVIATIONS

DEA	Data Envelopment Analysis
DMUs	Decision Making Units
GMA	Gross Margin Analysis
IFAD	International Fund for Agricultural Development
IMR	Inverse Mills Ratio
Kgs	Kilograms
KHDP	Kenya Horticultural Development Program
Km	Kilometer
Ksh	Kenyan Shillings
MPP	Marginal Physical Product
MTs	Metric Tones
OLS	Ordinary Least Squares
SFA	Stochastic Frontier Analysis
Sq	Square
TE	Technical Efficiency
USA	United States of America
USAID	United States Agency for International Development

DEFINITION OF TERMS

Adoption - Process in which farmers make a decision to acquire and use new agricultural technologies

Adoption Extent – Proportion of land allocated to passion fruit given overall land size of the farmers.

Crop diversification - Risk-reduction strategy that involves adding more crops in farms

Drivers – Factors that drives farmers to either accept or reject adoption of passion fruit

Grain-crops - Cereal crops such as maize and wheat.

High-value crops - Refers to crops that have high market value.

Incentives – Factors that encourages farmers to adopt passion fruit

Poverty - Situation where farmers live below a dollar per day and inability to meet daily basic needs (definition by United Nations (UN)).

Technical efficiency - Ability of farmers to produce maximum possible output by use of minimum possible levels of input

Trade-off – Act of balancing various farm activities in order to achieve the best combination

Traditional crops – Refers to crops which are commonly grown. For example maize and wheat for this study

Uptake – Acquisition and usage of new agricultural technologies (for example passion fruit)

Communal land – Used in this study to refer land owned by family members.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Agriculture still remains the main activity among the poor rural households. In Kenya, agriculture is the main source of food and income for the majority of rural small-scale farmers, and those in Uasin-Gishu County are no exception. About 80% of the farmers in the County are small-scale owning less than 5 acres of land and depend mainly on agriculture as source of livelihood (Jayne *et al*., 2001). The main economic activities in the study area include agriculture and manufacturing industries. Agricultural activities involve: mixed farming, food crops, commercial crops and livestock keeping (Baraza *et al*., 2008). Main crops grown are maize, beans and wheat among others. Livestock keeping is still a common activity though currently declining among majority of the farmers due to increasing land sub-division and fragmentation.

Poverty in Africa emanates from low farm incomes and unemployment (IFAD, 2001). In Uasin-Gishu County the poverty mainly emanates from low farm incomes among majority of farmers. Maize and wheat have traditionally been relied upon by the farmers in the county as main source of food and income. Unfortunately the continued production and over dependence on these crops have not been beneficial to the smallholder farmers due to low incomes associated with them. This is because many farmers have remained net zero sellers and buyers in almost every production season. The increasing land sub-division and cost of production among other factors have resulted to low farm incomes and consequently the growth of poverty among majority of the farmers in the County (Jayne *et al*., 2001; Nyoro *et al*., 2004). The farmers face high cost of production due to escalating fertilizer, seed and fuel prices and relatively low output prices. For example in the case of maize production in the year 2008, the average production cost per acre increased by 50%. At the same time land preparation cost rose by 75% per acre while labor cost per worker per day rose by 100%. The cost of a 50 kg bag of Diamonium Phosphate (DAP) fertilizer rose by 111.11% (Kariuki, 2008).

To improve the low farm incomes and consequently reduce the growing poverty, the farmers have gradually diversified their farming activities by adopting horticultural crops. Passion fruit is one of such horticultural crops adopted and several farmers are practicing crop trade-off. That is, they substitute land under grain-crops such as wheat and maize for the passion fruit production.

According to Gockowski and Michel (2004), horticultural crops are high yielding and have high market value but labour intensive in production. Anderson (2003) argues that horticultural crops have high market value and yields more and regularly and hence suit the needs of smallholder farmers who face resource constraint and have no marketable surplus. The adoption of commercial production of passion fruit in Kenya began in 1933 and was expanded in 1960 (Morton, 1987). Apart from Uasin-Gishu County, passion fruit is produced in neighboring Marakwet and Keiyo Counties. The total annual passion fruit production in Kenya was approximately 40,650 MTs in 2006 and 36% of this comes from Rift Valley province alone (KHDP, 2006). Uasin-Gishu County alone in 2006 earned Kenya $33,000 (approximately 2.2 million shillings) from passion fruit production. Passion fruit can yield up to 9.7 MTs/ha and cost per Kg of fresh fruits is between Ksh.8 and Ksh.12 (KHDP, 2006).

To improve adoption of passion fruit in Uasin-Gishu County in order to increase the low farm incomes, Kenya Horticultural Development Program (KHDP) have initiated programmes that offer extension services on production and marketing of passion fruit. Beside passion fruit, KHDP also promotes adoption, production and marketing of other horticultural crops that includes avocado, pepper, and peas. The program operates in Central, Coast, Eastern, Nyanza, Rift Valley and Western provinces and is currently working with more than 15,000 passion fruit farmers countrywide (KHDP, 2006). Uasin-Gishu County has approximately 166,635 farmers (Baraza *et al*., 2008) and according to KHDP, only about 1,500 have managed to adopt passion fruit.

1.2 Statement of the problem

The increasing cost of production, price fluctuations of grain crops and land sub-division among other factors have negatively affected farm incomes for majority of farmers in Uasin-Gishu County. The effect is that, majority of these farmers who depend on grains as their main source of food and incomes are unable to meet their basic household demands. To mitigate against the increasing inability of grain growing to support livelihoods in Uasin-Gishu county, a diversification strategy was conceived through the introduction of passion fruit as an alternative cash crop.

Despite the strong project support in terms of extension, production, and marketing the adoption of passion fruit in the county has been achieved with partial success (KHDP, 2006).

Passion fruit like any agricultural crop is likely to be affected by factors typical of such products and that is why it is imperative to understand why the adoption of this apparently profitable farm enterprise has not been widespread

1.3 Objectives

1.3.1 General objective

To provide insights into the economic potential of passion-fruit production in an integrated and diversified crop enterprise system under conditions of resource constraint in Uasin-Gishu County.

1.3.2 Specific objectives

(i) To determine the socio-economic characteristics of both adopters and non-adopters of passion fruit in Uasin-Gishu County.

(ii) To determine factors affecting passion fruit adoption in Uasin-Gishu County

(iii) To determine extent of passion fruit adoption and factors affecting the extent of adoption in Uasin-Gishu County

(iv) To compare profitability of passion fruit *vis-à-vis* other farm enterprises in order to justify the rationale of the crop trade-off.

1.4 Research questions

(i) What are the socio-economic characteristics of the farmers in Uasin-Gishu County?

(ii) What are the factors affecting passion fruit adoption in Uasin-Gishu County?

(iii) What is the extent of passion fruit adoption and factors affecting the extent of passion fruit adoption in Uasin-Gishu County?

(iv) Is passion fruit production a profitable farm enterprise as compared to other farm enterprises?

1.5 Justification of the study

Poverty among the poor rural farmers has been increasing due to low farm incomes. To mitigate problems arising out of poverty, there is need to promote adoption and performance of high yielding and high value crops such as passion fruit. This will increase the income base for the farmers and consequently reduce the poverty level.

Understanding the incentives and constraints facing the farmers will help stakeholders such as KHDP to establish effective and efficient policies, extension projects and programmes. This will facilitate the adoption and performance of passion fruit and other new agricultural technologies.

1.6 Scope and limitation of the study

This study was carried out in Uasin-Gishu County because that is where KHDP program was located. Only two divisions, Moiben and Ainabkoi were selected for study due to lack of sufficient funds to cover all the project area. Both small scale and large scale farmers were sampled in order to give a representative sample. Due to lack of farm records among farmers, this study mainly relied on the farmer's memory in the collection of the data. Furthermore, this study determined efficiency scores for the different farm enterprises but did not determine causes of the inefficiency.

CHAPTER TWO

LITERATURE REVIEW

2.1 Economic importance of passion fruit and its role in distribution

The spread of passion fruit across the world was attributed to its diverse uses and profitability trait. Passion fruit vines are grown in full sun except in very hot areas where partial shade is preferable. Passion fruit vines grow on many soil types but light to heavy sandy loams with a pH of 6.5 to 7.5 are the most suitable. Excellent drainage is absolutely necessary. Also, the soil should be rich in organic matter and low in salts. If the soil is too acid, lime must be applied. Because the vines are shallow-rooted, they will benefit from a thick layer of organic mulch. Regular watering will keep a vine flowering and fruiting almost continuously. Water requirement is high when fruits are approaching maturity. If the soil is dry, fruits may shrivel and fall prematurely.

According to Morton (1987), Brazil is the origin and the world's largest producer of passion fruit before spreading through Paraguay to northern Argentina. In 1915 Hawaii adopted the crop from Argentina and later in 1958; University of Hawaii chose passion fruit as the best performing and profitable crop for economic development. About 1,200 acres (486 ha) of land was devoted to passion fruit production. In 1927, commercial production of passion fruit in New Zealand was started and remained profitable enterprise until 1930s when higher incidence of pest and disease attack was reported. This led to reduced yields and increased costs of production (Morton, 1987). In Africa, South Africa adopted purple passion fruit for the first time in 1947 under small-scale production where about 2,000 tons/ha were produced. Later in 1965 the crop was grown in plantations to meet the high market demand by then. In Kenya, production of passion fruit begun in 1933 and was expanded in 1960 (Morton 1987). According to KHDP (2006), currently about 5 percent of the total productions are exported while 95 percent are locally consumed. The exports earn Kenya approximately US$ 12.3 million per year.

Profitability may not be the only passion fruit trait that influences a farmer to adopt. However, there are other uses of passion fruit that are equally important for adoption. For example, Passion fruit is commonly used for preparing juice and diluted with water or other juices (especially orange or pineapple) to make cold drinks (Morton, 1987). In Australia, Passion fruit juice is used in the making of sauce, candy, ice cream and cake icing (Vanderplank, 1991). According to

Morton (1987), passion fruit is also widely used as medicinal plant. In Peru, passion fruit juice was used for treating urinary infections and in United States of America and Europe, passion fruit flower was widely used by herbalists and natural health practitioners as pain killer. In South America, the passion fruit juice is used as a natural remedy to calm asthma, whopping cough and bronchitis infections (Vanderplank, 1991). It is also used in manufacture of cosmetics and livestock feed (Morton, 1987).

2.2 Factors affecting adoption of new agricultural technologies

There is a large body of literature on adoption and diffusion of technologies in agriculture and it involves innovation on crops, crop varieties, inputs and many others. Several studies have found that farmer characteristics, technology traits, farm traits, institutional and economic factors to be major factors determining farmer’s decision to either adopt new agricultural technology or not (Rogers, 2003). Sheikh *et al*. (2003) classifies further the factors as follows: technology traits (cost, ease of use, expected benefit and support of labor), off-farm conditions (pest and disease pressure) and farmers’ characteristics (health, age, availability of household labour, education level, gender and attitude towards risk).

Education catalyses the process of information flow and exposes farmers to a wider field of knowledge. According to Masuki *et al*. (2003) and Ersado (2001) farmers with more information pathways intensify adoption of technologies and increases as household head education level increases. Higher level of formal education equips farmers with more knowledge and skills hence facilitate innovation of new and complex technologies (Faturoti *et al*., 2006). Fernandez-Cornejo *et al*. (2001) found that better educated farmers respond positively to adoption of soybeans. However, some studies have found contrary. Akkaya (2007) established that farmers tend to engage in off-farm activities as education level increases hence reducing the probability of adopting new farm technologies.

The role of framer’s age in explaining technology adoption is inconsistent. According to Ashenafi (2007) as farmers get older they tend to intensify adoption of new technologies in their farms as a result of more years of experience, higher accumulation of capital and large family sizes. Older farmers in some cases lack receptivity towards newly introduced technologies (Arellances and Lee, 2003). The argument is that older people are risk averse due to failure to change their old ways of doing things. The younger household heads are more willing to try out new agricultural technologies (crops and varieties) than older household heads who are risk adverse. Rogers (1983) found an inverse relationship between farmer's age and adoption of new farm practices. That is, younger farmers who were educated were more able to adopt new agricultural practices. However, Ndiema (2000) on the other hand found no relationship between age and adoption of agricultural technologies.

The role of gender in agricultural development in Africa is widely recognized. In Kenya, women supply about 70-75 percent of agricultural labour in agriculture (Njeri, 2007). Unlike men, women lack access and control over production resources such as land, information, credit and labour. Individuals with greater access to resources are more able to take advantage of a change in circumstances than less powerful and poorer individuals (Kaliba *et al.*, 2000). In African societies, crops produced for subsistence are associated with women because they are responsible for feeding the family, while men grow cash crops because they are responsible for providing cash income for the family. As a result, women's overall responsibilities affect poor households' capacity to adopt new activities especially when additional family or hired labour is not available (Njeri, 2007). Also, most of extension workers are men and are biased towards men in their service delivery especially in developing countries. This has resulted to more men adopting new agricultural technologies than women (Langyintuo and Mulugetta, 2005). Female headed households therefore negatively influence adoption of new technologies due to weak decision making mechanisms (Masuki *et al*., 2003). Contrarily, Onemolease (2003) and Onemolease and Alakpa (2009) found that males are less likely to adopt livestock technologies than females.

On experience, Langyintuo and Mulugetta (2005) argue that farmers with more years of experience are generally better and able to assess the relevance of new technologies. Farmers with more years of experience acquire more skills and knowledge necessary for use in the new technologies. This often arises from farmer's interaction with their neighbors and the rest of the world. On the effect of household size, large households positively affect adoption of new agricultural technologies through provision of sufficient labour (Rana *et al*., 2000). The argument is that, the increase in crop farming diversification is as a result of sufficient labour derived from large households. Ashenafi (2007) found availability of household labor positively affecting adoption of wheat in Ethiopia.

Farm size affects positively adoption of agricultural technologies. According to Fernandez-Cornejo *et al*. (2001), farmers with large farms responded positively to adoption of soybeans in USA. Ashenafi (2007) also found large farms significantly and positively affecting adoption of wheat in Ethiopia. The adoption of technologies is also promoted by access to credit. Access to credit facilitates adoption of new agricultural technologies due to financial ability (Fernandez-Cornejo and Mcbride, 2002). The effect of household income (on and off-farm) on adoption is ambiguous. However, houseld off-farm income has been found to have a positive effect on adoption of rice farming technologies in Nigeria (Igbokwe and Okoye, 2000). According to Akkaya (2007), higher household income increases likelihood of farmers adopting new agricultural technologies. Contrary, households that receive off-farm income are less likely to pursue on-farm diversification as a method of reducing financial risk (Rana *et al*., 2000).

Extension services promote agricultural productivity and adoption of new farm technologies (Baidu-Forson, 1999; Agbamu, 1993; Manyong, *et al*., 1996). It provides farmers with adequate and appropriate information that enables them to make informed decisions as well as optimize the use of the scarce resources. Extension services such as field days, seminars and technology profitability were found to affect positively adoption of lupins in Australia. However, the variability in the adoption of lupins across the farmers was accounted for by the distance to the extension services and markets as well as previous experience of the technology (Marsh *et al*., 1995). Chitere and Doorne (1985) in agreement conclude that access to agricultural education and extension creates awareness on new agricultural technologies among farmers and thus increases the ability to adopt the new agricultural technologies. According to Onemolease and Alakpa (2009), respondents in contact with extension agents are about two times more likely to adopt crop-related innovations than those with no contact. However, Tshiunza *et al*. (2001) found that extension support for the innovation was almost non-existent with 38.8% of the respondents recording a no visit by extension.

Availability and access to water for irrigation positively correlate with adoption of new farm technologies (Arellanes and Lee, 2003). Hwang, *et al.*, (1994) found a positive relationship between security of land tenure and adoption of soil conservation measures. They argue that farmers who own land privately are more than four times likely to employ new farming techniques due to security of tenure. It is the security of land access that enables farmers to make necessary investments in their lands. Market access promotes agricultural innovations (Tshiunza *et al*., 2001). Market uncertainties, low commodity prices and the high price paid have been identified as major determinants of maize adoption among farmers in United States of America (USA). The market uncertainty was significant and influenced negatively the adoption of improved maize varieties while price significantly and positively influenced the adoption of improved maize varieties (Marra *et al*., 2003). Arellanes and Lee (2003) and Fernandez-Cornejo *et al*. (2001) concurs that higher crop price positively affects adoption of agricultural technologies. Market failure (lack of access and asymmetry of information) brings about high transaction costs arising from searching, negotiation and acquisition of new farming technologies. Distances near good roads and towns are used to capture differences in market development and transaction costs involved (Jones and Jayne, 2003). It has been realized that when good infrastructure reaches a certain village, new activities such as trade and act of adding new crops on farm emerges (Smale *et al*., 2001). Obare *et al*. (2003) also established that state of infrastructure (roads) influence cost of inputs and outputs through transport costs. The higher the transport cost the higher the cost of inputs. This consequently leads to low usage of farm inputs and in turn affects negatively farm productivity.

Farmers in USA adopted soybean because of the need to increase yields, cut pesticide costs and increase planting flexibility (Fernandez-Cornejo and Mcbride, 2002). Farm traits also affect adoption of farm technologies. Heterogeneity in farm condition tends to increase crop farming diversification while greater homogeneity decreases the crop diversification. The regional location captures the differences in cultural and physical environment in which farmers make their decisions. The differences in soils and topography influence the choice of enterprise options on the farm and the development of alternative methods of marketing the agricultural products (Marshall and Brown, 1975). Many studies on new agricultural technology adoption mainly focuses on problems related to decision to either adopt or not but do not determine the extent of adoption (Pattanayak *et al*., 2003). Therefore this study further determined extent of passion fruit adoption and factors affecting the extent.

2.3 The role of farm enterprise diversification and trade-off

Specialization and commercialization in agriculture have been for long believed to be part of a broader strategy of improving farm incomes. The argument behind this was that, farmers were constrained in terms of resources and hence cannot produce all crops at the same time (Jones and

Jayne, 2003). On the other hand agricultural diversification and trade-off arises from the notion that benefits from different agricultural enterprises do not fall simultaneously, so that incase income from one enterprise falls it will be compensated by the rising income of the other enterprise. It is therefore a risk management strategy farmers employ to increase and stabilize farm incomes. In addition, diversification provides an opportunity to exploit potential complementary relationships between enterprises through improved utilization of the scarce resources (Meuwissen, 2001).

Agricultural incomes among majority of Kenyan households account for 60% of the total income (Kuyiah *et al.*, 2006). The agricultural incomes have also been argued to be improved through use of high yield and adequate inputs such as fertilizers, seeds, credit as well as availability of good rural infrastructure and no doubt good results have been achieved (Ishtiaq *et al*., 2005). However this has been considered by many studies as insufficient in improving the farmer's income because exploitation of such opportunities have been exhausted in many rural farming areas in the world and Uasin-Gishu County is not an exception in this case. Farm diversification at optimal levels therefore remains as one of the alternative strategies to alleviate poverty through increase and stable farm income under conditions of resource constrain and price instability. According to Kuyiah *et al.* (2006), high-value farm enterprises are suitable for smallholder farmers because they give more returns to scarce resources. Farm enterprises such as horticulture, tea and dairy farming can increase farm incomes even under conditions of risk (Obare *et al*., 2003).

Since the farmers face resource constraint and lack the market surplus (net zero sellers), proper utilization of the scarce resources in order to increase farm incomes is recommended. However, this will depend on the farmer's ability to operate optimal combination of profitable farm enterprises. According to Ishtiaq *et al*. (2005), farmers normally face problems when choosing optimal combination of crops to produce due to resource constrain and reiterated that farmer's profit maximization objective cannot be achieved if cropping mix chosen is not optimal. Anderson (2003) in his study revealed that combination of some agricultural enterprises at sub-optimal levels leads to reduction in farm incomes. He criticized the adoption of cash crops on the grounds that they compete with production of food crops and therefore subjects the households to food insecurity.

2.4 Theoretical framework

2.4.1 Technology adoption theory

An adoption of new crop or technology can be modeled on two grounds: the rate and extent of adoption. Rate of adoption refers to percentage of adopters while extent of adoption is the level of use of the new technology (Mercer and Pattanayak, 2003). Adoption of new technologies involves two stages, the decision to either adopt or not and in the second stage involves how much of the new technology to adopt or use. In the first stage according to Caviglia-Harris (2003), the decision to adopt a new technology or not depends on whether the new technology gives the farmer higher utility than the existing technology. According to Ayuk (1997), the decision to either adopt or not is modeled as a binary choice because the dependent variable is dichotomous (adopt (1) or not adopt (0)). Binary choice models are appropriate for such estimation if the following assumptions are observed: (i) the households are faced with only two alternative choices and (ii) any choice an individual choose depends on their characteristics. The decision to either adopt a new technology or not was thus built on utility maximization framework so that the expected net utility derived from adopting or not adopting new technology given farmer's characteristics was determined as follows:

$$Eu_iA = f(W_i) + e_i$$
$$Eu_iN = f(X_i) + e_i \quad \text{...} (2.1)$$

where, Eu_iA is the expected net utility of household i from adopting the new technology and Eu_iN is the expected net utility of household i from not adopting the new technology. A denotes new technology adopted while N denotes new technology not adopted. X_i and W_i are independent variables denoting technology, farm, institutional and household characteristics and e_i is an error term. The expected net utility from each of the decisions is then compared such that:

$$Eu_iA - Eu_iN > 0$$
$$Eu_iA - Eu_iN < 0 \quad \text{...} (2.2)$$

Y_i was then used as an indicator of whether household i adopted the new technology or not, so that $Y_i=1$ if adopted and $Y_i=0$ if not.

$$Y_i = 1 if Eu_i A - Eu_i N > 0$$
$$Y_i = 0 if Eu_i A - Eu_i N < 0 \quad \text{.. (2.3)}$$

The interpretation of equation (2.3) according to Caviglia-Harris (2003) is that, the probability that the household *i* adopts the new technology is the probability that the expected net utility derived from adoption of the new technology is greater than the expected net utility derived from not adopting the new technology. The decision to either adopt new technology or not and extent of adoption are dependent variables which can be estimated simultaneously. In this case, Heckman two-step procedure was identified to be suitable for estimation. In the first step, the decision to adopt is a matter of two interrelated choices, either to adopt new technology or not. The second step involves determination of the extent to which the new technology was adopted. The equation in the second step is only observed if first step is observable (positive). That is; *Y* is only observable if *Z=1*, where *Z* is the dependent variable in the first step (dichotomous variable (*1, 0*) specifying whether households adopted the new technology or not). The equation in the first step (Selection equation), *Z** was estimated with a set of *W* independent variables and error term *e* and alpha coefficients (α) are obtained. The dependent variable of the selection equation is binary (discrete) and simple Ordinary Least Squares (OLS) cannot be used. Instead Probit was used to estimate the selection equation because the dependent variable was discrete. The equation is specified as follows:

$$Z_i^* = W'_i \alpha + e_i \quad \text{.. (2.4)}$$

where, $Z_i=0$ if $Z_i^* \leq 0$ and $Z_i=1$ if $Z_i^* > 0$. The *Z* (a dummy variable) is a realization of an unobserved continuous variable *Z** which has a normal distribution, independent error term ***e*,** mean zero and constant variance sigma squared. In the second step (Outcome equation**),** the expected value of *Y* is modeled conditional on its being observed. Therefore, for values of *Z=1*, *Y* is observed which is observed realization of a second latent variable *Y**. The decision to either adopt or not was modeled with some independent variables *X* (Socio-economic, institutional and physical factors) and a vector of coefficients (β) was estimated. The equation is specified as follows:

$$Y_i^* = X'_i \beta + u_i \quad \text{.. (2.5)}$$

where, $Y_i = Y_i$ * if $Z_i=1$ and Y_i is not observed if $Z_i = 0$. Y^* has a normal distribution, independent error term *u*, mean zero and constant variance sigma squared *u*. The two errors (*u* and *e*) are assumed to have a correlation *rho* and their joint distribution is normal bivariate. The estimation of the relationships is normally problematic due to sample selection bias. To overcome sample selection bias, Heckman (1979) recommends the use of two-step procedure estimation. According to Heckman (1979), inverse mills ratio (IMR**) (**in the Heckman two-step procedure) is a correction term for selectivity bias problem. Therefore in this study, the Heckman two-step procedure was used to correct sample selection bias in obtaining the sample. The IMR is calculated in the selection equation and included in the outcome equation as an independent variable. Prevalence of zero values of the dependent variable in selection equation violates OLS assumption of continuous variable and therefore the estimation of OLS with a binary dependent variable was inappropriate. The parameters are not efficient due to heteroscedastic structure of the error term (Gujarat, 2003). Therefore the use of Probability estimate was crucial in correcting the model (Heckman, 1979).

Apart from probit model, logit model could have also been used. They all have normal distribution and are based on cumulative distribution function and thus no model had an advantage over the other as they all give the same results. The only difference between probit and logit is the size of their tails where the logit model has a fatter tail (Gujarat, 2003). However, according to Long (1997), probit model is preferred in the case of two equations and thus the use of probit model in the selection equation.. In the outcome equation, the dependent variable is extent of technology adoption. It is a continuous variable hence OLS is appropriate for estimation.

2.4.2 Production theory

According to Chambers (1988), the basic assumption is that there exist a relationship between the outputs and inputs. This relationship of inputs and outputs is represented by production function which show the maximum output that can be attained given optimal combination of inputs (Upton, 1984). The production function is given as follows:

$$y = f\{x\} \qquad (2.6)$$

where *y* is a vector of none negative outputs (Total physical product (*TPP*)) and *x* represent a vector of non-negative inputs. In this case, only inputs which are economically scarce (for fertilizer, seeds and agrochemicals) are considered. The reason is that inputs such as sunlight in production of crops that are not under control of the farmer, are not economically scarce That is, the variables normally do not enter as choice variables during decision making by the farmers (Chambers, 1988).

Furthermore, according to Chambers (1988), assuming that the production function yields the maximum obtainable output from a given input vector does not provide sufficient basis to support the construction of a theory that successfully approximates the stylized facts of economic behavior. Therefore he suggests that it is important to make some assumptions for the production function. These assumptions include:

i) If $x' \geq x$, then $f(x') \geq f(x)$ (monotonicity)

ii) The input requirement set (input combination capable of producing a certain output level) is a convex set (quasi-concavity)

iii) $f(0_n)=0$, where 0_n is the null vector

iv) The input requirement set in production is closed and nonempty for all $y>0$

v) $f(x)$ is finite, non-negative, real valued and single valued for all non-negative and finite x.

vi) $f(x)$ is everywhere continuous

Assumption (i) implies that, for maximum output to be achieved, additional units of inputs should never degrease the level of output (That is all marginal productivities must be positive). In other words, assumption (i) excludes the possibility of the existence of third stage of production where marginal product is negative. Assumption (ii) ensures that the law of diminishing marginal rate of technical substitution in the inputs holds (that is the production function is convex to the origin). Assumption (iii) means an input is essential to the production of output if a positive amount of output cannot be produced without a strictly positive utilization of the input. Assumption (iv) means that it is always possible to produce any positive output while assumption (v) means the number of inputs under production process are known and never negative (that is, there are no negative inputs). Finally, assumption (vi) is made to rule out discontinuous jumps in technology.

To achieve maximum profits for different farm enterprises, the usage of the available scarce resources should be at optimal levels. The average physical product (*APP*) is the partial measure of efficiency of an input and is calculated as follows:

$$APP_f = y / x \quad (2.7)$$

where y is the total output of a given farm enterprise while x is the quantity of inputs used in a particular farm enterprise. Given output price say P_y**,** total value product (*TVP*) and marginal value product (*MVP*) are derived as follows:

$$TVP = TPP * P_y \quad (2.8)$$

$$MVP = MPP * P_y \quad (2.9)$$

where *MPP* is the marginal physical product. Also given input prices say r, the total variable costs (TVC) are given as follows:

$$TVC = x_i * r \quad (2.10)$$

Gross margin is then derived from the difference between total value product and total variable costs as follows:

$$\Pi_i = TVP_i - TVC_i \quad (2.11)$$

where Π_i is the gross margin level, *TVP* is total value product and *TVC* is the total variable costs. It is important to note that fixed costs were not used in calculating gross margins because, in calculating gross margins, only variable costs are normally considered and fixed costs are only considered when one is deriving net profit.

2.5 Evaluation of farm profitability

Farm profitability can be determined by use of several techniques. Gross Margin Analysis (GMA) and budgeting analysis are some of the techniques. Also benchmarks such as milk per cow or output per unit of input (average physical product) and returns to labour and capital can be used but according to Whittaker *et al*. (1995), these are partial measures of efficiency and can be preferred because of their simplicity and flexibility. Also, the partial measures of efficiency do not obey the law of diminishing returns to scale and instead assumes constant returns to scale

(Whittaker, *et al.*, 1995). According to Waweru (2007), GMA assesses economic efficiency of farm productions. There is also Linear programming (LP) model and has advantage over budgeting analysis in that its results yield to most optimal solution. The results provide specific enterprise mix and level of resource use that yields to maximum profits. Its assumptions include additivity, linearity, non-negativity, divisibility, finiteness and proportionality (constant returns to scale). However, some of these assumptions are not realistic. For example, linearity and proportionality in production is not always true to the reality (Waweru, 2007).

To deal with the shortcomings of such techniques, other techniques such as data envelopment analysis (DEA) and stochastic frontier analysis (SFA) have been developed. SFA is non-restrictive technique that involves econometric methods. It allows economies of scale to vary with output levels and measures one-sided effects. It further provides quantitative information on the level of production efficiency. It is a parametric method and differs from DEA in that an error term is included in the model. It relies on specific distributional assumptions for the error term and functional form for the relationship between inputs and outputs. If the distributional assumptions and functional form of SFA are mis-specified, the results will likely be biased (Whittaker, *et al.*, 1995). DEA on the other hand is a non-parametric method of calculating the efficiency of each DMU by use of mathematical programming. It can be used for performance measurement, analysis and benchmarking. It can compare multiple levels of inputs and outputs for a given DMU against all other DMUs in the data set to determine which DMUs are producing at efficient levels. It also provides information about which efficient DMU an inefficient DMU should benchmark to (Coelli, 1998). It is a non-stochastic technique (deterministic) and hence no assumptions required for its use. This method is also the best in determining the best allocation of farm scarce resources and the scale of operation (Stokes, *et al.*, 2007). There are three types of DEA commonly used; input, output and profit orientations (Coelli, 1998). However, DEA has limitations, for example it attributes any deviation from "best practice frontier" to inefficiency and neglects the influence of nature and human incompetence. Also it does not allow statistical testing of hypotheses concerning production functions and inefficiency.

2.6 Conceptual framework

Figure 1 presents structure of the conceptual framework. The decision to either adopt new technology or not was assumed to be determined by several factors: household (education, age, gender, household size, availability of labour), technology (profitability, complexity, flexibility) physical and institutional (credit, soils, distance to market, farm size) traits. Only those who adopted the new technology were expected to expand the usage of the new technology (extent of adoption). It was further assumed that the adopters of the new technology were after profit maximization in order to increase farm incomes and consequently reduce the creeping poverty. Finally it was believed that the adopters could only maximize gross margins from the new technology if they practiced proper utilization of scarce resources.

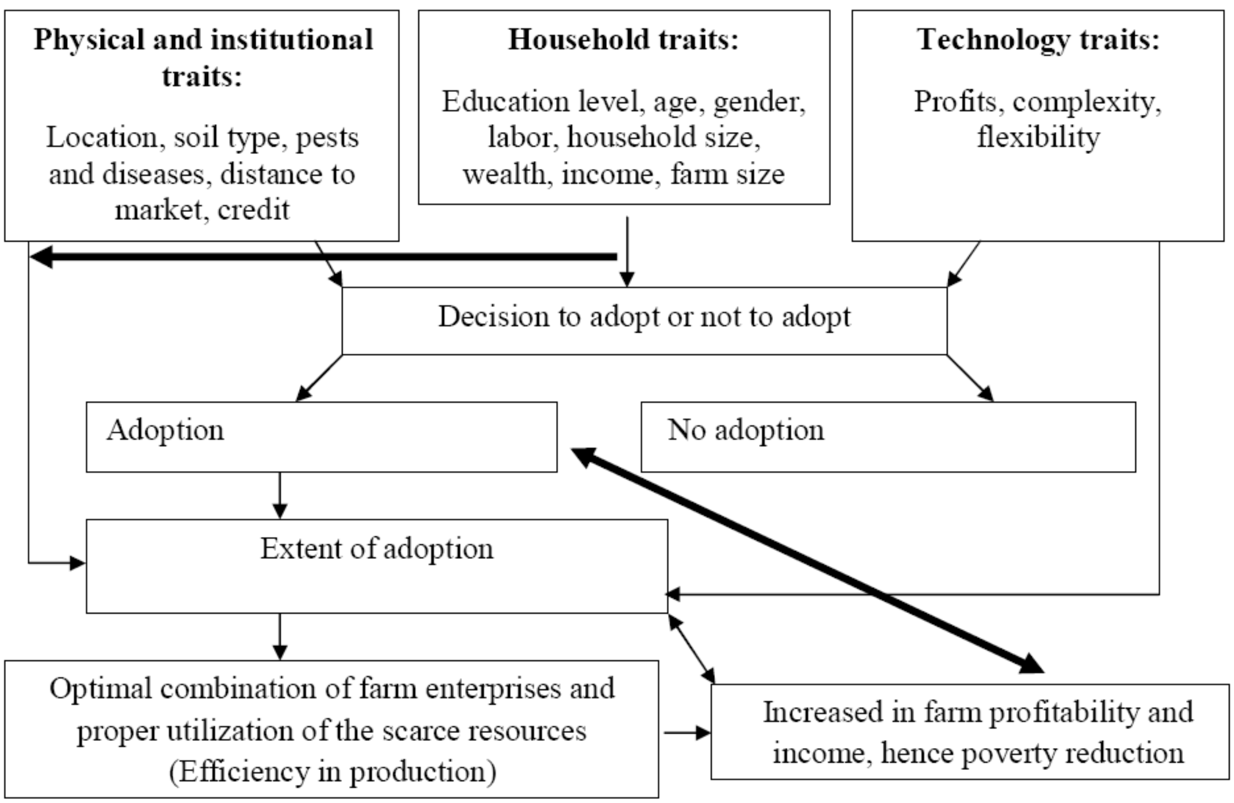


Figure 1: Conceptual framework

CHAPTER THREE

METHODOLOGY

3.1 Study area

Uasin-Gishu County (Figure 2) was selected as the study area because that was where KHDP programme was running. In addition, it is one of the few Counties in Rift Valley Province that is suitable for passion fruit production and an interest in passion fruit production was growing among farmers. According to Baraza *et al*. (2008), the County covers a total area of 3327.8 km^2 and projected population is about 771,536 people. It has a population density of 232 per sq km. Approximately 2603.2 sq. km of the total area is arable land while 218 sq. km is land under water, swamps, rocks and hills. Urban areas cover about 196 sq km and current total land under agricultural production is 134,490 ha. The approximate total number of farmers is approximately 166,635. The type of farming systems and livelihoods include mixed farming (food crops and livestock), mixed farming (commercial crops and livestock) and formal/casual employment (Baraza, *et al*., 2008).

The County is located in the high potential (>1,800m) and low potential (<1,800 m) agro-ecological zones. The high potential zone generally receives more rainfall over a longer period of time than the low potential zone. Rainfall ranges from 500 mm to 1,000 mm in low potential zones and 1,200 mm to 1,800 mm in high potential zones. The average annual rainfall is between 900 to 1,200 mm per year. Altitude ranges between 1500m to 2700m above the sea level while longitude lies between 34^o50’ and 35^o 37’ East and between latitude 0^o 03’south and 0^o 05’ North (Baraza, *et al*., 2008). Rainfall is unimodal with distinct peaks in April and August. Soils in Uasin-Gishu County developed from tertiary or older basic igneous rocks that are extremely deep and are well drained. Uasin-Gishu County borders Nandi North, Nandi South, Kericho, Koibatek, Marakwet, Trans Nzoia and Lugari Countys. It has 6 Divisions namely: Moiben, Ainabkoi, Kesses, Soy, Turbo, and Kapseret (Baraza, *et al*., 2008). The map of Uasin-Gishu County is shown in Figure 2.

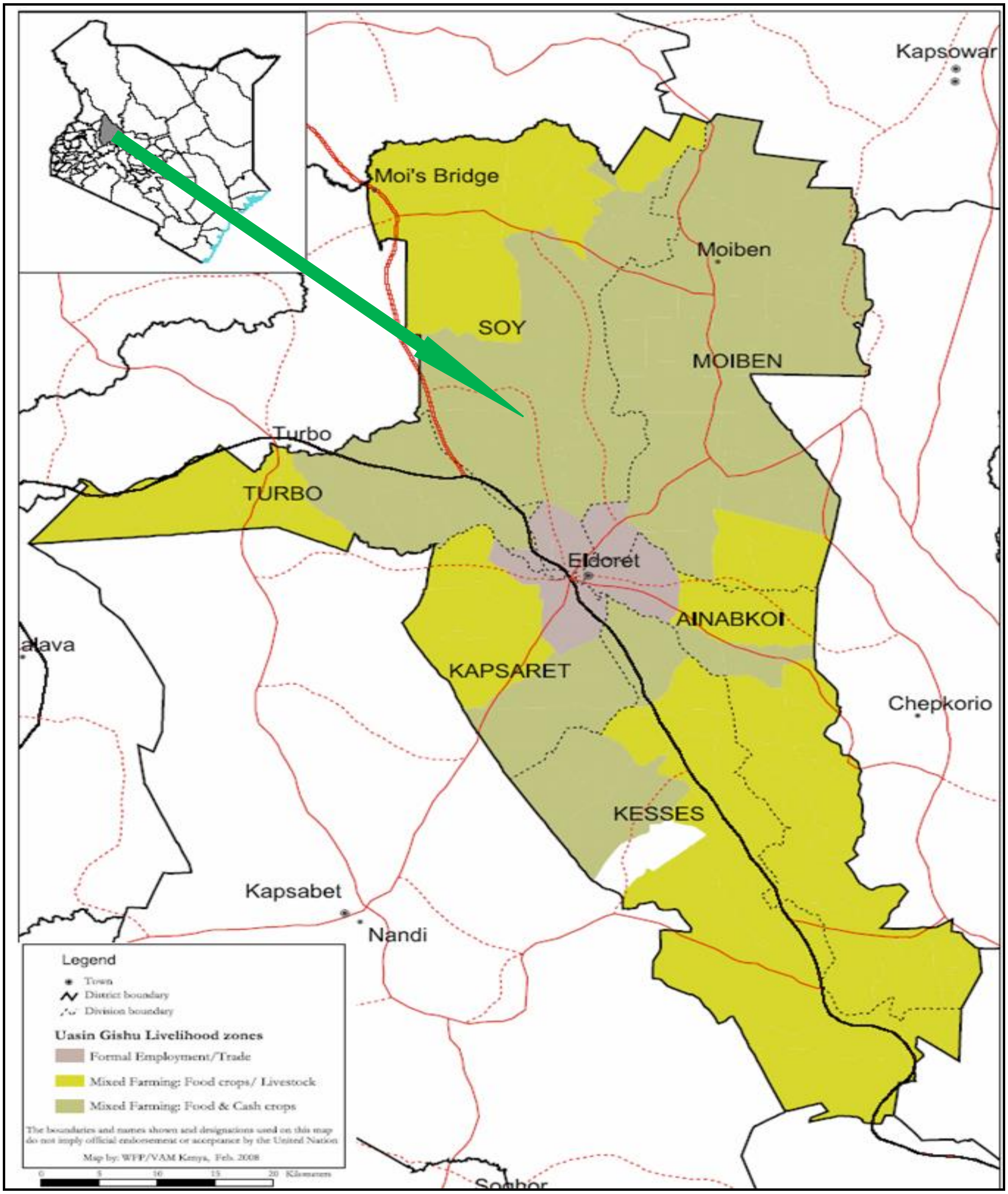


Figure 2: Map of Uasin-Gishu County
Adopted from Baraza *et al*. (2008)

3.2 Data and sampling procedure

Multi-stage sampling method was used in obtaining appropriate sample size. First, Uasin-Gishu County was purposively selected. Within Uasin-Gishu County, Moiben and Ainabkoi divisions were purposively selected because it was where KHDP program was based as well as the major passion fruit growing divisions in the County. In each division, 5 locations were randomly selected to give a total of 10 locations. Each location was stratified into two groups of farmers: those who adopted passion fruit and non-adopters to give a total of 20 strata. From each stratum, 5 farmers were randomly selected to give a total sample of 100 farmers (50 passion fruit adopters and 50 non-adopters). Passion fruit farmers were randomly selected from the list of passion fruit farmers obtained from KHDP Eldoret offices. Primary data were collected using a structured questionnaire. Data on physical, institutional and socio-economic factors, output and input quantities as well as prices were collected.

3.3 Sample size

Out of the 100 farmers sampled, 50 were passion fruit producers while 50 were non-passion fruit producers. The sample size was determined using formula by Anderson *et al*. (2007).

$$n = \frac{(Z_{\alpha/2})^2 \overset{*}{P}(1-\overset{*}{P})}{E^2} \qquad \text{(3.1)}$$

The population of farmers *(N)* in Uasin-Gishu County is approximately 166,635. As earlier stated, the number of passion fruit farmers ***(****x****)*** was 1500. Proportion *(P^*)* is thus; *x/N* = 1500/166,635 = 0.009002. The desired margin of error *(E)* = 0.018512, while the confidence interval is 95% and $z_{\alpha/2} = 1.96$. There sample size for passion fruit adopters was calculated as follows:

$$n = \frac{(1.96)^2 0.009002(1-0.009002)}{0.018512^2} = 100 \qquad \text{(3.2)}$$

3.4 Data analysis

SPSS computer program was used to determine farmer's socio-economic characteristics. STATA program was used to estimate Heckman two-step procedure to determine factors affecting passion fruit adoption and extent of adoption. Microsoft Excel and Data Envelopment Analysis Program (DEAP) version 2.1 were used to determine comparative profitability of different farm enterprises.

3.4.1 Empirical models

Descriptive analysis and two empirical models were used to estimate the desired variables. In the first objective, descriptive analysis was used to profile the characteristics of the respondents. Heckman two-step procedure was used in the second objective to determine factors affecting adoption of passion fruit and the extent of adoption. In the third objective, Gross Margin Analysis and Data Envelopment Analysis (output oriented) model were used to determine comparative profitability of passion fruit *vis-à-vis* other farm enterprises.

3.4.1.1 Heckman two-step procedure

Heckman (1979) proposed a two-step procedure which only involves the estimation of a standard probit and a linear regression model. The two equations for the two steps are specified as follows:

Selection equation (Probit)

$$typfrmer = \beta_0 + \beta_1* (ageyrs) + \beta_2* (lnwealth) + \beta_3* (fbusines) + \beta_4* (individ) + \beta_5* (wtrirrig) + \beta_6* (edulevel) + \beta_7* (extbfore) + \beta_8* (gnder) + \beta_9* (dstmkt) + \beta_{10}* (creditk) + \beta_{11}* (hsize) + \beta_{12}* (farmsize) + \beta_{13}* (farmonly) \quad (3.3)$$

Outcome equation (Simple OLS)

$$extent = \alpha_0 + \alpha_1* (ageyrs) + \alpha_2* (creditk) + \alpha_3* (fbusines) + \alpha_4* (individ) + \alpha_5* (wtrirrig) + \alpha_6* (edulevel) + \alpha_7* (extbfore) + \alpha_8* (pasprice) + \alpha_9* (farmonly) \quad (3.4)$$

Table 1: Description of variables used in Heckman two-step procedure

Variable	Full definition	Description of the variables	Expected Sign
typfrmer	Type of farmer (adopters and non-adopters)	Dependent variable for selection equation. (Dummy)	None
Extent	Extent of adoption in acres	Dependent variable for outcome equation (Proportion of land allocated to passion fruit production)	None
fbusines	Farming and businesses combined	Farmers with off-farm activities (Dummy)	(-)
Ageyrs	Age in years	Household head age	(+/-)
Individ	Individual land tenure	Farmers with title deeds (Dummy)	(+)
Gnder	Gender	Sex of the household head (Dummy)	(+/-)
extbfore	Extension services	Accessibility to agricultural extension services (Dummy)	(+)
wtrirrig	Water for irrigation	Availability of water for irrigation (Dummy)	(+)
lnwealth	Wealth in Kshs	Value of household assets	(+)
Dstmkt	Market distance in kilometers	Distance to the near markets in kilometers	(-)
Creditk	Credit	Dummy(1 =access, 0 =not)	(+)
pasprice	Passion fruit price in Kshs	Price paid for passion fruit	(+)
farmonly	Farming only	Farmers with farming as main activity	(+)
edulevel	Education level	Farmer's level of education	(-/+)
farmsize	Farm size in acres	Overall farm size owned by the farmers	(+)
Hsize	Household size	The size of households sampled	(+)

3.4.1.2 Comparative enterprise profitability

3.4.1.2.1 Gross Margin Analysis

Gross Margins, returns to labor and capital for each farm enterprise were used in benchmarking the farm enterprises. Gross margin is the difference between total revenues and total variable costs. The use of gross margin analysis depends on assumptions. For example in this case land was not treated as an input because it is a fixed input shared by several farm enterprises. Both hired and family labor was considered and assumed to have equal productivity. In addition, all farmers were assumed to have used same production technology and prices used were those prevailing during production season for each of the farm enterprises for each of the farmers.

$$GM_{jf} = (P_j Y_j - \sum_{i=1}^{n} P_i X_i) \quad (3.5)$$

where;

GM_{jf} - Gross margin of enterprise j for farmer f

P_j - Output price of enterprise j

Y_j - Output of enterprise j

P_i - Price of input i

X_i - Amount of input i used

3.4.1.2.2 Data Envelopment Analysis

The Data Envelopment Analysis (DEA) model (output oriented) that is based on Variable Returns to Scale (VRS) assumption was used as outlined by Coelli (1998). Output oriented approach refers to how much output levels can be proportionally increased without altering the input levels. On the other hand, input oriented approach refers to how much input levels can be reduced while maintaining the same level of output. However, the choice of orientation in many cases has no influence on the results (Coelli, 1998). Data Envelopment Analysis utilizes Linear Programming (LP) methods because LP methods does not suffer from statistical problems like those witnessed in econometric estimation processes like stochastic frontier analysis (Coelli, 1998). Stochastic estimations incorporate a measure of random error. This involves the estimation of a stochastic production frontier, where the output of a firm is a function of a set of inputs, inefficiency and random error. An often quoted disadvantage of the technique, however, is that they impose an explicit functional form and distribution assumption on the data. In contrast, the linear programming technique of DEA does not impose any assumptions about functional form; hence it is less prone to mis-specification. Further, DEA is a non-parametric approach so does not take into account random error. Therefore, DEA it is not subject to the problems of assuming an underlying distribution about the error term. However, since DEA cannot take account of such statistical noise, the efficiency estimates may be biased if the production process is largely characterized by stochastic elements (Whittaker, *et al*., 1995).

Variable returns to scale was preferred for use instead of constant returns to scale (CRS) because the farmers faced imperfect markets, capital constrains among other factors hence preventing optimality in production. However, the input and output oriented efficiency scores are the same under CRS assumption but differ under VRS assumption on the measures of inefficiency scores. That is, input and output oriented models estimate same frontier and identifies same set of efficient Decision Making Units. DEA model generates optimal input/output mix that yield to maximum profit for each farm and thus helps to identify the most efficient farmers for benchmark purposes (Coelli, 1998).

$$Max_{\theta}\lambda\theta, \quad \text{.......} \quad (3.6)$$

Subject to

$$-\theta y_i + Y\lambda \geq 0, \quad \text{.......} \quad (3.7)$$

$$x_i - X\lambda \geq 0, \quad \text{.......} \quad (3.8)$$

$$N1'\lambda = 1$$

$$\lambda \geq 0$$

Table 2: Description of variables used in Data Envelopment Analysis model

Variable	Definition
θ	Efficiency score for each DMU
x_i	Inputs vector
y_i	Output vector
λ	N*1 vector of constants
$\lambda \geq 0$	Non-negativity condition
X	Input matrix (K*N) where: K- Inputs and N-number of farmers
Y	Output matrix (M*N) where: M – Outputs

Source: Coelli (1998)

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents findings of the study and includes results and discussions.

4.1 Descriptive analysis

4.1.1 Socio-economic characteristics of the farmers

Table 3: Test for equality of means for the socio-economic characteristics

Variable	T	df	p-value	Mean difference	Std. error difference
Age	1.512	98	0.134	4.140	2.738
Household size	-0.044	98	0.965	-0.020	0.457
Farm size	0.182	98	0.856	0.460	2.531
Experience	0.134	98	0.893	0.280	2.084

Source: Survey data 2009

Table 3 presents t-test results (at 5% level of significance) for equality of means for age, household size, farm size and experience between passion fruit adopters and non-adopters. The results shows that all the variables tested had $p>0.05$ indicating that there was no significant difference between the passion fruit adopters and non-adopters in terms of age, household size, farm size and years of experience.

The results presented in table 4 show that, most of the farmers were relatively young as indicated by the mean age in each category. The youngest farmer among passion fruit adopters was 20 years old while the oldest farmer was 70 years old. Among non-adopters, the youngest farmer was 22 years old and oldest farmer was 72 years old. The mean age of the adopters of passion fruit was approximately 38 years while that for non-adopters of passion fruit was approximately 42.5 years. Older farmers were few denoting that younger farmers were more receptive to new technologies than older ones. Many studies have attributed lack of adoption of new agricultural technologies to failure of the older farmers to change their old ways of doing things (Langyintuo and Mulugetta, 2005).

The farmer with small household size in both categories had 1 person while the one with large household size had 12 people. The households with 1 person were either unmarried person or widow/widower. The average household size for both categories was approximately 5 people and is in line with Kenya's national mean figure of 5 members per household (CBS, 2005). It has been found that large household size positively influences adoption of new agricultural technologies through provision of sufficient labour (Faturoti, *et al*., 2006). Rana *et al*. (2000) further revealed that increasing farm diversification among large households was as result of sufficient labour capacity. Ashenafi (2007) found availability of household labor positively affecting adoption of wheat in Ethiopia. On experience, a good number of farmers had at least 10 years of experience. This is denoted by the average figure of years of experience which stood at approximately 13 years. Farmers with more years of experience acquire knowledge and skills necessary for choosing appropriate new farm technologies (Faturoti, *et al*., 2006).

The farmer with the smallest land size among non-passion fruit adopters had 1 acre while among adopters of passion fruit had 1.5 acres. The farmer with the largest size of land had 60 and 40 acres among non-passion fruit adopters and adopters respectively. The average land size for both categories of farmers in the selected area was approximately 14 acres. However, Jayne *et al*. (2001) found that majority of the farmers in the County had 5 acres. Large farm sizes have been found to have positive effect on adoption of agricultural technologies (Rana, *et al*., 2000; Fernandez-Cornejo, *et al*., 2001).

Table 4: Description of farmer's demographic characteristics

Division	Type of farmer	Variables	N	Min	Max	Mean	Standard deviation
Moiben	Non-passion fruit producer	Age (years)	25	22	70	43.20	15.71
		Household size	25	1	12	5.04	2.56
		Farm size (acres)	25	1	60	16.40	17.16
		Experience (years)	25	2	32	13.12	9.19
	Passion fruit producer	Age (years)	25	25	70	40.72	13.46
		Household size	25	1	12	5.24	2.35
		Farm size (acres)	25	2	40	15.01	11.39
		Experience (years)	25	3	44	14.12	11.25
Ainabkoi	non-passion fruit producer	Age (years)	25	25	72	42.20	13.91
		Household size	25	1	10	5.76	2.20
		Farm size (acres)	25	1	38	12.64	11.46
		Experience (years)	25	1	40	13.52	11.32
	Passion fruit producer	Age (years)	25	20	70	36.40	11.55
		Household size	25	3	12	5.60	2.02
		Farm size (acres)	25	1.5	34	13.11	9.43
		Experience (years)	25	2	40	11.96	10.08

Source: Survey data 2009

NB: Max-maximum, Min-minimum

In terms of gender, male farmers dominated female counterparts in both categories of the farmers (Table 5). Among the passion fruit adopters, 80% were male while 20% were female. Among non-passion fruit adopters, 78% were male and 22% were female. In both categories, male were the majority. The difference can be attributed to the fact that unlike men, women in majority of Kenyan communities have neither rights to own agricultural production resources (especially land) nor power to make major decisions regarding agricultural productions. This renders women unable to acquire and use new agricultural technologies. The findings concur with that of Masuki *et al*. (2003) and Njeri (2007).

Table 5: Gender percentage distribution by type of farmer category

Type of farmer	Gender	Frequency	Percent	Valid Percent
Non-passion fruit producer	Male	39	78	78
	Female	11	22	22
	Total	50	100	100
Passion fruit producer	Male	40	80	80
	Female	10	20	20
	Total	50	100	100

Source: Survey data 2009

On occupation, large percentage of the respondents in both categories had farming as main occupation (Table 6). The results show that 72% of passion fruit adopters had farming as their main activity, those who combine farming with business were 16% and finally 12% had formal employment alongside farming. In the category of non-passion fruit adopters, 62% depended wholly on farming while those who had businesses and formal employment were 18% each. The results revealed that majority of the farmers in Uasin-Gishu County depends mostly on agriculture as the main source of livelihood and concur with the findings of Kariuki (2008). The farmers with farming as the main occupation tend to adopt more agricultural technologies than those with several off-farm activities alongside farming (Akkaya, 2007)

Table 6: Occupation percentage distribution by type of farmer category

Type of farmer	Occupation	Frequency	Percent	Valid Percent
Non-passion fruit producer	Farmer	31	62	62
	Farming and business	9	18	18
	farmer and employed	9	18	18
	Student	1	2	2
	Total	50	100	100
Passion fruit producer	Farmer	36	72	72
	Farming and business	8	16	16
	farmer and employed	6	12	12
	Total	50	100	100

Source: Survey data 2009

Table 7 presents farmer's level of education. Only 1 out of 100 respondents did not go to school. This means that 99% of the respondents accessed formal education. However, majority of them attained only secondary education while very few attained tertiary education. Among the passion fruit adopters, those who attained primary, secondary and college education were 30%, 58% and 12% respectively. On the other hand, 2% of non-passion fruit adopters attained no formal education, 26% primary education, 62% secondary education, 4% middle college education and finally 6% attained university education. The low percentage of farmers who attained tertiary education can be attributed to the fact that farmers tend to engage in off-farm activities as education level increases (Akkaya, 2007).

Table 7: Level of education percentage distribution by type of farmer category

Type of farmer	Education Level	Frequency	Percent	Valid Percent
Non-passion fruit producer	None	1	2	2
	Primary	13	26	26
	Secondary	31	62	62
	College	2	4	4
	University	3	6	6
	Total	50	100	100
Passion fruit producer	None	0	0	0
	Primary	15	30	30
	Secondary	29	58	58
	College	6	12	12
	University	0	0	0
	Total	50	100	100

Source: Survey data 2009

On land tenure system, majority of the farmers owned land privately and very few were under communally and leasehold land tenure systems (Table 8). Among passion fruit adopters, those who were under individual, leasehold and communal land tenure systems were 90%, 2% and 8% respectively (average figures of the two divisions), while non-passion fruit producers were 82%, 6% and 12% respectively (average figures of the two divisions). Among passion fruit adopters, higher percentage (82%) was under individual land tenure system. This shows that the right to land ownership played a key role in the adoption of passion fruit. The security of land access induces farmers to make necessary investments in their land (Rana, *et al*., 2000).

Table 8: Land tenure percentage distribution by type of farmer and division categories

Type of farmer	Division	Land tenure	Frequency	Percent	Valid Percent
Non-passion fruit producer	Moiben	Individual	19	76	76
		Communal	6	24	24
		Total	25	100	100
	Ainabkoi	Individual	22	88	88
		Lease	3	12	12
		Total	25	100	100
Passion fruit producer	Moiben	Individual	21	84	84
		Lease	1	4	4
		Communal	3	12	12
		Total	25	100	100
	Ainabkoi	Individual	24	96	96
		Communal	1	4	4
		Total	25	100	100

Source: Survey data 2009

Statistical test was also performed to determine if there was a significant difference between passion fruit adopters and non-adopters in terms of gender, occupation, education level and land tenure system. To test, t-test was used at 5% level of significance.

Table 9: Test for equality of gender, occupation, education level and land tenure

Variable	t	df	p-value	Mean difference	Std. error difference
Gender	0.243	98	0.808	0.020	0.082
Occupation	1.161	98	0.249	0.500	0.431
Education level	-0.611	98	0.542	-0.100	0.164
Land tenure	0.965	98	0.337	0.120	0.124

Source: Survey data 2009

Results in table 9 shows that p>0.05 for all the variables tested. This means there was no significant difference between the passion fruit adopters and non-adopters in terms of gender, occupation, education level and land tenure system.

4.2 Extent of passion fruit adoption

The extent of adoption was determined as proportion of land allocated to passion fruit production given overall farm size per household. The extent of adoption was then compared between the two divisions as shown in table 10. But before comparing, t-test at 5% level of significance was used to determine whether there was significant difference in the extent of passion fruit adoption between the two divisions (Ainabkoi and Moiben). However, the results in table 10 indicates that, there was no significant difference (p>0.05) in the extent of passion fruit adoption between the two divisions.

Table 10: T-test for equality of means for extent of adoption between Moiben and Ainabkoi division

Variable	t	df	p-value	Mean difference	Std. error difference
Extent of adoption	-0.003	48	0.997	-0.00012	0.0345

Source: Survey data 2009

The overall average extent of passion fruit adoption in the study area as represented by the two divisions was 0.169 (Table 11).

Table 11: Extent of passion fruit adoption by type of farmer and division categories

Type of farmer	Division	Variable	N	Minimum	Maximum	Mean
Passion fruit producer	Moiben	Extent of adoption	25	0.025	0.5	0.169
	Ainabkoi	Extent of adoption	25	0.038	0.53	0.169

Source: Survey data 2009

This means 16.9% of the overall farm size per household was allocated to passion fruit. Among the adopters of passion fruit, the average overall farm size per household was 15.60 acres (Table 3). This shows that on average, 2.64 acres of land was allocated to passion fruit per household in Uasin-Gishu County. In Moiben division, the lowest extent of passion fruit adoption was 0.025 (2.5% of the overall farm size) while highest was 0.50 (50%). The overall extent of passion fruit adoption in Moiben division was 0.169 (16.9%). In Ainabkoi division, the lowest extent of passion fruit adoption was 0.038 (3.8%) and the highest was 0.53 (53%) while the average extent of adoption was 0.169 (16.9%).

4.3 Econometric results

4.3.1 Results of Heckman two-step procedure

Heckman two-step procedure was used to determine the factors affecting passion fruit adoption and extent of adoption. The procedure was chosen for estimation to correct the sample selection bias as proposed by Heckman (1979). The variables included in the estimation were age, occupation (variable representing farming as main activity and that for combination of farming and businesses), gender, wealth, distance to market, credit access, access to extension services, individual land tenure, farm size, household size, education level, passion fruit price and access to irrigation water. Post estimation of the selection equation results was done to determine marginal effects of variables for use in interpretation. The reason is that coefficients have no direct interpretation because they are just values that maximize the likelihood function. On the other hand, marginal effects have direct interpretation and hence facilitate discussion of the results.

4.3.1.1 Factors affecting passion fruit adoption

Age **(ageyrs)**, farming as main occupation **(farmonly)**, individual land tenure system (**individ)** and availability of water for irrigation (**wtrirrig)** significantly affected the decision to adopt passion fruit. The coefficient of IMR was also significant and positive (0.080) indicating that there were unobserved variables that both increased the probability of selection and a higher than average score on the dependent variable.

Table 12: Marginal effects of Heckman two-step selection equation

Marginal effects after Heckman					
Variable	**Marginal effects**	**Std. Err.**	**z**	**p>|z|**	**x**
farmonly*	0.487	0.183	2.660	0.008*	0.62
fbusines*	0.336	0.204	1.650	0.100	0.20
Ageyrs	-0.009	0.006	-1.770	0.077***	41.43
Edulevel	0.096	0.108	0.890	0.371	2.95
individ*	0.316	0.159	1.990	0.046*	0.84
extbfore*	-0.082	0.155	-0.530	0.596	0.27
Dstmkt	0.001	0.005	0.210	0.836	22.11
creditk*	0.081	0.205	0.400	0.691	0.11
Gnder	-0.055	0.174	-0.320	0.750	1.20
Hsize	-0.005	0.035	-0.160	0.875	5.54
Farmsize	-0.003	0.007	-0.370	0.710	15.93
Lnwealth	0.085	0.085	0.990	0.320	12.31
wtrirrig*	0.481	0.123	3.930	0.000**	0.15
_cons	-3.944	2.589	-1.520	0.128	
mills lambda	0.111	0.064	1.750	0.080***	
Rho	0.941				
Sigma	.1179				

Source: Survey data 2009

(*****) is for discrete change of dummy variable from 0 to 1
** indicates significance at 1%, * significance at 5% and *** significance at 10%

As stated earlier in the literature review, the effect of age in adoption of new agricultural technologies is inconsistent. It can either have positive or negative effect. In this case, age **(ageyrs)** significantly and negatively affected the adoption of passion fruit with marginal effect of 0.009. The interpretation is that, the older farmers were less receptive to adoption of passion fruit. This was attributed to the fact that the older farmers are risk averse when compared to younger farmers (Langyintuo and Mulugetta, 2005; Arellanes and Lee, 2003). According to Omonona, *et al.* (2005), farmer's age significantly and positively affected adoption of improved cassava varieties. However, Masuki *et al*. (2003) found that older farmers were more receptive towards new agricultural technologies due to adequate experience and accumulation of capital. The experience and availability of capital enable farmers to acquire new farming technologies easily as they arise. On the other hand, U-rungsimawong (2000) found no relationship between farmer's age and adoption of neem extracts for use as an insecticide. Ndiema (2000) further found no relationship between age and technology adoption.

Availability of water for irrigation (**wtrirrig)** significantly and positively affected the adoption of passion fruit with marginal effect of 0.481. The farmers who accessed water for irrigation were more able to adopt passion fruit than those who did not have access to. Most parts of Uasin-Gishu County are dry especially Moiben division, therefore availability of water for irrigation was an incentive for farmers to adopt passion fruit. Passion fruit productivity performs poorly when subjected to long dry spells but does well when water is adequate and well distributed throughout the production season. According to Arellanes and Lee (2003), availability of water for irrigation influences positively adoption of new farm technologies due to its sustainability effect in crop production especially during dry spell season.

Farming as a main occupation (**farmonly)**, significantly and positively affected the decision to adopt passion fruit with marginal effect of 0.486. Table 5 indicates that majority of the farmers in Uasin-Gishu County had farming as their main source of livelihood. The perceived trait of passion fruit of being a high yield and high value crop was an incentive for the farmers who depended wholly on farming to adopt it in order to improve on their income. The farmers who engaged themselves on off-farm activities such as schooling, businesses and formal employment had less time to pursue on-farm diversification. The findings concur with that of Rana *et al*. (2000) who found that households who received off-farm income were less likely to pursue on-farm diversification as a method of reducing financial risk. However, some studies have found contrary results, for example Igbokwe and Okoye (2000) found off-farm activities significantly and positively correlating with adoption of rice farming technologies. The argument is that off-farm activities provide income that eventually increases ability of farmers in acquisition of new agricultural technologies. On the other hand, Nantharatana (2003) found that major occupation in farming has effect on adoption of soil and water management practices.

Individual land tenure system (**individ)** significantly and positively influenced the adopting passion fruit with marginal effect of 0.316. This means that security in land use enables farmers to adopt agricultural technologies. Those farmers who privately owned land were more able to adopt passion fruit than those who were under leasehold and community land tenure systems. The private land ownership ensures security of tenure and thus creating an incentive for farmers to adopt new, long term and even riskier agricultural technologies. A study by Arellanes and Lee (2003) confirmed that farmers with title deeds were four times likely to employ more of new techniques due to security of land access. Hwang, *et al*. (1994) found security in land tenure significant and positively affecting adoption of soil conservation practices.

4.3.1.2 Factors affecting the extent of passion fruit adoption

Table 13 presents Heckman two-step outcome equation results. Three variables (age, access to extension services and individual land tenure system) significantly affected the expansion of passion fruit production.

Table 13: Dependent variable – Extent of passion fruit adoption

Variables	**Coefficients**	**Std. Err.**	**z**	**p>|z|**
Farmonly	0.089	0.097	0.93	0.354
Fbusines	-0.001	0.088	-0.02	0.987
Ageyrs	-0.004	0.002	-2.51	0.012*
Edulevel	-0.007	0.033	-0.20	0.840
Pasprice	-0.0001	0.002	-0.07	0.948
Individ	0.139	0.066	2.11	0.035*
Extbfore	0.094	0.040	2.32	0.020*
Dstmkt	-0.0002	0.001	-0.18	0.854
Credit	-0.067	0.055	-1.21	0.225
_cons	0.074	0.241	0.31	0.759

Source: Survey data 2009

*Means variable is significant at 5%

Individual land tenure system (**Individ**) significantly and positively influenced adoption of passion fruit. Those farmers with full rights of land ownership and usage were more able to increase the production of passion fruit in terms of acreage. Private land ownership with title deeds gives farmers right to use the land for anything at anytime (security of tenure) thus creating an incentive to the farmers to adopt new, long term and even riskier technologies. Arellanes and Lee (2003) found that farmers who privately own plots were four times more likely to employ new techniques due to security of land access.

Age (**Ageyrs**) significantly and negatively influenced expansion of passion fruit production. This means that older farmers were less concerned with expansion of passion fruit production. The reason behind this was that unlike younger farmers, older farmers were resistant to change. They believed that they were tired and the expansion of farm enterprise was upon the younger generation. According to Arellanes and Lee (2003), older farmers lack receptivity towards newly introduced farm technologies. Ashenafi (2007) found that as farmers get older, they tend to intensify adoption of new technologies in their farms as a result of more years of experience, higher accumulation of capital and large family sizes. Contrary, Masuki *et al*. (2003) revealed that older farmers tend to intensify adoption of technologies in their farms and attributed this to more years of experience associated with older farmers.

Access to extension services (**Extbfore**) significantly and positively affected the expansion of passion fruit production. Extension agents supply farmers with important information and skills on production, management and marketing. The availability of relevant and adequate information reduces the risk associated with crop production. The reduction in the risk therefore provided an incentive to the farmers to expand production of passion fruit. According to Onemolease and Alakpa (2009) argument, farmers in contact with extension agents are two times more likely to increase adoption of crop-related innovations than those with no contact. Furthermore, Chitere and Van Doorne (1985) found agricultural education and extension services significant and positively affecting adoption of new agricultural technologies. The argument is that the education and extension service facilitates awareness among farmers. Qaim and de Janvry (2003) found that farmers in Argentina with first-hand technical information about Bt cotton were willing to pay more for the technology. Omonona, *et al.* (2005) found contact with extension agents significant and positively affecting adopting improved cassava varieties. They concluded that contact with the extension agents were the major factors for the adoption of improved cassava varieties. Some studies however have revealed the contrary, for example Tshiunza *et al.* (2001) found a negative relationship between extension visits and adoption of bananas.

4.4 Comparative profitability of passion fruit production

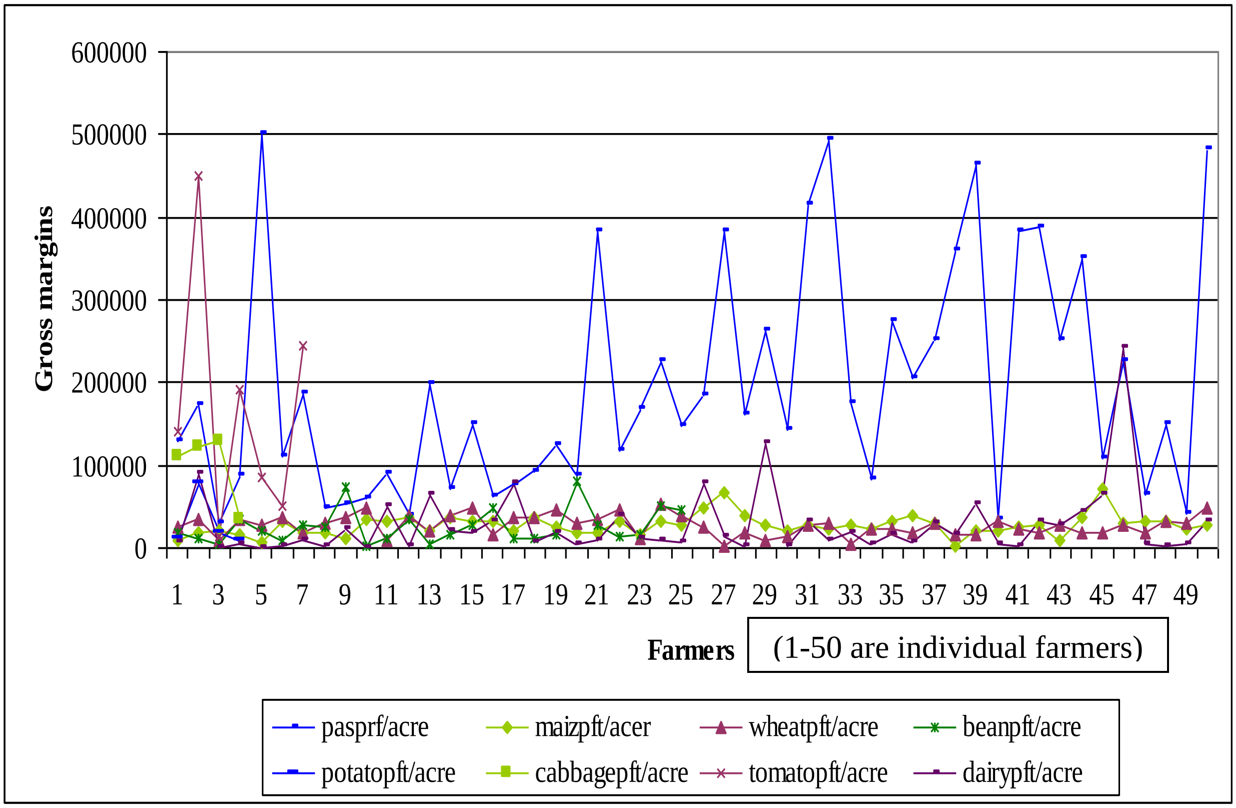
Gross Margin Analysis and DEA model were used to compare profitability of various farm enterprises.

4.4.1 Gross Margin Analysis

Economic variables such as gross margins, returns to land, labour and capital were used to determine whether passion fruit was the most profitable farm enterprise.

4.4.1.1 Graphical comparison of farm enterprises

Figure 3 shows gross margin curves for different farm enterprises. The results indicate that curve for passion fruit gross margin lies above the curves of other farm enterprises. This indicates that passion fruit was more profitable farm enterprise among majority of farmers. Majority of farmers got gross margin per acre of passion fruit ranging from Ksh. 100,000 to Kshs 500,000 as compared to other farm enterprises. The next enterprise in the rank was tomatoes with gross margin per acre ranging from Ksh. 100,000 to Kshs 450,000. Dairy production was third in the ranking with highest gross margin per acre of about Ksh. 250,000. The traditional crops (maize and wheat) which were commonly produced in the County earned farmers less than Ksh. 100,000 per acre as shown in figure 3. Therefore from this comparison, passion fruit was more profitable farm enterprise than other farm enterprises.



Source: Survey data 2009

Figure 3: Graphical comparison of various farm enterprises profitability

4.4.1.2 Mean Gross Margins

For further analysis, all Gross Margins per acre for each farmer per farm enterprise were summed and averaged as shown in table 15. The figures were then used for comparative analysis. But before comparing, it was important that statistical tests were done to determine if differences between the farm enterprises in terms of gross margin really existed. Tukey HSD test at 5% level of significance was performed and results are shown in table 14. Tukey HSD test was preferred because of its ability to compare multiple groups.

The results show that, there was significant difference ($p<0.05$) between passion fruit crop and Maize, wheat, beans, millet, potatoes and dairy farming in terms of gross margin levels. On the other hand, cabbage and tomatoes production had $p>0.05$ indicating no significant difference between their gross margin levels and that of passion fruit.

Table 14: Tukey HSD test for significant difference in gross margins for different farm enterprises

Crop (i)	Farm enterprise (j)	Mean difference (i-j)	Std. error	p-value
Passion fruit	Maize	167839*	14153	0.000
	Wheat	167813*	14153	0.000
	Beans	169138*	17334	0.000
	Millet	140309*	36770	0.005
	Potatoes	166107*	36770	0.000
	Cabbage	96007	36770	0.188
	Tomatoes	26750	28557	0.991
	Dairy	167514*	14153	0.000

Source: Survey data 2009

NB: * Indicates existence of significant difference (at 5%) between gross margin of passion fruit and the farm enterprise bearing the star symbol

Therefore when compared, passion fruit (Ksh. 195,167) still remained the more profitable farm enterprise followed by tomatoes (168,417) while cabbage (Ksh. 99,160) was third in the ranking. Maize (Ksh. 27,328 per acre) and wheat (Ksh. 27,353 per acre) were ranked the last (Table 15).

Table 15: Average Gross Margin for each farm enterprise

Farm enterprise	Average gross margins
Passion fruit	195,167
Tomatoes	168,417
Cabbage	99,160
Potatoes	29,060
Dairy	27,653
Wheat	27,353
Maize	27,328
Beans	26,029

Source: Survey data 2009

4.4.1.3 Returns to Labor and Capital

Returns to labour and capital were used to determine further if passion fruit was still the most profitable farm enterprise. Labour included both family and hired labour and was assumed to have equal productivity. Capital was considered to be the same as total variable costs (labour and input costs) involved in production of a particular farm enterprise. Returns to labour was then calculated by dividing the gross margin per acre by the labour costs per acre for each of the farm enterprise and the results are summarized in table 16.

The return to farmers' capital in tomatoes (5.70) was higher than in the case of passion fruit (2.24) and other farm enterprises yet passion fruit had the highest Gross Margin per acre. This was due to the fact that tomatoes had the lowest total variable costs (Ksh 29,526) when compared with passion fruit (Ksh. 87,032). Another reason may have been that, tomatoes are normally short season crops as compared to passion fruit and as a result, total variable costs within the short production season in tomatoes were expected to be lower. The difference may also have been due to inefficiency in the use of resources (either underutilized or over utilized) in production of passion fruit. In the case of returns to labour, tomato production was leading at 14.95 while passion fruit had 5.54. The higher value of returns to labour in tomatoes was attributed to the fact that tomatoes production had lowest labour costs (Ksh. 11,267) as compared to passion fruit (Ksh. 35,225) production. The differences in the labour costs may have been due to the differences in the length of their production seasons. That is tomatoes have shorter production season than passion fruit production and hence the lower labour cost. Maize and wheat were ranked last despite the low labour and total variable costs associated with them. The reason behind this was that maize and wheat had low value of gross margins resulting from low yields and low market value of their output.

It was expected that farm enterprises with higher production costs will have low returns to labour and capital. However it was not the case for this study. Tomatoes and passion fruit had the highest production costs and at the same time higher returns to labour and capital when compared with maize and wheat which had low production costs as well as low returns to labour and capital. The reason was that, unlike maize and wheat, horticultural crops (like tomatoes and passion fruit) are high yielding and high value crops (Obare, *et al*., 2003; Kuyiah, *et al.,* 2006) which eventually translates to higher gross margin levels even under circumstances of higher production costs. The higher total variables costs associated with passion fruit and tomatoes were attributed to the fact that passion fruit and tomatoes (horticultural crops) are high consumers of pesticides and labour intensive.

Table 16: Returns to labor and capital

Farm enterprises	Average Gross margin (Ksh/acre)	Labor costs (Ksh./acre)	Total variable Costs (TVC) (Ksh./acre)	Returns to labour (GM/labor costs)	Returns to cash capital (GM/TVC)
Passion fruit	195,167	35,225	87,032	5.54	2.24
Tomatoes	168,417	11,267	29,526	14.95	5.70
Cabbage	99,160	9,788	18,173	10.13	5.46
Potatoes	29,060	8,963	21,428	3.24	1.36
Wheat	27,353	9,088	19,029	3.01	1.44
Beans	26,029	6,835	9,739	3.81	2.67
Dairy	27,653	9,556	17,710	2.89	1.56
Maize	27,328	8,258	16,806	3.31	1.63

Source: Survey data 2009

4.4.2 Data Envelopment Analysis

From the literature review, it was noted that the use of gross margin analysis for comparative analysis is not an adequate tool due to its partial measurement of production efficiency. Therefore, further analysis was done by use of DEA model (output oriented) to identify technically efficient farmers in each of the farm enterprises. In most cases, farmers especially small-scale face resource constraint in production and therefore efficiency in resource use under conditions of farm diversification was crucial in determining the optimal farm profits. Data Envelopment Analysis considers units under analysis as decision making units (DMUs) and therefore farmers in this case were assumed to be the DMUs. The gross margins of technically efficient DMUs in each of the farm enterprises were used for comparative analysis. The rule of the thumb was that, technically efficient DMU must have an efficiency score of one while inefficient DMU must have an efficiency score less than one.

The selected sample showed that there were 50 farmers producing Passion fruit, maize, wheat and dairy farming. Beans, cabbage, potatoes and tomato production had varied number of observations (farmers) and at the same time less than fifty and thus they were dropped in the analysis. For better results, only Passion fruit, maize, wheat and dairy enterprises were used in the analysis and enterprise comparisons because of their homogeneity in terms of number of observation (the DMUs). The DEA results are presented in appendix 2 and summary of the same results are presented in table 17.

The results shows that the mean technical efficiency in passion fruit was (0.566) meaning that only 56.6% of the possible output per acre in passion fruit were obtained and 43.4% of the possible output per acre were lost due to improper utilization of the resources. In maize, 66.3% (0.663) of the possible output per acre were obtained and 33.7% were lost as a result of improper use of resources. In wheat 75.3% (0.753) of the possible output per acre were obtained while 24.7% were also lost due to poor utilization of resources. Dairy farming had attained only 40.4% (0.404) of the possible output per acre and lost 59.6% of the output due to the poor resource utilization.

Table 17: Summary of Data Envelopment Analysis results

Passion fruit		**Maize**		**Wheat**		**Dairy**		**Farm enterprise**	**Efficiency Mean**	**DMUs**	**Percentage of TE DMUs**
TE DMUs	**GM Levels**	**TE DMUs**	**GM Levels**	**TE DMUs**	**GM Levels**	**TE DMUs**	**GM Levels**	**Passion fruit**	0.566	50	16
1*	130,000	2**	19,595	6*	37,600	2*	90,989	**Maize**	0.663	50	16
4*	88,467	11**	32,630	15**	49,467	6*	1,374				
5*	500,000	17*	20,741	24**	51,980	15**	17,789	**Wheat**	0.753	50	12
7**	186,800	24*	32,100	18**	36,900	24*	8,416				
27*	381,933	26*	47,550	27*	2,617	40**	5,078				
32*	493,600	27*	66,290	50**	48,715	41*	2,207	**Dairy**	0.404	50	18
38**	361,020	32**	22,357	–	–	42**	32,068				
39**	464,975	45**	70,580	–	–	45**	64,116				
–	–	–	–	–	–	46*	242,000				

Source: Survey data 2009

GM - Gross margin
TE - Technical efficiency
DMU – Decision making units (farmers)
* DMU is technically efficient under variable returns to scale assumption only
** DMU is technically efficient under both variable and constant returns to scale assumptions

4.4.2.1 Enterprise mean gross margins under conditions of efficiency

Gross margins for technically efficient DMUs in each of the farm enterprises were isolated, summed and averaged as shown in table 18. The results show that passion fruit (Ksh. 325,849 per acre) was still leading in profitability even after considering efficiency in production. It was followed by dairy farming with Ksh. 51,560 per acre while maize (Ksh. 38,980 per acre) and wheat (Ksh. 37,880 per acre) remains the crops with low profitability.

Table 18: Mean gross margins of farm enterprises given efficiency in production

DMUs	Passion fruit	Maize	Wheat	Dairy
1	130,000	19,595	37,600	90,989
2	88,467	32,630	49,467	1,374
3	500,000	20,741	51,980	17,789
4	186,800	32,100	36,900	8,416
5	381,933	47,550	2,617	5,078
6	493,600	66,290	48,715	2,207
7	361,020	22,357	_	32,068
8	464,975	70,580	_	64,116
9	_	_	_	242,000
Total gross margins	2,606,795	311,843	227,278	464,037
Number of DMUs	8	8	6	9
Mean gross margin	325,849	38,980	37,880	51,560

Source: Survey data 2009

Although passion fruit and dairy farming were more profitable farm enterprises, they experienced poor resource utilization in production than in the case of maize and wheat. However, this indicates that passion fruit and dairy enterprises still have a lot of potential to increase further the current farm income. That is, 43.4% and 59.6% of the total possible output was not attained in passion fruit and dairy production respectively when compared to 33.7% and 24.7% for maize and wheat respectively. This means that, if full efficiency in production is achieved in all the farm enterprises, passion fruit and dairy farm enterprises will increase the current farm income by a bigger margin than the increase by maize and wheat.

Wheat had highest efficiency score (0.753) when compared with maize (0.663). The differences in the efficiency scores might have been the use of mechanization and scale of production. Mechanization is widely used in wheat farming operations than in maize production. Mechanization improves production efficiency and that is why the efficiency score in wheat production is higher.

4.4.2.2 Highest gross margin given efficiency in production

Among the technically efficient DMUs (farmers) in each of the farm enterprises, only one efficient DMU with highest level of gross margin (Table 17) was picked for comparative analysis. The results are then tabulated in table 19.

Table 19: Highest gross margin of farm enterprise given efficiency in production

Farm enterprise	Highest Gross margins/acre
Passion fruit	500,000
Dairy	242,000
Maize	70,580
Wheat	51,980

Source: Survey data 2009

The results show that passion fruit crop (Ksh.500, 000/acre) was still the more profitable farm enterprise than dairy (Ksh.242, 000/acre) maize (Ksh.70, 580/acre) and wheat (Ksh.51, 980/acre) even after considering efficiency under conditions of resource constraint. In conclusion, passion fruit production is suitable for smallholder farmers who face scarcity of resources.

The comparative profitability of passion fruit have shown that passion fruit is more profitable farm enterprise and it has high potential for increasing further farm incomes than traditional crops such as maize and wheat. Passion fruit is a horticultural crop (and cash crop) associated with high market value hence its ability to increases farm incomes by greater margin. Other studies have also confirmed that horticultural crops are more profitable than traditional crops such as sorghum. According to Akoroda and Teri (2004), cash crops such as cassava generate more cash income for the largest number of households in comparison with other staple crops.

Reddy, et al. (2002), in their study compared performance of horticultural crops (seed spices like cumin, coriander and chilli and cabbage, cauliflower and tomato and perennial tree fruit like aonla) with traditional dry land crops (mustard, taramira, chickpea (gram), green gram, black gram, horse gram and sorghum + red gram) in terms of yields and economic returns under watershed and non watershed conditions. Their findings show that, crop yields and net profits increased in all the commodities when they were raised in a watershed. However, horticultural crops in the system yielded more returns than traditional crops in a watershed area on a sustainable basis. A net profit of Rs 100,500 / ha was realized from growing cumin (a horticultural crop).

Table 20: Economic evaluation of horticultural crops vis-à-vis traditional dry land crops in a watershed area (per ha area)

No	Crop	Expenditure (*Rs*)	Gross Income (*Rs*)	Net profit (*Rs*)
Horticultural crops				
1.	Chilli (dry)	30,500	55,000	24,500
2.	Coriander	7,900	30,500	22,500
3.	Cumin	21,500	122,000	100,500
4.	Cabbage or Cauliflower	12,800	30,000	17,200
5.	Tomato	9,000	23,500	13,500
6.	Aonla	10,000	56,000	46,000
Traditional dry land crops				
7	Mustard	8,900	18,500	9,600
8	Taramira	7,800	15,000	7,200
9	Chickpea (gram)	9,800	18,750	8,950
10	Green gram	5,800	11,200	5,400
11	Black gram	5,600	10,500	4,900
12	Horse gram	1,200	3,900	2,700
13	Sorghum + Red gram (3:1 ratio)	7,400	11,400	4,000

Adopted from Reddy, et al., 2002

The study further revealed that, expenditure to raise horticultural crops in one hectare area was in general higher than that of the traditional dry land crops. It ranged from *Rs*. 7,900 / ha in coriander to *Rs*.21, 500 in cumin in horticultural crops and *Rs*. 1,200 in horse gram to *Rs*. 8,900 in mustard in traditional dry land crops of Rajasthan. Gross and net margins were also much higher with horticultural crops when compared with traditional dry land crops even when they were grown in a watershed area. Highest income: cost ratio (6.26) and net profits (1,005,000) were realized by growing cumin closely followed by aonla (5.60 and *Rs*. 46,000 respectively) as presented in table 20. Raising chilli or coriander was even more profitable than raising vegetable crops like tomato, cabbage and cauliflower (Reddy, et al., 2002).

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Different socio-economic characteristics of both categories of farmers (passion fruit adopters and non-adopters) were determined. These include age, Household size, farm size, experience, land tenure system, education level, occupation and gender. However, the statistical tests showed that there was no significant difference between the two categories of the farmers in terms of the socio-economic characteristics ($p>0.05$). In conclusion, the adopters of passion fruit had no comparative advantage of adopting passion fruit over the non-adopters of passion fruit.

Farming as main occupation, private land ownership and availability of water for irrigation positively affected the decision to adopt passion fruit. Farmers who had no off-farm activities were more able to adopt passion fruit. This indicates that majority of passion fruit adopters were depending mainly on farming as main source of livelihood. Access to land title deeds also played a key role in adoption of passion fruit. Land title deeds provide security of using land and as collateral in securing agricultural credit. Security in land ownership and usage is crucial as it increases the ability of the farmer to adopt passion fruit. Access to water for irrigation is crucial in the areas where rainfall is low like most parts of Moiben division. Irrigation is very important more so during dry spell season which is somehow longer in Moiben division. On the other hand age showed an inverse relationship with the decision to adopt passion fruit. However this can be reversed through increasing agricultural education among older farmers in order to expose to them the importance of adopting new agricultural technologies. In conclusion, the incentives for adopting passion fruit are necessary but not sufficient for wider adoption of passion fruit.

On the factors affecting extent of passion fruit production, age, individual land tenure system and extension services were significant with positive effect except age. Farmers with land title deeds found it easier to increase land under passion fruit due to the right to access and use the land. Access to extension services equipped farmers with more knowledge and skills hence enabling them to expand passion fruit production. Age had negative effect on expansion of passion fruit production showing that older farmers were risk averse in adoption of agricultural technologies. In conclusion, the incentives for expansion of passion fruit production were necessary but not sufficient.

The extent of passion fruit adoption in Uasin-Gishu County was found to be 0.169 while the average farm size per household was about 14 acres. This means that about 2.4 acres (16.9%) of the overall farm size (14 acres) per household was allocated to passion fruit. Therefore the extent of adoption was not low as such given that many farmers were small scale and that several farm enterprises were competing for the same farm size.

As reported earlier, the farmers were facing resource constraints in the diversification process and that in most of the cases; the uptake of passion fruit was in form of crop trade-off. It was then expected that production of passion fruit should be a profitable enterprise to justify its adoption and farm enterprise trade-off. Gross margin levels of different farm enterprises were compared and their significant differences tested and indicated that the gross margin levels were different ($p>0.05$). The results showed that passion fruit was the more profitable farm enterprise when compared to other farm enterprises. This indicates that it was a rational decision for the farmers to adopt passion fruit. This further shows that comparative advantage of producing passion fruit in Uasin-Gishu County exists.

Technical Efficiency scores for different farm enterprises were determined. The results show that passion fruit (56.6%) and dairy (43.4%) farming had the lowest level of Technical Efficiency and higher levels of gross margins (Kshs 325,849 and Kshs 51,560 respectively). On the other hand, maize (66.3%) and wheat (75.3%) had the highest level of Technical Efficiency and at the same time low gross margin levels (Kshs 38,980 and Kshs 37,880 respectively) relative to passion fruit and dairy farming. The results clearly concludes that passion fruit and dairy farming still have a lot of potential to increase further farm incomes than maize and wheat farm enterprises if only proper utilization of the scarce resources is observed.

5.2 Recommendations

This study recommends that more farmers should adopt passion fruit and dairy farm enterprises because they are the more profitable farm enterprises with a higher potential to increase farm incomes even under conditions of resource constrain. The technical efficiency scores showed that passion fruit has more potential to increase further farm incomes. Farmers therefore advised to utilize properly the scarce production resources. This will reduce cost of production as well as increases yields and consequently farm incomes.

However to ensure widely adoption of passion fruit, it is important that government should formulated policies related to water supply and distribution to ensure accessibility and usage in irrigation especially in dry areas of Moiben division. This will facilitate adoption of passion fruit and other useful crops. The government should also ensure that farmers access land title deeds so as to create an incentive for adoption of passion fruit and other new agricultural technologies. Extension services also played a key role in the expansion of passion fruit production and therefore government should deploy more agricultural extension officers to rural areas to facilitate dissemination of new agricultural knowledge, skills and other new agricultural technologies.

Generally, agricultural industry should be improved by the government through formulation and implementation of relevant and effective agricultural policies as well as increasing funding. These will create incentives for the farmers to pursue on-farm diversification rather than off-farm diversification.

5.3 Further research

This study determined Technical Efficiency scores for different farm enterprises but did not determine the causes of inefficiency in production of the farm enterprises. Therefore further research to determine causes of the production inefficiency is recommended. Understanding the causes of production inefficiencies in different farm enterprises will be important in formulation of effective and efficient policies necessary for improvement of agricultural sector in Kenya.

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APPENDICES

APPENDIX 1: QUESTIONAIRE

This study is conducted to find out the factors determining passion fruit adoption and evaluation production efficiency of the adopters. The information provided will assist the program to formulate policies and programmes that will improve spread and performance of passion fruit crop in the County. The information needed is for the period January-December, 2008 and all information will be treated as confidential.

Questionnaire identification

Questionnaire number____

Division____________________ Location____________________________________

Name of enumerator____

Farmers' name____

Type of farmer (Tick) ☐ passion fruit producer ☐ Non-producer of passion fruit

Date_______________________ Starting time_____________ Ending time_______________

1.0 Farmers' background information

1.1Gender/sex: ☐ Male ☐ Female (*Tick where appropriate*)

1.2 Relation to head (*Tick where appropriate*)

- i) Head ☐
- ii) Wife ☐
- iii) Sibling ☐
- iv) Other (specify)____

1.3 Occupation (*Tick where appropriate*)

- i) Farmer ☐
- ii) Business man ☐
- iii) Employed ☐
- iv) Others (*specify*)____

1.4 Age (in years) ____

1.5 Education level (*Tick where appropriate*)

- i) None ☐
- ii) Primary school ☐

iii) Secondary school ☐
iv) University ☐
v) Others (*specify*)__________________

1.6 Household size (*number of people living and eating together*) _________________________

1.7 Household wealth

i) House (specify)________________________
ii) Vehicle______________________________
iii) Overall farm size (*in acres*) _____________
iv) Livestock ____________________________
v) Others (*specify*)________________________

1.8 How many years have you been farming? _________________________________

2.0 Physical and economic factors

2.1 Sources of household off-farm income and capital

Sources	**Number of days/month**	**Total annual amount (Kshs)**
Credit/loan		
Remittances		
Gifts		
Others specify 1.		
2.		
Total amount		

2.2 Land tenure: ☐ Individual ☐ Leasehold ☐ Communal (*tick*)

Specify other ____

2.3 Total acres of land hired in for passion fruit ______ Total acres of land hired out ______

Hiring in cost per acre/year____________ Hiring out income per acre/year ___________

2.4 i) have you ever grown passion fruit? Yes ☐ No ☐ (*tick*)

ii) If yes, what attracted you to grow passion fruit?

____

iii) If yes, what are the factors constraining the expansion of your passion fruit enterprise?

1) High initial cost of production Yes ☐ No ☐
2) Lack of capital Yes ☐ No ☐
3) Lack of access to clean seedlings Yes ☐ No ☐
4) Lack of land Yes ☐ No ☐
5) Poor soils Yes ☐ No ☐
6) Lack of market Yes ☐ No ☐
7) Pests and diseases Yes ☐ No ☐
8) Others(specify)____
____

iv) If not, what are reasons for not adopting it? (*Tick where appropriate*)

1) High initial cost of production Yes ☐ No ☐
2) Lack of capital Yes ☐ No ☐
3) Lack of access to clean seedlings Yes ☐ No ☐
4) Lack of land Yes ☐ No ☐
5) Poor soils Yes ☐ No ☐
6) Lack of market Yes ☐ .No ☐
7) Pests and diseases Yes ☐ No ☐
8) Others(specify)____
____

v) can you say price paid for passion fruit in market influenced you to grow passion fruit?

Yes ☐ No ☐

2.5 Do you have water for irrigation? Yes ☐ No ☐

i) If yes, do you use in production of passion fruit? Yes ☐ No ☐

ii) If no, give reasons____

iii) If no, and given water, can you produce passion fruit or expand its production?

Yes ☐ No ☐

reasons____
____

1.6 i) If you have grown passion fruit, has any diseases affected your passion fruit crop?

Yes ☐ No ☐

ii) How did the disease affected your passion fruit crop? (*Circle*)

a) Reduction in yield

b) Increased cost of production

c) Others specify____

iii) How the disease effected your decision in production of passion fruit? (*circle*)

a) Increased the land under passion fruit (*specify no. of acres*)________________

b) Reduced the land under passion fruit (*specify no. of acres*)________________

c) Maintained the number of acreage under passion fruit

d) Stopped producing passion fruit

e) Others (*specify*)____

iv) Rate the effect of the disease in your passion fruit farm (*circle*)

1) No effect (2) Light effect (3) Moderate effect (4) High effect

1.7 i) If you have grown passion fruit, has any pest affected your passion fruit crop?

Yes ☐ No ☐

ii) if yes, how did the pest affected passion fruit production and farm decisions? (*circle*)

a) Reduction in yield

b) Reduction in acreage under passion fruit production

c) Stopped production of passion fruit production

d) Increased cost of production

e) Others specify____

iii) How did the pests affected your decision in production of passion fruit? (*circle*)

a) increased the land under passion fruit (*specify no. of acres*)_______________

b) reduced the land under passion fruit (*specify no. of acres*)________________

c) Maintained the number of acreage under passion fruit___________________

d) Stopped producing passion fruit___________________________________

iv) Rate the effect of the pests in your passion fruit farm (*circle*)

1) No effect (2) Light effect (3) Moderate effect (4) High effect

2.8 Extension services;

i) Did you have an extension contact before starting passion fruit production? (*tick*)

Yes ☐ No ☐

ii) If yes, what information did you obtained and influenced you to adopt passion fruit?

a) ______________________________

b) ______________________________

c) ______________________________

iii) Can you say the extension services influenced you to grow passion fruit? (*tick*)

Yes ☐ No ☐

2.9 i) Name of the nearest passion fruit market ______________________________

ii) Distance to the market in Kilometers______________________________

iii) Total transport cost to the market ______________________________

1.9.1 Is the source of capital used in production of your passion fruit enterprise a credit/loan? (*tick*)

Yes ☐ No ☐

3.0 Resource use and output levels

3.1 Composition of the household and labor profile

HH number	First name	Sex	Age in Years	Years of schooling	Months worked on farm	Days per month	Hours per day
1.							
2.							
3.							
4.							
5.							
6.							

3.2 Crop enterprises production information

3.2.1 Labor use information in crop production

Activity	Crop	Labor type (f=family and h=hired)	Quantity (hours, days, months)	Cost (Kshs)
Totals				

Activity: Clearing of land, ploughing, harrowing, planting, weeding, spraying, pruning, harvesting, transportation (from farm and to market), threshing, shelling and others specify.

3.2.2 Input expenditure in crop production

Crop	Type of input	Unit (litre, kg)	Total units used	Unit cost	Total costs
Totals					

Inputs: Seeds, fertilizers, agrochemicals (herbicides, pesticides, and fungicides), seedlings, manure and others (*specify*)

3.2.3 Crop output information

Crop	Acres	Annual productions (bags, kgs)	Unit price (Kshs)	Total value
Totals				

3.3 Livestock production information

3.3.1 Labor use information in livestock production

Livestock type	Activity	Labor type (f=family and h=hired)	Quantity(hours ,days, months)	Unit cost	Total(Ksh)
Totals					

Activities: Herding, feeding, shed cleaning and others (*specify*)

3.3.2 Input expenditure in livestock production

Livestock type	Type of input	Unit(litres, kg)	Total units used	Unit cost	Total costs
Totals					

3.3.3 Livestock output information

Livestock type	Output units (meat-kg, eggs-number, milk-litres)	Total annual units of the output produced	Unit price (Kshs)	Total value
Totals				

APPENDIX 2: RESULTS OF THE DATA ENVELOPMENT ANALYSIS MODEL

DMU NO.	Passion (θ)	Passion Π/acre	Maize (θ)	Maize Π/acre	Wheat (θ)	Wheat Π/acre	Dairy (θ)	Dairy Π/acre
1	1.000	130000	0.347	10355	0.896	25933.3	0.221	7376
2	0.492	173986.7	1.000	19595	0.772	33810	1.000	90988.8
3	0.188	29550	0.472	21450	0.438	9750	0.204	821.1
4	1.000	88466.6	0.287	16271.43	0.819	33700	0.141	3759.7
5	1.000	500000	0.475	6610	0.660	27000	0.051	549.6
6	0.390	111220	0.760	32153.33	1.000	37600	1.000	1374.1
7	1.000	186800	0.643	18200	0.738	19450	0.151	8950
8	0.247	48700	0.623	19120	0.848	29800	0.089	1591.1
9	0.251	52500	0.331	11040	0.830	37810	0.540	22720
10	0.245	60760	0.766	35043.33	0.975	48025	0.116	543.4
11	0.284	90000	1.000	32630	0.921	8361.8	0.368	51846.6
12	0.259	39550	0.980	36100	0.868	38950	0.400	1724.9
13	0.519	197800	0.456	20265	0.602	21450	0.136	65510
14	0.260	72000	0.616	35783.33	0.835	39900	0.248	20232
15	0.334	150800	0.623	31560	1.000	49466.6	1.000	17788.8
16	0.448	63000	0.587	32300	0.469	15550	0.238	32780
17	0.323	76200	1.000	20741.25	0.901	36250	0.540	79600
18	0.301	92300	0.703	36550	1.000	36900	0.159	7128.5
19	0.444	123700	0.527	26416.67	0.941	45580	0.226	18487.5
20	0.292	87800	0.452	18071.88	0.707	31100	0.114	3910
21	0.863	383200	0.535	19056.22	0.912	35175	0.135	9350
22	0.362	118666.7	0.603	31335	0.875	45700	0.386	39143.3
23	0.453	168200	0.571	16176.67	0.705	10630	0.196	12100
24	0.546	225865	1.000	32100	0.911	51980	1.000	8416
25	0.427	147400	0.749	26878.33	1.000	38900	0.136	6466.6

26	0.511	185300	1.000	47550	0.701	26100	0.535	78330
27	1.000	381933.3	1.000	66290	1.000	2616.6	0.238	13860
28	0.436	161900	0.851	40069.2	0.562	19520	0.105	3100.6
29	0.767	262650	0.628	26600	0.921	8361.8	0.810	127330
30	0.407	143200	0.456	20020	0.460	14200	0.113	3161.5
31	0.915	414500	0.701	28150	0.692	26900	0.278	31445
32	1.000	493600	1.000	22357.14	0.763	29470	0.165	9147.8
33	0.444	175400	0.556	26738	0.359	5735	0.472	19100
34	0.262	83950	0.534	23750	0.679	24214.2	0.107	3683.6
35	0.704	274150	0.746	33000	0.649	22900	0.272	16903
36	0.503	204720	0.814	39506	0.552	18300	0.137	6330.9
37	0.918	250500	0.943	30700	0.777	30775	0.231	29710
38	1.000	361020	0.404	1586.5	0.527	15150	0.186	15413.3
39	1.000	464975	0.536	21795	0.549	16650	0.450	52900
40	0.282	35320	0.497	20280	0.980	32240	1.000	5078.1
41	0.863	383200	0.511	25102	0.672	23666.6	1.000	2207.4
42	0.836	387200	0.616	28590	0.599	18700	1.000	32068
43	0.626	250750	0.489	8293.667	0.736	28825	0.602	26921.3
44	0.818	350400	0.762	35996.67	0.517	18945	0.700	43380
45	0.639	109166.7	1.000	70580	0.601	19100	1.000	64116
46	0.387	225875	0.610	29355	0.682	26675	1.000	242000
47	0.416	65000	0.599	32140	0.506	19504.6	0.110	4538
48	0.401	149600	0.587	32300	0.811	32700	0.113	2487.5
49	0.243	42480	0.549	22553	0.739	28933.3	0.117	4450
50	0.989	483075	0.654	27300	1.000	48715	0.675	31829.4

(θ) Efficiency score, **Π** gross margins and **DMU** decision making units (Farmers)