AN ASSESSMENT OF THE IMPACT OF EXPORT HORTICULTURE FARMING ON FOOD SECURITY OF SMALLHOLDER FARMERS IN MBOONI, KIRINYAGA AND BUURI, KENYA

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DECLARATION AND RECOMMENDATION

DECLARATION

I, Jane Wambui Chege hereby declare that this is my original work and has not been presented to any other university for examination.

Sign: ----------

Date: ----------

RECOMMENDATION

This work has been submitted with our approval as supervisors.

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ASDS	Agricultural Sector Development Strategy
ATT	Average Treatment Effect for the Treated
CIA	Conditional Independence Assumption
CSC	Common Support Condition
DFID	Department for International Development of the government of United Kingdom
EU	European Union
EurepGAP	European Retailers Produce Working Group for Good Agricultural Practices,
GDP	Gross Domestic Product
Global GAP	Global Good Agricultural Practices
HDDI	Household Dietary Diversity Index
HFIAI	Household Food Insecurity Scale Access Indicator
IFAD	International Fund for Agricultural Development
IV	Instrumental Variable
KBM	Kernel Based Matching
MDGs	Millennium Development Goals
MPND	Ministry of Planning and National Development
NNM	Nearest Neighbor Matching
OLS	Ordinary Least Squares
PSM	Propensity Score Matching
RM	Radius Matching
SHGs	Small-holder Growers
VIF	Variance Inflation Factor

ABSTRACT

In attempting to achieve household food security for smallholder farmers, the question of having food security in the pocket, which is the use money from cash crop to purchase food or food security through food self-sufficiency by consumption of one's own produce, elicits strong debate. Synergies and tradeoffs exist between cash cropping, food cropping and food security. Available evidence on the impact of cash cropping on food security shows mixed results. Different potential negative and positive impacts can be identified which vary with choice of cash crops and the situation in which they are being grown and marketed. Following these mixed results from literature, the relationship between cash cropping and food security seems non-linear and unpredictable and it is not possible to tell what the effect of a particular cash crop on food security is, unless an empirical analysis is carried out.

Production of horticultural products for export is a major cash cropping practice in Kenya which is ranked third in terms of foreign exchange earnings after tourism and tea. It is practiced in different regions in the country but three districts (Kirinyaga, Mbooni and Buuri) were used in this study for comparative reasons.

The study sought to assess the food security situation in the study areas, estimate the factors influencing the food security situation and finally assess the impact of export horticulture on food security situation. Per capita calorie intake (7-day recall) and Household Dietary Diversity Index (HDDI) methods were used to measure food security. Per capita calorie intake assessed the adequacy of food intake while the HDDI assessed the quality of food intake. Ordinary Least Squares (OLS) and Poisson regressions were estimated to assess the factors affecting food security. To assess impact of export horticultural farming on food security, a propensity score matching method was employed on per capita calorie intake. Per capita calorie intake results indicated that on average smallholder farmers in Mbooni were food insecure while those of

Kirinyaga and Buuri were food secure. However, there was no significant difference in the diet quality in these districts as indicated by the HDDI. Export horticulture farming had a positive effect on per capita calorie intake in Kirinyaga district but a negative effect in Mbooni district. The effect in Buuri district was not statistically significant.

Household size was found to negatively affect per capita calorie intake across all the districts. It was also found to affect HDDI negatively in Buuri and Kirinyaga but had a positive influence in Mbooni. Household head education, water source, wealth and the household head years of farming experience were positively influencing per capita calorie intake in Mbooni. In Kirinyaga, total acres, the gender of the household head and income category were found to positively influence per capita calorie intake. In Buuri, the proportion of the time when the household head is able to get employment in or out of his or her farm was found to positively influence the per capita calorie intake and so was group membership, source of water and the total acres in a household. Growing export horticulture was found not to have any significant effect on diet quality in Buuri and Mbooni but had a positive effect in Kirinyaga.

Policies aimed at encouraging smallholder farmers to participate in export horticulture farming should be promoted in Kirinyaga. However, the study recommends further analysis on the production and marketing conditions of export horticulture in Mbooni. An in depth livelihood analysis and gender dimensions of income use is also called for.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

1.1.1 Kenya Horticultural Industry

The horticulture industry is the fastest growing agricultural sub-sector in the country, and is ranked third in terms of foreign exchange earnings from exports after tourism and tea (HCDA, 2009). In 2011 the horticultural industry earned the country Kenya shillings 91.2 billion from exports and an estimated Kenya shillings 113.8 billion from the domestic market (Republic of Kenya, 2012). Horticulture contributes 36 percent of agricultural GDP and continues to grow at between 15 and 20 percent per year. The industry employs over six million Kenyans both directly and indirectly. Of the total horticultural production, about 95 percent is consumed locally while the remaining 5 percent is exported, yet in terms of incomes, the export segment earns the country large amounts of foreign exchange (Republic of Kenya, 2012). The Government has therefore identified horticulture as a major sub-sector in realizing the country's "Vision 2030" which envisages Kenya as middle income earner economy and semi-industrialized country by the year 2030.

Recognizing the subsector as one of the most important ones in the achievement of the vision 2030, the government has put in place a national horticultural policy to propel the industry to growth and sustainability, with an objective to sustain the industry's growth and development to ensure among others objectives, food and nutrition security. The subsector is thus expected to contribute to the Millennium Development Goal number one that is aimed at halving the proportion of people who suffer from hunger by the year 2015, towards eradicating extreme poverty and hunger.

Kenya has been the second most successful sub-Saharan Africa exporter of horticultural products next to South Africa. The country is one of the world's leading exporters of fresh green beans (French and runner beans, snow peas and sugar snaps) as well as a minor exporter of tropical fruits (e.g. avocado, papaya and passion fruit). Other vegetables exported include squash, peas, aubergines, chilli and sweet corn. The European Union (EU) is the dominant market for Kenyan exports – and after Morocco, Kenya is the biggest fresh vegetable supplier to the EU. Other markets for Kenyan exports include Saudi Arabia and South Africa (Legge *et al*. 2006).

Export of fresh fruits and vegetables from Kenya, targets almost exclusively the European market, thus stricter regulations, like European Retail Produce Working Group Good Agricultural Practices (EurepGAP), present a challenge for the Kenyan horticulture sector (Asfaw *et al*. 2007). These exports have been associated with significant smallholder involvement in production. In the 1990s, researchers estimated that three quarters of fresh fruit and vegetable exports production came from small-holder growers (SHGs). However, smallholder participation has declined in recent years due to the high cost of managing smallholder out growers and the need to have a critical size and number (Legge *et al*. 2006). Most of the decline has occurred in Kenya, despite the large amount of donor support. This indicates the harsh reality and high risks of supplying fresh produce to this highly demanding sector. The SHGs decline in number is mostly as a result of the increased costs and managerial burden associated with meeting private sector food safety standards and the decrease in external funds to maintain smallholder participation. Nevertheless, McCulloch and Ota (2002) report that smallholders participating in export horticulture, whether as producers or the workforce employed in the sector are better off than non-participating ones, with average annual household incomes of the former being higher.

1.1.2 Definition of Food Security

Food security is a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 2002). This definition integrates distinct but inter-related dimensions of the concept of food security, that is; access to food, availability of food, and the biological utilization of food, as well as the stability of all these factors.

Food availability is achieved when sufficient quantities of food are available to all individuals, while access is ensured when a household and all members of the household have enough resources to acquire food to meet their nutritional and dietary requirement. Food utilization has public health dimensions and requires a diet providing sufficient energy and essential nutrients, along with access to potable water and adequate sanitation. Stability concerns the balance between vulnerability, risk, and insurance which are often termed as security.

1.2 Problem Statement

Production of horticultural products for export is a major cash cropping practice in Kenya. This is considered so since, while horticultural products for domestic market are readily consumed in the farm households where they are produced in Kenya, most export horticulture products are seen as cash crops intended only for the export market. Thus, unlike domestic market vegetables and staple crops such as maize, Irish potatoes and cabbages, the contribution of export horticulture to food security in Kenya is less direct and more similar to conventional cash crops such as tea and sugarcane.

The debate of the impact of cash cropping system on food security has two divergent views. Proponents argue that cash crops are a prerequisite for agricultural growth and development and

say that synergies exist between cash and food crops. The opponents advocate for "food first" strategy for smallholder farmers since cash crops expose them to unpredictable market fluctuations, compromising their food security. Different potential negative and positive impacts can be identified which vary with choice of cash crops and the situation in which they are being grown and marketed. For instance, Von Braun and Kennedy (1986); Jayne and Govereh (1999) and Bolwig and Odeke (2007), independently show that cash cropping is associated with increased staple food production due to the synergy between the two systems. On the other hand, Anouk (2010) and Sorre (2011), also independently indicate that cash cropping often increases the competition for resources (e.g., land and labour) between cash and food crops, and pose a threat to food security. Langat *et al*. (2010), after assessing household food security of commercialized subsistence economies, pointed to the deteriorating food security situation of tea farmers in Nandi South Kenya and recommend diversification of farm enterprises. After reviewing several studies carried out in Africa, Schneider and Gugerty (2010), reckon that given the heterogeneity of crops and production structures across the continent, it is challenging to draw strong policy conclusions from the available evidence. From the review, the empirical data available to evaluate the impact of cash crop production on smallholder welfare remains relatively weak.

Following these mixed results from literature, the relationship between cash cropping on food security seems non-linear and unpredictable and it is impossible to tell what the effect of a particular cash crop on food security is unless an empirical analysis is carried out. This is particularly so for French beans, the main export crop in consideration in this study, which Strasberg *et al*. (1999) found to be negatively correlated with food crop productivity, and so was sugarcane and tea.

So far, the concern of the macro-economic impact of horticultural export subsector in terms of growth and export earnings and employment creation has been termed a success, but the micro-level impacts remain largely under investigated. In assessing the micro level impact, a study by McCulloch and Ota (2002) report that households involved in horticultural export had higher income compared to those which were not. However, increased income does not automatically result to increased food security. Moreover, the presence of private food safety standards in the horticultural export sector further complicates the issue and makes prediction intricate. Great initial investment, operating production and transaction costs are involved in complying with the private standards in order to access the export market, and they act as a challenge to continued smallholder export participation. Afari (2007), reports that notwithstanding the enormous contribution of horticultural exports to foreign exchange earnings in Ghana, the micro level distributional effects had not favoured the chronically poor households who are structurally impeded from seizing the existing opportunities of the export boom by virtue of their poor resource endowment and liquidity constraints. There is evidence in Kenya too that some smallholders have exited from the business (Okello *et al*. 2007; Graffham *et al*. 2007).

Nevertheless there are studies focusing on the impact of private food safety standards on the industry, that have shown that despite the great initial investment in compliance with standards, the standards have had, among other benefits a positive impact on income (Asfaw *et al*. 2007; Mithofer *et al.* 2007; Mwangi, 2008). However, it was not clear whether these benefits were sustainable in the long run or whether the increased income resulted to improved food security status and general improvement of smallholder farmers' wellbeing.

Although the national horticultural policy in place has an objective of among others, achieving food and nutritional security, the impact of horticulture export on smallholder household food security is not documented and probably remains under-investigated. Thus, it is not known how far the Kenya smallholder export horticulture production has impacted on food security and livelihood, hence the motivation for this study.

1.3 Purpose and Objectives

The purpose of this study is to determine the impact of export horticulture farming on the food security of smallholder farmers in Mbooni, Kirinyaga and Buuri Districts in Kenya. The specific objectives are;

1. To assess the food security situation of smallholder farmers in Mbooni, Kirinyaga and Buuri Districts.
2. To assess the factors determining food security among the small holder farmers in the study areas.
3. To estimate the impact of export horticulture farming on household food security of smallholder farmers.

1.4 Hypotheses

1. Smallholder farmers are not food secure.
2. Individual Social economic factors like age, education, household size etc. have no effect on the food security of smallholder export horticulture farmers
3. Participation in export horticulture farming has no impact on food security.

1.4 Justification

Kenya's Agricultural Sector Development Strategy (ASDS), envisions a food secure and prosperous nation with the overall goal of the agricultural sector to achieve an average growth rate of 7 per cent per year. The strategy has, among others, target to reduce food insecurity by 30 per cent to surpass the MDGs by the year 2015 (Republic of Kenya, 2010). The government has also put in place a national horticultural policy with an objective of sustaining the horticulture industry's growth and development to ensure food and nutrition security. The policy also aims at ensuring that the industry provide materials for primary processing, compete favorably in the export market and earn more foreign exchange. It is also expected to generate increased incomes and employment for producers, and generally contribute to the broader economic goals as envisaged in Vision 2030 (Republic of Kenya, 2012).

Evidence from a study by McCulloch and Ota (2002) shows that horticulture contributes to poverty reduction and is associated with increased income. However, although food security is closely linked with income and/or poverty level, traditional income and poverty measures do not provide clear information about food security even though food insecurity and hunger stem from constrained financial resources. The food security measures provide independent, more specific information on the dimension of well-being than can be inferred from income data alone (Bickel *et al*. 2000). Accurate measurement and monitoring of the food security situations, in addition to those of poverty prevalence and household income can help public officials, policy makers, service providers and the public at large to assess the changing needs for intervention. It also helps in determining the effectiveness of existing rural development programmes as well as monitoring the extent of achievement of Millennium Development Goals.

While the determination of the food security situation of the households can provide an indispensable tool for assessment and planning, examination of how specific factors influence food security situation of a particular population may help in assessing effect of changing policies or social economic conditions for policy redress. To formulate public policies to solve food insecurity problems, it is necessary to understand what factors are responsible for them. Understanding determinants of food security presents a window for improving targeting, the policy focus and success for addressing food insecurity.

Understanding the impact of export horticulture farming on food security provides an opportunity for improving export horticulture promotion policy programming for enhanced social welfare. The information generated will assist policy makers in designing horticultural production and export policies or conditions in order to ensure that positive effects are promoted while any negative impacts are minimized or entirely eliminated and farmers' welfare and livelihood improved.

CHAPTER TWO

LITERATURE REVIEW

2.1 Smallholder Export Horticulture Farming in Kenya

Smallholder farming dominates the agriculture sector in Kenya and plays a crucial role in food production for both rural and urban populations. It also remains a major source of income, employment and export earnings. Over time more and more people in growing economies have shifted from a wholly subsistence farming to commercialized agricultural production. They have however not yet reached the stage of pure commercial farming (Dijkstra, 2001). There is a general consensus from research findings and among policy makers that the future of food security and poverty eradication in both the developing and less developed countries is hinged on commercialization of smallholder agricultural production (Kennedy, 1989; Goverah and Jayne, 2003). With the recent macroeconomic reforms currently sweeping the developing world, opening up of markets both internally and externally and increasing urbanization, incentives are being provided to farmers to shift towards cash crops, and agriculture can be expected to become increasingly diversified and commercialized in coming years.

One particular manifestation of commercialization is cash cropping. Smallholder production of horticultural products for export is a major cash cropping practice in Kenya. Empirical evidence indicating the positive relationship between export crop adoption and household income has ignited widespread optimism about the beneficial effect of adoption of export crop production on the well-being of poor adopters. Promising early signals have led many development practitioners and international donors to the unconditional promotion of these crops. In Kenya return to investment in horticulture is comparatively better than most other forms of agriculture. In assessing the micro level impact McCulloch and Ota (2002) found that households involved in

horticultural export had higher income compared to those which were not. However, export of horticultural produce from developing countries such as Kenya has been met with increased demand for food safety by major European importers following changing consumer tastes and preferences (Okello, 2008). Consumer demand for safety has led major European retailers to develop private food safety protocols to be followed by their suppliers, for example the Global GAP formally referred to as European Retailers Produce Working Group for Good Agricultural Practices, Eurep-GAP (Okello, 2008).

The farmers who comply with private food safety standards have been shown to incur high production and transaction costs which raise doubts about the sustainability of developing countries' smallholder horticultural export in the face of compliance. There is also evidence that many smallholder horticultural farmers have exited the lucrative export market due to their inability to comply with these standards (Okello *et al*. 2007). Resilient farmers, however, have developed different institutional mechanisms to comply. For example, Okello (2008) report that some farmers have adopted exporter-individual farmer (private) partnerships or organized themselves into groups. These institutional arrangements have helped support smallholders who continue to function in the export-oriented supply chains by jointly investing in the facilities needed to meet the food safety standards and gain access to technical advice, insurance and credit though the sustainability of these initiatives is not yet known (Okello *et al*. 2007).

Despite the high initial cost of compliance with standards, the general view is that compliance with these standards in Kenya has had a positive effect on household income (Mithofer *et al*. 2007). However, some studies done in Africa have established that whereas most households who shifted to commercial crop production realized increased incomes, household nutritional status did not improve proportionately (Kennedy, 1989; Kennedy and Cogill, 1987). Research on

the distributional effects of cash crop adoption and its impact on household food security has been sporadic, and the results often ambiguous. The current study adds to the literature with a unique aspect of comparison among three districts (two from high potential area and one from the semi-arid region) of the impacts of smallholder export horticultural farming and compliance with private food safety standards on food security.

2.2 Effect of Cash Cropping on Food Security

For developing countries, where more than 70 percent of the population lives in rural areas and depends on agriculture for its livelihood, increasing food production and commercialization of agriculture are the cornerstones for increasing food security and economic development (Kennedy, 1989). One particular manifestation of commercialization is cash cropping. Whilst commercialization can include market-oriented production of staple food crops (for example maize, wheat or rice), cash cropping involves crops produced for cash that have a higher value than those consumed for food within the household and tends to require a greater degree of specialization.

Cash cropping may affect household food security in several ways. The issue has been a subject of extensive analysis and evidence from different studies point to dissimilar results. Proponents see it as a means of improving the general welfare of smallholder households while the critics express concern that cash cropping, or just more production for the market and less for subsistence could undermine food security and poverty reduction. They argue that income benefits do not automatically translate to increased food intake. They see crops produced for the market to offer a less direct route to improved food security and nutrition than staple food production. Moreover, since women traditionally do not control cash crops, they lose control over income and household food supply (DFID, 2004). International Fund for Agricultural

Development (IFAD, 1998) reports that women's control over household resources is an important factor in determining household food security and nutritional status.

The shift to cash cropping may cause local food prices to rise because of the transfer of land and other resources out of food production causing a decrease in local supply or because of costly transport and marketing (IFAD, 1998). Dependence on cash-crops exposes households to food price fluctuations. This is because cash crop producers are more dependent on market conditions for adequate availability of food. Cash crops may also displace food crops and household consumption of own produced staple food may fall. Thus the household vulnerability to food insecurity tends to increase particularly with increased fluctuation of food prices and other uncertainties in the food market. Moreover, a drop in cash crop prices will reduce household income and thereby the ability to purchase food, a danger that increases, the narrower the range of cash crops and market outlets upon which the farmer is dependent on. The shift to cash crops may also reduce the time available to seek alternative employment opportunities especially for cash crops requiring more labour than food crop production. It may also lead to reduction in the area of land available for household production of staple foods, putting pressures on their staple food supplies.

On the other hand, food crops do not always compete with cash crops; they are sometimes complementary through rotation or intercropping practices. Some cash crops also serve as food crops. Meeting domestic consumption needs may entail buying of food so that food security needs are met through cash crops such that proceeds from the cultivation of the cash crops compliment food needs. However, this may not happen automatically for all households due to household specific characteristics, missing food markets, and decisions taken by persons controlling income within the household.

Sorre (2011) assessed the effect of sugarcane farming on food security and nutritional status in Nambale Division Busia District, to determine agricultural and economic parameters that affect food supply and nutritional status in rural Kenya. The study found that there was a competition between cash and food crop cultivation and that there was little motivation for food crop production, leading to household food insecurity and the residents of Nambale were suffering from malnutrition problems. Anouk (2010) focusing on the impact of agro-export specialization on food security in flower-producing municipalities in the savanna of Bogotá region in Colombia found that trend towards export crop specialization lead to decline or stagnation of food production and increased household dependence on imported food products thus raises the households vulnerability to food price fluctuations.

Using data from a random household survey in Kenya, Strasberg *et al.* (1999) examined the impact of the degree of household commercialization on food crop productivity. The authors found that the degree of agricultural commercialization was positively and significantly correlated with gross food crop productivity per food crop acre. However, the effect of particular cash crops was found to be markedly different depending on the region, regardless of the household level effects of commercialization. For instance, French beans, sugarcane and tea were negatively correlated with food crop productivity, but coffee was positively correlated. District-crop interactions revealed even more variation, such as the negative impact of coffee in Meru and positive impact of sugarcane in Bungoma. Remarkably, all the crops demonstrated positive relationships in some districts while not in others highlighting the importance of regional differences.

Afari (2007) studied the distributional effects of horticultural export value chains among smallholders in Southern Ghana. The study found that households producing export crops were

better off, in terms of income and food availability, than those producing food crops. The author however, noted that crop choice alone was not a sufficient condition for improving household food security. The author found that the largest landholders were the most likely to adopt export crops and therefore land size was a significant determinant of household food security. The same study also found that notwithstanding the enormous contribution of horticultural exports to foreign exchange earnings, the micro level distributional effects had not favored the chronically poor households who were structurally impeded from seizing the existing opportunities of the export market by virtue of their poor resource endowment and liquidity constraints. The majority of households were also exposed to the risk of inadequate technological know-how in meeting the ever increasing quality standards and health control traceability requirements by European consumers, price collapse on the export market and a breakdown of local marketing institutions.

Kuhlgatz and Abdulai (2011) assessed the determinants and welfare impacts of export crop cultivation in Ghana using generalized propensity scores to control for self-selection bias into treatment. The results showed a non-linear relationship, whereby household welfare was hardly affected at low levels of export revenue shares, but rose with increasing level of specialization. Relative to households with low levels of export crop cultivation, fully specialized farms were found to substantially improve their standard of living, with the threshold occurring around 70 percent level of specialization. The impact of export cropping on poverty reduction was found more ambiguous since the probability of falling below the poverty line was virtually similar for export share between zero and 40 percent but begun to rise between 40 percent and 70 percent, only to decline after that threshold. These results suggest that export crop cultivation cannot be considered as a magic bullet in rising farmers' living standards. Marginal benefits from low and medium export intensity may be easily outweighed by immeasurable benefits of non-export

agriculture, such as predictability of local markets and risk insurance through consumption of own produce. Moreover, uncertainties about foreign markets, self-sufficiency reasons as well as financial and infrastructural constraints may hinder most farmers from increasing their revenue shares from export cropping activities.

Carletto *et al*. (2009) by use of panel data over the period 1985–2005, employed difference - in differences estimation to investigate the long-term impact of non-traditional agricultural export adoption on changes in household consumption status and asset position in the Central Highlands of Guatemala. The results indicate that while, on average, welfare levels have improved for all households irrespective of adoption status and duration, the extent of improvement has varied across groups. Long-term adopters exhibit the smallest increase even less than non-adopters in the lapse of two decades, in spite of some early gains. Conversely, early adopters who withdrew from non-traditional agricultural export production after reaping the benefits of the boom period of the 1980s are found to have fared better and shown greater improvements in durable asset position and housing conditions than any other category. They concluded that the endurance of the positive welfare impacts of nontraditional agricultural exports production is a function of the sustainability of viable institutional arrangements that mitigate their marketing and production risks.

IFAD (1998) report on experience with non-traditional export crops in Guatemala showed that these crops proved to be unfavorable for poor farmers, who lacked the resources to face increasing problems associated with production. In the presence of limited marketing channels for the products, excessive reliance on nontraditional export crops for income often translated into extreme subordination by poor peasants to powerful agro-exporters. Farmers considered the treatment they received from agro-exporters as highly unfair; agro-exporters often rejected their

products because of alleged low quality, or else imposed excessive discounts for these perceived defects. The agro-exporters were also blamed for charging excessively for the inputs they advanced to the farmers, paying late, or, in some cases, not paying at all. In these circumstances, the greater risks and exposure to unequal bargaining power made households cultivating nontraditional export crops vulnerable to food insecurity in spite of sizeable of increases in average income (IFAD, 1998).

Bolwig and Odeke (2007) examined the effects of certified organic export production on household food security in Uganda. The study indicated that conversion to organic export production had not reduced food security in the examined cases but rather improved it by rising cash incomes that enabled households to increase the amount and quality of food purchased in the market. Organic pineapple farmers enjoyed high levels of food self-sufficiency and organic conversion did not appear to have reduced food production. This was mainly because the expansion of pineapple farms and their improved management had occurred through additional investments in land and hired labour rather than through the diversion of household resources away from food crops. Hence most organic farmers could satisfy their calorie needs through own production and moreover purchase higher value foods such as meat, fish, sugar, tea, and rice

Dewalt (1993) reviewed the results of studies examining the impacts of agricultural commercialization on food consumption and nutritional status and drew the following conclusions. First, the income effects of shifts to cash cropping are highly dependent on pricing policy for cash crops. Short term gains seen in some schemes are often highly dependent on the maintenance of high prices for commercial crops. Second, those schemes in which subsistence production is protected or stabilized are more likely to show positive results with an increase in income generated from cash cropping. Third, increased income does not translate directly into

increased food consumption at either the household or individual level and that shift in control of income from women to men are important determining factor. The author concludes that the impacts of commercialization on food security are mixed and highly dependent on the nature of the crop, the control of production and income, and the allocation of household labor, the maintenance of subsistence production, land tenure, and pricing policies for both cash crops and food stuffs.

In summary, the effect of cash cropping on household food security and nutrition status is mixed, but this does not support their wholesale commendation or condemnation. Contextual factors prove to be critical determinants of positive welfare gains from cash crop production (Schneider and Gugerty, 2010). In addition to the physical characteristics of the crop, and whether it is a food crop or not, the policy conditions under which the crop is introduced is an important factor. The above studies have mostly focused on impact of cash cropping on food availability based on own food crop production and productivity. However, the main problem of household food insecurity is lack of access rather than availability in the market place. Indeed, what the malnourished need is an entitlement to food that cash crop income can help to provide. Good marketing systems are likely to overcome food shortages that non-food cash crops can generate (Longhurst, 1988). The current study mainly focuses on the access dimension of food security defined as the access by households to adequate resources (entitlements) for acquiring appropriate food for a nutritious diet. It investigates among other socio- economic factors the impact of horticultural export production on the food security status of smallholder horticultural farmers in the study area. This is because other economic and social factors play an important role though the relative importance varies significantly between places, over time and between different groups in society.

2.3 Issues on Food Security Measurement

There are approximately 200 definitions and 450 indicators of food security (Hoddinott, 1999). Like the concepts of health or social welfare, there is no single, direct measure of food security- that can effectively capture the multiple dimensions to the problem (Frank *et al.* 1999). Consensus has still not been reached on acceptable indicators and methods of measuring household food security (Haddad *et al*. 1994).

Orewa and Iyangbe (2009) and Bashir *et al*. (2010) used household calorie consumption method to measure food security. Orewa and Iyangbe (2009) used a 48-hour recall method while Bashir *et al*. (2010) used a 7-day recall period in obtaining information on the type and quantity of food each household member consumed over the relevant period. The calorie content in each food item consumed was determined and used in estimating the total food intake of the household members. A cut-off point of the minimum level of per capita calorie below which a household was considered food insecure was used. Food consumption in enough quantity to meet for energy and nutrient requirement is the core of the concept of food security concept which is the main focus of this method. Its error structure is also far well understood than for any other method employed for assessing food security. It has thus been used in validating other food security measures. However, it is not without shortcomings, which include possibility of underreporting, logistic complexity and prohibitive cost of survey.

Hazarika and Khasnobis (2005) while studying children's food security in Pakistan used anthropometric measures, a measure of nutritional status that focuses on the utilization component of food security. This measure does not however, necessarily reflect food consumption or energy adequacy as they are influenced by other environmental determinants of nutritional status such as infections.

Oni *et al*. (2010) used a subjective method, household food perception that classified households in to two distinct groups categorized as food secure and food insecure. The food secure group consisted of individuals who answered "in agreement or yes" to all the food security perception items; while a food insecure group, comprised individuals who answered "not in agreement or no" to one or more of the household food security perception items. These items were tailored to fit the local residents' perceptions of food insecurity. This was on the basis of spending patterns, reasons for enough food but not the kinds of food wished by the respondents and household food statements. Other authors that have used subjective method include Shiferaw *et al.* (2003) and Kassie *et al*. (2012). Shiferaw *et al.* (2003) relied upon strategies developed by households and sequential responses for dealing with insufficiency of food commonly referred to as coping strategies at the household level as direct indicators. The main problem of the subjective approach is non-comparability across different contexts. Moreover, the presence or absence of particular strategies is often not a standard indicative of food security status. For example, a household may not have taken credit to cover for food expenditures simply because none was available or it is too poor to qualify for one, while another may fail to take credit because it never needed one. However, both will have the same answer of not having taken credit to cater for food expenditures.

Other measures or indicators of food security include Household Dietary Diversity Index (HDDI) and the household food insecurity access indicator (HFIAI) both of which are preferred due to simplicity of administration of surveys and that they are easy to use in combination with other measures (Hoddinott, 1999; Coates *et al*. 2007)

No method has been accepted as a "gold standard" for an analysis of household food security (Maxwell, 1995). The choice of a particular indicator must be based on the specific objectives of

the research, and the trade-offs between resource constraints and information needs. For greater efficiency, indicators are used in combination. Thus the current study utilizes the calorie intake method with a 7-day recall, together with HDDI. A similar approach was used by Belay (2012) who combined calorie intake method with the coping strategy method of assessing food security in Ethiopia, while Garrett and Ruel (1999) and Kennedy (1989) used calorie intake in combination to assessing children's anthropometric measures.

2.4 Determinants of Food Security

Determinants of food security are different at different levels of application. That is at global, national, regional, household and individual levels (Ejaz and Abid, 2009). This is because even the definition of the concept itself differs at these different levels.

Orewa and Iyangbe (2009) attempted to identify the socio-economic and household characteristics that have major impact on the level of food calorie intakes of rural and low-income urban households in Nigeria. To identify the variables that had significant influence on household members' daily per capita calorie intake, the Ordinary Least Squares (OLS) multiple regression analysis was carried out. The result of the analysis revealed a significant positive relationship between daily per capita calorie intake and household size, age, education level, sex and salary income earners. On the other hand a negative significant relationship was observed between daily per capita calorie intake and dependency ratio and non-engagement in farming.

Pankomera *et al*. (2009) assessed the determinants of food security and the local perceptions of targeted food policies in Malawi. The authors used a binary probit model with the dependent variable taking a value of one for food secure households and zero otherwise. The study found that household size negatively affected household food security, and that the households with

educated heads were likely to be more food secure. The presence of off-farm enterprise in a household was found to have a positive effect on its food security. Credit availability also had a positive effect on household food security.

Hazarika and Khasnobis (2005) studied children's food security in Pakistan. They applied OLS model on micro-data taken from Pakistan Integrated Household Survey. The study found out that children's food security is positively related to women's status in the household.

Oni *et al*. (2010) assessed the social economic factors affecting smallholder farming and food security in Thulamala South Africa. The study found out that total income, education level, household own food production, number of people living in a household and spending patterns significantly affected food security.

Shiferaw *et al.* (2003) in his study of determinants of food security in Southern Ethiopia at the household level, developed a recursive household food security model within the framework of consumer demand and production theories, and compared the relative importance of supply-side (technology adoption, farm size, land quality, farming system) versus demand-side (for example, wealth, household size, off farm income) variables. He concluded that the supply-side variables are more powerful determinants of food security than the demand-side variables.

Determinants identified in the above studies are not identical. Different factors were found to influence food security in different areas. The current study adds to this existing literature, by assessing the factors influencing food security in the Kirinyaga, Buuri and Mbooni, Kenya. The study brings a new dimension by assessing factors affecting diet quality an aspect of food security to the standard diet adequacy dimension of food security.

2.5 Impact Assessment Methods for Food Security Interventions

Impact assessment of events such as participation, adoption, attendance is indeed an estimation of treatment effect in policy analysis. However, change in 'impacted' outcome is a function of multiple endogenous and exogenous 'impacting' factors. The problem arises in identifying part of the change in the 'impacted' outcome for the target population that is due to the change in the selected 'impacting' factor. This is necessitated by the inability to observe the counterfactual corresponding to any change induced by a treatment. Yet, it is necessary to observe the counterfactual if the impact is to be assessed. Determining the counterfactual is at the core of impact evaluation. This can be accomplished using several methodologies which fall into two broad categories, experimental designs (randomized), and quasi-experimental designs also known as nonrandomized (Baker, 2000).

Experimental designs, also known as randomization, are generally considered the most robust of the impact evaluation methodologies. They yield powerful outcome because, in theory, the control groups generated through random assignment serve as a perfect counterfactual, free from the troublesome selection bias issues that exist in most evaluations. The main benefit of this technique is the simplicity in interpreting results—the impact on the outcome being evaluated can be measured by the difference between the means of the samples of the treatment group and the control group (Baker, 2000). However, among other shortcomings, the methods are not applicable in observational data in which the evaluator has no control on treatment assignment.

Quasi-experimental (nonrandom) methods can be used to carry out an evaluation when it is not possible to construct treatment and comparison groups through experimental design. These techniques generate comparison groups that resemble the treatment group, at least in observed characteristics, through econometric methodologies, which include matching methods,

instrumental variables methods, and reflexive comparisons. The main benefit of quasi-experimental designs is that they can draw on existing data sources and are thus often quicker and cheaper to implement, and they can be performed after a program has been implemented, given sufficient existing data. The principal disadvantages of quasi-experimental techniques are that there is a problem of selection bias (Baker, 2000).

When panel data are available, selection bias can be addressed by the difference in differences matching estimator, as employed by Kennedy (1989). In the absence of panel data, statistical matching (propensity score matching) can be employed to address the problem of selection bias. This involves pairing adopters and non-adopters that are similar in terms of their observable characteristics. Propensity score matching is a way to correct the estimation of treatment effects controlling for self-selection based on the idea that the bias is reduced when the comparison of outcomes is performed using treated and control subjects who are as similar as possible (Becker 2002). The PSM is defined as the conditional probability that a farmer adopts a new technology, given pre-adoption characteristics (Rosenbaum and Rubin, 1983).

Some authors have employed the Heckman two-step method or similar approaches to address selection bias. However, the two-step procedures are completely dependent on the strong assumption that unobserved variables are normally distributed.

Another way of controlling for selection bias is to employ instrumental variable approach (IV). A major limitation of the approach is that it normally requires at least one variable in the treatment equation to serve as instrument in specifying the outcome equation. Finding such instruments remains an arduous task in empirical analyses. Moreover, IV procedures tend to impose a linear functional form assumption, implying that the coefficients on the control variables are similar for adopters and non-adopters. This assumption may not hold, since the coefficients could differ (Ali and Abdulai, 2010). Unlike the other methods mentioned above, propensity score-matching applied in the current study requires no assumption about the functional form in specifying the relationship between outcomes and predictors of outcome.

CHAPTER THREE

METHODOLOGY

3.1 Conceptual Framework

Sen's (1981) entitlement theory outlines the different ways in which individuals can acquire food: a) production-based entitlements i.e. through own food production; b) trade-based entitlements that is through exchange of cash crops or physical assets; c) own-labour entitlements through sale of labour power for wage; and, d) inheritance, and transfer entitlement which refer to informal gifts from individuals and formal from government. The level and the mix of these entitlements depend on a households resource endowments including human capital, type of market integration for agricultural produce, food and labour. Effect on these variables, ultimately affect food intake.

Following this theory, the current study conceptualizes the food security status as an outcome of household/farmer social economic characteristic and non-controllable external environmental factors. The same factors also affect farmer's decision to grow export horticulture or not to grow as shown in the Figure 1.

This decision affects farmer resource allocation either toward export horticulture production, food crop production and or off-farm employment all of which affect food security. Households that choose to grow may undergo a transition from food crop farming for sale to domestic consumers and own consumption to an intensive production for export market. Income from export horticulture could either be utilized (according to the decision of the one in control of the income) on non-food expenditures like education and purchase of durable assets or on boosting food production or on food expenditures, ultimately affecting food security.

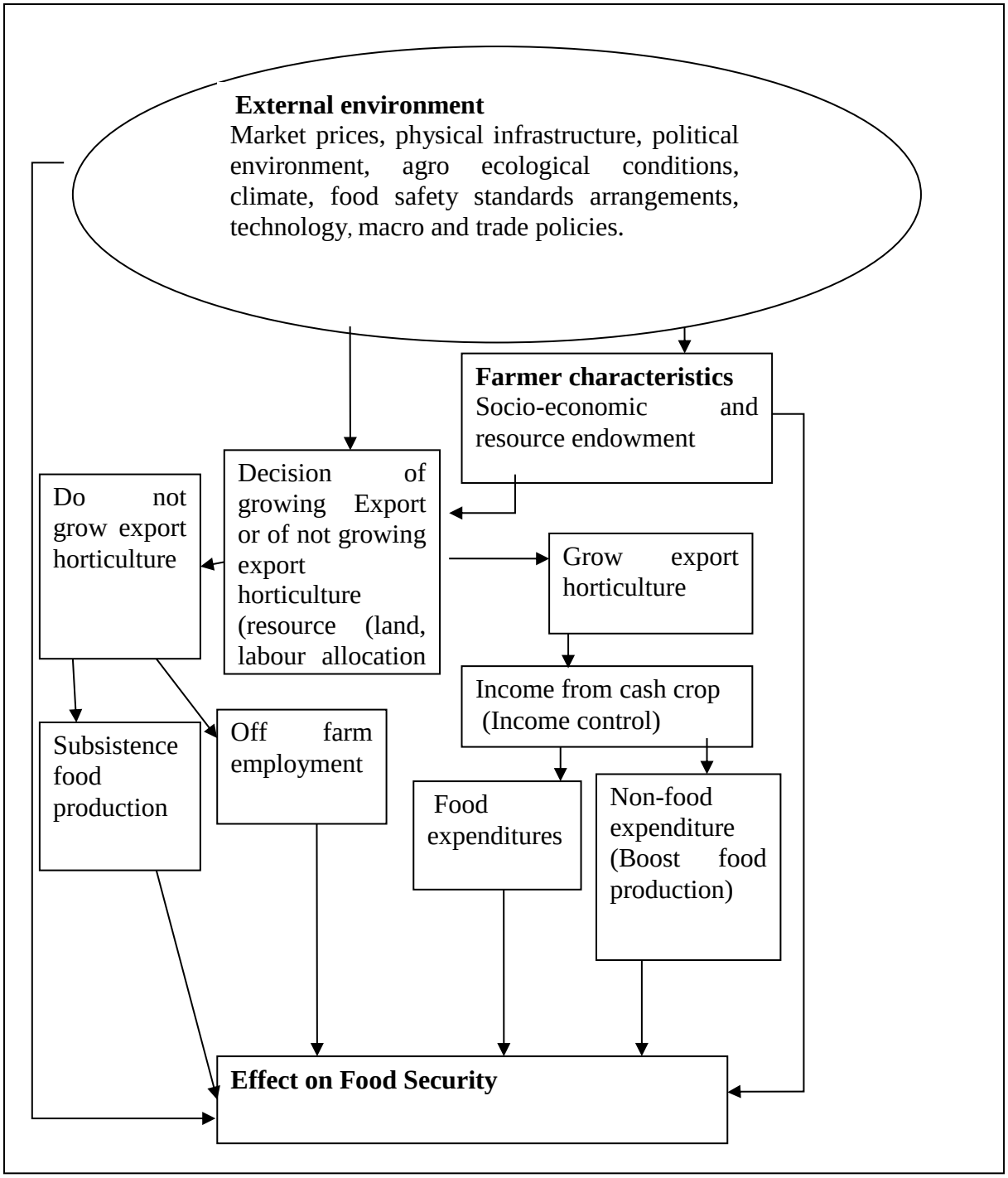

Figure 1; Conceptual framework of the linkages between horticultural export production and food security

The ultimate effect of export horticulture on food security given the complex interactions thus becomes an empirical issue since the possible effects and interactions are not straight forward, and vary depending on the household social economic, prevailing production and marketing and policy conditions.

3.2 Sample Descriptive Statistics

Before embarking on inferential statistics used to test hypotheses, and answer to the main objectives of the study, more information on the structure of the sample and social economic characterization is necessitated. These statistics provide a comparison of the social economic characteristics of the sampled farmers in the three districts and a further comparison between the grower and non-grower categories in each of the districts. This is done using simple measures of central tendencies, variance and test of difference in means. The sample descriptive statistics provides more insight into the sample used.

3.3 Measuring Food Security Situation

Food security status was measured using indicators of food consumption which is an outcome indicator of food availability, access and other underlying factors. This was done using 7 –day recall where two indicators were developed. i) Household Dietary Diversity Index (HDDI) (Hoddinott and Yohannes, 2002). ii) Household per capita calorie intake (Swindale and Bilinsky, 2006).

3.3.1 Household Dietary Diversity Index (HDDI)

Consuming sufficient dietary energy, the most commonly used measure of dietary quantity, does not ensure adequate intake of protein and micronutrients necessary for leading an active and healthy life. These nutrients are found in high concentrations in legumes, foods of animal origins, and fruits and vegetables. Deficiencies of micronutrients, such as iron, Vitamin A and

iodine cause impaired cognitive development and blindness among children, reduced productivity, increased morbidity, and in severe cases, mortality. Protein deficiency also compromises immunity and increases vulnerability to infectious diseases (Smith, 2004). Thus there is need to address issues of dietary quality in addition to those of dietary quantity, when addressing food security.

Dietary diversity, defined as the number of different foods or food groups eaten over a reference time period without regard to the frequency of consumption, is used to assess diet quality. Household dietary diversity index was developed by calculating a simple count of the sum of the different number of food types consumed in the previous day, following the United Nations Food and Agriculture Organization (FAO) food groups.

1. Cereals	7. Fish and seafood
2. Root and tubers	8. Oil/fats
3. Pulses/legumes	9. Sugar/honey
4. Milk and milk products	10. Fruits
5. Eggs	11. Vegetables
6. Meat	12. Miscellaneous

HDDI is an attractive proxy indicator because: a) obtaining these data is relatively straightforward; b) it is associated with a number of nutrition indicators such as birth weight, child anthropometric status, hemoglobin concentrations and protein adequacy (Swindale and Bilinsky, 2006); c) a more diversified diet is highly correlated with such food security indicators as household per capita consumption (Hoddinott and Yohannes, 2002).

3.3.2 Household per Capita Calorie Intake

The calorie intake estimate was obtained through recall of consumption of all significant sources of calories during the previous 7 day period. The principal person responsible for preparing meals was asked how much food she/he prepared over the reference period. Data included what meals were consumed, the ingredients and the quantity. The data was converted into standard weight and measures and then converted to calories using food composition tables (Swindale and Bilinsky, 2006). Using the formulae;

$$Ci = \sum_{1}^{n} WiBi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (1)$$

Where; *Ci* is the household total calorie intake estimate

Wi is the weight in grams of intake of food commodity i.

Bi is the standardized food energy content of the i^{th} food commodity (from nutrient conversion tables).

Ci was then divided by household size to get per capita calorie intake, and then compared to 2250 kilocalories threshold (as used by the (Kenya National Bureau of Statistics). The first hypothesis that smallholder farmers are food insecure would be rejected, if the average per capita calorie intake exceeds the 2250 Kcal threshold; otherwise fail to reject if per capita calorie is below this threshold.

Per capita calorie intake is the most widely used method of assessing calorie intake. However, literature points to the intrinsic limitation of this method in assessing calorie intake indicating that it does underestimate calorie intake in that it does not take into consideration the different age and activity levels of the household members and is thus at fault (Claro *et al.* 2010). However, it is easy and less expensive to calculate thus used in this study.

3.4 Estimating Factors affecting food security

To achieve the second objective of assessing the factors determining food security, two models were estimated:

i) Ordinary Least Squares model

Per capita calorie intake, a measure of diet adequacy, which is continuous and normally distributed, was used as the dependent variable. Ordinary Least Squares produces best linear unbiased estimators of the coefficients given that sum errors have an expectation of zero and are uncorrelated and have equal variances.

ii) Poisson regression

Household Dietary Diversity Index, a count variable used to measure diet quality was used as the dependent variable. The higher the diversity index so is the quality of diet and vice versa. Poisson regression model expresses the natural logarithm of the event or outcome of interest as a linear function of a set of predictors. Poisson regression analysis is a useful tool for the analysis of count data. It derives its name from the Poisson distribution, which is a mathematical distribution often used to describe the probability of occurrence of count data, under the assumption that the conditional means equal the conditional variances.

Let Y_i denote the number of food groups, out of 12, consumed by the ith household. The empirical specification of this "count" variable assumed to be random and, in a given time interval (24 hrs), has a Poisson distribution with probability density

$$P(y_i) = \frac{e^{-\mu}\mu^{y}}{y!} \quad \ldots\ldots (9)$$

Y= 1, 2, 3…12

μ = E(Y) expected index (and variance)

Model log of μ as a function of X

$$\mu = e^{\sum_{j=1}^{K} \beta_j X_{ji}} \qquad \text{……………………………………………………………………………… (10)}$$

Equation (10) can also be written as

$$\ln(\mu) = \sum_{j=1}^{K} \beta_j X_{ji} \qquad \text{……………………………………………………………………………… (11)}$$

Or

$$ln(\mu) = \beta_0 + \beta_j X_i + \ldots + \beta_\kappa X_k \text{ ....(12)}$$

Where **β**s are the regression coefficients and the **X**s are the predictors

Note that Y >0 as the number of food groups consumed by a household over the previous 24 hour period must be strictly positive. This is a case of truncation from below, a feature that is taken into account by specifying a truncated Poisson model. OLS may produce biased inconsistent and insufficient estimates of count data. The Poisson Regression model is estimated using maximum likelihood estimation procedure. The variables used in the models are presented in Table 1 that follows here.

Table 1: Variables Definition and Hypothesized Signs for Determinants of Food Security

Variable	Explanation	Expected sign
DISTINPUT	Distance in walking hours to the nearest input shop	-
DISTURBAN	Distance in Km to the nearest urban center	-
DISTWATER	Distance in Km to the nearest source of water	-
EMPLOYMENT	Proportion (%) of months of the year that the farmer is able to get employment.	+
EXTENSION	Whether a farmer had any contact with an extension worker over the last one year.	+
FAMLABOURERS	Family labourers	+
FARMEXPR	Total number of years of experience in farming	+
FARMINCOME	Total income from all farming enterprises	+
GROUPMEMBER	Whether a farmer belongs to a farmer group Dummy 1 if yes zero otherwise.	+
GROWEXPVEG	Whether a farmer grows vegetables for export. Dummy 1 if yes zero otherwise.	+/-
HHEDUC	Household head number of years of formal education.	+
HHGENDER	Gender of the household head dummy 1 if Male 0 if female.	+/-
HHSIZE	Number of persons in a household.	+/-
INCOMECAT	Whether a household monthly income is above Kshs 5000 or not. 1 = Yes 0= No.	+
LIVESTOCKUNITS	Number of livestock equivalent units owned by the household	+
MAINOCCUP	Whether farming is the main occupation of the household head. Dummy 1 if yes zero otherwise.	+/-
SCHEXPND	Total expenditure in Ksh on school fees.	+
TOTACRES	Total acreage of land area owned and rented.	+
TOTASSETS	Total Value of assets owned by the household.	+
TOTLABOURERS	Total number of labourers in the farm (family labourers plus hired labourers)	+

Variable	Explanation	Expected sign
TRANSCOST	Cost of transport (Ksh) to the most important town.	-
WALLTYP	Type of wall of the main house. dummy, 1 if stones 0 otherwise	+
WATERSOURCE	Main source of water; dummy, 0 if River and Unprotected spring and 1 otherwise	+

Variables used in the models and their hypothesized signs.

Access to extension service: Field extension officers are important in dissemination of improved technology. Lewin (2011) and Kassie *et al.* (2012), state that government investment in agricultural extension has a significant impact in food security status. Lewin (2011) found that at least one visit to each household from an agricultural extension agent during each cropping season would reduce food insecurity by 5.2 percent.

Distance to the nearest source of water: Short distance to a source of water means less time is spent by women to looking for water. Hence they can dedicate their time to food preparation and income generating activities. It could also mean access to irrigation water which can be used to counter the unpredictability of rainfall and ensure food production all year round. Thus this variable was hypothesized to have a negative effect on food security.

Distance to the nearest urban centre/ and the distance to the nearest input shop and transport cost to the most nearest town: Long distances to the urban centre and input shops translate to high transport and fare paid by farmers, most importantly when sourcing important inputs for farming. The higher the distance, the higher the cost associated with acquiring inputs and generally the higher the transaction costs involved. Higher input prices have been shown to contribute to food insecurity (Lewin, 2011). Proximity to the urban centre would also mean access to well-functioning market systems hence better food security situation. The longer the

distances to the urban centre, the less frequently the farmer visits the urban centre and hence, the less likely he is to get market information. When there is lack of adequate information about prices, farmers may sell their produce at times when prices are low and buy when prices are high (Lewin, 2011).

Education: It is hypothesized that the more the years of education of the household head the better the food security situation of the household. This is because education is positively attributed to uptake of improved technology, improved managerial capacity even at the farm level and more probability of off farm employment opportunities either self-employment or otherwise (Pankomera *et al*. 2009)

Employment: The proportion of months of the year when the farmer is able to get employment in or outside his farm is hypothesized to have a positive effect on the household food security situation, in that it represents the time when the farmer is actively engaged in income generating activity or in food production in his/her farm.

Experience: The total number years of experience in farming is expected to have a positive impact on food security as it represents buildup of local traditional knowledge on climate variability and advice from extension workers.

Farm income: The higher the income, the higher the expected per capita calorie intake and the more diverse a household diet is expected to be.

Gender: Several studies including Orewa and Iyangbe (2009) and Kassie *et al.* (2012) have documented an increased food security of male headed households compared to female headed household stating that female headed households are mostly single parented and have limited access to productive resources.

Group membership: This is a form of social capital which Martin *et al*. (2004) found to be significantly positively associated with food security. Social capita is also positively associated with technology adoption hence food security.

Growing export vegetables: Export vegetable farming in Kenya as mentioned earlier is cash cropping system whose effect of food security could either be positive or negative as literature has so far indicated.

Household size: The expected sign for household size is either positive or negative. Large families are mostly associated with a high dependency ratio and more food requirements, depicting a negative effect on food security. However, an increase in a household size could translate to an increase in the number of income earning adults depicting a positive effect on food security (Orewa and Iyangbe, 2009).

Income category: This variable is a dummy variable which was set in consideration of the minimum amount of income a household in the rural area can survive on. It was however a case of data limitation where the income per month was collected as a categorical variable collected during the baseline data collection phase. However it was expected that the households above this threshold would be having more per capita calorie intake and a more diversified diet than their counterparts who were below this threshold.

Labourers: Access to economic resources such as labour translates to production capability. It is thus hypothesized that the more the labour accessible to a household, family or hired, the more the food secure a household is.

Livestock units owned: Livestock can be a source of food for instance, milk, eggs and meat and can also be considered as assets thus a form of wealth indicator. Households having more livestock units are expected to have more HDDI and more per capita calorie intake.

Main occupation: While non-engagement in farming has been found to negatively affect per capita calorie intake of a household (Orewa and Iyangbe, 2009), more steady sources of income like salaries and wages are a surer and reliable sources of monthly income hence households members are able to plan out their diet. Therefore, this variable could either have a positive or a negative effect on food security.

Total acres: This is the total size of farmland owned and rented in by a household measured in acres[1]. The larger the farmland, the higher the production level thus, it is expected that households with larger farmland will have a higher HDDI and more per capita calorie intake than households with smaller farmland.

Total assets: The value of total assets owned by a household is taken as a proxy of wealth and thus it is expected that the higher it is, the better the food security situation.

Total Expenditure on school fees: Similar to the total assets and wall type discussed above, this variable was also taken as a proxy for wealth and the expectation was that the wealthier a household is the more diversified its diet is and so is the per capita calorie intake.

Wall type: The wall type of the main house of a household is a wealth proxy and households having more wealth are expected to have more HDDI and more per capita calorie intake.

Water source: The main water source for the household ie whether river or unprotected spring is another proxy for wealth which is expected to have a positive effect on both the per capita calorie intake and HDDI. The access to clean water also apart from being a proxy for wealth is a factor that affects food utilization in the body which is an important dimension of food security, since it directly affects health status of a person

[1] 2.5 acres = 1 hectare

The second hypothesis that individual social economic factors like age, education, household size etc. have no effect on food security ie $\beta_i = 0$ for all the variables included in both the Poisson and the OLS models is tested individually for each of the variables. This hypothesis will be rejected if the P value corresponding to each variable is less than the significance value of 0.1000. Otherwise we fail to reject the null hypothesis and conclude that an effect of a particular variable is statistically insignificant and not different from zero.

Other Variables Used in the Study

Variable	**Definition**
AGRICLAND	Total acres of cultivated land in a household
CONTRACT	Whether an export horticulture farmer has entered into a contract with an export company. 1 if Yes, 0 otherwise
CREDIT	Whether an export horticulture farmer has used credit for export horticulture production. 1 if Yes, 0 otherwise
DISTMARKET	Distance to the nearest market center from the farm (Kms)
EXPVEGAREA	Land area in acres under export horticulture
FARMINCOME	Total income from all farm enterprises
GLOBALCOMP	Whether a grower of export horticulture is GlobalGAP compliant. 1 if Yes, 0 otherwise
HHAGE	Household head age in years
OWNLAND	Total acres of land owned
SALARIED	Whether a household head earns a salary or not

3.5 Assessing Impact of Participation in Export Horticulture

3.5.1 Propensity score matching theory

To assess the impact of participation in export horticulture farming on food security of participating farmers' households, the average treatment effect for a household can be given by

$$\lambda_i = Y_i\,(1) - Y_i\,(0) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where λ_i is the impact on food security, $Yi\ (1)$ is the food security status when the i[th] household participates in export horticulture production while $Y_i\ (0)$ is the food security status when the same household does not participate .The first problem arises because we would like to know the difference between the participating household's food security outcome with and without treatment. Clearly, we cannot have both outcomes for the same household at the same time. Hence, estimating the treatment effect λ_i is not possible and one has to concentrate on (population) average treatment effects. Since one cannot also observe the food security status of participating households before participation when there is no baseline data (the study data is cross-sectional in nature), there is need to develop a proxy for the missing data. This missing data is known as counterfactual in impact assessment literature. Taking the mean outcome of non-participants as an approximation of the counterfactual is not advisable, since participants and non-participants usually differ even in the absence of treatment. This problem is known as selection bias (Caliendo and Kopeinig, 2008).

The basic idea is to find in a large group of non-participant households who are similar to the participant households in all relevant pretreatment characteristics X. That being done, differences in outcomes of this well selected and thus adequate control group (non-participant households)

and of treatment group (participant households) can be attributed to the participation in export horticulture farming. Since conditioning on all relevant covariates is limited in the case of a high dimensional vector X, a balancing score b (X) which is a function of the relevant observed covariates X such that the conditional distribution of X given b(X) is independent of the assignment into treatment is used. This balancing score is the propensity score i.e. (the probability of participating in export horticultural farming given the observed characteristic X), and is given by,

$$b(X) = Pr(Z=1/X) \quad \ldots\ldots(3)$$

Where Z denotes the participation in export horticultural farming where 1 denotes a household participates, 0 otherwise.

X is the multidimensional vector of pre-treatment characteristics.

The propensity score is a function such that the conditional distribution of X given $b(X)$ is the same for both groups. Given that the propensity score is a balancing score, the probability of participation conditional on X is balanced such that the distribution of observables X is the same for participants and non-participants. Consequently, the differences between both groups are reduced to the only attribute of treatment assignment and unbiased impact estimates can be produced (Rosenbaum and Rubin, 1983). Propensity score is estimated using choice models, either probit or logit model which yield similar results.

An estimate of the propensity score is not enough to estimate the Average Treatment effect to the Treated (ATT). The reason is that the probability of observing two units with exactly the same value of the propensity score is in principle zero since b (X) is a continuous variable. Various methods (matching procedures) have been proposed in the literature to overcome this problem.

Matching procedures based on this balancing score are known as propensity score matching (PSM). Three of the most widely used are Nearest Neighbor Matching (NNM), Radius Matching and Kernel Based Matching (KBM). All matching procedures contrast the outcome of a treated individual with outcomes of comparison group members.

The NNM involves choosing individuals from the adopters and non-adopters that are closest in terms of propensity scores as matching partners. NNM faces the risk of bad matches if the closest neighbor is far away. Several variants of the NNM have been proposed in the literature, including NNM matching 'with replacement' and 'without replacement'. In the former case, an untreated individual can be used more than once as a match, whereas in the latter case it is considered only once. Matching with replacement involves a trade-off between bias and variance. If replacement is allowed, the average quality of matching will increase and the bias will decrease (Caliendo and Kopeinig, 2008).

Radius matching, a variant of caliper matching uses not only the nearest neighbor within each caliper, but all of the comparison members within the caliper. Applying caliper matching means that an individual from the comparison group is chosen as a matching partner for a treated individual who lies within the caliper (propensity range), and is closest in terms of propensity score. This method avoids the risk of bad matches by imposing a tolerance level on the maximum propensity score distance (caliper), a form of imposing a common support condition. Hence bad matches are avoided and the matching quality rises. However, if fewer matches can be performed, the variance of the estimates increases. A possible drawback of caliper matching is that it is difficult to know *a priori* what choice for the tolerance level is reasonable (Caliendo and Kopeinig, 2008).

The KBM method is a non-parametric matching method that uses the weighted average of the outcome variable for all individuals in the group of non-adopters to construct the counterfactual outcome, giving more importance to those observations that provide a better match. This weighted average is then compared with the outcome for the group of adopters. The difference between the two terms provides an estimate of the treatment effect for the treated case. A sample average of treatment effect over all adopters is then the estimate of the sample average treatment effect for the treated group. One major advantage of this approach is the lower variance which is achieved because more information is used. A drawback of this method is the possibility of using observations that are bad matches.

3.5.2 Estimating Treatment effect

ATT is defined as the difference between expected outcome values with and without treatment for those who actually participated in treatment.

$$ATT = E\{Y_1 - Y_0 | Di = 1\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

As the counterfactual mean for those being treated, $E[Y_0/D = 1]$ is not observed, one has to choose a proper substitute for it in order to estimate ATT.

Using the mean outcome of untreated individuals $E[Y_0 | D = 0]$ in non-experimental studies is usually not a good idea, because it is most likely that components which determine the treatment decision also determine the outcome variable of interest. Thus, the outcomes of individuals from the treatment and comparison groups would differ even in the absence of treatment leading to a selection bias.

ATT can be denoted as;

$$E[Y_1|D = 1] - E[Y_0D = 0] = ATT + E[Y_0|D = 1] - E[Y_0D = 0] \ldots\ldots\ldots\ldots (5)$$

The difference between the left-hand side of the equation and *ATT* is the so-called 'selection bias'. The true parameter *ATT* is only identified if

$$E[Y_0|D = 1] - E[Y_0D = 0] = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

(Caliendo and Kopeinig, 2008).

In non-experimental studies, like the current one, one has to invoke some assumptions to solve the selection problem namely; Unconfoundedness, also known as Conditional Independence Assumption (CIA) and the Common Support Condition (CSC)

Conditional independence assumption indicates that the selection is exclusively based on the vector of observables *X* that determines the propensity score (Rosenbaum & Rubin,1983; Caliendo & Kopeinig, 2008) and that treatment is random and uncorrelated with the outcome once controlled for *X*. Sensitivity analysis a test of fulfillment of conditional independence assumption examines how strong the influence of unobservable characteristics on the participation process needs to be, in order to attenuate the impact of participation on potential outcomes.

Additionally, in order to ensure randomized selection the common support condition needs to be applied, which guarantees individuals with identical observable characteristics a positive probability to belong both to the participation group and controls. ATT is defined only within the region of common support. This is because only in the overlapping subset of the comparison group and treatment group can comparable observations are matched. A violation of the CSC is a major source of bias due to comparing incomparable individuals (Heckman *et al.* 1997).

Individuals that fall outside of the region of common support have to be disregarded and the treatment effect cannot be estimated.

Given that CIA holds and assuming additionally that there is overlap between both groups, the PSM estimator for ATT can be written in general as;

$$ATT = E\{E\{Y_1|Di = 1, p(Xi)\} - E\{Y_0|Di = 0, p(Xi)\}|Di = 1\}\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where ATT= Average treatment effect on the treated conditioned on participation.

Y_1 denotes the food security outcome for an individual if the person is a participant and

Y_0 the food security outcome if the person is non-participant,

In a regression framework, the treatment effects model is given by

$$Y = a + \beta b_i + c\,\mathbf{X_i} + e_i\}\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where Y is the household food security level as measured by per capita calorie intake

$b_{i\,is}$ the propensity score, of the i^{th} farmer,

$\mathbf{X}_i$ *is* a vector of control variables such as farmer/ household characteristics.

β measures the impact of participation in export horticulture on per capita calorie intake.

The hypothesis that participation in export horticulture farming has no impact to food security is rejected if the **t**-statistic corresponding to the impact is more than $\left|1.65\right|$, 90 percent confidence interval.

3.6 Methods and procedures

3.6.1 Study areas

The study was carried out in Mbooni district, (which since the revision of administrative boundaries in the year 2013 became a sub county within Makueni county) the larger Kirinyaga District (which is currently a county) and Buuri district (which is now a sub county within Meru County). However for the purpose of this report, study areas are referred to as districts-their former administrative names as was when the study was designed and data collection done.

Mbooni district is a new district in Kenya originally part of Makueni district, and is one of the districts that form Eastern Province. It is generally a low lying district rising from 700 meters above sea level at the lowlands to 1900 meters above sea level. The district lies within the arid and semiarid zones of the country. Hills are the main land feature in the district, which are composed of granite rocks. The district experiences two rainy seasons namely the long rains occurring in March to April and the short rains occurring in November to December. The hilly parts receive 800-1400mm of rainfall per year. With a population of 177,832 persons the district covers an area of 894.6 sq Km and has very high poverty level with absolute poverty standing at 64.3 percent (MPND, 2008a)

Kirinyaga District is one of the six districts in Central Province. The district covers an area of 1,437sq Km and has a population of 528,054. Kirinyaga District has absolute poverty of 36 percent. The district lies between 1150 to 5380 meters above sea level. It receives two rainy seasons the long and the short rains between March to May and October to November respectively (MPND, 2008b)

Buuri district is one of the new districts created by the Kenya government in the recent past. It was originally part of Imenti North district. The district lies between 3000-5199 meters above

sea level and covers an area of 919 square kilometers. It has a population of about 280 000. In 2002, approximately 50 percent of the population was living below the poverty line (MPND, 2008c)

3.6.2 Study Context, Data and Sampling

This study was one of several work packages in a larger research project -Drivers Viability and Livelihood Impact of Compliance with Private Food Safety Standards among Smallholder Horticultural Producers in Kenya (DriVLIC Kenya) funded by International Development and Research Centre (IDRC) . The list of farmers from an initial baseline survey of the DriVLIC-Kenya Project formed the sampling frame for this study, with a household as the sampling unit. The sampling frame was used to generate seven categories of farmers: Individually fully compliant farmers who are growers of exporters, Group contract farmers (who own facilities, production process and keep their own records), Group scheme farmers (exporters own facilities, keeps records and controls production), Non-compliant farmers who abandoned standards after adopting, Non-compliant farmers who have never adopted standards, Farmers who do not grow French beans. Based on the list which comprised of 1324 farmers, a total of 573 households were sampled in the three study areas using proportionate to population size (PPS) selection of the follow-up respondents. However due to missing response the sample size used for analysis in this study comprised the following households as presented in Table 2 below categorized as growers and non-growers in each of the three districts?

Table 2: Sample structure by district

District	Growers	Non-growers	Total
Kirinyaga	154 (67%)	74(32%)	228
Mbooni	80 (56%)	64(44%)	144
Buuri	109 (80)	28(20)	137
Total	**343**	**166**	**509**

3.6.3 Data Collection Procedures

Sampling unit in this study was a household, comprising of people living together headed by one person and having one cooking arrangement. Data used in this study was collected in two phases; baseline data containing farmer socioeconomic characteristics and production information for the whole project, that was collected between July and October 2010 and the consumption household data was collected between August and November year 2011. Cross-sectional primary data was used where recall information on the number of different types and quantity of food consumed over the previous day was captured using a structured questionnaire. In a number of instances the person responsible for meal preparation, was different from the main respondent, prompting the need to have two respondents. Otherwise the meal preparer was the respondent of the whole questionnaire. In instances where the meal preparer was absent, the food consumption section was left blank and marked for revisiting later. The data was used to assess the level of dietary diversity and household calorie consumption. The quantities of the different foods consumed was recorded and converted to caloric value and then divided by household size then compared to 2250 Kcal threshold. Data on household characteristics, sex and age of the household head, farm and non-farm income, education level of the household head, and household compliance to food safety standards, whether or not a household produced for export had been captured in the first phase using a structured questionnaire too.

Data collected was analyzed using Excel where calculations and conversion of food items to their calorie value were done. Descriptive statistics and summaries and other data analysis procedures were done using STATA and SPSS.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Sample Descriptive statistics

4.1.1 Social-economic Characteristics of Smallholder Farmers in Mbooni, Buuri and Kirinyaga

Table 3 presents the summary statistics of the social-economic characteristics for the individual districts' samples. Typical of smallholder farming in Kenya, the three districts were characterized by land scarcity. However, renting of land appeared a common practice in the three districts. Kirinyaga had an average land owned of 0.53 acres, Mbooni 0.50 acres and Buuri 1.36 acres. But the average area of total land representing owned land plus rented land in districts was 2.92 acres, 2.53 acres and 3.25 acres of land in Kirinyaga, Mbooni and Buuri district respectively. This shows that on average in Kirinyaga 2.39 acres was rented- in, 2.03 acres in Mbooni and an average of 1.89 acres were rented-in in Buuri. Thus rent is an expenditure item among the surveyed households. The difference of the land owned and total land may indicate that some farmers in these areas are not originally from the same locality or majority of land owners do not cultivate their land but instead rent it out to other people. The mean land area under cultivation was 2.48 acres in Kirinyaga, 1.65acres in Mbooni and 3.48 acres in Buuri. Thus smallholder farmers in Buuri had the largest land area under cultivation while those in Mbooni had the least.

Annual income from the farm was highest in Buuri with an average of Kshs 169254. Kirinyaga had an average farm income of Kshs 108 581, while Mbooni had only Kshs 56 523 this income varied positively with the size of agricultural land. The other cause of the difference in this

income could be the fact that highest proportion, 87 percent of households in Buuri reported that farming was their main occupation with only 2 percent earning a salary.

Table 3: Social Economic Characteristics of Smallholder Farmers in Kirinyaga, Mbooni and Buuri

	Kirinyaga		**Mbooni**		**Buuri**	
Variable	Mean	Std.D	Mean	Std.D	Mean	Std.D
AGRICLAND	2.48	1.67	1.65	1.02	3.48	3.07
CONTRACT	0.50	0.50	0.66	0.47	0.57	0.50
CREDIT	0.49	0.50	0.79	0.40	0.51	0.50
DISTINPUT	1.14	0.96	1.43	0.93	1.64	2.09
DISTMARKET	3.37	2.87	6.10	5.00	4.28	2.80
DISTWATER	0.32	0.87	0.62	1.73	0.08	0.28
EXPVEGAREA	0.53	0.54	0.24	0.13	0.53	0.84
FAMLABOURERS	1.84	0.87	2.10	1.17	1.78	1.02
FARMINCOME	108581	130147	56523	67602	169254	184406
GLOBALCOMP	0.46	0.50	0.33	0.47	0.42	0.50
GROUPMEMBERSHIP	0.64	0.48	0.45	0.50	0.86	0.34
HHAGE	49.92	13.52	48.52	13.93	49.38	14.08
HHEDUC	8.26	3.92	7.95	4.26	8.05	3.96
HHFARMEXPR	20.54	13.25	20.37	12.35	18.64	11.72
HHGENDER	0.82	0.38	0.79	0.41	0.88	0.32
HHSIZE	3.91	1.73	5.79	2.2	4.71	1.84
LVSTKUNITS	2.99	1.80	3.21	1.86	3.48	2.07
MAINOCCUP	0.85	0.36	0.70	0.45	0.87	0.33
OWNLAND	0.53	1.29	0.50	0.77	1.36	2.98
SALARIED	0.04	0.20	0.11	0.32	0.02	0.12
TOTACRES	2.92	2.38	2.53	1.68	3.25	2.72
TOTLABOURERS	3.90	2.40	3.38	1.62	3.33	1.78
WALLTYP	0.22	0.41	0.06	0.24	0.13	0.34
WATERSOURCE	0.73	0.44	0.56	0.50	0.90	0.29

In Kirinyaga 85 percent had farming as their main occupation with 4 percent earning a salary. In Mbooni a lower, 70 percent reported farming as their main occupation. More so, 11 percent of the household heads were earning a salary. This may stem from the unreliability of farming as a source of livelihood in Mbooni due to the unpredictability of rainfall coupled with the less developed irrigation systems, unlike in Kirinyaga and Buuri, prompting residents to seek alternatives.

The surveyed households were hiring in labour and were thus incurring labour costs as shown by the difference in the number of total labourers and the number of labourers from the family meaning that there exist active labour markets in the three districts. With an average of 3.90 total labourers and only 1.84 labourers from the family, households from Kirinyaga hired an extra 2.06 labourers. Those in Mbooni hired on average 1.28 labourers having 3.38 as the total labourers and 2.10 labourers from the family. On the other hand households in Buuri, with an average of 1.78 family labourers hired 1.55 more to bring the number of total labourers to 3.33. The presence of hired labour raises question of the efficiency and productivity of labour and the possible effect on the profitability particularly in the face of small land area under export horticulture.

The average age of the household head was 49.92 years, 48.52 years and 49.38 years in Kirinyaga Mbooni and Buuri districts respectively. The average education of household heads in all the districts was no more than primary education equivalent, with Mbooni having slightly less average years of formal education than the rest. This implies that the three districts are more or less similar in respect to the age and education level of the household heads.

Mbooni had the largest families with an average of 5.79 persons. Kirinyaga had an average of 3.91 members and Buuri had an average of 4.71 members. Mbooni residents seemed disadvantaged as they were covering on average the most distances whether to the nearest market 6.10 km, or to the nearest source of water, 0.62 km and also spent 1.43 hours walking to the nearest input shop. In Kirinyaga the average distance to the nearest market was 3.37 km, they covered 0.32 km to get to the nearest water source and only walked for 1.14 hours to get to the nearest input shop. On the other hand Buuri residents covered the shortest distance to the nearest source of water 0.08 km, walked for 1.64 hours to get to the nearest input shop and also covered on average 4.28 km to get to the nearest market centre. This shows that the technology structures are less developed in Mbooni.

The three districts devoted only small portions of land to export vegetable production with 0.53 acres in Kirinyaga, 0.24 acres in Mbooni and 0.53 acres in Buuri. This represents 21 percent of the agricultural land in Kirinyaga, and 15 percent in both Mbooni and Buuri. Livestock units owned by the household were least in Kirinyaga with an average of 2.99 and highest in Buuri with an average of 3.48. Mbooni had an average of 3.21 livestock units owned. Only 6 percent of households in Mbooni had stoned walled houses as opposed to 22 percent in Kirinyaga and 13 percent in Buuri. This and the fact that only 56 percent of households in the district were using safe water as opposed to 73 percent in Kirinyaga and 90 percent in Buuri, underscores the high poverty levels in Mbooni as reported by the national poverty statistics. This could be among reasons why a high percentage, 79 percent of households were taking credit in Mbooni, as opposed to only 51 percent in Buuri and only 49 percent in Kirinyaga. The form of credit commonly used by farmers in these areas was in kind (farm inputs provided by export companies to the farmers and later deducted from sale proceeds and the reminder remitted to the farmer)

4.1.2 Comparison of Growers and Non growers Social Economic Characteristics

Table 4, Table 5 and Table 6 present comparisons of the social economic characteristics between growers and non-growers in Kirinyaga, Mbooni and Buuri districts, respectively

Table 4: Comparison growers' and non-growers' social economics characteristics in Kirinyaga District.

	Growers		Non-growers		Test of difference in means	
Variable	mean	sd	mean	sd	t-stat	P-value
AGRICLAND	2.70	1.81	1.88	1.01	-2.13	0.04**
DISTINPUT	1.13	0.96	1.16	0.99	0.23	0.82
DISTMARKET	3.32	2.87	3.50	2.91	0.41	0.68
DISTURBAN	9.05	10.10	9.58	6.26	0.41	0.68
DISTWATER	0.28	0.54	0.43	1.35	1.15	0.25
EXTCONTACT	0.63	0.48	0.51	0.50	-1.60	0.11
FAMLABOURERS	1.83	0.86	1.87	0.88	0.36	0.72
FARMINCOME	129650	148125	63732	58772	3.59	0.00***
GROUPMEMBER	0.67	0.47	0.58	0.49	-1.2	0.22
HHAGE	47.43	12.56	55.07	14.05	4.10	0.00***
HHEDUC	8.66	3.50	7.32	4.68	-2.36	0.02**
HHFARMEXPR	19.45	11.60	22.82	16.04	1.78	0.76
HHGENDER	0.87	0.34	0.72	0.45	-2.91	0.00***
HHOCCUPATION	0.86	0.35	0.83	0.38	-0.49	0.63
HHSIZE	4.13	1.69	3.47	1.75	-2.71	0.01***
LNTOTASSETS	11.98	0.99	11.93	1.17	-0.21	0.83
LVSTKUNITS	3.21	1.78	2.58	1.74	-2.67	0.01***
OWNLAND	0.55	1.34	0.49	1.20	-0.19	0.85
TOTACRES	2.91	2.22	2.93	2.70	0.45	0.96
TOTLABOURERS	4.08	2.38	3.55	2.52	-1.47	0.14

*significant at 10% **significant at 5% and *** significant at 1%

Kirinyaga District

As presented in Table 4 above, social economic characteristics of growers and non-growers in Kirinyaga were statistically significant in gender of the household head, household size, household head's years of education, the size of land under cultivation, farm income, household head age and livestock units. Growers had a higher household size and a higher percent of male headed households and more livestock units. However, non-growers had on average older household heads. Growers had more land under cultivation and consequently more farm income all at five and one percent level of significance respectively. The household head years of formal education of growers were also higher than that of non-growers. The higher percentage of male headed households may be explained by the tendency of men being more concerned with cash crops as opposed to women who are biased towards food crops certainly because of structural barriers for women's ability access land, markets, education and networks and on the more complex workload of women in rural areas resulting to lower technology adoption .Moreover, women in relatively traditional societies focus a lot of their attention on child rearing a phenomenon that drives them to food production before any other task. The fact that there is no significant difference between growers and non- growers in the distance to the nearest input shop, to the nearest market, urban center and to the nearest water source suggest that these households were from the same neighbourhood.

Mbooni District

Growers in Mbooni were found to have significantly larger families of 6.16 members compared to 5.33 members in the non-grower category, at 5 percent level of significance; this enabled them to use the free family labour. The household head years of farming experience was also significantly different at 10 percent level with the growers having an average of 21.90 years while the non-growers had 18.46 years.

Owned land, total acres and agricultural land between the two groups were significantly different at 10 percent, 1 percent and 10 percent respectively, with the growers owning more land and having a larger area under cultivation than the non-growers. Farm income was consequently higher for growers than the non-growers at one percent level of significance.

Table 5: Comparison Growers' and Non-growers' Social Economics Characteristics in Mbooni District

	Growers n=78		**non-growers N=62**		**Test of difference in means**	
Variable	**mean**	**sd**	**mean**	**sd**	**t-stat**	**P-value**
HHGENDER	0.80	0.40	0.77	0.42	-0.37	0.71
HHSIZE	6.16	2.15	5.33	2.25	-2.26	0.03**
HHEDUC	8.19	4.39	7.65	4.11	0.76	0.45
GROUPMEMBER	0.56	0.50	0.32	0.47	-2.55	0.01***
HHOCCUPATION	0.72	0.45	0.68	0.47	-0.50	0.62
HHFARMEXPR	21.90	12.31	18.46	12.24	-1.66	0.10*
TOTLABOURERS	3.90	1.52	2.76	1.53	-4.43	0.00***
FAMLABOURERS	2.08	0.92	2.13	1.43	0.26	0.80
OWNLAND	0.76	1.09	0.29	0.46	-1.83	0.07*
AGRICLAND	1.92	0.97	1.36	1.02	-1.86	0.07*
EXTCONTACT	0.87	0.33	0.48	0.50	5.39	0.000***
HHAGE	48.81	13.50	48.17	13.36	0.27	0.78
LVSTKUNITS	3.50	1.89	2.86	1.77	-2.07	0.04**
DISTMARKET	5.86	4.89	6.40	5.15	0.63	0.53
DISTINPUT	1.43	0.80	1.40	1.07	0.05	0.96
DISTURBAN	14.48	13.76	14.75	16.31	0.10	0.92
DISTWATER	0.53	0.59	0.71	0.56	1.62	0.11
TOTACRES	2.95	1.73	2.01	1.43	-3.30	0.01***
LNTOTASSETS	12.46	1.00	12.47	1.25	0.03	0.97
FARMINCOME	75965	76808	24935	29038	-4.41	0.00***

*significant at 10% **significant at 5% and *** significant at 1%

The livestock units owned by growers, 3.5 units were more than those owned by the non-growers 2.86 units this was found to be statistically different at 5 percent level of significance. The total labourers for the grower category, 3.90 labourers, were found to be more compared to the non-grower category, 2.76 labourers; in-spite the fact that the two categories had insignificant difference in the number of family labourers, with growers having an average of 2.08 and non-growers having an average of 2.23 labourers. Thus growers hired more (1.82 labourers) as opposed to non-growers who hired only 0.63 labourers on average, which is about 3 times as many. This is because export horticulture requires more labour for instance, during spraying and harvesting. Harvesting must also be done in the morning hours and at specific period which may require more labour than the family can supply. This was different at one percent level of significance.

More growers, 87 percent, had contact with the field extension as opposed to only 48 percent of the non-grower category. This was found to be significantly different at one percent level of significance probably due the initiative of exporting companies sourcing export from the area vegetables employing field extension officers to advice farmers on general agronomic practices of export horticulture farming. More export horticulture growers than non-growers belonged to a farmer group probably for horticulture marketing. As with Kirinyaga district, these households were drawn from the same area thus there were no significant difference in terms of distance to the market, input shop, water source or the nearest input shop. Other variables considered were found to have insignificant differences between the two groups.

Buuri District

The average years of farming experience of growers in Buuri district was significantly less than that of non-growers and so was the average age of the household head, suggesting that in this

district the younger generation is embracing growing of export vegetables. Growers had more education and larger household sizes. 91 percent of growers reported that farming was their main occupation as compared to 73 percent in the non-grower category.

Table 6: Comparison of Growers' and Non-growers' Social Economics Characteristics in Buuri District

	Growers n=107		non-growers n=24		Test of difference in means	
Variable	mean	sd	mean	sd	t-stat	P-value
HHGENDER	0.90	0.31	0.81	0.40	-1.14	0.26
HHSIZE	4.84	1.86	4.18	1.72	-1.72	0.09*
HHEDUC	8.42	3.82	6.64	4.24	-2.14	0.03**
GROUPMEMBER	0.88	0.32	0.81	0.40	-0.96	0.34
HHOCCUPATION	0.91	0.29	0.73	0.45	-2.44	0.02**
HHFARMEXPR	17.50	11.08	23.14	13.24	2.31	0.02**
TOTLABOURERS	3.53	1.81	2.61	1.45	-2.49	0.01***
FAMLABOURERS	1.75	1.10	1.88	0.71	0.23	0.82
OWNLAND	1.22	2.94	1.76	3.20	0.54	0.59
AGRICLAND	3.52	3.00	3.21	4.01	0.21	0.83
EXTCONTACT	0.72	0.45	0.46	0.51	-2.64	0.01***
HHAGE	47.05	12.67	58.50	15.76	4.01	0.00***
LVSTKUNITS	3.75	2.12	2.46	1.55	-3.00	0.00***
DISTMARKET	4.05	2.66	5.22	3.17	1.85	0.07*
DISTINPUT	1.57	1.05	1.98	1.28	1.59	0.11
DISTWATER	0.03	0.17	0.24	0.48	3.70	0.00***
TOTACRES	3.17	2.58	3.62	3.26	0.76	0.45
LNTOTASSETS	11.64	0.70	11.85	1.10	1.12	0.26
FARMINCOME	190486	194358	65990	65933	-2.97	0.00***

*significant at 10% **significant at 5% and *** significant at 1%

The level of contact with extension officers, and group membership were found to be significantly different at 1 percent and 5 percent level of significance with the growers having a higher percentage having had contact with the extension officers and a higher percentage

belonging to a group. Smallholder horticulture farmers have had the initiative of forming producer and marketing groups in an attempt to reduce transaction costs associated with export horticulture farming. There are increasing efforts to increase extension services to farmers to offer advice on export crops by companies involved in export horticulture which normally utilize farmer groups.

Growers had more labourers and more livestock units than the non-growers the difference being significant at one percent level of significance. The growers also covered shorter distances compared to the non-growers to get to the nearest water source meaning that farmers nearer to water sources were more likely to grow export crop probably due to the need to irrigate. Like in the other two districts the amount of farm income between growers and non-growers was significantly different at 1 percent level with the growers having more farm income than the non-growers.

4. 2 Food Security Situation

This sub section addresses the first objective of this study. Table 7 presents the average per capita intakes and the household dietary diversity indices for the three study areas which are disaggregated according to growers and non-growers of export horticulture as well as the aggregate average for each district. The table shows that the average per capita intake was highest in Buuri 2480 Kcal and lowest in Mbooni at 2188 Kcal. The per capita intake in Kirinyaga was 2410 Kcal. This shows that on average Kirinyaga and Buuri districts were above the cutoff point of 2250 Kcal and thus food secure while Mbooni district was food insecure.

Table 7: Average Per Capita Calorie Intake and Dietary Diversity Indices by District and Growing Status

District	Growers/Non growers	Per capita calorie intake (Kilocalories)	HDDI
Kirinyaga	Growers	2462.10	7.79
	Non growers	2303.25	6.45
	Average	2409.86	7.68
Mbooni	Growers	2152.98	7.49
	Non growers	2230.79	7.63
	Average	2187.56	7.55
Buuri	Growers	2511.17	7.38
	Non growers	2361.73	7.14
	Average	2480.21	7.33

Both growers and non-growers in Kirinyaga and Buuri Districts were found to be food secure while both the growers and non-growers in Mbooni district were found to be food insecure. This leads to the rejection of the null hypothesis that smallholder farmers are not food secure in Kirinyaga and Buuri and failure to reject the same hypothesis in Mbooni due to the fact that the average per capita calorie intakes in Kirinyaga and Buuri were beyond the 2250 Kcal threshold while that of Mbooni was below the threshold. The lowest per capita calorie intake was found among growers in Mbooni district with an average of 2152 Kcal. The diet quality measure HDDI did not exhibit a similar pattern. Growers in Kirinyaga had the most diverse diets while non- growers in the same district had the least diverse diets. This demonstrates the need to combine different measures of food security to capture the different dimensions.

Table 8 presents the absolute numbers and percentages in brackets, of growers and non-growers that are food secure/insecure in each district. In Kirinyaga, 90 growers representing a 60 percent of all growers and 39 non growers representing a 53 percent of the non-growers were food secure. On the other hand 59 growers representing a 40 percent of growers were food insecure while 34 non-growers who were 47 percent of non-growers were food insecure.

Table 8: Food Security Situation by District and Growing Status

District	Growers/ Non growers	Food secure (%)	Food insecure (%)
Kirinyaga	Growers	90 (60%)	59 (40%)
	Non growers	39 (53%)	34 (47%)
Mbooni	Growers	35 (56%)	45 (44%)
	Non growers	35 (55%)	29 (45%)
Buuri	Growers	71 (65%)	38 (35%)
	Non growers	17 (57%)	12 (43%)

In Mbooni, out of the 70 food secure category, 35 were growers representing a 56 percent of all growers and 35 were non growers representing a 55 percent of non-growers. 45 households of the grower category were food insecure and so were 29 households from the non-grower category. These represented a 44 and a 45 percent for growers and non-growers respectively. In Buuri, 87 households were food secure while 50 were food insecure. Out of the food secure households 71 were growers while the rest 15 were non growers. Of the 50 food insecure households, 38 of them were growers while the rest, 12 were non growers. This represented a 35 percent of growers and a 43 percent of non-growers. The percentages shown in the table indicate that in all the categories, a higher percentage of growers were food secure than the non-grower category hence the need to report the absolute numbers.

Figures 2, 3 and 4 give the graphical representations of the percent of food secure and food insecure households in the growers and non-grower categories for Kirinyaga, Mbooni and Buuri respectively.

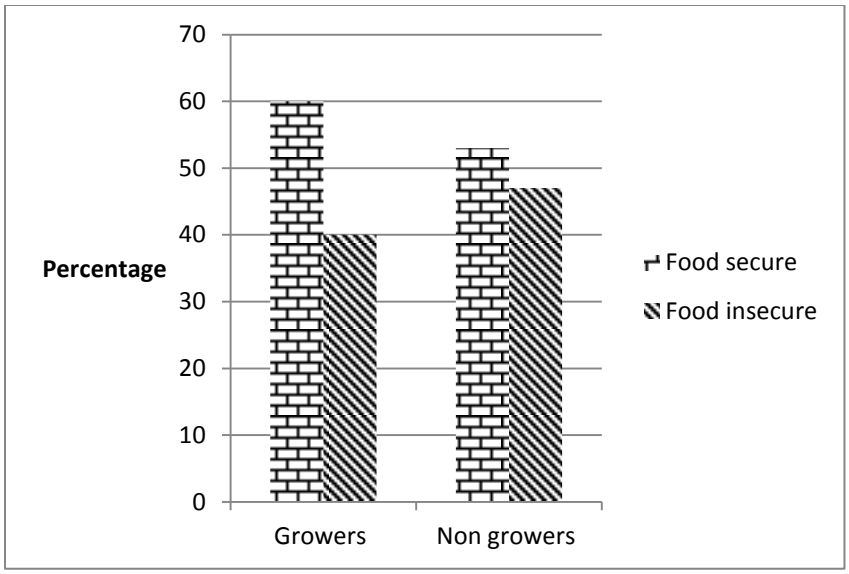

Figure 2; Percentage of the food secure /insecure households in Kirinyaga

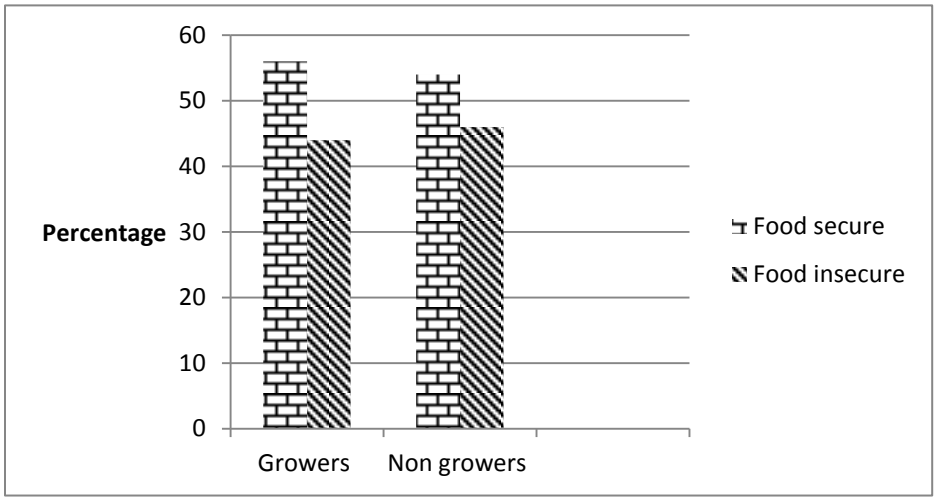

Figure 3; Percentage of the food secure /insecure households in Mbooni

Figure 4; Percentage of the food secure /insecure households in Buuri

4.3 Factors Influencing Food Security Situation

Table 9 and Table 10 present the results of the OLS model and Poisson Model regression results respectively. OLS regression results present the factors affecting food security as measured by per capita calorie intake or the diet adequacy aspect of food security. The Poisson regression results present the factors affecting food security as measured using HDDI which reflects diet quality aspect of food security.

4.3.1 Model Diagnostic Tests

All model estimations in this study i.e. OLS, Poisson and logit model estimations for generating propensity scores, followed diagnostic tests for heteroskedasticity and multicollinearity where applicable. The Breusch-Pagan test designed to detect any linear form of heteroskedasticity, which is inbuilt in STATA was used. In all instances mild heteroskedasticity was noted and the robust standard command in STATA was used to estimate the robust standard errors.

Moderate multicollinearity is fairly common since any correlation among the independent variables is an indication of collinearity. However, when severe multicollinearity occurs, the

standard errors for the coefficients tend to be very large (inflated), and sometimes the estimated coefficients can be highly unreliable. Tests for multicollinearity were done using pair wise correlation and the variance inflation factor (VIF) technique. Gujarati (2007) notes that "although a study of partial correlations may be useful, there is no guarantee that they will produce an infallible guide to multicollinearity, some authors therefore, use VIF as an indicator of multicollinearity". The study employed the two tests to check for the presence multicollinearity. The larger the value of the VIF, the more collinear a variable is. Gujarati (2007) argues that "as a rule of thumb, if the VIF of a variable exceeds 10, which will happen if R^2_j exceeds 0.9, that variable is said to be highly collinear". The results of the VIF for the variables included in all the models were less than 10 and the pairwise correlations were less than 0.5. However, some variables hypothesized to be in the model had to be dropped due to multicollinearity. For example whether a farmer is global Gap compliant or not was dropped in both OLS and Poisson Models since it ether showed a high correlation with whether a farmer received extension service or with whether a farmer grows export vegetable or not.

Table 9: OLS Regression Estimates of the Factors Affecting Per Capita Calorie Intake in Kirinyaga, Mbooni and Buuri Districts.

	Mbooni			Kirinyaga			Buuri		
Variable	Coef	t	p-value	Coef	T	p-value	Coef	t	p-value
DISTINPUT	-	-	-	-64.19	-1.08	0.28	-	-	-
DISTWATER	-5.73	0.06	0.95	-17.73	-0.22	0.33	-	-	-
EMPLOYMENT	1.19	0.45	0.65	3.79	1.82	0.07***	10.10	3.12	0.00***
EXTENSION	127.27	0.71	0.48	-	-	-	70.78	0.64	0.53
FARMEXPR	12.10	2.14	0.04**	-	-	-	-	-	-
FARMLABOURER	-	-	-	47.14	0.98	0.38	-	-	-
GROUPMEMBER	-10.93	-0.08	0.94	47.44	0.45	0.65	278.27	2.04	0.05**
GROWEXPVEG	-266.90	-1.89	0.06*	240.12	1.95	0.06 **	149.08	1.05	0.30
HHEDUC	37.20	1.86	0.07*	23.07	1.47	0.145			
HHGENDER	-233.30	-1.33	0.19	287.68	2.04	0.04**	-8.01	-0.07	0.95
HHSIZE	-65.88	-1.90	0.06*	-236.63	-5.85	0.00***	-86.60	-3.03	0.00***
INCOMECAT	-	-	-	302.71	2.51	0.01***	483.19	4.02	0.00***
SCHEXPND	0.01	0.84	0.40	-	-	-	-	-	-
TOTACRES	-	-	-	70.91	3.15	0.00***	54.83	2.94	0.00**
WALLTYPE	392.30	2.91	0.01***	9.33	0.07	0.94	184.07	1.64	0.11
WATERSOURCE	436.84	3.05	0.00***	-	-	-	349.03	1.59	0.02**
CONSTANT	1730.20	4.34	0.00***	2676	9.68	0.00***	1139.17	3.10	0.00***
R^2	0.43			0.43			0.41		

significant at 10 percent, ** at 5 percent and * at 1 percent level*

Table 10: POISSON Regression Estimates of the Factors Affecting HDDI in Kirinyaga, Mbooni and Buuri

	Mbooni			**Kirinyaga**			**Buuri**		
Variable	Coef	dy/dx	p-value	Coef	dy/dx	p-value	Coef	dy/dx	p-value
GROWEXPVEG	-0.08	-0.44	0.325	0.19	1.03	0.04**	-0.05	-0.22	0.76
TOTACRES	0.01	0.05	0.67	0.02	0.11	0.14	-0.01	-0.06	0.47
HHEDUC	0.22	0.12	0.02**	-	-	-	0.05	0.25	0.00***
TRANSCOST	-0.00	-0.01	0.05**	-	-	-	-	-	-
HHSIZE	0.06	0.32	0.00***	-0.05	-0.26	0.08**	-0.04	-0.16	0.10*
GROUPMEMBER	0.06	0.31	0.44	-	-	-	-	-	-
HHGENDER	-0.30	-1.74	0.01***	-	-	-	-	-	-
WATERSOURCE	0.17	0.91	0.01***	-	-	-	-	-	-
SCHEXPND	-	-	-	0.00	0.00	0.01***	-	-	-
WALLTYPE	0.35	1.19	0.00***	-0.01	-0.08	0.90	-	-	-
TOTASSETS	-	-	-	0.00	0.00	0.37	-	-	-
MAINOCCP	-	-	-	-1.33	-0.78	0.08*	-	-	-
DISTINPUT	-	-	-	0.02	0.13	0.52	-	-	-
EXTENSION	-	-	-	0.19	1.13	0.00**	0.03	0.12	0.77
FARMINCOME	-	-	-	-	-	-	0.06	0.31	0.15
FARMEXPR	-	-	-	-0.00	-0.02	0.13	0.01	0.04	0.06*
FARMLABOURER	-	-	-	0.01	0.06	0.39	0.15	0.71	0.01***
DISTWATER	-	-	-	-	-	-	-0.52	-2.39	0.00***
DISTURBAN	-	-	-	-	-	-	-0.01	-0.03	0.04**
CONSTANT	1.38		0.00***	1.82		0.00***	0.53	0.33	0.00
PseudoR^2	0.12			0.10			0.15		
Prob > chi^2	0.00			0.00			0.00		

significant at 10 percent, ** at 5 percent and * at 1 percent level*

4.3.2 Mbooni District

Out of twelve variables included in the OLS model six variables were found to significantly affect the per capita calorie intake. On the other hand six of the nine included in the Poisson regression in Mbooni were significantly affecting per capita calorie intake. The results of both the models are comparable to some extent. Export horticulture farming was found to negatively affect the per capita calorie intake. This was found to be statistically significant at 10 percent level. With all other variables held constant a, grower of export vegetable was found to consume 266 Kcal less than a non-grower. However, growing export horticulture was found to have insignificant, effect on the dietary quality as measured by the HDDI.

Household head years of formal education, household size, whether household has access to tap water or protected springs, and the type of wall of the main house, were all found to be significant in both the models. One additional year of formal education was found to result to an increment of 37 Kcal and 0.12 units of HDDI, all else held constant. One additional member to a household was found to reduce the per capita calorie intake by 66 Kcal but increased the HDDI by 0.32 units according to the marginal effect analysis. These were both significant at one percent level. As mentioned earlier the effect of household size may either be positive or negative. If for instance the large numbers of household members are all in their productive stage then the more they are the more resources a household has hence better diet quality. But in the case of a positive effect on HDDI yet a negative effect on per capita calorie intake, a household may comprise children under five years and it is common practice in most communities in food insecure households to ensure that these get enough and nutritious meals even when the adults may be skipping meals or eating less than the recommended intakes.

The type of wall of the main house which signifies the wealth status of a household was found to statistically influence both the HDDI and the Per capita calorie intake. Households having stone walled households were found to be consuming 392 Kcal more than the households living in non-stone walled houses. Also movement from a non-stone walled house to a stone walled one, all else held constant, increased the HDDI by 1.19 units. All else held constant, households that could access safe water for domestic use were found to be consuming 437 Kcal more than their counterparts who were using water from the river and non-protected springs for domestic use. Movement from using water from rivers and unprotected springs to using water from taps, borehole and protected springs was found to increase the HDDI by 0.91 units all else held constant. This was significant at one percent level in both models.

Movement from female headed households to male headed one, with all other variables held constant resulted to a decline of the HDDI by 1.74 units which was found to be statistically significant at one percent level. The same variable, showed a statistically insignificant effect on the household per capita calorie intake. Kiriti and Tisdell (2003) found a similar negative influence of cash cropping on per capita food availability in the male-headed households in Nyeri district in Kenya. This negative influence was not apparent in the female-headed households and in fact, per capita food availability increased with increased agricultural commercialization. The authors concluded that men are less likely than women to use the cash earned from cash cropping for food purchases.

The results of the test of the second hypothesis, which is an individual variable test of significance in Mbooni leads to rejection of the null hypothesis for six of the variables included in the OLS model. These variables are; Farming experience of the household head, whether a farmer participates in export horticulture, household head education, household size, wall type

which is a proxy of wealth and the main source of water for the household. The model results provide evidence that these variables are significant determinants of food security situation as measured by the per capita calorie intake. However, the study fails to reject the null hypothesis concerning the rest of the factors included in the model.

For the Poisson Regression model the null hypothesis have been rejected as pertains six variables; Household size, Household head education, Transport cost, Gender of the household head, source of water and the wall type. This is because these variables are significantly affecting the household food security in terms of diet quality or the household dietary diversity index.

4.3.3 Kirinyaga District

Six out of twelve variables included in the OLS and five of the eleven included in the Poisson model, were found to significantly affect household per capita calorie intake and HDDI respectively. These variables are; the proportion of months a farmer gets employment in his/her farm or outside the farm, whether a farmer grows export horticulture, household head gender, household size, income category and total acres in OLS model. In the Poison model the variables are; whether a farmer grows export horticulture, household size, and household expenditure on school fees, main occupation of the household head and whether a farmer had been visited by an extension worker. It is in respect to these variables that the test for the second hypothesis leads to rejection of the null hypothesis since they are significantly affecting the food security situation and failure to reject the same hypothesis with respect to the rest or the variables.

The two models showed a positive effect of export horticulture farming on food security both in terms of household per capita calorie intake and the HDDI. The OLS indicate that all else held constant growers of export horticulture consume 240 Kcal more than the non-growers. This was found statistically significant at 1 percent level. The Poisson regression model on the other hand

indicate that all else held constant movement from being a non-grower to a grower increases the HDDI by 1.03 units significant at five percent level.

Household size was found to be negative in both the models. One additional person in the household, all else held constant resulted to a decline of 0.26 units of HDDI and 237Kcal. These were statistically significant at 10 percent and one percent significance levels respectively. One additional acre of total land, with all the other variables held constant was associated with an increase of 71 Kcal to the household per capita calorie intake. However, same variable's positive effect on the HDDI was found to be statistically insignificant.

The movement from below-five thousand Kenya shillings per month to above-five thousand Kenya shillings income category, with all other variables held constant resulted to 303 Kcal increase in the household per capita calorie intake. Male headed households were consuming 288 Kcal more per capita than the female headed ones with all other variables held constant. This was found to be significant at five percent level.

4.3.4 Buuri District

Out of the 10 variables included in the models six, in both OLS and Poisson models were significantly influencing per capita intake and HDDI intake respectively. In both the models, growing of export horticulture was found to have no significant influence on household per capita intake or the HDDI. Household head's employment, water source, group membership, income category and total acres were the significant variables found to positively affect the per capita calorie intake of a household. Household size on the other hand had a negative effect on both per capita calorie intake and the HDDI. One additional member of a household was associated with 87 Kcal and 0.16 units decline in the household per capita intake and HDDI respectively.

The number of total labourers in a household was found to positively affect HDDI intake. One unit increase in the number of labourers was found to be associated with 0.71 units increase in the HDDI significant at one percent level. Households in the above five-thousands income category all else held constant were found to be consuming 483 Kcal more than their counterparts. Household head's years of education was found to positively influence the HDDI. One additional year of formal education resulted to an additional 0.25 units in the HDDI significant at 1 percent level.

Following the same procedure of test for individual variable significance, as in Kirinyaga and Mbooni, these results leads to the rejection of the second hypothesis with reference to; household head education, household size, farmer experience in farming, family labourers, distance to the nearest source of water and to the most important urban center in the Poisson regression and with reference to employment, group membership, household size, income category total acres and the source of water in the OLS model. These variables were significantly affecting the food security situation.

4.4 Impact of Export Horticulture Farming on Per Capita Calorie Intake

4.4.1 Estimating Propensity scores

Tables 11, 12, and 13 present the results of Logit regression models for Kirinyaga, Mbooni and Buuri districs respectively. This is for the purpose of estimating the probability of being in the treatment group of all sample units. The results also represent factors affecting participation in export horticultural farming. These have however been a subject/ purpose of an earlier study, McCulloch and Ota (2002), and thus the current study does not expound on the same. The results are only relevant in as far as they are a step to impact assessment using the Propensity Score Matching method, the purpose of this study.

Table 11; Logit Model for estimation of propensity scores in Kirinyaga district

Variable	coefficient	Std-err	z	P value
FAMLABOURERS	-0.30	0.22	-1.41	0.16
GROUPMEMBER	0.68	0.38	1.79	0.07*
HHAGE	-0.06	0.16	-3.79	0.00***
HHEDUC	-0.03	0.05	-0.63	0.53
HHGENDER	0.50	0.47	1.06	0.29
HHSIZE	0.21	0.12	1.67	0.09*
LIVESTOCKUNITS	0.20	0.11	1.78	0.08*
LNTOTASSETS	0.34	0.19	1.81	0.07*
WALLTYP	0.35	0.46	0.70	0.50
CONSTANT	-1.65	2.37	-0.70	0.49

Pseudo R^2 0.1515 LR $\chi 2$ (P value) 35.66(0.000)

*significant at 10% **significant at 5% and *** significant at 1%

Table 12; Logit Model for estimation of propensity scores in Mbooni district

Variable	coefficient	Std-err	Z	P value
EXTENSION	2.02	0.56	3.57	0.00***
FAMLABOURERS	0.23	0.26	0.92	0.36
GROUPMEMBER	1.61	0.54	2.98	0.00***
HHAGE	-O.00	0.02	-0.17	0.87
HHGENDER	-0.05	0.66	-0.07	0.94
HHSIZE	0.29	0.14	2.04	0.04**
LIVESTOCKUNITS	0.29	0.16	1.80	0.07*
MAINOCCUP	0.53	0.60	0.89	0.38
CONS	-5.03	1.70	-2.97	0.00***

Pseudo R^2 0.25 LR $\chi 2$ (P value) 34.17 (0.000)

*significant at 10% **significant at 5% and *** significant at 1%

Table 13; Logit Model for estimation of propensity scores in Buuri district

Variable	coefficient	Std-err	z	P value
DISTURBAN	0.06	0.03	2.20	0.03**
EXTENSION	0.40	0.71	0.56	0.57
FARMLABOURERS	-1.50	0.67	-2.24	0.03**
GROUPMEMBER	0.48	0.98	0.49	0.62
HHAGE	-0.10	0.03	-3.05	0.00***
HHGENDER	0.48	1.03	0.46	0.64
HHSIZE	0.19	0.19	0.96	0.33
LIVESTOCKUNITS	0.58	0.22	2.62	0.01***
MAINOCCUP	1.31	0.95	1.39	0.7
CONS	3.32	2.32	1.43	0.15

Pseudo R^2 0.39 LR $\chi 2$ (P value) 43.73 (0.000)

*significant at 10% **significant at 5% and *** significant at 1%

4.4.2 Assessing Overlap and Common Support condition

Implementing the common support condition ensures that any combination of characteristics observed in the treatment group can also be observed among the control group. ATT and ATE are only defined in the region of common support and violation of the common support condition is a major source of evaluation bias as conventionally measured (Heckman *et al*. 1997). Comparing the incomparable must be avoided, i.e. only the subset of the comparison group that is comparable to the treatment group should be used in the analysis (Dehejia and Wahba, 2002). Hence, an important step is to check the overlap, the region of common support between treatment and comparison group. Several ways are suggested in literature, where the most straightforward one is a visual analysis of the density distribution of the propensity score in both groups as shown by the following propensity histograms as figures 5, 6 and 7.

The histograms show that the distribution of the propensity scores between the groups of growers and non-growers were within the region of common support in Kirinyaga and Mbooni but a significant number of non-growers in Buuri were in the off common support region .This implies that the Common Support Condition was thus satisfied in Mbooni and Kirinyaga. In Buuri this condition was not met thus the average treatment effects estimated are biased and unreliable. This is a common feature in small samples where an acceptable balance on relevant covariates is rarely achieved. At this juncture, it is worth noting that the control group in Buuri only comprised of 27 non growers which is quite a small number. Consequently, the impact of export horticulture on food security using propensity score matching could not be assessed in Buuri.

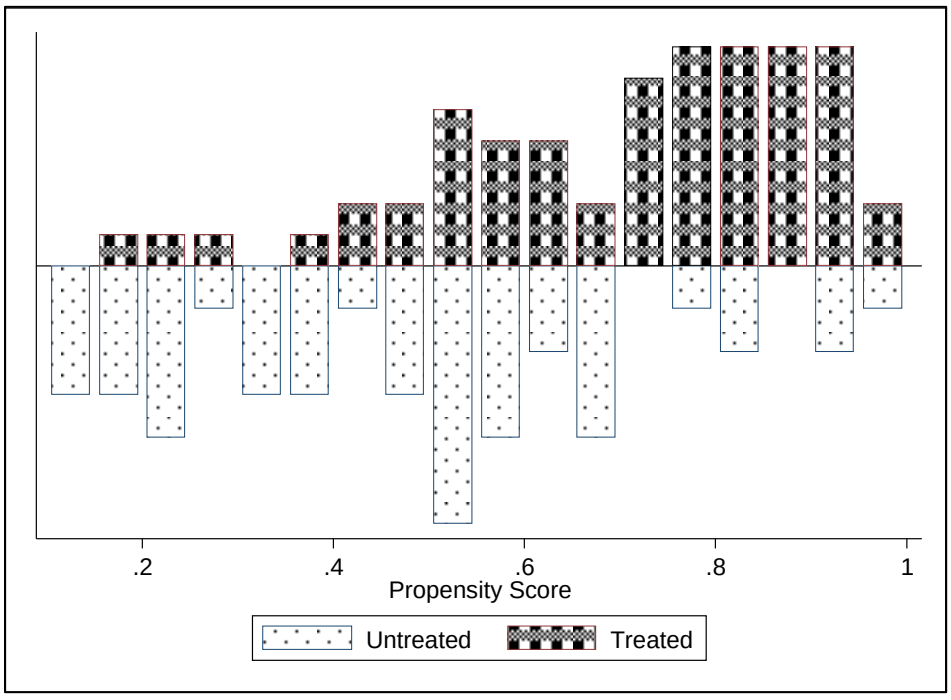

Figure 5; Propensity score histogram Kirinyaga district

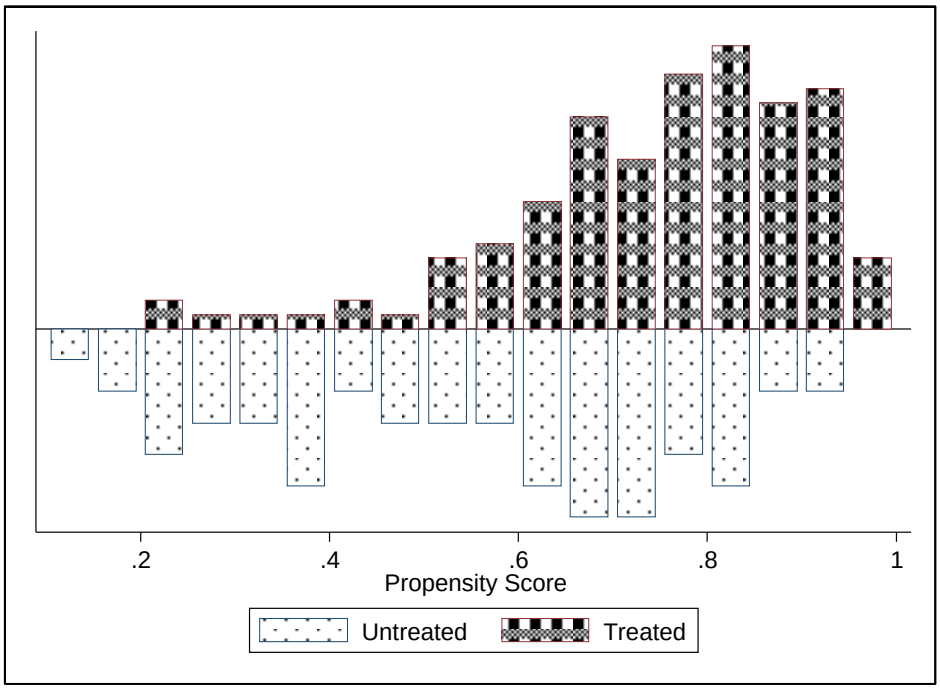

Figure 6; Propensity score histogram Mbooni district

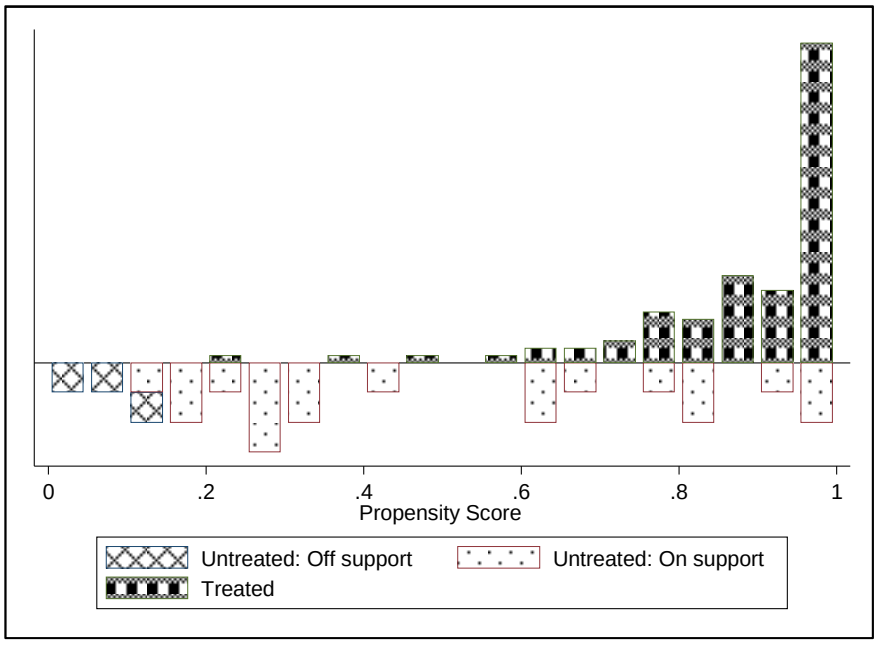

Figure 7 Propensity score histogram Buuri District

4.4.3 Treatment Effects

The results as presented in Table 14 show a positive impact in Kirinyaga and a negative impact in Mbooni. The impact in Buuri is statistically insignificant and is unreliable due to the violation of the common support condition as indicated histogram in figure 7. Following the reported **t-**statistics, the results leads to rejection of the third hypothesis that participation in export horticulture farming has no effect on food security in Kirinyaga and Mbooni. However there is no sufficient evidence to reject the same hypothesis in Buuri and the results may not be conclusive because of the violation of the common support condition. The Gamma level indicates the results of the sensitivity analysis that is discussed in the next section.

Table 14; Treatment Effects on Capita Calorie Intake- (Gamma level for Sensitivity Analysis)

	Kirinyaga district			**Mbooni**			**Buuri**		
Matching Algorithm	**ATT**	**t stat**	**Gamma level**	**ATT**	**t-stat**	**Gamma level**	**ATT**	**t-stat**	**Gamma level**
NNM	263	**2.00**	1.9-1.95	-389	**2.29**	**2.65-2.7**	99	0.18	-
KBM	267	**2.23**	1.65-1.7	-337	**2.06**	2.3-2.35	116	0.21	-
RM	262	**2.23**	1.6-1.65	-341	**-2.17**	2.25-2.3	90	0.17	-
Mean	264			-355			102		

As indicated earlier, the small holder horticultural farmers in Mbooni were producing export horticulture on very small land areas averaging 0.24 acres. This is as opposed to 0.53 in Buuri and 0.53 in Kirinyaga. The results are thus in line with those of Kuhlgatz and Abdulai (2011) who after assessed the determinants and welfare impacts of export crop cultivation in Ghana, found that household welfare was hardly affected at low levels of export revenue shares, but rose with increasing level of specialization. Fully specialized farms were found to substantially

improve their standard of living, with the threshold occurring around 70 percent level of specialization.

The probability or falling below the poverty line was virtually similar for export share between zero and 40 percent but begun to rise between 40 percent and 70 percent, only to decline after that. This suggests that there is a probable optimal level of production that smallholder farmers ought to have to ensure benefits of participation in export horticulture are accrued. This requires further investigation. The marginal benefits from a low export intensity may be easily outweighed by immeasurable benefits of non-export agriculture, such as predictability of local markets and risk insurance through consumption of own produce. Moreover, uncertainties about foreign markets especially the price levels, increased input prices, reduced bargaining power, the private food safety standards that come with a cost, rejection of produce due to defects are all challenges faced by the export horticulture farmers, all suppressing realization of probable benefits. In South Africa, business orientation of small scale farmers in the Venda region was found to have insignificant effect too on food security; the authors concluded that the reason behind the findings was the marginal nature of commercialization of these small scale farmers (Roy *et al*. 2000).

The different impact of export horticulture in the study areas is comparable to the review done by Dewalt (1993) who after going through the results of studies examining the impacts of agricultural commercialization on food consumption and nutritional status concluded that those schemes in which subsistence production were protected or stabilized are more likely to show positive results with an increase in income generated from cash cropping. This is probably due to better functioning local food markets that result to affordable and accessible food items that the cash crop growers can buy once they get cash from sale of cash crops.

4.4.4 Sensitivity analysis

Sensitivity analysis can be conducted to ascertain the robustness of estimates. Given that matching only balances the distribution of observed characteristics, if there are unobserved variables that simultaneously affect assignment into treatment and the outcome variable, a hidden bias might arise (Rosenbaum, 2002). This study addresses this problem with the bounding approach suggested by Rosenbaum (2002). The goal of the approach is to determine how strongly an unmeasured variable must influence the selection process to undermine the implications of the matching process. The sensitivity analysis indicated that the estimated treatment effects were insensitive to hidden bias with gamma values being from 1.9 to 1.95 for the nearest neighbor matching, 1.65 to 1.7 for kernel based matching and 1.6 to 1.65 for the radius matching in case of Kirinyaga. Estimated effects in Mbooni were even more insensitive to hidden bias with gamma values being from 2.65 to 2.7 for the nearest neighbor matching, 2.3 to 2.35 for kernel based matching and 2.25 to 2.3 for the radius matching. These value imply that, for instance in the case of Kirinyaga, nearest neighbor matching a gamma level of 1.9, if individuals that have the same X-vector differ in their odds of participation by a factor of 90 percent, the significance of the participation effect on per capita calorie intake may be questionable. Similarly a gamma level of 2.65 imply that if individuals with same X- vector differ in their odds of participation by a factor of 165 percent, the negative impact reported in Mbooni may be questionable. The implication is the same for the others. The study therefore concludes that even considerable amount of unobserved heterogeneity would not alter the inference about the estimated effects. In other words the average treatment effects are insensitive to hidden bias. No sensitivity analysis was carried out in case of Buuri since there were no statistically significant treatment effects.

4.4.5 Assessing the Matching Quality

The success of propensity score matching method is assessed by the resulting balance between the treatment group and the control group. Thus, after matching balancing tests need to be carried out to check for the extent to which differences in the covariates in the two groups in the matched sample have been eliminated. This indicate whether the matched comparison group can be considered as plausible counterfactual (Caliendo and Kopeinig, 2008). The basic idea of this step is to compare the situation before and after matching and check if there remain any differences after conditioning on the propensity score. The objective is to verify that treatment is independent of the unit characteristics after conditioning on observed characteristics. If there are differences, matching on the score was not (completely) successful and remedial measures must be done (Caliendo and Kopeinig, 2008). One suitable indicator of balancing powers of the estimations is ascertained by considering the reduction in the mean absolute standardized bias between the matched and unmatched models as shown in Table 15 below. The high percentage values of reduced standardized bias indicate the effectiveness of matching in reducing biases in the estimates.

Pseudo-R^2 from the propensity score estimation and from re-estimation of the propensity score after matching are also presented in Table 15. The pseudo R^2 indicates how well the regressors explain the participation probability. Thus before matching it is fairly high but reduces after matching to show that there are no systematic differences in the distribution of covariates between both groups after matching.

The P-values of the likelihood ratio tests before and after matching are also presented. Low p-values before matching shows that hypothesis that the regressors are jointly insignificant in determining probability of participation is always rejected before matching. After matching the p-values increases considerably, thus we fail to reject the same hypothesis, suggesting that there is no systematic difference in the distribution of covariates between growers and non- growers after matching.

Table 15: Covariate balancing tests

Test Indicator	Kirinyaga	Mbooni	Buuri
Before Matching			
Pseudo R^2	0.1515	0.244	-
Mean Bias	29.19	32.38	-
LR $\chi 2$ (P value)	35.22(0.0000)	33.94(0.0000)	-
After Matching using Nearest Neighbor Matching			
Pseudo R^2	0.05	0.05	-
Mean Bias	6.55	10.80	-
Percentage bias reduced	78	67	
LR $\chi 2$ (P value)	4.63 (0.87)	7.95(0.44)	-
After Matching using Kernel Based Matching			
Pseudo R^2	0.02	0.03	-
Mean Bias	6.54	10.26	-
Percentage bias reduced	78	68	
LR $\chi 2$ (P value)	6.22 (0.72)	5.46 (0.70)	-
After Matching using Radius Matching			
Pseudo R^2	0.03	0.04	-
Mean Bias	8.12	11.60	-
Percentage bias reduced	72	64	
LR $\chi 2$ (P value)	9.19 (0.42)	6.19 (0.63)	-

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

Attainment of food security is a major development objective in Kenya as outlined the MDGS and in the Kenya's Vision 2030. The horticulture subsector, identified as the fastest growing agricultural sub-sector in the country and ranked third in terms of foreign exchange earnings from exports after tourism and tea, is expected to contribute to this end. However, while horticultural products for domestic market are readily consumed in the farm households in Kenya, most export horticulture products are seen as cash crops intended only for the export market. These products' demand in the local markets though gradually coming up is low too. Thus, unlike domestic market vegetables and staple crops such as maize, Irish potatoes and cabbages the contribution of export horticulture to food security in Kenya is less direct and more similar to cash crops such as tea and sugarcane. However, there has been concern that production for the market and less for subsistence termed as cash cropping could undermine food security and poverty reduction. Debate in this matter shows mixed results and the available evidence is not enough to draw strong policy recommendations.

This study contributes to this debate and attempts to address three objectives; first, assessing the food security situation of smallholders in Kirinyga, Mbooni and Buuri, secondly assessing the factors that influence food security situation and lastly estimating the impact of export horticulture farming on food security. To measure food security situation seven day recall was used to get household per capita calorie intake and Household Dietary Diversity Index. To assess the determinants of Household Dietary Diversity Index, a truncated Poisson regression model was estimated while the determinants of per capita calorie intake were estimated using

Ordinary Least Squares. To assess the impact of export horticulture farming on food security, propensity score matching method was used.

All model estimations followed diagnostic tests for heteroskedasticity and multicollinearity where applicable. In instances where heteroskedasticity was noted and the robust standard command in STATA was used to estimate the robust standard errors.

Moderate multicollinearity is fairly common since any correlation among the independent variables is an indication of collinearity. However, when severe multicollinearity occurs, the standard errors for the coefficients tend to be very large (inflated), and sometimes the estimated coefficients can be highly unreliable. Tests for multicollinearity were done using pair wise correlation and the variance inflation factor (VIF) technique. The larger the value of the VIF, the more collinear a variable is. Gujarati (2007) argues that "as a rule of thumb, if the VIF of a variable exceeds 10, which will happen if R^2_j exceeds 0.9, that variable is said to be highly collinear". The results of the VIF for the variables included in all the models were less than 10 and the pairwise correlations were less than 0.5 indicating the estimates are reliable. The results are presented in the appendices.

5.2 Conclusion

Per capita calorie intake measure indicates that both growers and non-growers of export horticulture were food secure in Kirinyaga and Buuri, since they were above the 2250 Kcal threshold. However, the two groups were found to be food insecure in Mbooni with both their average intake falling below this threshold. This was despite there being no major difference in the HDDI, a measure of diet quality in these districts. This highlights the inadequacy of using one measure of food security and underlines the importance of using several measures. The first

hypothesis that smallholder farmers are not food secure has consequently been rejected for Kirinyaga and Buuri but we fail to reject the same hypothesis in Mbooni.

The factors affecting food security were different in the different areas. As hypothesized, access to productive resources i.e, land in Kirinyaga and Buuri was found to positively influence per capita calorie intake while access to family labour was found to positively influence HDDI in Buuri. Employment and higher income positively affected the per capita calorie in Kirinyaga and Buuri. Household size had a negative effect on per capita calorie intake and HDDI all through except in Mbooni where a large household size was associated with a higher HDDI. If the higher number of household members comprised children under the age of five, then this could be the case since parents tend to secure the nutritional quality and quantity of these young ones even in cases where the adults go without the recommended energy intakes or consume lower quality diet. The scenario could also explain the near equal HDDI in all the districts while the per capita calorie showed that Mbooni was food insecure. The results for the second hypothesis tests led to the rejection of the hypothesis for those factors whose p-value was less than 0.10 and failure to reject the same hypothesis if the p value was more than 0.10, in both OLS and Poisson regressions

Propensity score matching method show that impact of participation in export horticulture is different in different regions. Kirinyaga had a positive impact Mbooni had a negative impact while Buuri results are not conclusive because the common support condition was violated.

5.3 Recommendations

Following the mixed results the study recommends that policies and strategies promoting export horticulture farming as a means of achieving food security to combat food insecurity and to some extent other cash crops should consider specific area and production differences.

They are in noway one-size-fits-all interventions, as specific regional characteristics play an important role and have to be put into consideration and addressed as uniquely as they are for optimal results. Continued and increased smallholder participation in export horticulture production in Kirinyaga should be encouraged.

There is a need to devise measures address the food insecurity situation in Mbooni. Results of the estimation of factors affecting food security will help in targeting interventions at the household level. For instance, those with non-stone walled, or households without access to safe water for domestic purposes could be targeted for intervention. The negative effect of gender on per capita calorie intake and diet quality in Mbooni indicates the need to consider gender dimensions in designing food security promotion programs. For instance women enterprises could be targeted and policies to ensure that women gain access to productive resources be adopted.

5.4 Limitations of the Study

Most of the data utilized in the study was collected during the baseline of the main project with very little room if any for modification to answer the current research questions. For instance household income which is theoretically one of the most important determinants of food security was collected as a categorical variable rather than a continuous variable. Similarly data on the quantity of home produced and

consumed food items was not collected and was largely neglected when reporting the farm income. The data used as farm income was farmer reported and farmers normally consider gross revenue which is inclusive of cost of production.

Data on the intra-household distribution of income was also left out. Literature points out that food security depend on not only the amount of the income, but also on the decisions taken by persons controlling income within the household pointing to the different spending patterns of men and women.

Buuri results are somewhat inconclusive due to data inadequacy (PSM has large data set requirements for it to be effective)

5.5 Suggestions for Further Studies.

Propositions for further studies largely stem from the perceived limitations of the study mentioned above. The negative impact of participation in export horticulture on food security in Mbooni was in spite of there being a significant difference in the amount of farm income between the growers and the non-growers, with the growers having more farm income than the non-growers. Data and information on cost of production would help evaluate the net revenue due to farmers. The value of home produced and consumed food items would be imputed and included as part of the revenue to avoid underreporting income for those who grow food for home consumption at the expense of cash crops. Consequently assess and compare the level of profitability for the different enterprises. It may to be more profitable participate in domestic horticulture and staple food production than engage in export horticulture farming but this need empirical evidence.

The optimal level of specialization or the minimum land area farmers must have to profitably engage in horticulture production in a way that will positively influence their livelihoods need to be investigated.

The use of income resulting from export horticulture farming, need to be investigated to explain the observed results. A comprehensive evaluation of the livelihoods, intra-household income distribution and use, in Mbooni is needed.

Reasons behind the low level of intensification in export crop participation in the study areas are not well understood. Given the evidence that specialization in high value export crops has high financial and economic benefit, and the current's study findings that farmers only apportion small percentage of their agricultural land to these crops, the question is to why smallholder farmers fail to specialize in these crops. An assessment of the factors affecting the level of participation in export horticulture need to be undertaken in order to inform policy makers on the factors hindering higher degree of specialization and those factors that promote the same.

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APPENDICES

Appendix 1: Research Survey Questionnaire

Household Food Consumption Information

1. Household Composition

Name	**Sex [1] female [2] male**	**Age**		**Physiological status of women 14-60 years only**	**Activity level**	**Residential status [1] Yes [2] No**
		No	Unit			

Codes:

1. Physiological status of women – codes: [1] Not pregnant or lactating [2] Pregnant [3] Breastfeeding child <6months [4] Breastfeeding child>6months [5] Pregnant & breastfeeding child<6months [6] Pregnant & breastfeeding child>6months
2. Activity levels – code: [1] High [2] Medium [3] Light

2 Dietary Diversity Data (24 hr. recall)

Did **YOU OR ANYONE ELSE IN YOUR HOUSEHOLD** eat any kind of the following foods yesterday during the day and at night?

Food group	Examples (any other locally available food)	Code 1 Yes 2 No
1. Cereals	millet, sorghum, maize, rice, wheat, or	
2. Root and tubers	potatoes, yams, manioc, cassava or any other foods	
3.Pulses/legumes	beans, peas, lentils, or nuts	
4. Milk and milk products	cheese, yogurt, milk or other milk products	
5. Eggs	eggs	
6. Meat	beef, pork, lamb, goat, rabbit wild game, chicken, duck, or other birds, liver, kidney, heart, or other organ	
7. Fish and seafood	fresh or dried fish or shellfish	
8. Oil/fats	Oil/ fat	
9. Sugar/honey	Sugar, honey	
10. Fruits	Mangoes, oranges, pineapples	
11. Vegetables	Kales, cabbage, carrots, frenchbeans,	
12.Miscellaneous	coffee, tea	

3 Calorie Intake (24 hr recall)

Meal	**No of household members** present - & Eating	**Visitors**						**Dish**	**Dish code**	**Ingredients**	**Ingredients code**	**Quantity prepared**	**Unit measure**	**Unit measure code**	**Left over quantity**	**Source code**
		Adults Above 18yrs		Adolescents 12-17yrs		Children < 12 yrs										
		Male	Female	Male	Female	Male	Female									

Household food consumption frequencies

Did any member of the household consume the following foods and drinks?

Food item	**Yes**	**No**	**Qty Day 1**	**QTYDay 2**	**QTY Day 3**	**QTY Day 4**	**QTY day 5**	**QTY Day 6**	**Qty day 7**	**Total**
Cereals										
Maize flour										
Millet flour										
Sorghum										
Other (specify										
Porridge from										
Maize meal										
Millet/										
sorghum										
Rice										
Bread										
Chapatti										
Starchy foods										
Sweet potatoes										
Irish potatoes										
Cassava										
Yams										
Cooking Bananas										
Legumes										
Beans- fresh										
Beans- dry										
Peas- fresh										

Peas dry										
Peas- dry										
Green grams										
Groundnuts										
Other legumes										
Vegetables										
Tomatoes										
Onions										
Spinach										
Kales										
Pumpkin leaves										
carrots										
Cabbage										
other										
Fruits										
Bananas										
Citrus										
Passion fruits										
Avocado										
Pineapples										
Pears										
Pawpaw										
Mangoes										
Guavas										
Other										
Animal foods										

Beef										
Chicken										
Rabbit										
Mutton										
Pork										
Other meat										
Eggs										
Fish										
Drinks										
Milk										
Oil and fats										
Margarine										
Cooking fats and oils										

Appendix 2: Proximate Principles and Energy Composition in terms of 100g of Selected Food items

Name of Food Stuff	Kcal	Name of Food Stuff	Kcal	Name of Food Stuff	Kcal
Brown Bread	254	Irish potatoes	81	Strawberry	44
White Bread	261	Yam	110	Water melon	16
Maize grain	348	Beans	325	Beef	220
Maize Meal	373	Black gram	360	Chicken	163
Finger millet	336	Green beans	139	Pork	114
Rice	330	Dry cowpeas	334	Pork sausage	370
Sorghum	343	Green cowpeas	123	Cooking oil	900
Weetabix	340	Green gram	231	Biscuits	450
Wheat grains	333	Fresh peas	123	Guava	50
Wheat flour	340	Dry peas	338	tangerine	89
Arrow roots	129	Pigeon Peas	351	Sugar	373
Cassava	134	Cashew nuts	588	Egg	154
Sweet potatoes	143	Groundnuts	543	Goat meat	166
Amaranthus vegetables	45	Cabbage	28	Beef sausage	270
Cassava leaves	90	Cowpeas leaves	41	milk	305
Kales	52	Pumpkin leaves	39	margarine	745
Lettuce	22	Managu	32	Potato chips	250
Spinach	34	Sweet potato leaves	45	Pineapple	54
Carrots	38	Cauli flower	25	Avocado	128
Onion	65	Pumpkin	30	Bananas ripe	94
Tomatoes	28	Apple	59	Banana Raw	109
Orange	43	Mangoes	31	Passion	57

Appendix 3: Kirinyaga Variable Correlation matrix;

OLS Model

	GROWEXPVEG	TOTACRES	HHEDUC	HHSIZE	WALLTYPE	EMPLOYMENT	FAMLABOURERS	GROUPMEMBER	HHGENDER	INCOMECAT	DISTINPUT	DISTWATER
GROWEXPVEG	1											
TOTACRES	-0.1276	1										
HHEDUC	0.3812	-0.2003	1									
HHSIZE	0.3064	-0.1765	0.1462	1								
WALLTYPE	0.0506	0.2016	-0.1455	0.0137	1							
EMPLOYMENT	0.1301	0.1150	0.0741	-0.0248	-0.0383	1						
FARMLABOURERS	0.2663	0.1365	0.2100	0.2444	0.0507	0.0210	1					
GROUPMEMBER	0.0600	0.1653	-0.1765	0.1292	0.0072	-0.0351	-0.0250	1				
HHGENDER	0.0714	-0.0436	0.3814	0.0129	-0.0174	0.0131	0.2010	-0.0821	1			
INCOMECAT	0.2370	0.1669	0.2329	0.1775	-0.2021	0.1921	0.1687	0.1171	0.1033	1		
DISTINPUT	0.0349	0.0101	0.0224	0.1068	0.0746	-0.1447	-0.0522	0.0661	-0.0772	-0.0995	1	
DISTWATER	0.0377	-0.0415	-0.1049	0.1173	-0.1892	-0.0375	0.0869	0.0057	-0.1116	0.0939	-0.1299	1

Poisson Model

	GROWEXPVEG	TOTACRES	HHSIZE	SCHEXPND	WALLTYPE	TOTASSETS	MAINOCCUP	DISTINPUT	EXTENSION	FARMEXPR	FAMLABOURERS
GROWEXPVEG	1										
TOTACRES	-0.0473	1									
HHSIZE	0.2255	-0.0381	1								
SCHEXPND	0.0094	0.0216	0.2944	1							
WALLTYPE	-0.0270	0.1089	0.0823	0.2865	1						
TOTASSETS	0.1406	0.0237	0.0170	-0.0027	0.1382	1					
MAINOCCUP	-0.0137	0.0272	-0.0310	-0.0348	-0.0581	0.0760	1				
DISTINPUT	0.0043	0.1164	0.1885	0.2119	-0.0831	-0.0134	0.0262	1			
EXTENSION	0.0850	-0.1169	0.1675	0.0924	0.0790	-0.0434	0.1099	0.0337	1		
FARMEXPR	-0.1830	0.2356	-0.2223	0.0089	0.0881	0.0353	0.1316	0.0036	-0.1692	1	
FAMLABOURERS	-0.0009	0.0185	0.2293	0.0518	0.0778	0.1743	0.0123	0.0238	0.0943	0.0962	1

Appendix 4: Kirinyaga regressors VIF

POISSON Model

Variable	VIF	1/VIF
HHSIZE	8.08	0.123796
MAINOCCUP	5.87	0.170433
FAMLABOURERS	4.82	0.207404
GROWEXPVEG	4.35	0.229910
FARMEXPR	3.77	0.265184
TOTACRES	3.53	0.283407
EXTENSION	3.18	0.314057
DISTINPUT	2.79	0.358951
WALLTYPE	1.89	0.530264
TOTASSETS	1.84	0.542656
SCHXPEND	1.72	0.581700
Mean VIF	3.80	

OLS Model

Variable	VIF	1/VIF
HHEDUC	1.66	0.604171
GROWEXPVEG	1.43	0.701585
TOTACRES	1.35	0.738179
FAMLABOURERS	1.32	0.756996
INCOMECAT	1.32	0.757849
HHGENDER	1.31	0.763670
HHSIZE	1.27	0.785006
WALLTYPE	1.23	0.814310
GROUPMEMBER	1.13	0.883536
DISTWATER	1.13	0.886110
EMPLOYMENT	1.10	0.906916
DISTINPUT	1.10	0.909689
Mean VIF	1.28	

Appendix 5: Mbooni Variables Correlation matrix;

OLS Model

	GROWEXPVEG	HHEDUC	HHSIZE	GROUPMEMBER	HHGENDER	WATERSOURCE	EXTENSION	SCHEXPND	WALLTYPE	FARMEXPR	DISTWATER	EMPLOYMENT
GROWEXPVEG	1											
HHEDUC	-0.0918	1										
HHSIZE	0.1924	0.1136	1									
GROUPMEMBER	0.2021	0.2193	-0.0658	1								
HHGENDER	0.0230	0.3700	0.1938	0.0541	1							
WATERSOURCE	-0.2243	0.0218	-0.1094	-0.0580	0.0630	1						
EXTENSION	0.4081	0.1124	0.1684	0.0269	0.0450	-0.4340	1					
SCHEXPND	0.0169	0.3047	0.0941	0.2906	0.0189	0.0601	-0.0242	1				
WALLTYPE	0.1062	0.3227	0.0889	0.2827	0.0949	-0.1576	0.0506	0.3158	1			
FARMEXPR	0.1967	-0.2788	0.1192	0.0106	-0.4329	-0.0078	0.0174	0.0996	0.0144	1		
DISTWATER	-0.1875	0.1267	0.0324	0.1202	0.0536	-0.1033	-0.1837	0.1390	0.0400	0.0164	1	
EMPLOYMENT	0.0546	0.1106	0.0263	0.0429	0.0567	-0.2226	0.0646	-0.0433	0.0235	-0.1462	0.0352	1

Poisson Model

	WATERSOURCE	WALLTYP	HHEDUC	TRANSCOST	HHSIZE	GROUPMEMBER	GROWEXPVEG	HHGENDER	TOTACRES
WATERSOURCE	1								
WALLTYP	-0.0562	1							
HHEDUC	0.0005	0.2484	1						
TRANSCOST	-0.1265	-0.1385	-0.0142	1					
HHSIZE	-0.0255	-0.0210	0.0185	-0.0026	1				
GROUPMEMBER	-0.1031	-0.0255	0.1656	0.1435	-0.0533	1			
GROWEXPVEG	-0.1910	0.0212	0.0259	-0.0692	0.1985	0.2349	1		
HHGENDER	0.0970	0.1143	0.4009	0.0405	0.1159	0.1249	0.1271	1	
TOTACRES	0.0536	0.0053	0.0554	-0.1344	0.0052	0.1393	0.2554	0.1547	1

Appendix 6: Mbooni Regressors VIF

POISSON MODEL		
Variable	VIF	1/VIF
HHGENDER	7.23	0.138312
HHSIZE	6.09	0.164246
HHEDUC	5.93	0.168512
TRANSCOST	5.12	0.195323
TOTACRES	3.42	0.292564
GROWEXPVEG	2.88	0.346915
WATERSOURCE	2.27	0.440304
GROUPMEMBER	2.10	0.475513
WALLTYPE	1.16	0.858775
Mean VIF	4.02	

OLS Model		
Variable	VIF	1/VIF
HHEDUC	2.44	0.409398
FARMEXPR	2.26	0.441904
EXTENSION	1.65	0.605477
WATERSOURCE	1.49	0.669851
GROWEXPVEG	1.47	0.681054
HHGENDER	1.39	0.717458
SCHEXPND	1.36	0.733861
WALLTYPE	1.35	0.740559
GROUPMEMBER	1.27	0.784646
HHSIZE	1.22	0.818008
DISTWATER	1.2	0.835827
EMPLOYMENT	1.09	0.919379
Mean VIF	1.52	

Appendix 7: Buuri Variables Correlation matrix;

OLS Model

	GROWEXPVEG	TOTACRES	HHSIZE	GROUPMEMBER	HHGENDER	WATERSOURCE	WALLTYPE	EXTENSION	INCOMECAT	EMPLOYMENT
GROWEXPVEG	1									
TOTACRES	-0.0130	1								
HHSIZE	0.0480	-0.0034	1							
GROUPMEMBER	0.0596	0.0012	0.0863	1						
HHGENDER	0.1465	0.1391	-0.0974	0.0258	1					
WATERSOURCE	0.3579	-0.1684	-0.0287	0.3301	0.0979	1				
WALLTYPE	0.1195	0.0854	0.2073	0.0833	0.1524	0.1211	1			
EXTENSION	0.1777	0.0683	0.2253	0.0263	-0.0441	0.1607	0.0939	1		
INCOMECAT	0.2096	0.2335	-0.0626	0.2941	0.2941	0.3086	0.1096	0.1354	1	
EMPLOYMENT	0.0383	-0.0558	0.1268	0.0778	-0.0703	0.1206	0.1481	-0.0120	0.0751	1

POISSON Model

	GROWEXPVEG	TOTACRES	HHEDUC	HHSIZE	FARMINCOME	EXTENSION	FARMEXPR	FAMLABOURERS	DISTWATER	DISTURBAN
GROWEXPVEG	1									
TOTACRES	-0.1365	1								
HHEDUC	0.2298	0.0220	1							
HHSIZE	0.0826	0.0749	0.1801	1						
FARMINCOME	0.2574	0.3041	0.2490	0.1190	1					
EXTENSION	0.2173	0.0455	0.2916	0.2127	0.2009	1				
FARMEXPR	-0.2755	0.2099	-0.4336	0.0161	-0.0527	-0.1740	1			
FAMLABOURERS	-0.0791	0.1210	0.0713	0.2548	0.1362	0.1600	0.0865	1		
DISTWATER	-0.2093	0.1989	-0.0933	0.0141	-0.1364	-0.1660	0.1169	0.0853	1	
DISTURBAN	0.2601	-0.0400	0.0111	0.0995	0.1931	0.0418	-0.0368	0.0917	-0.0489	1

Appendix 8: Buuri Regressors VIF

OLS Model		
Variable	VIF	1/VIF
WATERSOURCE	1.46	0.684667
INCOMECAT	1.40	0.713015
GROUPMEMBER	1.22	0.822587
GROWEXPVEG	1.21	0.828816
HHGENDER	1.17	0.855018
TOTACRES	1.16	0.862718
HHSIZE	1.16	0.864229
EXTENSION	1.14	0.877338
WALLTYP	1.12	0.889396
EMPLOYMENT	1.07	0.935664
Mean VIF	1.21	

POISSON Model		
Variable	VIF	1/VIF
HHSIZE	8.65	0.115661
FAMLABOURERS	7.24	0.138123
HHEDUC	7.18	0.139273
GROWEXPVEG	7.05	0.141831
EXTENSION	3.95	0.253148
FARMEXPR	3.57	0.280310
DISTURBAN	3.37	0.296688
TOTACRES	3.03	0.330085
FARMINCOME	2.39	0.418328
DISTWATER	1.22	0.822147
Mean VIF	4.76	

Appendix 9: Kirinyaga Covariate Balancing Tests

Nearest Neighbor Matching

Variable	Sample	Mean Treated	Mean Control	% Bias	% Reduc|bias|	t	p>|t|
WALLTYP	Unmatched	0.21374	0.16949	11.2		0.7	0.483
	Matched	0.21374	0.25191	-9.7	13.7	-0.73	0.467
LNTOTASSETS	Unmatched	11.989	11.79	20.5		1.31	0.191
	Matched	11.989	11.895	9.7	52.7	0.76	0.448
HHAGE	Unmatched	46.305	54.932	-66.5		-4.46	0
	Matched	46.305	46.59	-2.2	96.7	-0.2	0.842
HHSIZE	Unmatched	4.1985	3.5085	43.9		2.85	0.005
	Matched	4.1985	4.4122	-13.6	69	-1.07	0.287
LIVESTOCKU~S	Unmatched	3.1908	2.678	28.8		1.84	0.067
	Matched	3.1908	3.0782	6.3	78	0.47	0.639
FAMLABOURERS	Unmatched	1.7939	1.8475	-6.4		-0.41	0.685
	Matched	1.7939	1.8225	-3.4	46.6	-0.31	0.757
HHGENDER	Unmatched	0.8626	0.74576	29.6		1.98	0.05
	Matched	0.8626	0.85115	2.9	90.2	0.26	0.792
HHEDUC	Unmatched	8.7863	7.3898	34.6		2.35	0.02
	Matched	8.7863	8.4294	8.8	74.4	0.79	0.429
GROUPMEMBER	Unmatched	0.67939	0.57627	21.3		1.38	0.17
	Matched	0.67939	0.66794	2.4	88.9	0.2	0.844

Kernel Based Matching

Variable	Sample	Mean Treated	Mean Control	% Bias	% Reduc|bias|	t	p>|t|
WALLTYP	Unmatched	0.21374	0.16949	11.2		0.7	0.483
	Matched	0.21374	0.24033	-6.7	39.9	-0.51	0.609
LNTOTASSETS	Unmatched	11.989	11.79	20.5		1.31	0.191
	Matched	11.989	11.91	8.1	60.4	0.63	0.531
HHAGE	Unmatched	46.305	54.932	-66.5		-4.46	0
	Matched	46.305	47.031	-5.6	91.6	-0.51	0.611
HHSIZE	Unmatched	4.1985	3.5085	43.9		2.85	0.005
	Matched	4.1985	4.1855	0.8	98.1	0.07	0.947
LIVESTOCKU~S	Unmatched	3.1908	2.678	28.8		1.84	0.067
	Matched	3.1908	2.7447	25.1	13	1.97	0.05
FAMLABOURERS	Unmatched	1.7939	1.8475	-6.4		-0.41	0.685
	Matched	1.7939	1.8404	-5.5	13.2	-0.51	0.607
HHGENDER	Unmatched	0.8626	0.74576	29.6		1.98	0.05
	Matched	0.8626	0.85152	2.8	90.5	0.26	0.799
HHEDUC	Unmatched	8.7863	7.3898	34.6		2.35	0.02
	Matched	8.7863	8.7519	0.8	97.5	0.08	0.939
GROUPMEMBER	Unmatched	0.67939	0.57627	21.3		1.38	0.17
	Matched	0.67939	0.663	3.4	84.1	0.28	0.779

Radius Matching

Variable	Sample	Mean Treated	Mean Control	% Bias	% Reduc|bias|	t	p>|t|
WALLTYP	Unmatched	0.21374	0.16949	11.2		0.7	0.483
	Matched	0.21374	0.23705	-5.9	47.3	-0.45	0.653
LNTOTASSETS	Unmatched	11.989	11.79	20.5		1.31	0.191
	Matched	11.989	11.928	6.3	69.4	0.49	0.627
HHAGE	Unmatched	46.305	54.932	-66.5		-4.46	0
	Matched	46.305	47.69	-10.7	84	-0.97	0.333
HHSIZE	Unmatched	4.1985	3.5085	43.9		2.85	0.005
	Matched	4.1985	4.1084	5.7	86.9	0.47	0.64
LIVESTOCKU~S	Unmatched	3.1908	2.678	28.8		1.84	0.067
	Matched	3.1908	2.6742	29	-0.7	2.32	0.021
FAMLABOURERS	Unmatched	1.7939	1.8475	-6.4		-0.41	0.685
	Matched	1.7939	1.8514	-6.8	-7.4	-0.63	0.527
HHGENDER	Unmatched	0.8626	0.74576	29.6		1.98	0.05
	Matched	0.8626	0.84873	3.5	88.1	0.32	0.751
HHEDUC	Unmatched	8.7863	7.3898	34.6		2.35	0.02
	Matched	8.7863	8.8096	-0.6	98.3	-0.05	0.959
GROUPMEMBER	Unmatched	0.67939	0.57627	21.3		1.38	0.17
	Matched	0.67939	0.65716	4.6	78.4	0.38	0.704

Appendix 10: Mbooni Covariate Balancing Tests

Nearest Neighbor Matching

Variable	Sample	Mean Treated	Mean Control	% Bias	% Reduc|bias|	t	p>|t|
HHAGE	Unmatched	49.169	48.907	1.9		0.1	0.924
	Matched	49.169	46.081	22.4	-1076.6	1.41	0.161
HHSIZE	Unmatched	6.0847	5.1628	43.7		2.17	0.032
	Matched	6.0847	5.5424	25.7	41.2	1.36	0.178
LIVESTOCK	Unmatched	3.5593	2.907	37.6		1.87	0.065
	Matched	3.5593	3.2356	18.6	50.4	1.01	0.317
MAINOCCUP	Unmatched	0.74576	0.69767	10.6		0.53	0.595
	Matched	0.74576	0.73503	2.4	77.7	0.13	0.895
FARMLABOURERS	Unmatched	2.1525	2	15.6		0.79	0.434
	Matched	2.1525	2.4169	-27	-73.3	-1.35	0.178
EXTENSION	Unmatched	0.84746	0.48837	81.6		4.18	0.000
	Matched	0.84746	0.84746	0	100	0.00	1.000
HHGENDER	Unmatched	0.81356	0.76744	11.2		0.56	0.574
	Matched	0.81356	0.7548	14.3	-27.4	0.77	0.442
GROUPMEMBER	Unmatched	0.57627	0.30233	56.9		2.82	0.006
	Matched	0.57627	0.57627	0	100	0	1

Kernel Based Matching

Variable	Sample	Mean Treated	Mean Control	% Bias	% Reduc|bias|	t	p>|t|
HHAGE	Matched	49.169	48.907	1.9		0.1	0.924
	Unmatched	49.169	46.683	18	-847.4	1.12	0.264
HHSIZE	Matched	6.0847	5.1628	43.7		2.17	0.032
	Unmatched	6.0847	5.547	25.5	41.7	1.37	0.174
LIVESTOCK	Matched	3.5593	2.907	37.6		1.87	0.065
	Unmatched	3.5593	3.3981	9.3	75.3	0.48	0.632
MAINOCCUP	Matched	0.74576	0.69767	10.6		0.53	0.595
	Unmatched	0.74576	0.7428	0.7	93.8	0.04	0.971
FARMLABOURERS	Matched	2.1525	2	15.6		0.79	0.434
	Unmatched	2.1525	2.3308	-18.2	-16.9	-0.97	0.333
EXTENSION	Matched	0.84746	0.48837	81.6		4.18	0
	Unmatched	0.84746	0.83102	3.7	95.4	0.24	0.81
HHGENDER	Matched	0.81356	0.76744	11.2		0.56	0.574
	Unmatched	0.81356	0.79794	3.8	66.1	0.21	0.832
GROUPMEMBER	Matched	0.57627	0.30233	56.9		2.82	0.006
	Unmatched	0.57627	0.59029	-2.9	94.9	-0.15	0.879

Radius Matching

Variable	Sample	Mean Treated	Mean Control	% Bias	% Reduc|bias|	t	p>|t|
HHAGE	Unmatched	49.1690	48.9070	1.9		0.10	0.924
	Matched	49.1690	46.6450	18.3	-861.5	1.14	0.257
HHSIZE	Unmatched	6.08470	5.16280	43.7		2.17	0.032
	Matched	6.08470	5.51150	27.2	37.8	1.44	0.153
LIVESTOCKU~S	Unmatched	3.55930	2.90700	37.6		1.87	0.065
	Matched	3.55930	3.39000	9.8	74.0	0.51	0.614
MAINOCCUP	Unmatched	0.74576	0.69767	10.6		0.53	0.595
	Matched	0.74576	0.74235	0.8	92.9	0.04	0.966
FAMLABOURERS	Unmatched	2.15250	2.00000	15.6		0.79	0.434
	Matched	2.15250	2.32360	-17.5	-12.2	-0.91	0.362
EXTENSION	Unmatched	0.84746	0.48837	81.6		4.18	0.000
	Matched	0.84746	0.82210	5.8	92.9	0.37	0.714
HHGENDER	Unmatched	0.81356	0.76744	11.2		0.56	0.574
	Matched	0.81356	0.78586	6.7	39.9	0.37	0.710
GROUPMEMBER	Unmatched	0.57627	0.30233	56.9		2.82	0.006
	Matched	0.57627	0.54304	6.9	87.9	0.36	0.719