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78- Impact of Export Horticulture Farming on Food Security of Smallholder Farmers in Mbooni and Kirinyaga counties, Kenya

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Abstract

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. Available evidence in the debate of the impact of cash cropping systems on food security however 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. To assess impact, food security was measured using per capita calorie intake, 7-day recall and propensity score matching method employed. Results indicate that export horticulture farming has a positive effect on food security status in Kirinyaga County but a negative effect in Mbooni County. Small holder farmers in Mbooni both growers and non- growers were consuming less than the recommended per capita calorie intake. The study recommends that policies aimed at encouraging smallholder farmers to participate in export horticulture farming should be promoted in Kirinyaga but further investigation to be carried out on the production and marketing conditions of export horticulture and food consumption behavior and intra household income distribution in Mbooni. A clear strategy to achieve food security should also be devised.

Key words: Export horticulture, smallholder farmers, food security, per capita calorie intake, impact, propensity score matching, impact

1.0 Introduction

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. The attainment of food security has been for a long time now a development goal for most developing and developed countries. Food security is however affected by a myriad of factors both at the household and national level.

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 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. There has been concern that cash cropping, that is, more production for the market and less for subsistence could undermine food security and poverty reduction. Particular concern is that crops produced for the market are seen to offer a less direct route to improved food security and nutrition than staple food production, and that since women 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.

IFAD (1998) documents that 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. Anouk (2010) reports that dependence on cash-crops expose households to food prices 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 also reduce. 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. 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. Govereh and Jayne (1999) show that cash cropping is associated with increased staple food production due to existence of synergy between the two. 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 on decisions taken by persons controlling income within the household (Afari-sefa, 2007).

Export horticulture farming by smallholder farmers is major cash cropping activity carried out in Kenya. Horticulture industry being the fastest growing agricultural sub-sector in the country is ranked third in terms of foreign exchange earnings from exports after tourism and tea (HCDA, 2009). It contributes 30 percent of agricultural GDP and continues to grow at between 15 and 20 percent per year (MOA, 2010). Kenya has been the most successful sub-Saharan Africa exporter of horticultural products apart from 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). The European Union (EU) is the dominant market for Kenyan exports – and after Morocco Kenya is the biggest fresh vegetable supplier to the EU (Legge et. al, 2006). Thus stricter regulations, like EurepGAP, present a challenge for the Kenyan horticulture sector (Asfaw et.al, 2006). These exports have been associated with significant smallholder involvement. 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). 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 exporting smallholders, with average annual household incomes of the former being higher.

Though the export horticulture sector has been a success in terms of foreign exchange earnings, its impact on smallholder household food security remains under-investigated. It is thus not known how far the Kenya production of horticulture for export has impacted on food security and livelihood of smallholder participants. Schneider and Gugerty (2010) after reviewing several studies on the impact of cash cropping on food security concludes that given the heterogeneity of crops and production structures across the continent, drawing strong policy conclusions from the available evidence may not be right. The authors' major finding from the review was that the empirical data available to evaluate the impact of cash crop production on smallholder welfare remains relatively weak. The current study thus aimed to add onto the existing literature on this debate by assessing the impact of export horticulture farming on food security of smallholder farmers in Kenya. It also assesses the food security status of smallholder farmers in the study areas.

2.0 Methods of Analysis

2.1 Measuring food security

There are approximately 200 definitions and 450 indicators of food security (Hoddinott 1999) and 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 (Riely et al 1999). Consensus has still not been reached on acceptable indicators and methods of measuring household food security (Haddad et al. 1994). No method has been accepted as a "gold standard" for an analysis of household food security (Maxwell, 1996). 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.

This study measured food security status using indicators of food consumption which is an outcome indicator of food availably, access and other underlying factors. This was done using 7 day recall where Household Dietary Diversity Index (HDDI) (Hoddinott and Yohannes, 2002) and Household per capita calorie intake (Swindale and Bilinsky, 2006) were developed. 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 was used to assess quality of food intake. While per capita calorie intake assessed the quantity of food intake. The food groups considered were as follows

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

Per capita calorie intake calculated is the most widely used method of assessing food security and to validate other food security indicators. The amount of food eaten was converted into standard weight and measures and then converted to calories using food composition tables (Swindale and Bilinsky, 2006). Using the formulae;

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

Where; C_i is the household total calorie intake estimate

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

B_i 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 (PCI), and then compared to 2250 kilocalories threshold.

2.2 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

$$\lambda_i = Y_i\,(1) - Y_i\,(0) \text{ --- } (2)$$

Where λ_i is the impact on food security, $Yi\ (1)$ is the food security status when the i^{th} household participates export horticulture production while $Y_i\ (0)$ is the food security status when the same household when it 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 (ATT).

Since one cannot also observe the food security status of participating households before participation due absence of baseline data, 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 nonparticipants usually differ even in the absence of treatment. This problem is known as selection bias (Caliendo and Kopeinig, 2008).

The basic idea in propensity score matching method 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, we use 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. This balancing score is the Propensity score i.e. (the probability of participating in export horticultural farming given the observed characteristic X). Given by,

$$b(X) = Pr\ (Z=1/X) \text{ ---} (3)$$

Where *Z* denotes the participation in export horticultural farming as 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 in both groups. Given that the propensity score is a balancing score, the probability of participation conditional on *X* will be balanced such that the distribution of observables *X* will be 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 & Rubin, 1983). Propensity scores are 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 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). Four of the most widely used are Nearest Neighbor Matching (NNM), Radius Matching, Kernel Based Matching (KBM) and Stratification Matching**.** All matching procedures contrast the outcome of a treated individual with outcomes of comparison group members.

ATT can be noted as;

$$E[Y_1|D = 1] - E[Y_0 D = 0] = ATT + E[Y_0|D = 1] - E[Y_0 D = 0] \text{ ------------ } (4)$$

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

$$E[Y_0|D = 1] - E[Y_0 D = 0] = 0 \text{--} (5)$$

(Caliendo and Kopeinig, 2008)

In non-experimental studies, like the current one, one has to invoke some identifying assumptions when using propensity score matching 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 $\boldsymbol{X}$ that determines the propensity score (Rosenbaum & Rubin,1983; Caliendo & Kopeinig, 2005) 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.

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 only defined within the region of common support. This is because only in the overlapping subset of the comparison group and treatment group comparable observations can be matched. A violation of the CSC is a major source of bias due to comparing incomparable individuals (Heckman et al. 1997).

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

$$ATT = E\{E\{Y_1|Di = 1, p(Xi)\} - E\{Y_0|Di = 0, p(Xi)\} |Di = 1\} \text{-----------------} (6)$$

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

Y_1-denote the food security outcome for an individual if the person is a participant

Y_0 the food security outcome if the person is non participant.

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

$$Y = a + \beta b_i + c\, \boldsymbol{X_i} + e_i \text{ -- } (7)$$

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

b_i is the propensity score, of the ith farmer,

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

β measures the impact of participation on food security status.

2.3 Study Area

Mbooni County is in eastern province. Covers an area of 960.4 square kilometers with a population of 177,832 persons and lies at latitude 1^{o} 40'South and Longitude 37^{o} 27' east. It is generally low lying rising from 700 meters above sea level at the lowlands to 1900 meters above sea level and is 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 county has very high poverty level with absolute poverty standing at 64.3 percent.

Kirinyaga County is 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. The county is in the country's high to medium potential area.

2.4 Study context, Data and Sampling procedures

The study forms part of a larger project DriVLIC- Kenya, funded by International Development Research Centre undertaken by the University of Nairobi in collaboration with the Fresh Produce Exporters Association of Kenya and the Ministy of Agriculture in Kenya. The project purpose was to evaluate the drivers influencing adoption of private food safety standards, the economic and financial viability of compliance with these standards and the livelihood impacts.

Data used in this study was collected in two phases where the baseline data containing farmer socioeconomic characteristics and production information was collected between July and October 2010, while the consumption and household characteristics data was collected between

August and November year 2011. A simple random sample size of 140 households was selected in Mbooni, 241 households from Kirinyaga. The two districts are selected for comparative purposes due to the diversity in the growing conditions, infrastructure and climate.

3. 0 Results and Discussions

3.1 Characteristics of smallholder farmers

Appendix 1 presents summary statistics for the data collected in the two districts. Mbooni average household sizes are larger 5.76 persons, compared to 4.09 persons in Kirinyaga Households also tend to keep more livestock probably as a buffer against crop failure in a region which receives little and unreliable rainfall and the fact that the Kamba community that resides in Mbooni were traditionally agro pastoralists. Mbooni residents are disadvantaged as they cover a longer distances to the nearest urban centre and source of water and take longer period walking to the nearest input shop than those in Kirinyaga. The total assets of Mbooni smallholder farmers are worth less than those in Kirinyaga. Mbooni export horticulture farmers only apportion an average of 0.24 acres as opposed to Kirinyaga farmers who have an average of 0.5 acres. However, the two districts are not significantly different in terms of education level, gender, age, farming experience, total acres and extension contact rate.

3.2 Comparisons of growers' and non growers' characteristics

Appendix 2 presents comparisons for the smallholder export horticulture growers and non growers in the two Counties. It shows the means of variables and also the t-tests of differences in mean between the two groups.

In Kirinyaga the two groups exhibit significant differences with respect to their gender, main occupation, total labourers, and livestock unit's equivalent and total assets with the growers having a larger percentage of men farmers, majority having farming as their main occupation and having more livestock, total assets and total labourers. However these growers had less years of farming experience probably because they were younger too. They were also covering shorter distances to get to the nearest market centre than the non growers.

In Mbooni on the other hand, growers had significantly more years of farming experience than non growers, larger family sizes, higher number of total labourers, more livestock units and higher percentage of contacts with extension officers probably due to the high extension officers hired by horticulture export companies to oversee smallholder out growers' horticulture production. There were no significant differences in the other variables considered.

3.3 Food security status

Appendix 3 presents the results of the food security situation assessment. Using the 2250 Kcal threshold, results shows that the average per capita intake in Kirinyaga was 2405 Kcal with growers and non growers attaining an average of 2468 Kcal and 2297Kcal respectively. The average per capita calorie intake in Mbooni is 2152 Kcal with the growers having an average of 2139 Kcal and the non growers having an average of 2168 Kcal. Both growers and non growers of export horticulture in Kirinyaga are food secure while in Mbooni both the groups were insecure. Figure 1 and figure 2 illustrate the percentages of the food secure and food insecure in the two groups in Kirinyaga and Mbooni respectively. The Mbooni smallholder farmers also have lower HDDI. The two measures of food security used were found to have a correlation coefficient of 49 percent significant at one percent level of significance.

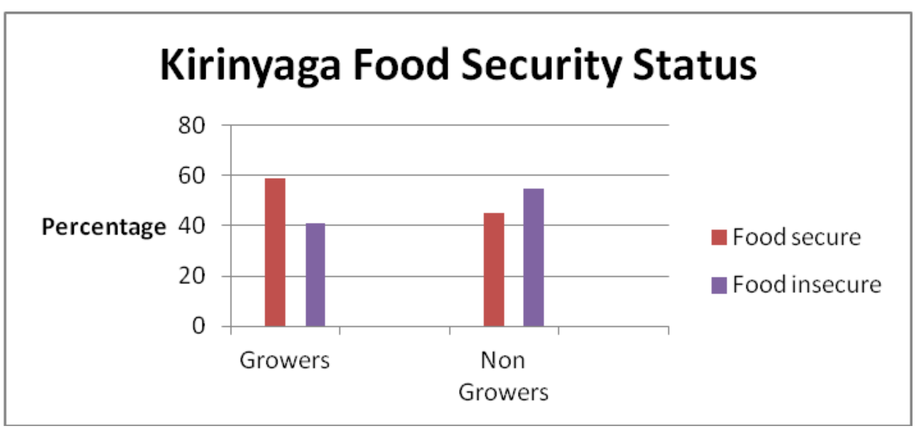

Figure 1: Kirinyaga district percentage of food secure and food insecure households

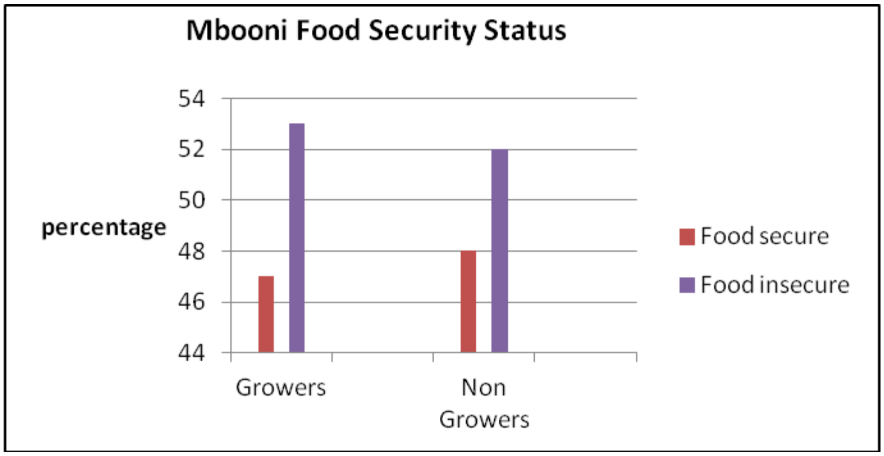

Figure 2: Mbooni district percentage of food secure and food insecure households

3.4 Impact of export horticulture farming on household adult equivalent calorie intake

In the estimation of the impact of export horticulture farming on the per capita calorie intake, the first step involves estimation of the probability of being in the treatment group of all sample units. This is done using choice models, probit or logit which give similar results. The results of this procedure also give us the factors affecting participation in export horticultural farming. The results are shown in appendix 4 for Kirinyaga and appendix 5 for Mbooni. These have however been subjects of earlier studies 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 the main purpose of the current study.

Overlap and Common Support condition

In propensity score matching 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 is 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). Hence, an important step is to check the overlap and the region of common support between treatment and comparison group. Several ways are suggested in the 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 propensity histogram below. The histograms shows that the distribution of the propensity scores between the groups of growers and non growers were within the region of common support.

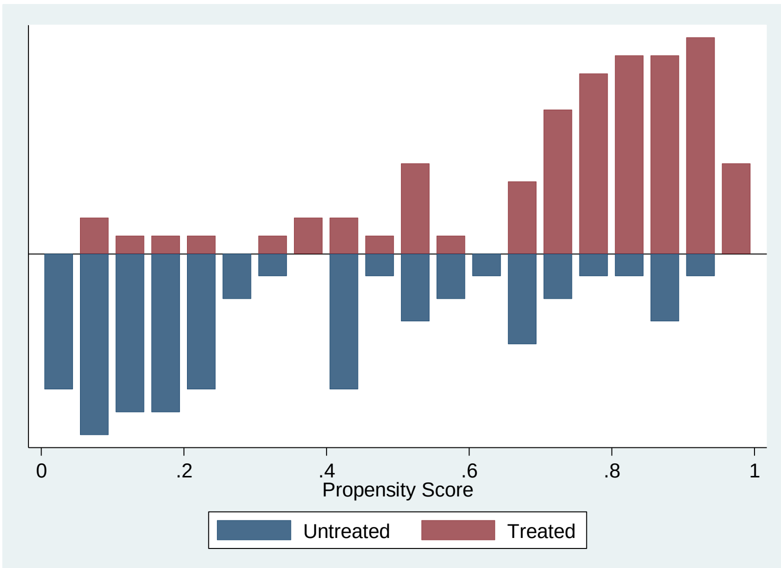

Figure 3: Propensity score histogram Kirinyaga district

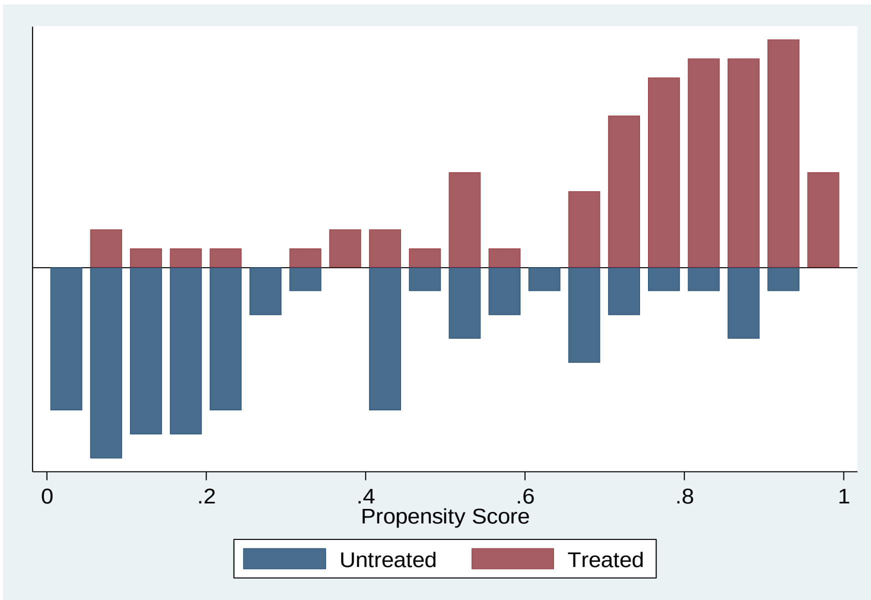

Figure 4: Propensity score histogram Mbooni district

Treatment effects

In appendix 6 results show that the three matching methods used pointed to statistically significant positive impact in Kirinyaga and a statistically significant negative impact in Mbooni, with an average ATT of +311 Kcal and -474 Kcal for Kirinyaga and Mbooni respectively. As indicated earlier, the small holder horticultural farmers in Mbooni were producing export horticulture on small land areas averaging 0.24 acres as opposed to 0.50 in Kirinyaga. The results are thus in line with those of Kuhlgatz Awudu (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% 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 export horticulture participation are accrued. 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 comes with a cost, rejection of produce due to defects are all challenges faced by the export horticulture farmers.

Mbooni is a semi arid area with high incidence of poverty and often is struck with famine from year to year. Thus results of export horticulture farming having a negative impact coincide with those of Dewalt (1993) who after reviewing the results of studies examining the impacts of agricultural commercialization on food consumption and nutritional status concluded that increased income does not translate directly into increased food consumption at either the household or individual level and 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.

Sensitivity analysis

Sensitivity analyses whose results are presented in appendix 6 with the treatment effects were conducted to ascertain the robustness of the 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 1.65 to 1.7 for the nearest neighbor matching, 1.55 to 1.6 for kernel based matching and 1.45 to 1.5 for the radius matching in case of Kirinyaga. Estimated effects in Mbooni are even more insensitive to hidden bias with gamma values being from 3.4 to 3.45 for the nearest neighbor matching, 3.25 to 3.3 for kernel based matching and 3.8 to 3.85 for the radius matching. These value implies that, for instance in the case of Kirinyaga, nearest neighbor matching a gamma level of 1.65, if individuals that have the same X-vector differ in their odds of participation by a factor of 65 percent, the significance of the participation effect on per capita calorie intake may be questionable. The implication is the same for the others. We can therefore conclude 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.

Assessing the Matching Quality

The success of propensity score estimation is assessed by the resulting balance and 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, thus 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. 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 appendix7. The high percentage values of reduced standardized bias clearly 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 together with the P-values of the likelihood ratio tests before and after matching. In all the different matching algorithm for the two areas, the joint significance of the regressors is always rejected after matching, whereas it was never rejected at any significance level before matching, suggesting that there is no systematic difference in the distribution of covariates between adopters and non-adopters after matching.

4. Summary, Conclusion and Recommendations

Available evidence in the debate of the impact of cash cropping system 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. Review of existing literature concludes that the available evidence is insufficient to draw strong policy recommendations. The current study contributed to the existing literature by assessing the impact of export horticulture farming a major cash cropping practice in Kenya on the food security status of smallholder farmers in Mbooni a semi arid area and Kirinyaga County which lies in the high zone. Export horticulture is ranked third in terms of foreign exchange earnings after tourism and tea.

Household per capita calorie intake was estimated using a seven day recall method. Smallholder farmers in Mbooni were found to be food insecure while those of Kirinyaga secure. Participation in export horticulture farming had a positive impact in Kirinyaga but a negative impact was identified in Mbooni.

Mbooni smallholder farmers' food insecurity both growers' and non growers' of export horticulture farmers should be addressed. Policies to ensure food security at the household and district level should be promoted as well as improvement of the road network in the area to make sure food and cash production and marketing systems are well functioning.

A comprehensive evaluation on farming systems and gross margins of different scales of export horticulture cultivation in Mbooni and probably other growing areas need to be carried out. It may be more profitable to participate in domestic horticulture and staple food production than engage in export horticulture farming in some areas considering the infrastructure and the lack of reliability of food market systems. Uses of income resulting from export horticulture farming also need to be investigated too, to explain the observed results.

Considering the positive impact that participating in export horticulture production in Kirinyaga has on the per capita calorie intake of smallholder farmers, they should be encouraged to participate. Policies to promote continued and increased smallholder participation in horticulture exports in Kirinyaga especially by the youth should be emphasized.

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Appendices

Appendix 1: Summary statistics of smallholder farmers in Kirinyaga and Mbooni.

		Kirinyaga N=241		**Mbooni N=140**	
Variable code	**Variable description**	Mean	Std.D	Mean	Std.D
HHGENDER	Gender of household head(1=Male 0 Female)	0.81	0.39	0.79	0.40

HHSIZE	Size of the household	4.09	1.78	5.76	2.13
HHEDUC	Years of education of the household head	8.09	4.07	8.07	4.19
GROUPMEMBER	Whether the household head belong to a group (1= Yes 0 = Otherwise)	0.95	0.22	0.81	0.40
HHOCCUPATION	The primary occupation of the household head	0.83	0.38	0.71	0.46
HHFARMEXPR	Number of years of farming	20.23	13.09	19.72	11.74
TOTLABOURERS	Family labourers plus hired labourers	3.89	2.47	3.00	1.05
FAMLABOURERS	Number of family labourers	1.73	0.63	1.86	0.62
OWNLAND	Land area owned by the household	0.72	1.02	0.86	0.55
AGRICLAND	Land area under cultivation	2.17	2.17	2.09	1.74
EXTCONTACT	Whether farmer had contact with an extension officer for the previous12 months	0.61	0.49	0.68	0.47
HHAGE	Age of the household head	48.62	13.5	46.56	12.99
LVSTKUNITS	Number of livestock equivalent	1.99	1.87	2.21	2.33
DISTMARKET	Distance in Km to the nearest market	3.9	3.68	5.94	4.93
DISTINPUT	Distance to the nearest input shop (walking hours)	1.52	2.89	2.99	6.69
DISTWATER	Distance in Km to the nearest water source	0.38	0.78	0.75	1.73
TOTACRES	Total acres of land owned plus rented	2.54	1.83	2.50	1.59
EXPVEGAREA	Land area under export vegetables	0.50	0.54	0.24	0.13
TOTASSETS	Value of total assets.	181 475	76	118 842	80 603

Appendix 2: Social economic characteristics of export vegetable growers and non-growers

Variable	Kirinyaga				Mbooni			
	Growers n=152	non-growers N=89	Test of difference in means		Growers n =78	Non-growers N=62	Test of difference in means	
	Mean	Mean	T-stat	P-value	Mean	Mean	T-stat	P-value
HHGENDER	**0.87**	**0.72**	**2.91**	**0.00*****	0.79	0.79	.06	0.95
HHSIZE	**4.24**	**3.84**	**1.67**	**0.10***	**6.12**	**5.31**	**2.26**	**0.03****
HHEDUC	**8.60**	**7.22**	**2.56**	**0.01*****	8.14	7.98	0.22	0.83
GROUPMEMBER	0.97	0.92	1.58	0.12	0.83	0.77	0.88	0.38
HHOCCUPATION	**0.87**	**0.76**	**2.10**	**0.04****	0.73	0.68	0.69	0.49
HHFARMEXPR	**18.72**	**22.81**	**-2.34**	**0.02****	**21.67**	**17.27**	**2.23**	**0.03****
TOTLABOURERS	**4.24**	**3.2**	**2.92**	**0.00*****	**3.36**	**2.5**	**4.89**	**0.00*****
FAMLABOURERS	1.72	1.75	-0.36	0.71	1.85	1.85	0.04	0.97
OWNLAND	0.70	0.73	0.20	0.84	0.85	0.47	1.4	0.15
EXTCONTACT	0.64	0.54	1.62	0.11	**0.86**	**0.45**	**5.6**	**0.000*****
HHAGE	**46.13**	**52.89**	**-3.86**	**0.00*****	47.42	45.48	0.88	0.38
LVSTKUNITS	**2.16**	**1.71**	**1.79**	**0.07***	**2.7**	**1.56**	**3.07**	**0.00*****
DISTMARKET	**3.57**	**4.47**	**-1.84**	**0.07***	5.67	6.29	-0.75	0.45
DISTINPUT	1.53	1.49	0.12	0.90	2.78	3.25	-0.41	0.68
DISTURBAN	9.45	10.64	-0.90	0.37	14.62	15.71	-0.38	0.70
DISTWATER	0.33	0.46	-1.26	0.21	0.80	0.70	0.33	0.74
LNTOTASSETS	**11.97**	**11.70**	**2.79**	**0.01*****	11.52	11.31	1.63	0.11*

Appendix 3: Average Per capita calorie intake and Dietary diversity levels by district and growing status

District	Growers/ Non growers	Per-capita calorie intake	HDDI
Kirinyaga	Growers	2468	7.68
	Non growers	2297	6.88
	Average	2405	7.39
Mbooni	Growers	2139	6.54

Non growers	2168	6.58
Average	2152	6.56

Appendix 4: Propensity scores estimates of Kirinyaga district

Variable	Coefficient	Std-err	z	P value
HHGENDER	0.53	0.38	1.40	0.16
LNTOTASSETS	**0.53****	**0.24**	**2.14**	**0.03**
HOUSECOND	**-0.64***	**0.34**	**-1.85**	**0.06**
LVSTKUNITS	0.04	0.10	0.48	0.63
GROUPMEMBER	0.94	0.64	1.46	0.14
HHSIZE	0.03	0.08	0.32	0.75
TOTLABOURERS	0.08	0.07	1.12	0.26
AGRICLAND	**0.24****	**0.12**	**1.93**	**0.05**
HHEADAGE	**-0.05*****	**0.01**	**-3.68**	**0.00**
DISTMARKET	**-0.11*****	**0.04**	**-2.64**	**0.01**
CONSTANT	**-5.09***	**2.81**	**-1.81**	**0.07**
Pseudo R^2 0.1478				
LRχ2(P value 46.93 (0.000)				

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

Appendix 5: Propensity scores estimates of Mbooni district

Variable	Coefficient	Std-err	Z	P value
LVSTKUNITS	0.14	0.13	1.04	0.30
EXTCONTACT	**1.93*****	**0.50**	**3.85**	**0.00**
HHOCCUPATION	0.50	0.55	0.91	0.36
HOUSECOND	0.53	0.56	0.96	0.34
HHGENDER	-0.97	0.61	-1.58	0.11
INCOMECAT	**1.77*****	**0.64**	**2.77**	**0.01**
LNTOTASSETS	-0.33	0.37	-0.88	0.38
HHEADAGE	-0.02	0.02	-1.08	0.28
TOTLABOURERS	**0.84*****	**0.25**	**3.40**	**0.00**
GROUPMEMBER	0.42	0.58	0.72	0.47
HHSIZE	**0.23*****	**0.11**	**2.16**	**0.03**
CONSTANT	-2.09	4.02	-0.52	0.60
Pseudo R^2 0.3321				
LR χ2 (P value)63.85 (0.000)				

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

Appendix 6: Treatment effects on Adult equivalent calorie intake (gamma level for sensitivity analysis)

	Kirinyaga district			Mbooni		
Matching Algorithm	*ATT*	*T stat*	*Gamma level*	*ATT*	*T stat*	*Gamma level*
NNM	339	**2.16**	1.65-1.7	-495	**-2.37**	3.4-3.45
KBM	304	**2.02**	1.55-1.6	-434	**-2.28**	3.25- 3.3
RM	292	**2.17**	1.45-1.5	-495	**-2.51**	3.8-3.85
Mean	311			-474		

Appendix 7: Covariate balancing tests

Test indicator	Kirinyaga	Mbooni
Before matching		
Mean bias before matching	29.13	44.52
Pseudo R^2	0.148	0.33
LR $\chi 2$ (P value)	47.09(0.000)	63.97(0.000)
After matching using nearest neighbor matching (NNM)		
Mean bias after matching	8.41	11.47
Percentage bias reduced	71	74
Pseudo R^2	0.021	0.054
LR $\chi 2$ (P value)	8.81(0.55)	11.63(0.39)
After matching using kernel based matching (KBM)		
Mean bias after matching	7.86	12.48
Percentage bias reduced	73	72
Pseudo R^2	0.022	0.049

LR $\chi 2$ (P value)	7.86(0.52)	10.66 (0.47)
After matching using radius matching (RM)		
Mean bias after matching	9.65	12.33
Percentage bias reduced	69	72
Pseudo R^2	0.029	0.049
LR $\chi 2$ (P value)	9.65 (0.271)	10.52(0.48)