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Impacts of farmer field schools on food security and environmental conservation in Western Kenya

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This study assessed the impacts of Farmer Field Schools (FFS) on household food security and environmental conservation in the Western Province of Kenya. The outcome variables were: Maize yield per acre, income per acre, household food insecurity score and environmental conservation score. Principal component analysis and propensity score matching techniques were used for analyses and regression method to test the robustness of matching results. We found that FFS households harvest higher crop yield of up to 9.45 bags which is significantly different (p<0.05) from their counterparts. Consequently, FFS households earn significantly (p<0.05) higher income estimated over KSh 2,800 per acre than Non-FFS households. Although the EC score were not significantly different, FS scores were low in FFS households. The study showed that FFS program significantly (-0.42) reduce severity of food insecurity this implies that FFS plays a critical role in enhancing household food security.**

Key words: Farmer field schools, food security, environmental conservation.

INTRODUCTION

Sustainable food production is a challenge facing many developing countries (Hickey et al., 2012; Kassie et al., 2014). In Kenya, the decline of land productivity has led to a decrease in the production of main staple foods such as maize leading to widespread hunger in recent years (Liu and Myers, 2009; Nyoro et al., 2004). Consequently, development agencies have invested in programs that focus on achieving the twin objectives of enhancing food security and environmental conservation. On this regard, the Food and Agriculture Organization (FAO) of the United Nations initiated the Farmer Field Schools (FFS) model to facilitate technology adoption in agriculture for enhanced crop productivity and use of environmentally friendly farming practices (Tripp et al., 2005). Whereas traditional extension methods such as training and visits, print, and media provide advice through trained technical staff, FFS adopts a participatory approach with the active engagement of farmers in on-farm research (Duveskog et al., 2011; Tripp et al., 2005). Studies indicate that this extension approach is effective in enhancing agricultural productivity and adoption of environmental conservation practices among FFS participants (Duveskog et al., 2011;

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Friis-Hansen and Duveskog, 2012; Larsen and Lilleør, 2014). However, these claims have elicited skepticism among stakeholders. It is argued that FFS is characterized by high training costs that exceed the benefits realized by farmers (Van den Berg and Jiggins, 2007). Moreover, some studies show that FFS lacks evidence of long-term impacts and hence can be regarded as unsustainable (Rejesus et al., 2012; Tripp et al., 2005). Although Duveskog et al. (2011) and Friis-Hansen and Duveskog (2012) indicate that FFS has enhanced farmers' well-being in East Africa, such outcomes are not evident in other countries like Vietnam, Philippines and Sri-Lanka (Rejesus et al., 2012; Sanglestsawai et al., 2015; Tripp et al., 2005).

Existing empirical evidence on FFS training outcomes vary from one country to another; hence, the results cannot be generalized to conclude that FFS training has been effective in enhancing food security and environmental conservation in Western Kenya. There is need to generate more documented evidence on the impacts of FFS training to aid policy makers in designing effective agricultural extension programs and also identify knowledge gaps to be addressed. The purpose of this study is to investigate the impacts of FFS on food security and environmental conservation in Western Kenya by evaluating the program's effects on maize crop productivity, income, household food insecurity status and adoption of agricultural conservation practices as measured in terms of environmental conservation score.

LITERATURE REVIEW

Overview

Environmental conservation and food security are interdependent, with the former playing a key role in providing support services for sustainable food production. Ecosystem services such as nutrient cycling, hydrological cycle, atmospheric composition and climate regulation are vital in enhancing agricultural productivity (Hanley et al., 2013). However, unsustainable farming practices such as continuous land tillage and lack of cover crop has led to a decline in productivity on some agricultural lands (Donohoe, 2003; Clay et al., 2014).

In order to mitigate the impacts of environmental degradation and contribute to sustainable food security, FFS were introduced to promote adoption of environmentally friendly agricultural technologies such as Integrated Pest Management (Rejesus et al., 2012; Sanglestsawai et al., 2015; Tripp et al., 2005). The FFS program is now spread and has been scaled up in many regions in Asia, the Middle East, Latin America and Africa. The FFS program was started in Kenya in 1999 and has been implemented in the Western, Central and Coastal regions (Beek et al., 2009; Davis et al., 2012; Najjar et al., 2013). The worldwide growth of FFS could be attributed to its perceived effectiveness in enhancing agricultural productivity (Larsen and Lilleør, 2014; Najjar et al., 2013).

Role of FFS in food security and environmental conservation - Case studies

Various empirical studies have evaluated the impacts of FFS on crop productivity, income, and environmental conservation through the adoption of integrated pest management practices in agriculture. In the context of Asian countries, different training outcomes have been reported. FFS has led to significant reduction in pesticide use and consequently reducing pollution of surface and underground water and improving soil quality (Godtland et al., 2004; Tripp et al., 2005; Sanglestsawai et al., 2015). However, Rejesus et al. (2012), fail to find a significant reduction in pesticides use that can be attributed to FFS training.

Despite the relevance of these studies, the findings cannot be generalized to conclude that FFS has had major impacts in Western Kenya. This is due to differences in farm structures and land productivity between Asia where these studies were conducted and Africa. Agriculture in Asia is irrigation-based and characterized by extensive use of farm inputs like fertilizer, pesticides and improved seed varieties, as opposed to Africa where most farming systems are predominantly rain-fed; many farms are less fertile due to continuous cultivation (Muyanga and Jayne, 2014). African agriculture is also characterized by minimal use of improved farm inputs leading to very low productivity (Duveskog et al., 2011).

Nevertheless, there are success stories attributed to FFS training in East Africa. The program is reported to have transformed farmers' behavior (Duveskog et al., 2011; Taylor et al., 2012). As demonstrated by Duveskog et al. (2011), FFS empowered farmers and improved their well-being. After FFS training, farmers had better farming knowledge, increased crop production and consequently enhanced general wellbeing (Duveskog et al., 2011; Taylor et al., 2012). However, these studies lack quantifiable training outcomes because they employed qualitative evaluation approaches. The study also did not account for selection bias that may significantly influence program outcomes.

Friis-Hansen and Duveskog (2012) and Davis et al. (2012), use statistical models to evaluate the impacts of FFS training on farmers' empowerment, agricultural productivity and income. Both studies report positive outcomes from FFS adoption. While these findings may be used to make inferences on how FFS has contributed to food security in Kenya, the results by Friis-Hansen and Duveskog (2012), are based on a minuscule sample size (20 farmers). Davis et al. (2012), study is limited in scope as it only evaluates program effects on agricultural productivity and income. It does not examine how the program has contributed to environmental conservation which presents a significant feature in ensuring sustainable food security.

The case studies depict variations in FFS training outcomes which may be attributed to differences in agro-ecological conditions of study areas, socio-economic factors of farmers, ideologies advocated for in training and analytical method used. Furthermore, soils, weather, and environmental conditions as well as farmers' financial status, knowledge and experience in agriculture are major determinants of agricultural productivity. Such differences can lead to substantial variation in program outcomes. Secondly, FFS was primarily introduced in Asia to enhance knowledge and adoption of integrated pest management practices so as to lower excessive use of insecticide (Godtland et al., 2004; Sanglestsawai et al., 2015; Tripp et al., 2005). Indeed, most studies in Asia have provided concurrent evidence of significant decline in pesticide use as opposed to other aspects of agriculture such as crop yield improvement. On the contrary, training in Africa focused on enhancing agricultural knowledge and empowerment to smallholder farmers.

A review of empirical literature indicates an increasing use of quantitative approaches in FFS program assessment. This is probably because quantitative findings are measurable and can be validated as opposed to qualitative results. Several quantitative studies have used propensity score matching method. Often in observational studies characteristics of treated observations vary widely from control observations. Thus, direct comparison of treated and control outcomes is confounding due to selection bias. To overcome this problem, the matching estimator statistically generates control observations called the counterfactual whose characteristics are comparable to the treated observations. Using a set of defined covariates in a participation probability model, it generates propensity households. It also seeks to assess the impact of FFS on environmental conservation by evaluating differences in the use of environmental conservation practices in agriculture between FFS adopters and non-adopters.

METHODOLOGY

Analytical framework

This study evaluated the impacts of FFS training on farmers welfare. A simple approach to do this would have been to compare the means of the outcome variables for FFS participants and non-participants. However, the computed means would be biased due to the problem of self-selection. Partcipation in FFS was on voluntary basis rather than randomized in the community. Therefore, some households might have chose not to participate even if they were targeted while some untargeted households may have failed to participate in the trainning even though they were targeted. To address this bias a control for the selection of participants of FFS was needed. The study used the Propensity Score Matching (PSM) method to control for selection bias attributed to observable characteristics.

The four outcomes variables used were: maize crop yields, income per acre, household food insecurity and environmental conservation. The household food insecurity and environmental conservation scores, annotated as FS-score and EC-score respectively, were generated using principal component analysis (PCA). PCA has been used in other studies to compute national and household food security index such as Abafita and Kim (2014), Demeke et al. (2011) and Qureshi (2007). It is a multivariate data reduction technique that captures the most important information of selected variables of a data set and transforms them into new variables called principal components (Abafita and Kim, 2014).

FS score was generated using five indicators including whether the household ever ran out of food, duration when they lacked food, the number of meals taken per day, how often they fried their food and whether the household bought food in the two previous seasons. Categories in each indicator were ordered based on the severity of food inadequacy as illustrated in Table 1. Thus, higher scores indicate a high level of food insecurity. Following Abafita and Kim (2014), we generated the FS score as follows:

$$PCAI_j = \sum \frac{F_i\left(X_{ji} - X_i\right)}{S_i} \qquad (1)$$

where $PCAI_j$ was the value of the j^{th} household's food insecurity score generated in the PCA model, F_i was the weight for the i^{th} indicator in the PCA model, X_{ji} was the value of the j^{th} household in the i^{th} indicator. X_i and S_i are mean and standard deviation respectively of the i^{th} indicator of all the households.

The same approach was used to compute EC score using four binary variables including whether or not a household planted trees, have terraces and whether they use compost and organic fertilizer on their farms. Thus, higher scores indicate increased use of conservation technologies in farming.

Estimation of treatment effect

As described by Rosenbaum and Rubin (1983), and cited by Sanglestsawai, et al. (2015), the propensity score matching (PSM) model creates a counterfactual group whose characteristics are comparable to the treated group that enables comparison of outcomes between treated and control group. It involves identification of observed covariates, *X,* that influence the probability of program adoption or participation. Using these covariates, the PSM generated propensity scores that defined the likelihood of program participation. It also defined the area of common support that is the region where propensity scores of treated and control group observations overlap and matched them based on the scores, leaving out observations outside the area of common support (Khandker et al., 2009). Various matching techniques such as nearest neighbor, kernel, radius, caliper, stratification and interval matching can be used (Khandker et al., 2009; Sanglestsawai et al., 2015). However, this study the nearest neighbour and kernel matching methods was used. Following the approach by Sanglestsawai et al. (2015), a probit model was used to determine the probability of FFS participation given a set of observed covariates, *X,* as shown in Table 3. It was theoretically expected that farmers would participate in FFS if the expected utility of participation (D_1^*) was greater than the utility of non-participation (D_0^*). Participation in FFS was depicted as an observable dichotomous choice: D=1 if $D_1^* > D_0^*$ and D = 0 if $D_1^* < D_0^*$, modelled as:

$$D_i^* = X_i\beta + \varepsilon_i \text{ with } D_i = 1 \; if \, D_i^* > D_0^*, \text{ otherwise } D_i = 0 \qquad (2)$$

Table 1. Indicators used in generating food insecurity score.

Variable	Category			
	1	2	3	4
How often food is fried in the house	Every meal	Once a week	Occasionally	-
Has the house ever bought food in the last two seasons	No	Yes	-	-
Has the house lacked food	No	Yes	-	-
How long did the house lack food	1 week	1 - 4 weeks	1-2 months	More than two months

Source: Author

where X represents a matrix of the covariate variables, β is a vector of parameters to be estimated and ε a vector representing normally distributed error term with mean zero and variance σ_ε^2.

Using the propensity scores estimated in equation (2), the average treatment effect on the treated (ATT) was estimated as follows:

$$ATT = E(Y_1 - Y_0|D = 1) = E(Y_1|D = 1) - E(Y_0|D = 1) \quad (3)$$

where D was a binary response variable of FFS participation; Y_1 was the outcome of FFS households; Y_0 was outcome for non-FFS households; $E(Y_1|D = 1)$ was the expected outcomes of households who actually received FFS training (partcipated) and $E(Y_0|D = 1)$ was expected outcomes of households who were trained assuming they were not trained (counterfactual outcome). However, $E(Y_0|D = 1)$ was missing information because it was unobserved; a household could not have a treatment and counterfactual outcome simultaneously (Khandker et al., 2009; Sanglestsawai et al., 2015).

When estimating treatment effects, literature indicates that the set of covariates, X, should satisfy the balancing property of the PSM model, and matching of treated and control observations should be done within the area of common support (Sanglestsawai et al., 2015). This implied that households with the same propensity score were to have same distribution of X, irrespective of their participation status. Matching within the common support improve the quality of matches as it excludes the tails of the distribution of $P(X)$. Thus, several combinations of independent variables were tested until we found a set that satisfied the balancing property. Having met this condition, we matched overlapping FFS and non-FFS households based on their probability of program participation expressed as:

$$P(X) \equiv Pr(D = 1|X) \quad (4)$$

where $0 < P(X) < 1$ is the range of propensity scores. Thus, by using the propensity scores, we express the counterfactual outcome, $E(Y_0|D = 1)$ in Equation 2 as:

$$E(Y_0|P(X), D = 1) = E(Y_0|P(X), D = 0). \quad (5)$$

Using Equation 5, the average treatment effect on the treated was estimated as:

$$ATT = E(Y_1|D = 1, P(X)) - E(Y_0|D = 0, P(X)). \quad (6)$$

Robustness test

Y = μ + aD + X′/3 + D(X – X̄)y + E

We used the regression-based approach to test the robustness of PSM results. This approach was also applied by Godtland, et al. (2004) and Sanglestsawai, et al. (2015). Assuming conditional independence of outcomes given the set of observed covariates X, the expected outcomes was expressed as:

$$E(Y_0|X) = \alpha_0 + (X - \bar{X})\beta_0 \quad (7)$$

$$E(Y_1|X) = \alpha_1 + (X - \bar{X})\beta_1 \quad (8)$$

where $(X - \bar{X})$ was the difference between the value of an observation and its corresponding average; $E(Y_1|X)$ and $E(Y_0|X)$ were the expected outcome of FFS and non-FFS household respectively. Thus, the regression function was expressed as:

$$Y = \mu + \alpha D + X'\beta + D(X - \bar{X})\gamma + \varepsilon \quad (9)$$

where μ, α, β and γ were parameters estimated using the ordinary least square (OLS) method, ε was the error term and Y is the outcome variable of interest.

Study area

In the study area (Figure 1), the average farm sizes tend to be small, ranging from 0.6 to 2.2 ha and maize was the predominant crop in the region (Tittonell et al., 2005; Duveskog et al., 2011). Climate in the region consists mainly of two seasons of rainfall, a long rainy season between March and May and a short season between October and November. We choose this study area due to the many farmer field schools that have been in operation for almost 20 years, a long enough period to observe program impacts.

Data source and sampling method

This study used secondary survey data obtained from the International Food and Policy Research Institute (IFPRI). The survey was funded by International Fund for Agricultural Development (IFAD) and conducted by IFPRI in collaboration with other institutions in Kenya, Uganda and Tanzania in 2008/09. In Kenya, the survey was conducted in the four districts of Western Kenya. A stratified sampling technique was used to identify survey respondents. Equal proportions of FFS households were selected from all FFS groups in the four districts. On the other hand, non-FFS households were randomly chosen from villages without FFS initiatives in all administration units.

Data Description

A total of 2791 respondents drawn from 398 households participated in the survey. In this study, the analysis was done at the household

Table 2. Summary statistics of key variables.

Variable	Full sample (n=363)		FFS households (n=254)		Non-FFS households (n=109)	
	Mean	Std Dev.	Mean	Std Dev.	Mean	Std Dev.
Dependent variable						
Yields per acre (bags)	8.72	4.16	9.32	4.04	7.33	4.11
Income per acre (KShs)	16218.5	8806.91	17472.60	8876.91	13296.09	7941.13
FS score	-0.00000002	1.05	-0.006	1.08	0.01	0.98
EC score	-0.01	1.15	0.05	1.27	-0.17	0.74
Independent variable						
Household characteristics						
Sex of HH (male = 1, female = 0)	0.83	0.37	0.84	0.36	0.81	0.40
Age of HH	49.14	12.27	48.62	12.42	50.35	11.88
Education of HH	2.32	0.74	2.39	0.75	2.17	0.70
Education of spouse	2.11	0.58	2.14	0.59	2.03	0.56
Household size	6.84	2.93	7.02	3.07	6.42	2.53
Farm characteristics, technologies and management practices						
Land size (Acres)	3.31	3.37	3.31	3.55	3.31	2.92
Yields before FFS (bags)	5.76	5.47	5.51	4.57	6.34	7.12
Income before FFS (KShs)	5371.96	5113.99	5291.59	4812.23	5559.27	5775.93
Use of improved seeds	0.84	0.36	0.89	0.31	0.74	0.44
Use compost	0.22	0.42	0.21	0.41	0.24	0.43
Use Terracing	0.18	0.39	0.20	0.40	0.13	0.34
Plant trees	0.15	0.36	0.16	0.36	0.15	0.36
Use organic fertilizer	0.18	0.38	0.17	0.38	0.20	0.40
Access to services and social capital						
Member to credit group	0.61	0.49	0.70	0.46	0.40	0.50
Distance to major town (Km)	5.69	4.86	5.96	4.98	5.08	4.58
Distance to tarmac road (Km)	9.71	7.72	9.96	7.99	9.11	7.04

Source: Author

level. Observations with income per acre greater than KShs. 70,000 and yield greater than 35 bags before FFS program implementation were deleted. This was based on farm size range in the study area and yield data in Kenya. It is unlikely to harvest more than 35 bags per acre. Most farms in high potential maize producing areas yield 15 to 30 bags whereas, in less productive areas, yield may be less than 5 bags (Nyoro et al., 2004). Jayne et al. (2005), indicates that the market price of maize per bag ranges between KShs. 1,000 to KShs. 2,500, hence it is unlikely that households earn more than KShs. 70,000 per acre. After removing these observations, a total of 363 households remained for analysis. We provide a summary of the data in Table 2.

According to the summary statistics FFS households harvest an average of 9.32 bags and earn KShs 17,472.60 whereas non-FFS households harvest 7.33 bags and earn KShs 13,296.09 per acre, suggesting that FFS training improves agricultural productivity. Additionally, FFS households are more food secure than non-FFS households as indicated by lower food insecurity scores in FFS households (-0.006) compared to their counterparts whose average rating is 0.01. These statistics also suggest that FFS program enhances the use of environmentally friendly farming practices as depicted by higher environmental conservation scores (0.05) in FFS households than non-FFS households whose mean score is -0.17.

The household characteristics indicate that most households are headed by men. However, the age and education were relatively similar across all household heads (HH). Most HH, including their spouses, had secondary school education. However, FFS families were large with an average of seven family members whereas non-FFS households had an average of six members.

According to the farm characteristics, technology use and farm management practices, the average farm size are comparable across the two groups. However, before the program commenced, non-FFS households had higher yields and earnings per acre than FFS households. Non-FFS households harvested 6.34 bags of maize per acre whereas FFS households harvested 5.51 bags. On the other hand, the average earnings were KShs 5,559.27 and KShs 5,291.59 for control and treated households respectively.

Although majority of the households use improved maize seed varieties, FFS households use improved seed much more than non-FFS households. The utilization of compost and organic fertilizer, as well as planting of trees, is almost similar across all households. Nevertheless, more FFS households established terraces on their farms and were members of savings and credit organizations. Proximity to town and all-weather road is comparable in all households.

The summary statistics suggest that FFS training enhances agricultural productivity, food security and environmental conservation. However, these results are not sufficient to draw

Figure 1. Map of Kenya indicating study region.
Source: http://www.nationsonline.org/oneworld/map/kenya_map2.htm.

Table 3. Probit model for FFS program participation.

Explanatory variable	Marginal effect	P>|z|
Gender of HH (Female)		
Male	0.0977	0.538
Age of HH	-0.0001	0.982
Education of HH (never been to school)		
Primary	-0.1106	0.312
Secondary	-0.0456	0.705
Tertiary	-0.0099	0.946
Education of spouse (never been to school)		
Primary	0.0927	0.382
Secondary	0.1989	0.100
Tertiary	-0.0439	0.843
Household size	0.0177	0.072
Member of savings/credit groups	0.2428	0.000
District (Butere ≥ Base)		
Kakamega	0.4865	0.019
Bungoma	0.3415	0.112
Busia	0.4735	0.024
Crop yield before (bags) FFS	-0.0117	0.031
Distance (Km) to town	0.0061	0.277

Prob > chi^2 = 0.0005; Log likelihood = -157.35164; Pseudo R^2 = 0.1127.
Source: Author

unbiased conclusions regarding the program's impacts due to differences in household characteristics and selection bias (Sanglestsawai et al., 2015). Hence, comparison of means may give misleading conclusions. In this regard, we evaluated the impacts of FFS training using propensity score matching (PSM) method to control for the selection bias as described in the next section.

RESULTS

Based on the probit model estimates in Table 3, the probability of a household participating in FFS is significantly influenced by household size, the initial maize yield before joining the FFS program, membership to a savings and credit organization, and the district where the household is situated. Households that had relatively high yields before the program was introduced are less likely to join FFS. However, the probability of participating in FFS training increases by 24% if a household is a member of a savings and credit organization. The likelihood of being an FFS member is 49% and 47% higher in Kakamega and Busia districts relative to Butere and Bungoma districts.

We find that gender and age of HH, education level of their spouses and distance to the nearest town have no significant influence on whether a household will participate in FFS training or not. However, the results suggest that male-headed households are more likely to join FFS than female headed households and households headed by older persons are less likely to take part in FFS training. Similarly, a household is likely to participate in FFS if the HH is educated compared to those led by uneducated heads. Primary and secondary education of spouses increases the chances of being an FFS member whereas having tertiary education reduces the likelihood of joining FFS.

Propensity score matching results

The PSM results in Table 4 suggested that FFS training had a significant effect on crop yields, income, and food security. The impacts on environmental conservation were insignificant. The unmatched sample showed that crop yields and revenue per acre were significantly different at 5% level between treated and control households. On average, treated households harvested 1.6 extra bags of maize and earned KShs 3,452 more income per acre than their counterparts. The one-to-one nearest neighbour matching model showed that FFS households had significantly high yields and income at 5% and 10% level respectively. FFS households harvested 9.35 bags per acre whereas non-FFS households harvested 7.74 bags. FFS households also earned about KShs 2,859 per acre more than their counterparts.

The one-to-five nearest neighbour matching method

Table 4. Training outcomes from PSM model.

Sample	FFS households	Non-FFS households	Difference	SE
Unmatched sample				
Yield per acre	9.448	7.812	1.637**	0.540
Income per acre	17367.00	13914.81	3452.18**	1116.73
FS score	-0.076	0.001	-0.077	0.146
EC score	0.10	-0.11	0.21	0.22
Matched sample				
One to one nearest neighborhood matching (1:1 NNM)				
Yield per acre	9.35	7.74	1.61**	0.76
Income per acre	17003.18	14144.36	2858.82*	1673.53
FS score	-0.12	0.21	-0.33	0.21
EC score	-0.01	0.16	-0.16	0.24
One to five nearest neighborhood matching (1:5 NNM)				
Yield per acre	9.45	7.70	1.74**	0.72
Income per acre	17366.99	13744.08	3622.90**	1416.49
FS score	-0.08	0.31	-0.39*	0.20
EC score	0.10	0.50	-0.41*	0.24
Kernel matching (km)				
Yield per acre	9.39	8.05	1.34*	0.76
Income per acre	17302.28	14095.72	3206.55**	1501.46
FS score	-0.09	0.33	-0.42**	0.20
EC score	0.04	0.20	-0.17	0.24

Significance level: *** p<0.01, ** p<0.05, * p<0.1.
Source: Author

consistently indicated more yields and income for the treated than untreated households. The results depicted that on average, FFS households harvest 1.74 bags of maize and earn KShs 3,623 more per acre. The Food insecurity scores and environmental conservation scores were significantly different (10%) for FFS parctipants and non-FFS parctipants, with FFS participants having a lower FS score and higher EC score. On the other hand, Kernel Matching results indicated a significant difference (5%) in yields, income and household food security. The model showed that FFS households harvested 1.34 bags per acre more than non-FFS households. Also, the revenue per acre was KShs 3,206 higher.

All the PSM models showed that FFS households and non-FFS households had statistically insignificant differences in EC scores.

Multiple linear regression results

Based on Equation 8, we used similar variables to evaluate the impact of participating in FFSs using linear regression models. The results were presented in Table 5.

Similar to the PSM results, the regression model indicated that FFS training enhanced crop yields by about 1.2 bags per acre and increased earnings by KSh 3,317 at 10% and 5% significant level respectively. Although the results showed that training had no significant effect on FS score, the negative coefficient (-0.079) suggested that it reduced the severity of food insufficiency which is in line with our PSM findings. Similarly, FFS training had no significant effect on adoption of environmental conservation practices.

Most of the explanatory variables had no significant effects on the outcome variables. However, the results showed that increased education for HHs reduced food insecurity. Households whose heads had tertiary education had significantly low (5%) food insecurity level relative to those whose heads had no tertiary education. Food insecurity was significantly higher (at 10% level) in Busia compared to Butere district. The results also showed that food insecurity and use of conservation farming practices increased with increased distance from town.

The interaction terms indicated that maize yield declined by 6.9 bags per acre if highly educated HH joins FFS training. Food insecurity significantly increased (at 5% level), particularly when HHs with tertiary education become FFS members. The use of conservation farming techniques by FFS households declined significantly at 5% level in the rural areas relative to those situated in town.

Table 5. Training outcomes from multiple regression model.

Variable	Yield	Income	Food insecurity score	Conservation score
FFS membership	1.210*	3,317**	-0.079	-0.186
Gender of HH: Male	-0.795	-2,039	0.710	-0.049
Age of HH	-0.007	-48.81	0.005	0.004
Education of HH				
Primary	-1.257	-723.0	-0.610	-0.080
Secondary	0.013	1,072	-0.409	-0.060
Tertiary	5.042	2,141	-2.781**	-2.436
Education of spouse				
Primary	2.311	2,854	-0.049	0.432
Secondary	2.729	1,726	0.571	1.401
Tertiary	1.663	10,316	0.174	1.590
Household size	0.240	354.3	0.057	0.071
Member of credit/saving group	1.338	3,668	0.320	0.492
District (Butere)				
Kakamega	0.196	-1,597	0.369	0.383
Bungoma	-1.096	-3,366	0.650	0.270
Busia	-3.612	-7,343	1.171*	0.702
Yield before FFS	0.036	80.58	-0.003	-0.002
Distance to town	0.002	-162.4	0.049*	0.158**
Interaction terms: Demeaned dependent variables × FFS membership				
Gender of HH: Male	-0.568	-3,640	-0.867	0.671
Age of HH	-0.043	-55.49	-0.007	-0.007
Education of HH				
Primary	1.439	-633.0	0.481	-1.505
Secondary	-0.735	-3,858	0.579	-1.369
Tertiary	-6.898*	-4,891	2.886**	1.860
Education of spouse				
Primary	-1.993	-638.2	0.030	0.346
Secondary	-0.400	3,801	-0.651	-0.349
Tertiary	-2.133	-12,429		-1.477
Household size	-0.136	-270.4	-0.114*	-0.002
Member of credit/saving group	-0.790	-833.6	-0.177	-0.319
District				
Kakamega	-4.511	-9,558	0.064	-0.165
Bungoma	-1.571	-5,153	0.109	0.335
Busia	-1.847	-2,231	0.262	0.610
Yield before FFS	0.085	23.21	-0.003	0.037
Distance to town (Km)	0.060	-45.85	-0.009	-0.160**
Constant	6.076	15,648	-1.753	-2.487
Observations	293	293	255	169
R-squared	0.266	0.195	0.271	0.261

Significance level: *** p<0.01, ** p<0.05, * p<0.1
Source: Author

DISCUSSION

The aim of this study was to examine the role of FFS training in food security and environmental conservation by evaluating its impacts on crop yields, income, food insecurity status and adoption of environmental

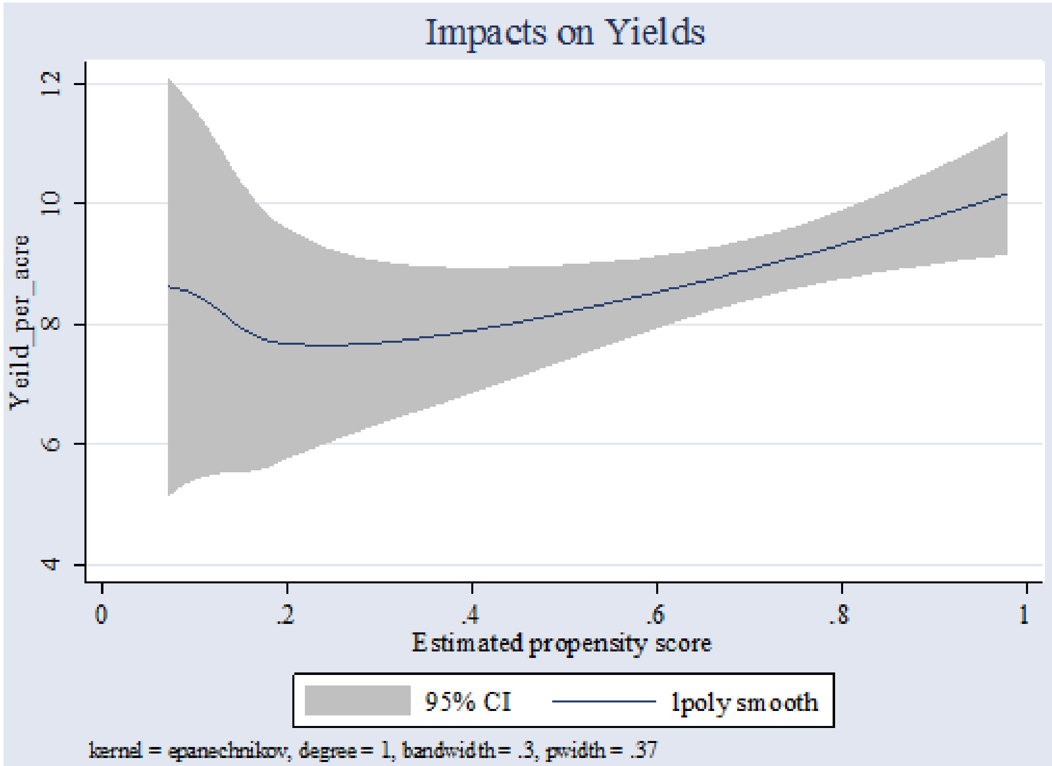

Figure 2. Impacts of FFS training on crop yields.
Source: Author

conservation techniques in agriculture at the household level in Western Kenya.

Impact on crop yields

According to the PSM results, FFS training significantly increased maize crop productivity. If households join FFS, productivity increased to 9.4 bags per acre compared to 8.0 bags if they did not participate in the program. Matching estimates indicated significant differences in crop productivity between trained and untrained households ranging from 1.3 to 1.7 bags of maize per acre. The regression analysis demonstrated a significant improvement in crop yields for FFS participation. Trained households harvested 1.2 extra bags of maize per acre which is consistent with the PSM findings. In Figure 2, local polynomial smoothing was used to fit a smooth curve over the scatter plot of yield and propensity scores. The figure demonstrated that maize yield was likely to increase as the likelihood of participating in FFS increased.

Based on the regression estimates, crop productivity significantly declined if HHs with higher education joined FFS training. This outcome is expected because educated persons are likely to be on full-time employment either in the private or public sector which directly reduce their time to fully engage in farming activities. This is likely to reduce their farm productivity.

Impact on income

Participation in FFS training improved income as depicted in Figure 3; the income increased as the likelihood of participating in FFS increased. The matching estimators indicated that income increased to more than KShs 17,000 per acre and KShs 13,744 for FFS households and non-FFS household respectively. The regression estimates also show similar effects with FFS households earning KShs 3,317 per acre more than non-FFS households. Similar results have been reported by Davis et al. (2012). These findings may be due to increased crop productivity and social capital. As depicted in the summary statistics, 70% of FFS households are members of savings and credit groups which may have played a role in marketing their maize hence better revenue.

Impact on household food insecurity status

The matching estimates demonstrate a decline in food insecurity score if farmers participate in FFS training, suggesting an improvement in household food security. Based on the 1:5 NNM and KM matching outcomes, there

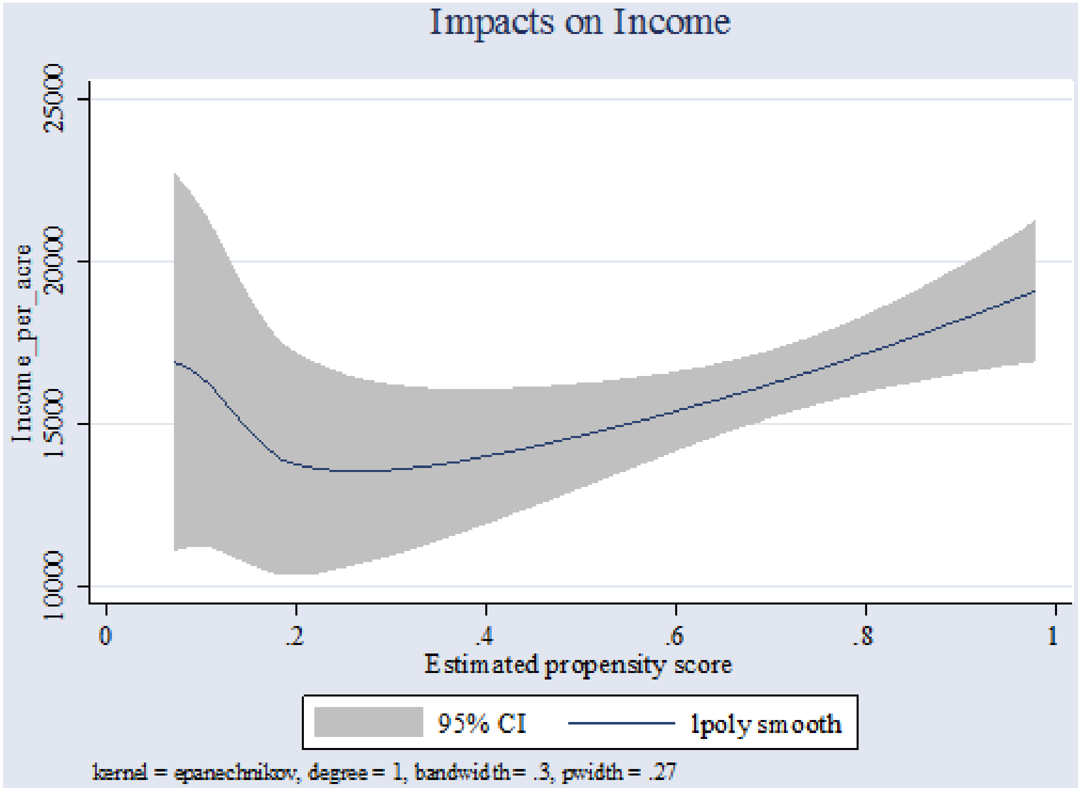

Figure 3. Impacts of FFS training on income.
Source: Author

is a significant difference in the food insecurity score for FFS households and non-FFS households. The regression estimate also highlights a decrease in household food insecurity, even though it is not statistically significant.

We note that if HHs are educated, food security increases. This effect is significant (at 5% level) if the head has tertiary education. Nevertheless, when educated family heads become FFS members, food insecurity status increases at 5% significance level. We attribute these findings to the fact that people with higher education are likely to have full-time employment in other sectors which may increase their earnings and ultimately enhance their access to food. Having full-time employment implies that they have limited time to undertake farming activities thus by participating in FFS training may reduce their economic productivity leading to food insecurity. Increasing distance from nearest town significantly increases household food insecurity which may be as a result of transaction costs associated with participation in both input and output markets. Distance to nearest town can also affect access to market information and credit necessary for smoothing consumption. For households with large size, the level of food insecurity tends to reduce if they participate in FFSs. This effect is expected because the program was introduced in Kenya to enhance productivity so as to enhance food security.

Impacts on environmental conservation

The findings of the study showed that FFS training had no significant effects on environmental conservation. Similar observations were reported by Rejesus et al. (2012), they found no significant reduction on insecticides use that are an environmental hazard. In contrary, FFS training reduced environmental pollution by significantly reducing insecticide use in Srilanka and Philippines (Sanglestsawai et al., 2015; Tripp et al., 2005). These variations may be attributed to differences in training objectives. Due to the declining crop productivity in Kenya FFS training paid more emphasis on crop productivity enhancement rather than environmental conservation.

The regression results showed that households located far from towns practices conservation farming techniques more than those close to towns. It is likely that farm inputs such as inorganic fertilizer and pesticides are costly in the rural areas due to increased transaction costs. Consequently, farmers are prompted to use alternative inputs such as compost manure and herbicides thereby reducing pollution attributed to insecticides and fertilizer use. With increasing distance from town, we also observe that environmental conservation considerably reduces if households join FFS. As illustrated in the summary statistics, 70% of FFS members are in savings and credit groups. Thus, even though such inputs may be costly in far-flung areas, FFS households have access to financial support; hence they can buy these inputs rather than use organic fertilizers and herbicides leading to a decline in the environmental conservation score. This implies that FFS households are likely to increase environmental degradation than their counterparts.

CONCLUSION, LIMITATIONS AND RECOMMENDATION

FFS program played a critical role in enhancing food security by increasing maize crop yields and income. However, FFS training did not have any significant effect on the use of conservation farming technologies. The study showed there were benefits associated with participation in FFS training implying that Farmer Field Schools can be effective extension strategy to combat food insecurity. However, considering the increasing level of environmental degradation in Western Kenya, the results suggested that use of conservation farming techniques needed more emphasis in FSS training to sustain agricultural productivity.

Nevertheless, there is one caveat to our analysis; the analytical methods did not control for bias attributed to unobserved variables. Therefore, future research could be done using approaches that control for both observable and non-observable effects. Computation of EC score was based on binary response variables; the score fails to capture the intensity of conservation; for instance, the size of land allocated for tree planting, the quantity of organic fertilizer and compost used by farmers. Thus, a comprehensive study is necessary to evaluate FFS impacts on environmental conservation.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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