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Promoting Livelihood Diversification Among Rural Farming Households in Kenya: What Role does Farm Forestry Farmer Field School Play?

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Abstract

Farmer Field School (FFS) is an agricultural extension approach designed to empower participants, enabling them to make adaptive decisions in farming practices under diverse and changing conditions. Because FFS provides participants with farming knowledge and practices of new crops and products, one of the expected effects of FFS is household livelihood diversification, which is seen as a key factor for enhancing the resilience of rural households to climate change impacts. This study empirically investigates the effects of a farm forestry FFS program on the livelihood diversification of rural households and its cascading effects on household vulnerability to climate-related shocks. In doing so, it employs an example of a farm forestry FFS program implemented in two counties in arid and semi-arid lands (ASAL) regions in Kenya from 2017 to 2020. In recent times, rural households in ASAL areas of Kenya have suffered from recurrent droughts exacerbated by climate change. We collected information through key informant interviews, focus group discussions, and a household survey of 344 households with and without graduates of the FFS program. The collected data were analysed qualitatively and quantitatively through a propensity score matching analysis to assess the relationship between FFS graduation and household livelihood diversification. Further, the relationship between household livelihood diversification and household losses from climate-related shocks was analysed using a simple multivariate regression analysis. The results of the propensity score analysis indicated that FFS graduate households have greater livelihood diversification in terms of both the number of income types and the number of agricultural, forestry, and livestock products they sold, compared with the counterfactual case where a household did not have an FFS graduate. The subsequent multivariate regression analysis showed that the diversity in household sales of agricultural, forestry, and livestock products was inversely correlated with the losses households suffered from recent events of droughts and crop diseases/pests. These results suggest that the farm forestry FFS facilitated participating households to diversify their livelihood, which is deemed beneficial for enhancing household resilience to climate-related threats such as droughts and crop diseases/pests.

Keywords: Farmer Field School, livelihood diversification, drought, household vulnerability to shocks, propensity score method

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1. Introduction

Farmer Field School (FFS) is an agricultural extension approach intended to empower participants (Davis et al. 2012). Through participatory adult learning, the FFS approach is designed to enable participants to make adaptive decisions in their farming practices under diverse and changing field conditions (Esbern Friis-Hansen and Duveskog 2012), including "hands-on" observation and experimentation (Mbeche, Mose, and Ateka 2022). One expected effect of FFS is livelihood diversification among rural farming households (Mariyono et al. 2021; Van Den Berg et al. 2020). Rural households diversify their income sources by employing a wide range of activities and opportunities to reduce household income unpredictability, mitigate the adverse effects of seasonality, and secure employment or supplementary income (Alobo Loison 2015; Barrett, Reardon, and Webb 2001; Ellis 2000). Livelihood diversification is a pivotal strategy in rural development, enabling rural households to escape poverty (Alobo Loison 2015; Diwakar and Shepherd 2022). It is crucial for reducing livelihood threats and vulnerability, as well as stabilising household incomes (Yego et al. 2021).

In the context of rural development, livelihood diversification extends beyond a mere shift from agricultural to non-farm activities. It involves a dynamic process where rural households intentionally build a diverse portfolio of endeavours, encompassing both agricultural and non-agricultural activities with varied income sources (Alemu 2023; Alobo Loison 2015; Ellis 1998, 2000). Scholars have identified reasons for livelihood diversification of rural households, such as seeking self-insurance against risks and crises and making an appealing choice for accumulating assets (Kassie et al. 2017). Scholars have also broadly classified the determinants for household diversification into push and pull factors. The push factors motivate households to diversify livelihood options for survival, while pull factors relate to diversification by choice or wealth accumulation (Ellis 2000; Yego et al. 2021).

In this paper, we explore the effects of farm forestry FFS on livelihood diversification. Farm forestry is one of the various themes that FFS commonly addresses (Waddington et al. 2014). It adheres to the adult learning principles of FFS and incorporates a tree-growing component, including planting and tending techniques, as well as tree and nursery management. Besides, farming, livestock, and other agriculture-related components are included in the FFS curriculum to address the participants' needs, as farmers commonly express interest in these aspects. Drawing on a case study of a farm forestry FFS project within a dryland ecosystem in Kenya, we examine whether farm forestry FFS guides its graduates toward livelihood diversification and brings any additional effects by analysing household survey data of the study area using propensity score matching analysis and multivariate regression analysis. We argue that analysing the effects of the farm forestry FFS is relevant in light of the escalating impacts of climate change. Integrating a forestry component into FFS offers a more comprehensive natural resource management approach, allowing farmers to adopt diverse strategies for climate change adaptation. Assessing the

effectiveness of this integration is therefore crucial for optimizing benefits and supporting broader climate adaptation efforts. As discussed in the next section, there is academic literature reporting the effects of FFS on livelihood diversification, but none focuses on farm forestry FFS. This study intends to address the research gap on the effects of farm forestry FFS on rural household livelihood diversification and its cascading effects on household resilience to climate change.

The rest of this article is organised as follows: Section 2 reviews the literature on FFS with a focus on its relation to participants' livelihood diversification and resilience to climate change. Section 3 provides a brief overview of the FFS project in Kenya, which is the subject of the case study. Section 4 explains the methodology and data used, and Section 5 presents the results and discussions. Section 6 concludes the article with a brief discussion of the implications and suggestions for future research.

2. FFS and livelihood diversification

FFS was developed for use in Southeast Asia by the Food and Agriculture Organization of the United Nations (FAO) in the late 1980s and has now been adopted in more than 90 countries (FAO 2016; Van Den Berg et al. 2020). The FFS approach to agricultural extension was initially operationalised in 1989 to enable farmers to learn and adopt integrated pest management in Indonesia (Davis et al. 2012; Mariyono 2009). Unlike previous agricultural extension methods, where experts act as teachers to transfer technical knowledge and skills to farmers in a top-down manner, the FFS approach is an experiential and reflective learning process (Larsen and Lilleør 2014). The learning process is organised by highly trained facilitators and delivered in a group setting among participating farmers (Friis-Hansen and Duveskog 2012). The process lasts through a production cycle or a season, with regular meetings in the field, usually once a week at an experimental farm. During these weekly field meetings, facilitators support farmers in conducting agro-ecosystem analysis, participating in group dynamics exercises, and discussing specific topics such as soil, crop, water management and value chains. This process fosters knowledge and skills in observation, critical analysis, knowledge sharing, debate, decision-making, and implementation (FAO 2016). Farmers engage in questioning and critical reflection by conducting comparative experiments and discovery-based activities, stimulating them to challenge their preconceived beliefs and norms about farming practices (Duveskog, Friis-Hansen, and Taylor 2011). While extension officers often take on the facilitation role, a move towards having local farmers who live in the target communities act as facilitators is preferred, as they know the community and its members and are seen as colleagues (Braun and Duveskog 2008).

Engaging in a year-long commitment to weekly practice and critical reflection in the field empowers FFS participants to embody their desired pursuits (FAO 2016). An indispensable aspect in facilitating this transformation is the participants' practical experiences and exposure to autonomously addressing tangible farm challenges through independent analysis and the

application of the knowledge and skills acquired during their FFS training, leading to increased self-confidence (Dzecoa, Amilaia, and Cristóvão 2010; Westendorp and Visser 2015). Creating trust among FFS group members is a prerequisite for accommodating such experiences and exposure (Friis-Hansen 2013). FFS can lead to income diversification through a series of interconnected processes (such as the adoption of improved agricultural practices, enhanced social capital and growing a variety of crops), which play a crucial role in equipping farmers with the necessary skills, knowledge, and resources to explore and implement various income-generating activities, ultimately leading to improved livelihoods and resilience.

A review of 65 FFS studies published between 2005 and 2017 demonstrated that one-third of projects described featured multiple crops and livestock, with several reporting increased diversification of agricultural systems and income sources (Van Den Berg et al. 2020). For example, through an FFS process, pastoralist groups in Uganda decided to increase their crop farming, recognising that their high dependence on livestock production put their livelihoods at high risk of livestock plunder (Hoeggel and Mbeyale 2014). In Kenya, a group of women learned about alternative income activities through FFS and started a small business using funds accrued through a savings scheme (Hoeggel and Mbeyale 2014). FFS courses in Uganda and Rwanda that focused on nutritional aspects resulted in participants starting home gardens, which diversified food production and increased sales income (Kuria 2014). A study in Bangladesh, using data from both FFS and control households, reported that FFS households produced 3.7 crop varieties compared to 3.1 for control households (DANIDA 2011). The study also noted that households in FFS villages had twice the increase in total annual household income following the FFS intervention compared to households in control villages. This was attributed to the diversification of income sources.

While the contribution of FFS to livelihood diversification has been widely observed, one criticism of impact assessments of FFS is concerned about the nature of non-random program placement and selection bias of participants (Larsen and Lilleør 2014). There are several methods, which are potentially applicable to assess the effects of FFS after controlling for selection biases. These include randomised controlled trials (RCT), difference-in-difference (DID) analysis, propensity score analysis, and multivariate analysis. Several studies have already adopted some of these methods for assessing the impacts of FFS interventions mainly on agricultural production, farmers' income, and farmers' acquisition of agricultural knowledge and skills of, such as pest management (Davis et al. 2012; Van Den Berg et al. 2020; Ateka, Onono-Okelo, and Etyang 2019). However, assessments of the effects of FFS implementation on livelihood diversification using such methods remain limited (Ali and Sharif 2012; Luther et al. 2018). To authors' knowledge, there are only a few empirical studies that have assessed the impacts of FFS on livelihood diversification, such as impact evaluation reports on the FFS implementation in the smallholder tea sector in Kenya in 2009-2016 (Waarts et al. 2016;) and the aforementioned report in

Bangladesh (DANIDA 2011). Using the propensity score matching method, these reports demonstrate that FFS participants diversify their income sources to a statistically significant level compared to non-participants.

As explained in the previous section, this study examines the effects of farm forestry FFS on household livelihood diversification. Because authors have access to detailed information on a farm forestry FFS project in Kenya, whose summary information is provided in the next section, this study analyses the effects of the project.

3. Farm forestry FFS projects in Kenya

Over 80% of Kenya's land comprises arid and semi-arid areas (ASAL), with only 8.83% of the country classified as forested. These forested areas have deteriorated rapidly due to the overexploitation of firewood and conversion to farmland. Consequently, the country's forest cover is below the internationally acceptable minimum of 10% (Republic of Kenya 2010). Although national policy has set an ambitious target to achieve 30% tree cover by 2032, opportunities for increasing the designation of protected areas in public forests remain limited. This suggests that there are greater opportunities for tree cover expansion for Kenya in growing trees on private farmlands, especially in ASAL, which constitutes more than two-thirds of the land area in Kenya. The integration of drought-tolerant trees on farms is critical for climate change mitigation, global food security and efforts to achieve the Sustainable Development Goals (Snilstveit et al. 2016).

In 2004, the Government of Kenya started the Intensified Social Forestry Project in Semi-arid Areas of Kenya (ISFP) in collaboration with the Japan International Cooperation Agency (JICA). The ISFP introduced the FFS approach for farmer extension as the project aimed to cover a wider geographic area and a greater number of beneficiaries. It was the first case of applying FFS to a farm forestry project in ASAL, and a comprehensive farm forestry FFS package was tailored from the existing FFS approach for agricultural extension (JICA 2013).

Following the completion of the ISFP project, the Capacity Development Project for Sustainable Forest Management (CADEP-SFM) was implemented from 2016 to 2021 by the Ministry of Environment and Natural Resources, Kenya Forest Service (KFS), and Kenya Forestry Research Institute (KEFRI) in collaboration with JICA. The CADEP-SFM included a forestry extension component in ASAL with the aim of 1) capacity development for county governments, 2) promotion of collaboration among stakeholders in enhancing tree growing, and 3) promotion of improved *Melia volkensii.*[1] Farm forestry FFS was conducted under the CADEP-SFM in two ASAL counties—Embu and Taita Taveta. Land and climate information on the two counties is presented in Table 1. In total, three cycles of FFS were conducted from 2017 to 2020 and 47

[1] *Melia volkensii* is an indigenous tree species from the semi-arid zone in Kenya and has traditionally been used for timber production (Muok et al. 2010).

farmer field schools were conducted, thirty-one (31) in Embu and sixteen (16) in Taita Taveta, where 851 farmers graduated, 70% of them female (JICA 2021). Farmers were provided with training on four enterprises: woodlots, crops, fruit trees and tree nurseries. The woodlot enterprise prioritised the growing of a drought-tolerant indigenous tree species, *Melia volkensii,* on farms. The main crops encouraged in Embu were green grams, cow peas, maize and beans, sorghum and dolichos beans (Njahe), while in Taita Taveta, the main crops were green grams, cow peas and maize. These crops were adaptable to the agroecological conditions of the target areas. Traditionally, maize, beans, cow peas and green grams were the main crops grown across the study sites. Vegetable and horticultural crops are cultivated along the riverine areas. Miraa (*Catha edulis*) has also emerged as a significant cash crop in the past decade. Crop cultivation and livestock rearing (cattle, goats and chicken) are the primary sources of livelihood in the region.

Table 1: Land and climate of Embu and Taita Taveta counties

County	Land area	Average altitude	Annual average mean temperature	Average annual precipitation
Embu	2,818 km^2	1,221 m	21℃	1,067.5 mm
Taita Taveta	17,084 km^2	695 m	23℃	650 mm

Source: Information except altitude; Embu (Embu County Government 2019), Taita Taveta (County Government of Taita Taveta 2018). Altitude information is drawn from topographic-map.com (https://en-gb.topographic-map.com/)

4. Methods for survey and analysis

4.1 Survey

We used the case of a farm forestry FFS conducted under the CADEP-SFM in Kenya to assess whether farm forestry FFS guided its graduates toward livelihood diversification and brought any additional effects. The field survey applied three methods, namely, key informant interviews (KIIs), focus group discussions (FGDs) and a household survey. These data collection activities were implemented at different times (in November 2022 for the KIIs and FGDs and later in May-June 2023 for the household surveys). The field activities were preceded by an in-depth review of existing documents, reports, and published literature.

4.1.1 Key informant interviews (KIIs)

KIIs were conducted before the FGDs and targeted community representatives and officers from local county governments and KFS. Key informants were identified for their official or other direct involvement in the forestry sector. The interviews were used to facilitate an understanding of the design and operations of the farm forestry FFS approach in the study area. Information obtained from the interviews also enabled the refinement of indicators on farm forestry and livelihood diversification and outcomes that were applied in the development of final tools for semi-structured interviews in the household survey.

4.1.2 Focus group discussions (FGDs)

FGDs were conducted to gain an in-depth understanding of various issues, including the experiential accounts of farmers' perceptions and implementation processes of farm forestry FFSs. The topics covered encompassed livelihood options and perceptions of the economic potential, biodiversity, and environmental services of tree growing. Other information collected from FGDs assessed the extent to which topics learned were implemented in the farmers' plots, levels of satisfaction with the farm forestry FFS approach, and the contribution of the FFS approach to the enhancement of climate resilience in rural communities. The study conducted a total of 13 FGDs (7 in Embu and 6 in Taita). Each FGD had 10–18 participants selected with the help of local forest officers or FFS facilitators. Gender and differences in demographic characteristics were taken into consideration in the selection of participants. Qualitative data from FGDs were broken into themes and then tagged and ascribed to different themes. In addition, the analysis focused on the use of phrases and narratives from the field data to explain issues.

4.1.3 Household surveys

Household interviews used a semi-structured questionnaire for both FFS participants and non-participants. The number of household interviewees was 155 for participants of FFS training provided by CADEP-SFM and 189 for non-participants (see Table 2 and Figure 1 for details). Among the 344 interviewees, six participated in FFS provided by other programs (not CADEP-SFM), but they were regarded as non-participants in our analysis because the other FFS programs did not focus on farm forestry. The survey respondents were randomly picked from the selected FFS groups. The selection of FFS groups was also done randomly from the lists obtained from project officers. A combination of multistage random sampling procedures was utilised to identify respondents among non-FFS participants. Sampling processes were assisted by county KFS officials and FFS facilitators. In both Embu and Taita Taveta, two out of four sub-counties were selected. In the two sub-counties chosen in Embu, six among eight wards were selected, whereas three among eleven wards were chosen in the two sub-counties selected for Taita Taveta.

Questions used in the semi-structured interview for this study consisted of (a) basic characteristics of households; (b) knowledge, perception and actions on tree growing and livelihoods; (c) socio-economic information of households; and (d) entrepreneurship capacity, status of capital, and household vulnerability to shocks. The complete questionnaire is attached in the Appendix. The household interviews were conducted in May-June 2023 (more than two and half years after the completion of the third FFS round in September 2020).

Table 2: Distribution of sample households

County	Sub-counties *	Wards	Number of sample households	Participation in FFS provided by CADEP-SFM	
				FFS Participants (FFS graduates) **	Non-participants
Embu	Mbeere North	Evurore	84	43 (43)	41
		Muminji	19	5 (4)	14
		Nthawa	21	9 (9)	12
		Subtotal	**124**	**57 (56)**	**67**
	Mbeere South	Mavuria	70	33 (31)	37
		Mbeti South	42	21 (20)	21
		Mwea	24	0 (0)	24
		Subtotal	**136**	**54 (51)**	**82**
Taita Taveta	Mwatate	Bura	41	21 (21)	20
	Voi	Marungu	22	12 (12)	10
		Mbololo	21	11 (11)	10
		Subtotal	**84**	**44 (44)**	**40**
Total respondents			**344**	**155 (151)**	**189**

Source: Authors

Notes: * The number of households in Mbeere North, Mbeere South, Mwatate, and Vio is 29,528, 46,065, 23,698, and 33,522, respectively (Kenya National Bureau of Statistics 2019).

** Numbers of FFS graduates are shown in parentheses. Graduates are those among the FFS participants who completed the program.

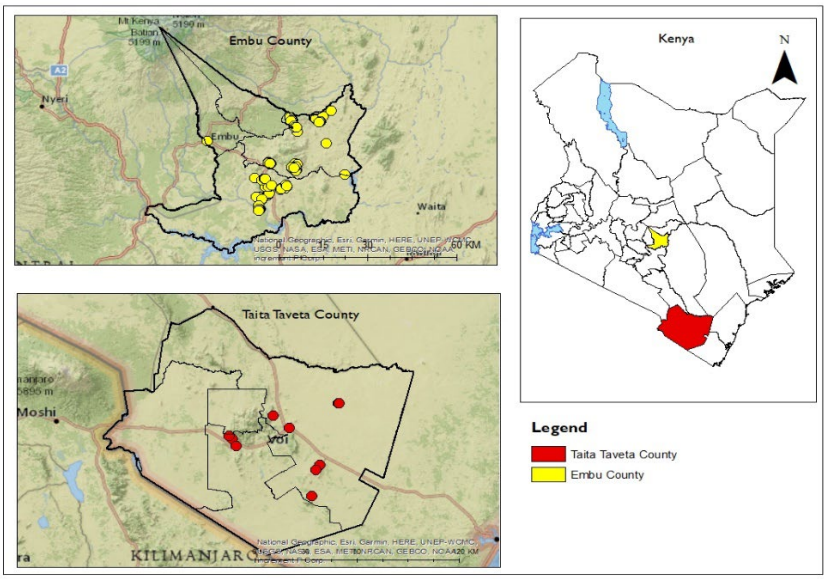

Figure 1: Location of study sites and distribution of sample households

Source: Authors

4.2 Analysis

To examine whether the farm forestry FFS in Kenya has brought any effects on livelihood diversification and beyond, we analysed the household survey data in two stages. In the first stage of the analysis, we estimated the effects of the FFS on household income diversification. In the second stage, we analysed the relationship between household income diversification and other variables, especially those related to household vulnerability to shocks. We also analysed the data collected through KIIs and FGDs for a qualitative understanding of the causal relationship between farm forestry FFS and livelihood diversification, and the effects of the diversification on vulnerability to climate-related shocks.

4.2.1 Analysis of FFS effects on household income diversification

For the first stage of the analysis, we used the propensity score (PS) methods proposed by Rosenbaum and Rubin (1983). PS was devised to balance the effects of multiple confounding factors collectively by consolidating them into the single metric of PS, thus enabling analysts to infer causal attribution of the outcome of interest to an intervention after controlling the effects of confounders using PS. By comparing data samples with similar PSs, analysts can reduce biases arising from confounders in estimating the treatment effects (Yasunaga 2020), providing that the PS's theoretical assumption of "strongly ignorable treatment assignment"[2] (Rosenbaum and Rubin 1983) is met. To calculate the PS, a regression analysis (usually logistic or probit regression) is undertaken to model the relationship between a variable representing treatment assignment as the explained variable and relevant covariates as explanatory variables, which include factors affecting the probability of participation in the FFS programs and the outcome. The estimated model is then used to calculate PS for each data sample.

A common alternative to the PS approach is multivariate regression. Although the literature suggests there is no clear frontrunner between the two (Benedetto et al. 2018; Williamson et al. 2012), we chose PS methods because we are interested in estimating the effects of FFS on households with members who graduated from FFS (i.e., average treatment effect on the treated (ATT)) as opposed to the effects of FFS on all households in the dataset (i.e., average treatment effect (ATE)).

There are several variations in PS methods, such as matching, stratification, inverse probability weighting, and using PS as an explanatory variable in a regression model for the outcome variable (Austin 2011). Benedetto et al. (2018) provide a decision tree to select a suitable method among

[2] Austin (2011, 403) explains that the assumption consists of two factors, that is, "treatment assignment is independent of the potential outcomes conditional on the observed baseline covariates," and "every subject has a nonzero probability to receive either treatment." The former means the treatment assignment depends on the observed covariates and does not depend on the outcomes. The latter means that all samples have both possibilities of receiving treatment and not receiving it. In other words, there is no condition of covariates that definitively decides whether a sample receives the treatment or not.

the alternatives. Based on the decision tree, we chose the propensity score matching (PSM) because we are interested in ATT, that is, the average effects of FFS on households with members who graduated from FFS. We used calliper matching since the ratio of the number of households with FFS graduates to the number of households without is less than three (Benedetto et al. 2018; Wang et al. 2013).

Table 3 shows the outcome variables and the treatment variable that we use in our PSM analysis. We estimated four models with different outcome variables but the same treatment variable. Two models are to assess the effect on overall livelihood diversification, and the other two focus on livelihood diversification in terms of forestry income and products. We selected the existence of forestry income and forestry product sale diversity as outcome variables because the FFS program in the study area was farm forestry FFS and the effects of the FFS might have influenced these outcome variables. We also selected agricultural, livestock, and forestry product sales diversity, as well as income source diversity, including both on-farm and off-farm income sources. These variables may have been influenced by the FFS not only due to its direct support for some of the activities related to the products and income types included in these variables but also due to the hypothesis that the FFS influenced the abilities and mindsets of its graduates, encouraging them to embark on new on-farm and off-farm enterprises. We regarded FFS graduation as the treatment instead of FFS participation because the effects of FFS may not have fully materialised for those who did not complete the program. Four FFS participants did not complete FFS.

The next step was to select covariates to be included in the PSM analysis. Based on experimental simulations, Brookhart et al. (2006) suggest that a PS analysis should include all variables related to the outcome of interest, including suspected confounders. They further suggest that contrary to intuition, variables related only to treatment assignment but not to the outcome should not be included. Based on this guidance, we reviewed the literature for factors affecting household income diversification in rural Kenya and its neighbouring country, Ethiopia. Tables 4 and 5 list extant empirical studies on factors influencing household participation in non-farm activities and household crop diversification, respectively. We identified common explanatory variables that appear in two or more studies in either Table 4 or 5. Based on these common variables and the availability of data from our survey result, we selected the covariates to be included in our PSM analysis, as shown in Table 6. We used the same set of covariates for the analyses of Models 1 to 4. Although land ownership was a variable included in more than one study shown in either Table 3 or 4, it was not included in the covariates because less than 3% of the surveyed households did not own farmland at all. Distance to the market, participation in cooperatives, and access to agricultural extension services are also common variables between at least two studies. However, these variables were not included in the covariates either, because our survey data did not have equivalent data items. Although we could not obtain the data for the selected covariates before

the FFS program was provided, we assumed that the covariates were not affected by the graduation from the FFS program.

Table 3: Summary of outcome variables and the treatment variable adopted in the propensity score matching analysis

Type	Variable	Description	Minimum	Maximum	Mean
Outcome variable (Model 1)	Inc_Div	The number (counts) of income types that a household had in the last 12 months. The income types consist of agriculture, forestry, livestock, and others. Agriculture, forestry, or livestock income is counted when the household sold at least one product that belongs to the respective income type in the last 12 months. The income type "others" includes all non-farm activity incomes, including wages of farm labour received from other households. The variable takes discrete integer values between 0 and 4.	0	4	2.16
Outcome variable (Model 2)	Prod_Div	The total number (counts) of item types of agricultural, forestry or livestock products sold by a household in the last 12 months. The variable takes discrete integer values.	0	8	1.92
Outcome variable (Model 3)	Inc_For	Availability of forestry income that a household had in the last 12 months. The variable takes a binary value of 0 or 1 (household without forestry income=0, household with forestry income=1).	0	1	0.24
Outcome variable (Model 4)	Prod_For	The total number (counts) of item types of forestry products sold by a household in the last 12 months. The variable takes discrete integer values.	0	3	0.31
Treatment variable (all Models)	FFS_Grad	Whether a household has an FFS graduate in its household members. The variable takes a binary value of 0 or 1 (household without FFS graduate=0, household with FFS graduate=1)	0	1	0.44

Note: The summary statistics are those of all 344 households surveyed. Out of 344 households, 151 households had an FFS graduate. Outcome variables do not take subsistence use of products into account.

Table 4: Empirical studies on factors influencing participation in non-farm activities by rural household in Kenya and Ethiopia

	Alobo Loison (2019)*	**Gebiso Challa (2019)**	**Kassie et al. (2017)**
Analysed data	Panel data of rural household surveys in 2 districts in Kenya in 2002, 2008, and 2013	Rural household data in 7 districts in Ethiopia (data year not specified)	Rural household data in 1 district in Ethiopia (data year not specified)
Modelling type	Static linear panel data regression model	Negative binomial regression model	Logit regression model
Explained variable	The share of non-farm income in total household income	The number of non-farm activities that households engage in for income	Whether households participate in non-agricultural activities (a binary variable)
Explanatory variables (those statistically significant at 10% level or lower)	- Initial level of non-farm income share - Household head gender - Use of hired labour - Access to agricultural input credit	- Household head age - Household head gender - Household head education level - Land ownership - Cultivated land size - Distance to the market	- Household head age - Household head education level - Location of the village - Land ownership - Distance to the market - Participation in cooperatives - Participation in agricultural extension

* Alobo Loison (2019) estimated 7 models with different subsets of data samples (i.e., grouped by districts or household head gender). The selection of explanatory variables in this table is based on one of the 7 models, which analysed all data samples.

Table 5: Empirical studies on factors influencing crop diversification by rural household in Kenya and Ethiopia

	McCord et al. (2015)		Mesfin, Fufa, and Haji (2011)	Rehima et al. (2013)
Analysed data	Rural household data in 8 communities in Kenya in 2012		Rural household data in 2 districts in Ethiopia (data year not specified)	Rural household data in 10 zones in Ethiopia in 2008
Modelling type	Linear regression model		Tobit regression model	Heckman two-stage regression model (Heckman 1979)
Explained variable	Number of crop types grown by the household among 8 types of crops	Number of crop species grown by the household (maize, potatoes, and mixed beans are combined to be counted as one species)	Modified entropy index representing household crop diversification (the index takes a value between 0 and 1, with a larger value representing more diversification)	Margalef index* of crop diversification
Explanatory variables (those statistically significant at 10% level or lower)	- Estimated average annual precipitation at the location	- Estimated average annual precipitation at the location - Household annual income - Contact with agricultural extension in the previous year - Crop field size	- District - Access to market information - Irrigation intensity - Machinery Ownership - Number of contacts with agricultural extension - Number of farm plots - Livestock holding	- Household head gender - Household head education level - Trade experience of household head - Participation in cooperatives - Farm size - Number of plots - Proportion of fertile plots - Access to agricultural extension - Distance to the market

* Margalef index (D_i) of household i in Rehima et al. (2013) is defined by $D_i = (S_i-1)/lnA_i$ where S_i denotes the number of cereal crops grown and A_i denotes the total area of cereal crops planted by household i.

Table 6: Covariates included in the propensity score matching analysis in this study

Covariate	Description	Minimum	Maximum	Mean
HH_Gender	Gender of the household head (female=1, male=0)	0	1	0.28
HH_Age	Age of the household head (year)	20	88	53.2
HH_Edu	Education level of the household head (informal=1, primary=2, secondary=3, tertiary=4, university=5)	1	5	2.39
County	The county that the household belongs to (Embu=1, Taita Taveta=0)	0	1	0.76
Parcel_No	Number of parcels used by the household for agriculture, forestry, or livestock production (count)	1	5	1.33
Land_Area	The total land area of parcels used by the household for agriculture, forestry or livestock production (acre)	0.13	25	3.70

Unit of measurement or scoring scale is shown in parentheses. The same set of covariates in this table were used for the analyses of Models 1–4. The summary statistics are those of all 344 households surveyed.

The specifications of the PSM analysis of this study are presented in Table 7. A logistic regression model was used to estimate PS. A one-to-one nearest neighbour matching method with calliper was adopted. The calliper width was set at 0.2 of the standard deviation of the logit of the PS following common practice (Austin 2011). Matching was undertaken without replacement because, as is explained in the result section, distributions of propensity scores between treated and untreated data samples are not significantly dissimilar and the overlap between the two groups is not small (the overlapping range of PS distributions for treated and untreated is 0.17–0.74), which would not justify the use of matching with replacement (Chen et al. 2022). "MatchiIt" library (Ho et al. 2011) of the statistical software R was used to undertake the PSM analysis.

Table 7: Specifications of the propensity score matching analysis of this study

Items	Specifications
The model used to generate a propensity score	Logistic regression
Matching ratio	1:1
Matching method	Nearest neighbour matching with calliper
Replacement	Without replacement
Calliper width	0.2 of the standard deviation

After matching is undertaken, ATT is estimated by regressing the following linear model with the ordinary least square (OLS) method. It should be noted that only the matched samples are used for the estimation.

$$O_i = \alpha + \beta Z_i + \varepsilon_i \quad (1)$$

where O_i denotes the value of one of the outcome variables shown in Table 2, Z_i denotes the treatment variable ($Z_i=1$ for a household with an FFS graduate and $Z_i=0$ for a household without an FFS graduate), and ε_i denotes the error term, respectively, for household i. α and β are coefficients to be estimated. The coefficient β is ATT. There are alternative methods to estimate ATT after matching. We tried an alternative method described by Greifer (2023), which may improve the precision of the estimate by potentially reducing the bias due to residual imbalance. The method includes in equation (1) additional terms of covariates used to calculate the propensity score and their interaction with the treatment variable. The alternative method produced similar results, probably because a good balance was achieved in our analysis. Therefore, we report the results of the simple method using equation (1).

4.2.2 Analysis of the relationship between household income diversification and variables related to household vulnerability to shocks

In the second stage of the analysis, we undertook OLS linear regression analyses to analyse the relationship between variables representing household income diversification and variables related to household vulnerability to shocks. Table 8 shows the variables used in the analysis. Two models with two different explained variables were estimated. Explanatory variables are the same for the two models, including all covariates listed in Table 6 and the two outcome variables for Models 1 and 2, listed in Table 3. We did not include the explained variables of Models 3 and 4 because, as explained in the result section, FFS graduation was not associated with these two explained variables. Sample data used for the analysis are subsets of the entire dataset. The "Drought" model used the data of 309 households that stated that they had experienced drought loss in the last year, and the "Crop_Loss" used the data of 221 households that had experienced loss from crop disease or pests.

Table 8: Summary of variables included in the linear regression analysis in this study

Variable	Description	Minimum	Maximum	Mean
Explained variable				
Drought	The estimated value lost due to drought in the last year (KES: Kenyan Shilling).	500	320,000	31,318
Crop_Loss	The estimated value lost due to crop disease or pests in the past one year (KES).	200	120,000	9,098
Explanatory variable				
All variables listed in Table 6 (see Table 6 for description and summary statistics)				
Inc_Div (see Table 3 for description and summary statistics)				
Prod_Div (see Table 3 for description and summary statistics)				
Ag_income	Total revenue from the sales of agricultural, forestry and livestock products of the household in the last 12 months (KES).	0	1,250,000	43,760
Group	The number of community groups which the household members participate in (counts), representing the social capital of the household (Alobo Loison 2019).	0	5	1.37
HH_Size	The number of household members over 5 years of age (persons), representing the household workforce, which reflects the local context that children over 5 often help with farm activities (Moyi 2011).	1	16	4.19
Livestock	The estimated total asset value of the livestock that the household owned in the last 12 months (KES).	0	3,006,200	117,725

Unit of measurement or scoring scale is shown in parentheses. The same set of explanatory variables is used in both models for the two explained variables. The summary statistics of explanatory variables are for the entire data samples of 344 households, whereas the summary statistics for explained variables are for data samples of households that experienced in the loss in the past one year, i.e., 309 households for Drought and 221 households for Crop_Loss.

To check if there was significant risk of a bias from multicollinearity, variance inflation factors (VIFs) were calculated for respective explanatory variables. As a result, all VIFs were smaller than 5.0, with the maximum value of 3.1, which did not suggest that the bias of multicollinearity would be significant.

4.2.3 Qualitative analysis

The qualitative information from KIIs and FGDs was transcribed into English and organised by categorising it into themes. The study focused on several themes, including sources of livelihood and livelihood diversification, skills acquired during FFS and their relevance to livelihood options, motivations for tree cultivation, impacts of climate change shocks and resilience strategies, and gender dimensions. These themes were then tagged and assigned to different categories for interpretation. Thematic analysis was applied to the datasets, followed by an iterative process to derive meaning from the qualitative data. This information was then utilised to elucidate the results and provide triangulation of the findings.

5. Results and Discussion

Table 9 reports the sample size before and after the PS matching. Figure 2 and Table 10 show the balance of the matching. The histograms of PS distributions of Treated (households with an FFS graduate) and Control (households without an FFS graduate) before matching (Figure 2 on the left side) appear to suggest the distributions between the two groups are not significantly dissimilar and the overlap of the PS distributions is not small, which justifies the selection of matching without replacement[3]. The histograms of PS distributions between the two groups after matching (Figure 2 on the right side) are similar, and the standardised mean difference of PS and covariates are all less than 0.1 (Table 10), which indicates the balance of distribution between the two groups after matching is reasonable (Yasunaga 2020).

Table 9: Sample size before and after the propensity score matching

	Treated	Control	Total
Before matching	151	193	344
After matching	130	130	260
Unmatched	21	63	84

Note: The number of households with an FFS graduate is given in the column, "Treated," and the number of those without is given in "Control."

[3] Chen et al. (2022, p635) explains that "[r]eplacement is appropriate when the distribution of PS is quite dissimilar and the overlap in the region of common support is small."

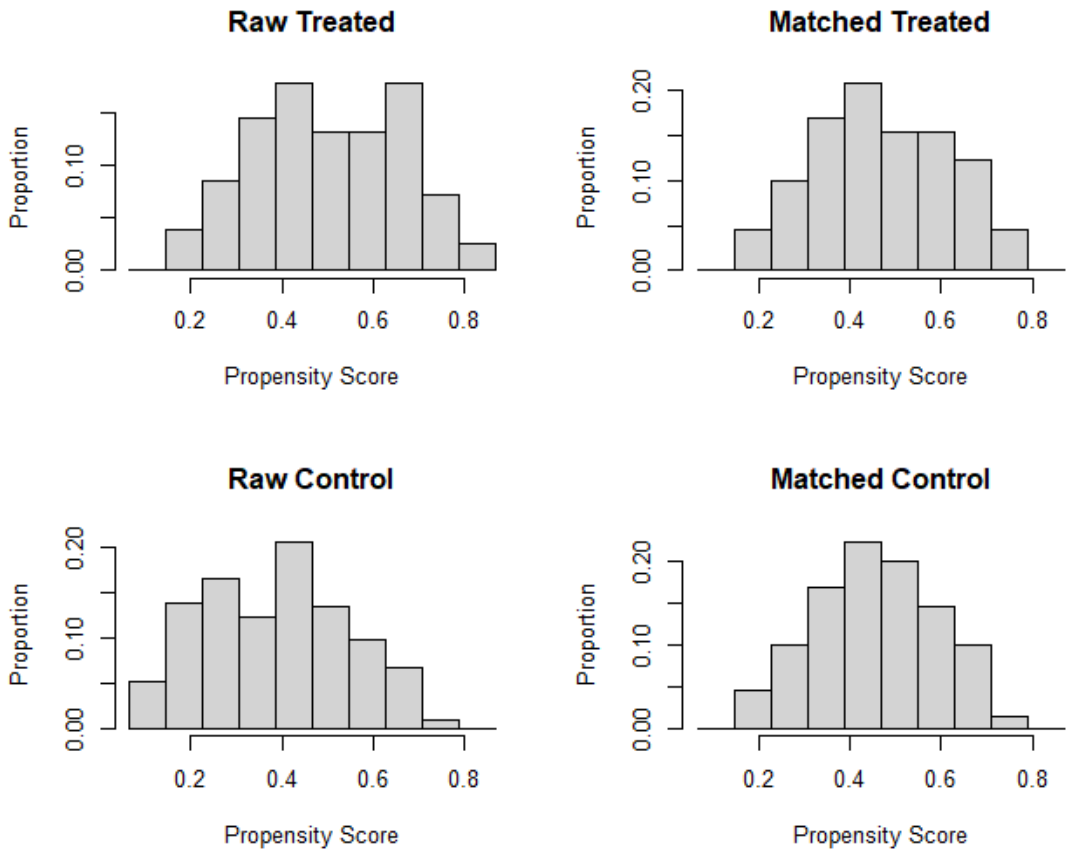

Figure 2: Distribution of data samples before and after matching
Source: Authors
Notes: The histograms show distributions of the number of data samples (households), grouped by their estimated propensity scores, before matching (Raw) and after matching (Matched) for households with an FFS-graduate (Treated) and without (Control).

Table 10: Means and standardised differences of covariates before and after matching

	Before matching (all data)			After matching (matched data)		
	Mean treated	**Mean control**	**Standardised mean difference**	**Mean treated**	**Mean control**	**Standardised mean difference**
Propensity Score	0.51	0.39	0.72	0.47	0.46	0.07
Gender of household head (HH_Gender)	0.32	0.25	0.15	0.29	0.30	-0.02
Age of household head (HH_Age)	57.99	49.46	0.63	55.47	54.69	0.06
Education of household head (HH_Edu)	2.20	2.53	-0.40	2.30	2.33	-0.04
County dummy (County)	0.71	0.79	-0.19	0.73	0.76	-0.07
No of land parcels (Parcel_No)	1.36	1.31	0.07	1.40	1.37	0.04
Land size (Land_Area)	3.70	3.70	0.00	3.81	3.65	0.05

Note: Variable names, defined in Table 6, are in parentheses.

Based on the matched samples, we calculated ATT, as shown in Table 11. The results indicate that households with an FFS graduate have diversified income sources in terms of both the number of income types they have and the number of agricultural, forestry and livestock products they sell. The ATT for Inc_Div implies that households with an FFS graduate gained income from 0.25 more income sources among the four income types—i.e., agriculture, forestry, livestock, and non-farm activities—in the last 12 months, compared with the same households but without an FFS graduate. Inferring from the information obtained through FGDs and KIIs, this may be because the group approach of the FFS encourages farmers to continue and expand their activities undertaken together as a group. FGDs and KIIs showed that FFS alumni had created networks of revolving funds and loans, which allowed them to participate in off-farm activities. Other studies have shown that FFS graduates were more likely to be engaged in rural savings and loan schemes, allowing them to diversify their livelihoods (DANIDA 2011; Mweri 2005). In Taita Taveta County, we received accounts of women-led FFS groups that had diversified their activities into basket-making and creating poster cards from elephant faeces to sustain their livelihoods. This is indicative of an entrepreneurial spirit and adaptability, which are essential for sustainable livelihoods.

Similarly, ATT for Prod_Div indicates that households with an FFS graduate sold 0.62 more types of agriculture, forestry, or livestock products in the last 12 months compared with similar households but without an FFS graduate. These results suggest FFS contributed to diversifying income sources, particularly those related to land use activities, of the participating households. During the FGDs, participants expressed perceptions that there were observable differences in livelihoods and farm management practices between the FFS graduates and other community members who had not been trained. Skills learned during the FFS include pest and disease management, spacing of crops, and soil and water management practices, such as mulching and construction of terraces. The grafting of mango plants and improved production of pulses (such as beans and peas) were also frequently mentioned as some of the impactful practices learned during the FFS. Other studies have shown that FFS training can increase productivity through good agricultural practices (Ateka, Onono-Okelo, and Etyang 2019; Waarts et al. 2016) and therefore incomes. According to the key informant interviews (KIIs), FFS groups have leveraged the training to secure additional support from other donors and the government, even after the conclusion of the FFS project. The observation shows that the FFS training not only benefited the participants during the program but also helped them to access further support and opportunities even after the project had ended, therefore highlighting the long-term impact and sustainability of the FFS approach.

While households with an FFS graduate had diversified income sources compared to the case without, the survey results also suggest that forestry activities within FFS, such as woodlot management and tree nursery operations, may not significantly contribute to income diversification through forestry products among these households. The estimated ATTs for both Inc_For and Prod_For in Table 11 are positive, suggesting that households with an FFS graduate are more likely to have income from forestry products and a greater variety of forestry products sold than households without FFS graduates. However, these differences were not statistically significant. It is possible that the timing of the survey impacted the findings, especially regarding forestry activities. Since tree harvesting for sale typically occurs several years after planting, it is understandable that households have not yet realised significant income from forestry products. However, the fact that households engaged in nursery operations were already selling seedlings suggests some level of early income generation from these activities.

Table 11: Estimated ATT and statistical significance of the difference

Outcome variable	ATT	p-value (t-test)	p-value (Wilcoxon signed rank test)
Inc_Div	0.246	0.027 *	0.029 *
Prod_Div	0.615	0.003 **	0.006 **
Inc_For	0.039	0.471	0.568
Prod_For	0.069	0.385	0.389

Notes: The p-value (t-test) was calculated for the ATT estimated as the coefficient of the linear regression model. Because all outcome variables take discrete integer values, the Wilcoxon signed-rank test was applied to compare the outcome variables of paired (matched) samples between treated and control groups. The symbols * and ** indicate the statistical significance at 5% and 1% level, respectively.

We undertook robustness checks of our PS matching analysis of Inc_Div and Prod_Div models. First, we estimated ATT separately for Embu and Taita Taveta counties after removing the "County" covariate from the models. The estimated ATT (p-value of t-test) for Embu was 0.304 (0.021) for Inc_Div model and 0.913 (< 0.001) for Prod_Div model. The estimated ATT (p-value of t-test) for Taita Taveta was 0.406 (0.016) for Inc_Div model and 0.781 (0.008) for Prod_Div model. Next, we estimated ATT with Inverse Probability Weighting (IPW). The estimated ATT (p-value of z-test) was 0.280 (0.005) for Inc_Div model and 0.754 (< 0.001) for Prod_Div model. These results suggest that the results of the PS matching analysis are reasonably robust.

Table 12 shows the results of the multivariate regression analysis of the relationship between household income diversification and variables related to household vulnerability to shocks, namely, drought and crop pests/diseases. For both models for the loss from droughts (Drought) and the loss from crop pests and diseases (Crop_Loss), the overall goodness of fit to the data is low, but the overall regressions are statistically significant. One possible reason for this low explanatory power of the regression models is a limitation of data accuracy of the stated amounts of losses from droughts and crop pests/diseases in the survey. Farmers' perceptions of losses tend to differ significantly across households due to various factors, such as variations in timing and the scale of measurement.

Table 12: Results of the regression analysis of the relationship between household income diversification and variables related to household vulnerability to shocks

	Drought		**Crop_Loss**	
Adjusted R^2	0.085		0.069	
F-Value	3.38		2.36	
Significance of F-value	0.0001		0.0074	
Number of samples	309		221	
Variable	Coefficient (Std. error)	p-value	Coefficient (Std. error)	p-value
Inc_Div	4082 (3610)	0.259	2188 (1576)	0.166
Prod_Div	-3999 (1929)	0.039 *	-1714 (820.8)	0.038 *
HH_Gender	5726 (4589)	0.213	724.8 (2129)	0.734
HH_Age	233.7 (155.4)	0.134	14.67 (69.05)	0.832
HH_Edu	3612 (2374)	0.129	409.8 (1071)	0.702
HH_Size	2802 (1013)	0.006 **	659.5 (468.2)	0.160
Group	-2392 (1986)	0.229	-1925 (902.8)	0.034 *
Ag_income	0.0044 (0.0270)	0.871	0.0209 (0.0088)	0.018 *
Livestock	0.0267 (0.0083)	0.001 **	0.0046 (0.0033)	0.166
Parcel_No	-483.6 (3050)	0.874	1137 (1380)	0.411
Land_Area	331.3 (635.1)	0.602	514.4 (277.8)	0.065
County	-15214 (4762)	0.002 **	4852 (2467)	0.051
Constant	6627 (13709)	0.629	-3445 (6621)	0.603

Note: The symbols * and ** indicate the statistical significance at 5% and 1% levels, respectively.

As expected, product diversification (Prod_Div) is negatively associated with both the loss from droughts and the loss from crop pests and diseases. The estimated coefficients suggest that all else being equal (*ceteris paribus*), households that sold one additional agricultural, forestry, or livestock product experienced a KES 4,000 reduction in loss from droughts and a KES 1,700 reduction in loss from crop pests and diseases compared to households with less diversified product sales. FGDs and KIIs showed that FFS graduates increased the scale of production for cowpeas and a fast-growing green gram variety—both crops are more ecologically adapted to the ASAL regions. This indicates a possible source of the resilience and adaptability of these graduates in the face of livelihood challenges.

Contrary to our expectation, the income diversity (Inc_Div) is positively associated with the loss from droughts, as well as crop pests and diseases. However, the estimated coefficients are not statistically significant at the 10% level. A possible explanation of why Inc_Div is not associated with a reduction of losses is that some households may have diversified income sources as a result of the losses they suffered. The ASAL regions of Kenya have endured three severe droughts in the last decade (2010–2011, 2016–2017 and 2020–-2022). The most recent one (2020–2022) was the most severe and longest, with widespread livelihood losses and massive displacement of populations (ASAL Humanitarian Network 2022). As a result of disruptions to their livelihoods, some women who were previously involved in farming have transitioned to wage labour, specifically offering laundry services to town residents at nearby shopping centres in Taita Taveta and Embu. Ellis (2000) shows that drought occurrence can significantly impact livelihoods and often serves as a catalyst for livelihood diversification. It may explain the positive correlation between income diversification and drought loss because those who suffered from severe losses might have diversified their livelihood by engaging in non-farm activities.

Prior to the analysis presented in Table 12, we experimented with regression models that included variables listed in Table 8 and the treatment variable—i.e., "FFS_Grad"—as an additional explanatory variable. The results indicated that the null hypothesis of no correlation between "FFS_Grad" and the respective explained variables could not be rejected even at the statistical significance of the 10% level. The results indicate that having an FFS graduate in the household does not significantly affect the amount of losses from droughts or crop pests/diseases. However, this does not diminish the relevance of FFS participation in reducing losses from these challenges. Previous studies have shown that FFS training enhanced farmers' agricultural practices, which can improve their resilience to climate change (DANIDA 2011; Van Den Berg et al. 2020; Waarts et al. 2016).

6. Conclusions

This study illustrates a case of farm forestry FFS in the ASAL region of Kenya that likely helped to facilitate livelihood diversification among rural households. The approach is deemed relevant to mitigating household vulnerability to shocks such as droughts, as well as crop pests and diseases. The analysis of this study suggests that having an FFS graduate in households is correlated with the diversification of agricultural, forestry, and livestock products sold by the households, which, in turn, is associated with smaller losses from droughts and crop pests/diseases. Although the introduction of forestry-related activities through FFS did not have discernible effects on forestry-related livelihood diversification, these impacts may be realised in the future once the planted trees facilitated by participation in the FFS program grow to the point that they can be harvested.

Despite the implications of the analysis explained above, the results of this study do not indicate the superiority of the livelihood diversification strategy over alternative strategies in terms of resilience to climate-related risks. For example, it is possible that concentrating on the production of the most profitable crops and maximising the financial savings may provide households with better protection against shocks. Comparative analysis of climate resilience across different livelihood strategies is a useful area for future research.

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Appendix

Annex 1: QUESTIONNAIRE FOR HOUSEHOLDS

SECTION 1: Introduction and Consent

We are from the Jomo Kenyatta University of Agriculture and Technology (JKUAT). In collaboration with JICA, Kenya, we are conducting a survey to understand the Impact of FFS on Tree Growing and Livelihood Diversification in Kenya. The data collected will be used to inform tree growing and livelihood programs in Kenya. The interview will take about 1 hour. All the information will remain anonymous and confidential; your name and the names of any other people you may mention during the interview will not be recorded, published or shared. If you accept the offer to participate in the interview, you can decide to withdraw at any moment. You can also skip any questions which you do not want to answer.

DO YOU AGREE TO BE INTERVIEWED? □ Yes, permission is given ⇒*Proceed to the next page to* - *assign an ID to the interview* - *record the time* *Then start the interview*	□ No, permission is not given ⇒*Do the following*: *Fill in the Household Sampling Log to explain why the interview cannot be conducted.* - *Move on to the next household*

S.N	Item	Response		Item	Response
1	Household ID		8	Ward (see codes)	
2	Survey date (DD/MM/YYYY)		9	Village/enumeration site	
3	Interview Start: (hh: min)				
4	Interview Stop: (hh: min)				
5	County codes: 1= Embu 2=Kitui 3=Taita				
6	Sub-county				
7	Enumerator name				

SECTION 2: Household Demographics

S.N	Item description / Question	Code	Response
1	Gender of respondent	1= male 0=female	
2	Age of respondent	Indicate age in years	
3	Highest level of education of respondent	1=informal 2=primary 3=secondary 4=tertiary 5=university	
4	Marital status of the respondent	1=married 2=divorced/ separated 3=widowed 4=never married	
5	Number of household members	Number of people in household	
6	Number of children <5 years	Number	
7	Number of household members below 18 years	Number	
8	Are you the household head?	1=Yes 0=No	
9	What the relationship with household head (HH)	1=spouse 2=child 3=worker 4=Other	
10	Gender of HH	1= male 0=female	
11	Age of HH	Indicate age in years	
12	Highest level of education of HH	1= informal 2= primary 3= secondary 4=tertiary 5 = university	

SECTION 3: Participation FFS (Treatment)

a)Membership in FFS

1	Have you ever participated in the FFS program? *If yes answer questions 2 to 10 below, If No go questions 12*	0=No 1=Yes
2	When did you first participate	Year
3	Which organisation supported the program?	1. JICA 2.GIZ 3. CARE 4. Other (specify)
4	What kind of enterprise did you participate in during FFS?	1= tree planting 2= crop enterprise 3= livestock 4=fruits 5= nursery management 6= other (Specify) (Multiple answers possible)
5	Did you graduate from the FFS	0=No 1=Yes
6	If Yes, why did you choose to continue with FFS until graduation?	
7	If No, why did you drop out?	
8	Please indicate the extent to which the following factors influenced your motivation to join FFS and stay on until graduation a) To gain knowledge on good agricultural practices (GAPs) for crops b) To gains skills on own experimentation to solve problems on my farm c) To gain skills in tree planting and maintenance	5= very high 4 =high 3=neutral 2=low 1= very low
9	Did you implement the practices leant in FFS for enterprises selected in 4 above	0=No 1=Yes
10	If No, what was the reason	① No input (seed, seedlings, fertiliser, etc.) available ② Too difficult/complicated to apply ③ Seemed not effective ④ No farm space to introduce new technique ⑤ No time to introduce new technique ⑥Others (specify)
11	Overall, to what extent were you satisfied with FFS training	1= very dissatisfied 2=dissatisfied 3=neutral 4=satisfied 5=very satisfied
12	Would you recommend other farmers to participate in FFS?	1=Yes 0=No
13	Have you continued to operate as a group after FFS training	1=Yes 0=No
14	Have you received follow up support following FFS	1=Yes 0=No
15	If Yes, who provided the support	State name of organisation
16	If No to 1, above, why have you never participated in FFS before	1=not aware 2=never been given time 3=not had the time 4=other, explain
17	Have you ever benefited from individual support of seedlings from the JICA project?	1=Yes 0=No
18	If Yes, when did you receive seedlings?	Month and year
19	How many seedlings were you supplied?	
20	How many of these are still surviving	

SECTION 4: Knowledge attitudes, subjective norms and perceived behavioural control in tree planting

a)Knowledge

SECTION P: KNOWLEDGE	
Please indicate whether the statement is correct or incorrect	1=correct or 2= incorrect Agree/Disagree
1. Trees cannot do well in dry areas	
2. Trees can only be grown in different plots from crops	
3. Timely planting to coincide with start of rain increases tree survival and growth	
4.. Growing of trees does not require any expertise	
5. Correct pruning of trees can improve the prices received for forest products	

Knowledge relevant to management skills	
1. What about the current price of wood at a local market (size and unit price)?	1 I know very well 2. I have some understanding. 3. I do not really know. 4. No idea at all.
2. What do you do if you find goats around your planted trees?	
3. What do you do if you find termites around planted trees?	
4. Have you implemented tree pruning in your farm in the last 3 years	
5. Are you aware of any Dos and Don'ts about tree pruning	1=Yes 0= No
6. If yes provide list of some of the Dos and Don'ts (Miriam provide slot for maximum 2)	
7. .Do you know how to carry out Melia propagation?	1=Yes 0= No

b)Salient beliefs

S/No	Salient beliefs Response 'strongly agree' (5) to 'strongly disagree' (1)	Response
1	Planting trees on my land will increase my income	
2	Planting trees on my land will increase the availability of firewood	
3	Planting trees on my land is an important source of poles and timber	
4	Planting trees on my land will improve soil fertility	
5	For my farm to have improved soil fertility is important to plant trees	
6	The shade provided by planting trees on my farm is impeding crop growth	
7	Planting trees in my compound is important in providing shade for my family rest and enjoyment	
	Normative beliefs Response 'strongly agree' (5) to 'strongly disagree' (1)	Response
1	My spouse thinks I should plant trees on my land	
2	My farmer group thinks I should plant trees on my land	
3	Extension workers think I should plant trees on my land	
4	The village chief thinks I should plant trees on my land	
5	Most of the people in my village are planting trees on their farm	
	Power of control factors Response 'strongly agree' (5) to 'strongly disagree' (1)	
1	Termite infestation on my land makes it more difficult for me to plant trees	
2	Shortage of water makes it more difficult for me to plant trees	
3	Livestock browsing on my land, makes it more difficult for me to plant trees	
4	Normally, I do not have enough time for me to plant trees	
5	The lack of seedlings makes it difficult to plant trees	
	Intentions Response 'strongly agree' (5) to 'strongly disagree' (1)	
1	For sure I will plant trees next season	
2	I may plant trees next season	

SECTION 5: Level of tree growing and motivation

1	Has your household planted any woodlots or trees on your farm over the past 5 years? If Yes, answer questions 2-9 and *If 'no', go to 10 in this section.*	*0= N0; 1= Yes*
2	If yes in 1, what are the reasons for planting these trees? 1=Yes 0=No (Here we could rank the motivations)	1=own use (firewood) 2= own use (timber) 3= fruit trees 4=sale of firewood 5=sale of timber 6=conservation 7=fodder 8=other specify
3	How much household land has been dedicated over the last 5 years to tree planting?	# of acres
4	How have the tree planting practices changed over the last 5 years	1= increased 2= decreased 3= remained the same
5	To what extent is the change influenced by your participation in FFS (only for participants)?	5=very high 4=high 3=neutral 2=low 1= very low
6	Briefly provide an explanation for the change in Question 4 above	
7	Which tree species did you grow?	1=Local melia 2= Improved melia *3=Senna siamea* 4=*Grevillia robusta 5=Gmenila arborea* 6=*Casuarina equistifolia* 7=Eucalyptus grandi 8=Terminalia brownii *9=Azadirachta indica* 10=*Melia azedarach 11=Gmenila arborea* 12=Fruits (avocado, passion, mango etc.)
8	Number of seedlings planted (size in acres) for each species selected above	#
9	No of seedlings survived	#
10	Reasons why the trees didn't survive (allow multiple response up three main ones)	1=land management issues (burning, frequent ploughing) 2=drought 3=lack of knowledge on how to manage trees 4=aging and death of trees 5= use pressure 6=impacts of invasive species 7=livestock browsing 8= mismanagement of trees 9= competition with crops 10= Pests and diseases 11= Others
11	What best describes your tree planting practice?	1= Grew trees on separate portion of land for tree growing with a clear aim of selling 2= Grew trees on the edge of the farm or along boundaries mainly for subsistence use (as fuelwood, building timbers and fodder) 3=Grow trees as intercrop with other farm crops 4= Grown trees within the homestead to provide shade and enjoyment
12	If you didn't grow any trees, what was the reason?	1= Lack of knowledge on tree growing 2= Lack of technical support 3= Lack of water 4= Shortage of the supply for tree seedling 5= Difficulties of small plot size 6= My soil conditions are not good for tree growing 7= Land management issues (burning, frequent ploughing)
13	If you were an FFS participant: What would you say is the reasons for 12 above?	

SECTION 6: Farmer Entrepreneurship orientation

Please give your response to the following questions using the scale of 1-5 as indicated below. (1= strongly disagree, 2=somehow disagree, 3=disagree 4=agree, 5=strongly agree)	
E4.01: Risk-taking	
1. I prefer to stick to my current farming practices rather than trying new ones	
2. With the current challenging farming environment, I prefer to avoid further investment on my farm	
E4.02 : Innovativeness	
1. I like to use new farming practices	
2. I like to have the latest information on farming practices	
E4.03: Proactiveness	
1. I am among the first farmers to adopt new farming practices in my village	
2. I am constantly looking out for new ways to improve my farm	

SECTION 7:
a) Household vulnerability (climate change)

Q1. Have you personally noticed changes in the following weather patterns in the recent times? (Tick appropriately)

1. Amount of annual rainfall	1= increasing 2= decreasing 3= remained the same
2. Length of rainy season	
3. Change in average temperatures over time	

Q2. Do you or any of member your household have access to an early warning system for weather 1= Yes 0=No

b) Household vulnerability (shocks)

a) Over the past five years, was your household severely affected negatively by any of the Following events?	b) Have you suffered from this shock in the past 1 year 1=yes 0=no	c) What was the estimated value lost due to this shock?	d) Coping activity to deal with the event	**COPING CODES**
1. Drought				1. spent savings 2. Sent children to live with relatives 3. Sale of various assets and products (assets, animals, crop, farmland, food for household consumption) 4. Take additional job 5. Start a new business 6. Took children from school to work 7. Borrowing (money or assets) 8. Received assistance (donors, local NGOs, government, family etc.) 9. Reduced food consumption 10. Consumed less preferred food 11. Reduced non-food expenditures 12. Harvested premature crops 13. Changed cropping patterns/ crops planted 14. Spiritual effort-prayer, sacrifices, diviner 15. Rented out land 16. Plant trees **17.** Sought compensation or Insurance payments
2. Floods/heavy rains				
3. Crop damage e.g. by livestock or wildlife				
4. Crop disease or pest				
5. Death of livestock/livestock diseases				
6. Death of household head				
7. Theft (Livestock or crop)				
8. Large fall in sale price for crops				
9. Loss of job by household head				
10. End of regular assistance, aid, or remittances				
11. Large rise in price of food				
12. Large rise in agricultural input prices				
13. Robbery/buggery/assault				
14. Theft of a major asset				
15. Dwelling, damaged, destroyed				
16. Ethical/clan clashes				
17. Long-term disease of a member				
18. Others (specify)				

c) Household Health Status

No	Health status	Code/response
1	During the past 12 months, did anyone in this household suffer from any illness or injury?	(1= Yes 2 = No)
2	For how many days did the affected household members have to stop doing their usual activities due to illness or injury?	
3	How frequently did a members or members of your household visit a medical facility	Codes: 1= not all, 2= once in a while, 3=monthly 4= regularly

SECTION 8: Household Capital

a) Asset ownership

Please inform us of any assets owned by your household in the past 12 months

	Does your household own one or more [item name]? ***(multiple select)***	Yes=1 No=0	How many?	Of these, how many are young/calves?	Estimate its average **Value/unit** if you were to buy it at its current state (KES)
Farm animals	1. Cows				
	2. Calves				
	3. Oxen/bulls				
	4. Goats				
	5. Sheep				
	6. Donkeys				
	7. Chicken				
	8. Ducks				
	9. Pigs				
	10. Rabbits				
Farm machinery and other implements	11. Tractors				
	12. Power tiller/cultivators				
	13. Power sprayers				
	14. Irrigation pump sets				
	15. Watering cans				
	16. Carts				
	17. Bicycles				
	18. Motorcycles				
	19. Wheelbarrows				
	20. Water pumps and hosepipes				
	21. Harvesting equipment/materials				
	22. Knapsack sprayers				
	23. Other mechanical equipment (trailer, truck etc.)				
	24. Beehives				
	25. Zero grazing units				
	26. Poultry or rabbit houses				
Durable farm assets	27. Farmhouse				
	28. Urban house				
	29. Other animal shelters				
	30. Storage house				
Other luxuries	31. Radio				
	32. Phone				
	33. Furniture				
	34. Television (TV)				
	35. Computer/laptop				
	36. Refrigerator				
	37. Generator				
	38. Solar panel				
	39. Bajaj (e.g., tuk-tuk)				
	40. - Cars/vehicles				
	-888 other (specify)				

b) Land ownership

Parcel ID	Parcel size		Tenure status (**see codes**)	How do you evaluate the fertility status of this parcel? (***see codes***)	How do you rate the topography of the land
Tenure codes (3.7): 1=owned with title 2=owned with no title 3=leasehold 4=government land/forest/reserve 5=rented in 6=borrowed in (no cost) 7=shared in 8=communal -888=other (specify) **Fertility code (3.8):** 1=highly fertile 2=moderately fertile 3=slightly fertile 4= not fertile					1=Steep slope 2=moderate slope 3= gentle slope 4= other

c) Household wealth indicators/conditions

1.	**statement**	**code**	**response**
2.	What type of dwelling does the household live in?	1= independent house 2= flat/apartment 3= informal mabanda/shacks 4= hut 5= other (specify)	
3.	What is its tenure status?	1= owned 2= rented 3= no rent (squatting) 4= supplied free by employer 5= other (specify)	
4.	How many rooms does your household use for sleeping?	indicate the total number of sleeping rooms	
5.	Do you have a separate room which is used as a kitchen?	1= Yes 0= No	
6.	What is the predominant wall material of the main house?	1= mud 2= bricks/stones 3= iron sheets 4= wood 5= plastered 6= other (specify)	
7.	What is the predominant roof material of the main house?	1= grass 2= iron sheet 3= tiles 4= other (specify)	
8.	What is the predominant floor material of the main house?	1= earth 2= cement 3= wood 4= tiles 5= other (specify)	
9.	What is the main type of appliance used for cooking?	1= ordinary jiko 2= improved jiko 3= traditional/ improved stone fire 4= kerosene stove 5= gas 6= electric cooker 7 = other (specify)	
10.	What is the main source of energy for cooking?	1= firewood/grass 2= electricity 3= gas 4= biogas 5= kerosene/paraffin 6= charcoal 7= animal dung 8= crop residue 9= other (specify)	
11.	What is the main source of lightning in your household?	1= electricity- grid 2= own generator 3= solar power 4= paraffin lantern 5= candles 6= battery 7= biogas 8= rechargeable lamps 9= other (specify)	
12.	What is the main source of water used for food preparation in your household?	1= borehole 2= piped water into the compound 3= piped water outside the compound 4= public tap 5= dug well 6= roof catchment 7= vendors (tankers, truck, bicycle) 8= surface water (river, stream, pond, dam, lake) 9= bottled water 10= other (specify)	
13.	Does the source 12 above change during the dry season?		
14.	If Yes to Question 13 (above) what is your main source during the dry weather?		
15.	Do you use any methods to make the water safe to drink?	1= yes 0= no	
16.	If yes to Question 15 (above), what method do you use?	1= boil 2= bleach/chlorine 3= sieve through a cloth 4= water filter (ceramic, sand etc.) 6= solar disinfection 7= let it stand and settle 8= buy bottled water 9= other (specify)	
17.	What kind of toilet facility does your household usually use?	1= flush toilet 2= pit latrine 4= bucket toilet 5= no facility/bush/ field 6= other (specify)	

d) Income and expenditure

1) Indicate the income of the households	2) Provide income range if no value is given in S1	**3)** How much did you spend on the following in the last week **(KES)**
KES	1= 0 - 3500 2=3501 – 7500 3=7501 – 15000 4=15001 – 30000 5=30001 – 50000 6=50001 – 70000 7=over 70000	a) Food expenses (salt, sugar, beverages etc) b) Non-food expenses (clothes, airtime, transport, etc**)**

e) Group participation

What type of groups are members of your household part of? (Multiple select) (see codes)	Which of your household members are part of this group? (Mem ID from HH roster)	Which activity/ **enterprise(s)** does this group deal with? *(multiple select)*	Services offered within the group (*multiple select*)	What is [..] role(s) in the **group?** 1=chair 2=vice chair 3=secretary 4=treasurer 5=committee member 6=ordinary member -888=other (specify)	How many **DAYS** in a **MONTH** do you spend doing these roles?	How many **HOURS** in a **DAY** do you spend doing these roles?

Type of group (2.1)
1=agriculture 2=crop pest management 3=savings & credit 4=school/education 5=women's group 6=community 7=church/religion 8=irrigation water users association 9=tree planting/ nursery 10=welfare 11=business 12=environmental 13=medical/health 15=community networks (e.g., Idir, Equb) -888=other (specify)

Enterprise (2.3)
1=vegetables 2=other crops 3=livestock 4=beekeeping 5=poultry 6=fish farming 7=irrigation 8=water management 9=saving & credit 10=agro-forestry -888=other (specify)

Services (2.4):1=training 2=marketing 3=input acquisition 4=financial services 5=Artificial insemination services 6=water provision -888=Other (specify)
Frequency of payment (2.10): 1=daily 2=monthly 3=per activity -888=other (specify)

f) Access to credit/finance

Do you have a savings/bank account? **(1=Yes 2=No)**	If YES, in which saving/banking institutions do you have an account with? **(Institution codes)**	Did your HH seek credit in the last 12 months? **(1=Yes 2=No)**	If **YES**, did your HH receive credit in the specified period? **(1=Yes 2=No)**	In what form was the credit 1=cash 2=in kind	If 15.5=1, amount of credit received (KES/Birr)	Source of credit (multiple select)	Purpose credit was received for **(see purpose codes)**	Who received the credit? (see recipient codes)

Institution codes (15.2): 1=commercial banks 2=friends/relatives /neighbours 3= SACCOS 4= Microfinance/MFI 5= groups (ROSCAS) 6=village bank 7=mobile/phone banking 8= NGOs (e.g., One Acre Fund) 9= cooperatives 10=government funds (e.g., KSAP) -888= other (specify).
Source (15.6): 1=commercial banks 3= SACCOS 4= microfinance MFI 5= groups (ROSCAS 6=village bank 7=phone banking 8= NGOs 9= cooperatives 10=private money lender/Shylock 11=output trader -888= other (specify).
Purpose (15.7): 1=to purchase inputs 2=to buy food 3=for medication 4=for schooling 5=for trading -888= other (specify).
Recipient (15.8): 1 = head only 2 = Spouse only 3 = head and spouse jointly 4=all members jointly -888=other (specify).

SECTION 9: Household livelihood strategies

a) Non-agricultural livelihood options

Have you received any of the following incomes over the past 1 year?

1=Yes, 0=No Income activity codes (9a.2):

S/No	Livelihood source (use codes below)	What is the estimated income in the last 12 months	
1			
2			
3			

1=salaried employment 2=pension 3=remittances 4=trading in food commodities 5=trading in non-food commodities (e.g., clothing, trees and tree products, tree seedlings) 6=self-employment (e.g., barbershop, tailoring etc.) 7=housing rent 8=earning dividends 9=driver 10=building/masonry 11=casual worker-off farm 12=casual worker-on farm 13=tout/turnboys 14=income from brokering -888=other (specify)

b) Income from livestock and livestock products

Did you sell any livestock or livestock products from your farm in the last 12 months?

1=Yes 2=No; *If Yes, please fill the table below*

Type of livestock or livestock product 1= Yes ; 0= No	If Yes, provide the total revenue from selling (KES)
9b.2	9b.6
1. Chickens	
2. Ducks	
3. Goats	
4. Sheep	
5. Cattle	
6. Fish	
7. Eggs	
8. Milk	
9. Manure	
10. Hides/skins	
11. Beehives	
12. Honey	
13. Lease of oxen for ploughing	
-888=other (specify)	

c)Income from sales of trees and tree products

Did you sell any trees or tree products in the last 12 months?

1=Yes 2=No; *If Yes, please fill in the table below*

Type of tree or tree product (*multiple select*)	Quantity sold	Unit (see codes)	Price per unit (KES)	Total revenue from selling (KES)

d)Income from the sale of crops and associated products

Did you sell any crops or associated products in the last 12 months?
1=Yes 2=No; *If Yes, please fill in the table below*

Type of crop or crop product (*multiple select*)	Quantity sold	Unit (see codes)	Price per unit (KES)	Total revenue from selling (KES)

SECTION 10: Gender and Decision-Making

I would like to ask you some questions about your participation in certain types of agricultural activities and on making decisions regarding various aspects of household life.

Have you/anyone in your household participated in the **[activity]** over the past 12 months?	1=food crop farming: foods grown for home consumption 2=commodity farming, processing, trading or marketing (cash crop) 3= tree nursery management 4=tree planting including harvesting and sale 5=livestock rearing (type and number) including sale	Yes=1 No=0
Did you participate in the **[activity],** in the past 12 months)		Yes=1 No=0
When decisions are made regarding the **[activity],** who normally makes the decision?	1= self/partner in the HH 97=non-HH member 2=spouse/partner in the HH 3=joint decision made 98=not applicable/no decision made 3=other HH member	
How much input did you have in making decisions about **[activity]** including	1= little to no input in decisions 2=input into some decisions 3= input into most or all decisions 98= not applicable / no decision made	
To what extent do you feel you can make your own personal decisions regarding **[activity]** if you want(ed) to? including harvesting and sale	1=not at all 2=small extent 3=medium extent 4=to a higher extent	

SECTION 11: Debriefing

OUT1. Result of the interview		**OUT2.Time finished**	**OUT3.Who answered the questions:**
☐ Interview completed ☐ Partly completed ☐ To be rejected because of poor data quality	☐ Other (specify)	___ : ___ (HH : MM, 24h)	☐ Only the respondent ☐ The respondent and other HH members

Abstract (in Japanese)

要　約

ファーマー・フィールド・スクール（FFS）は、参加者がフィールドでの試行錯誤を通じて新たな農業知識を獲得し、多様で変化する諸条件のもとで適応的な意思決定ができるようにする農業普及アプローチである。FFS に期待される効果のひとつは農村世帯の生計多様化であり、これは気候変動の影響に対する世帯のレジリエンス強化に繋がる重要な要因と考えられている。本研究では、2017 年から 2020 年にかけてケニアの乾燥・半乾燥地（ASAL）地域にある 2 つの郡で実施された農林業 FFS プログラムを事例として、農林業 FFS プログラムが農村世帯の生計多様化に及ぼす効果、および、生計多様化と気候変動の影響による経済的損失との関係を分析した。近年、ケニアの ASAL 地域の農村世帯は、気候変動によって悪化してきた度重なる旱魃に見舞われている。本研究では、FFS プログラムの卒業生と非卒業生を含む 344 戸への世帯調査、キーパーソンへのインタビュー、およびフォーカスグループディスカッションにより情報収集を行った。収集データは、定性分析するとともに、傾向スコアマッチング分析によって定量分析し、世帯における FFS 卒業生の有無と生計多様化の関係を評価した。また、世帯の生計多様化と気候変動影響による損失との関係を重回帰分析によって分析した。傾向スコア分析の結果、FFS 卒業生のいる世帯は、もし仮に FFS 卒業生がいなかったとした場合の仮想的ケースと比較して、収入の種類や販売する農林畜産物の種類において多様化が進んでいることが示された。さらに重回帰分析の結果、世帯が扱う農林畜産物の多様性は、最近発生した旱魃や作物病虫害による損失と逆相関していることが示された。これらの結果は、農林業 FFS が世帯の生計多様化を促し、旱魃や作物病虫害という気候変動の脅威に対する世帯のレジリエンスを高めるのに有益であることを示唆している。

キーワード：ファーマー・フィールド・スクール、生計多様化、干ばつ、ショックに対する家計の脆弱性、傾向スコア法
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