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Analysis of the Smallholder Horticulture Empowerment and Promotion ("SHEP") Intervention on Income and Food Security in Ethiopia

Hisako Nomura,* Asmiro Abeje Fikadu,† Girma Gezimu Gebre‡ and Payal Shah§

Abstract

Smallholder Horticulture Empowerment and Promotion (SHEP) aims to change small-scale horticultural farmers' attitudes from "grow *and* sell" to "grow *to* sell" and improve horticultural incomes by enhancing farming and cultivation skills. This study indicates that SHEP improves the income and food security of small-scale horticultural farmers. In particular, it demonstrates that joint gender decision-making addressed through the SHEP approach positively impacts household food security. For the evaluation, GIS data are used to identify comparison and control areas based on six agricultural specificities essential for horticultural production and commercialization. In addition, propensity score matching is used to reduce bias due to covariates, allowing comparison with control farmers who are as close as possible to farmers in the project area. Using a quasi-experimental sampling of 610 farmers, this study in Oromia, Ethiopia, shows that SHEP instigates a transition from subsistence to commercial farming. First, the average horticultural income (29,889 ETB or 560.6 USD) and food security (64%) of the treatment group were statistically higher than the other groups after propensity score matching. This shows that the horticultural income average of the treatment group was USD 130.6 higher than the net farm income average of USD 430 in Jimma, the capital of the Oromia region where the project was conducted. Thus, the intervention group had a higher horticultural income average than the control and pure control groups, even in the context of not being able to actively grow horticultural crops under the national wheat flagship program. Further, the treated farmers were food secure, while a higher proportion of the farmers in the control and pure control groups faced severe food insecurity. The data also show that the project's gender equality training has led to more joint couple decision-making among beneficiary households, thereby contributing to better food security. Finally, SHEP's training curriculum advocates adapting agricultural risk adaptation strategies aligned with climate-smart agriculture (CSA) principles. Our findings indicate a notable correlation between adapting these CSA measures and households' higher propensity towards food security. The study demonstrated that approaches such as SHEP are effective in improving smallholder farmers' incomes and household-level food security in Ethiopia.

Keywords: Horticulture commercialization, Propensity score matching, SHEP, Spatial data field selection method

JEL Codes: O13, R11, B54

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1. Background

Food security remains a pressing global issue, aligning with the United Nations 2030 Agenda for Sustainable Development Goal 2 targeting the eradication of poverty and hunger (FAO 2017). Despite these efforts, studies indicate that food insecurity persists, affecting over a quarter of the global population. This is particularly the case in Africa, where it is exacerbated by reliance on subsistence farming (Drammeh, Hamid, and Rohana 2019; Kabubo-Mariara and Mulwa 2019; Oduniyi and Tekana 2020; Thome et al. 2019). Sub-Saharan Africa, where agriculture is the primary livelihood for 90% of the rural population, faces challenges transitioning from subsistence to commercial farming—a shift critical for development and food security (Alliance for a Green Revolution in Africa [AGRA] 2022). The commercialization of agriculture, involving greater market engagement, is seen as a critical driver for economic growth and the alleviation of food shortages (Haggblade 2011; Woldemichael 2017).

Numerous studies (Carletto, Corral, and Guelfi 2017; Pingali 1997; Tipraqsa and Schreinemachers 2009; von Braun and Kennedy 1986; von Braun 1995) confirm that agricultural commercialization significantly boosts productivity, income, and food security. Smallholder farmers engaged in commercial ventures enjoy higher incomes, supporting household welfare and improving food access compared to subsistence farming (Bolarinwa, Oehmke, and Moss 2020). Additionally, agricultural commercialization is acknowledged as a poverty alleviation strategy in African rural communities (Muricho et al. 2017; Muriithi and Matz 2015).

Gender-based decision-making in agriculture is an essential aspect of food security. It involves active participation and consensus among household members regarding agricultural activities (Wang et al. 2018). Household decision-making encompasses men-alone, women-alone, and joint decision-making practices. Households that practiced joint decision-making tend to be more food secure than households that practiced sole decision-making (Mohammed et al. 2023). As elucidated by Mohammed et al. (2023), it is crucial to note that joint decision-making does not necessarily imply equality in the decision-making process since the household members might have different information and knowledge levels. Another study argued that women who have control over assets and decision-making tend to favor agricultural products that support and ensure household food security (Sariyev et al. 2020). Thus, the mechanism of decision-making during the production as well as the marketing process made more explicit could also influence their production outcome that could affect their household level food security.

Agriculture is the cornerstone of the Ethiopian economy, constituting approximately 37.6% and 67% of the total gross domestic product (GDP) and rural employment, respectively (World Bank 2023). Horticultural crops are the primary source of income for smallholder farmers, and their level of participation in production and marketing is high in Ethiopia, thereby improving their food security (Megerssa et al. 2020). Additionally, horticulture commercialization and gender-based decision-making arrangements have been considered sustainable agricultural development strategies in Ethiopia, improving smallholder farmers' livelihoods and incomes (Ethiopian Planning and Development Commission [EPDC] 2021). Given that horticultural crops make a vital contribution to the welfare of smallholder farmers, this paper focuses explicitly on horticulture farming.

Smallholder farmers in Ethiopia mainly practice subsistence farming and encounter various challenges, including a lack of quality extension provision (Leta et al. 2017), unreliable market information (Ethiopian Ministry of Agriculture and Natural Resources [EMANR] 2017), and a mixed understanding of decision-making arrangements, particularly their impact on income and food security. Thus, the Japan International Cooperation Agency (JICA) has introduced a market-oriented extension program called the Smallholder Horticulture Empowerment and Promotion (SHEP) project, which supports the empowerment of smallholder farmers for better welfare.

The SHEP project tailored a "grow *to* sell" principle, encouraging farmers to identify a specific market before growing horticultural crops. Adapting this approach to the crop selection process enables farmers to secure better market prices and reduce market problems as they cultivate crops guided by an analysis of market demand. Moreover, the interventions focus on promoting joint decision-making practices instead of a unitary (either men- or women-alone) decision-making arrangement through directing mindset change for both the men and women in the household. While there is growing literature on horticulture commercialization and decision-making in agriculture (Carletto, Corral, and Guelfi 2017; Tadesse et al. 2022), the effects of horticulture commercialization on the incomes and food security of smallholder farmers are yet to be fully understood. Thus, this paper focuses on conducting a comprehensive analysis of the Project for Smallholder Horticulture Farmer Empowerment through Promotion of Market-oriented Agriculture (SHEP) intervention in Ethiopia, called the "Ethio-SHEP." It also examines how horticulture commercialization and gender-based decision-making are associated with smallholder farmers' income and food security by comparing the treated group with the control and pure control groups.

2. Research methodology

2.1 SHEP project intervention in Ethiopia

The SHEP intervention (the first phase of the project) was promoted by JICA, and implemented by the Ethiopian Government from January 2017 to January 2023. The intervention is a new market-oriented extension program, which follows the "grow *to* sell" philosophy, empowering smallholder farmers to consider "farming as a business" (Shimizutani et al. 2021). Market-oriented extension involves the extension officers making a total effort to increase farmers' market orientation and participation. Therefore, market-oriented extension encompasses the entire endeavor of 1) counseling and assisting farmers in producing profitable market-oriented commodities and implementing suitable technologies and practices; 2) gathering and disseminating market-related information; 3) locating lucrative markets and buyers and connecting farmers with them; 4) enhancing farmers' marketing capabilities; and 5) assisting farmers in organizing to carry out cooperative marketing of their produce (Gebremedhin et al. 2012).

The "grow *to* sell" principle involves farmers first understanding the market demand and then producing horticultural crops based on the market demand results. However, the "grow *and* sell" principle is the opposite of the "grow *to* sell" approach, where farmers produce their horticulture crops first and then find a market to sell their harvests later (Shimizutani et al. 2021). The SHEP focuses on well-rounded and skill-oriented capacity-building training (e.g., sensitization workshops, market demand surveys, technical training on agronomy, nursery, and crop establishment, gender mainstreaming (resource control), disease control, post-harvest handling, and profit margin calculation), instead of simply providing physical agricultural inputs. The sensitization workshop serves as the initial step to elucidate the SHEP concept, outline detailed activities, share visions, and clearly define farmers' and other stakeholders' expected roles and responsibilities. A market demand survey, within the SHEP concept, entails farmers visiting nearby markets to observe and assess the sale of crops. Extension officers accompany farmers to gain first-hand market experience and obtain valuable information. This approach lets farmers sense market dynamics directly and understand crucial aspects such as marketable crops, and the required quality and quantity, which helps farmers establish connections with key market players. Moreover, gender mainstreaming in the SHEP concept involves participatory training for farmers (men and women together), incorporating a combination of lectures and practical sessions that recognize "a couple as a team for farm management," with gender being integral to the solution for increasing household income.

This project was implemented in the Oromia and Amhara regions during Phase I of SHEP between 2017 and 2023, with our study focusing on the Oromia region. The SHEP project intervention consists of four main steps: 1) sharing goals: farmers identify their vision and farming needs; 2) raising awareness: motivating farmers and fostering commitment to improving their practices; 3) farmers' decision-making: allowing farmers to decide which crops are most profitable for them; and 4) skill acquisition: providing training from site selection to harvesting to align farming with their plans. Finally, follow-up and monitoring sessions ensure that farmers apply the acquired knowledge in their daily farming.

Notably, the SHEP project delivers gender-oriented training in addition to horticulture skill training. The project aims to change the mindsets of both men and women, emphasizing joint decision-making within households, which differs from other women's empowerment programs that primarily focus on empowering women, leaving out the equal opportunity of men's empowerment (Mwololo et al. 2022), which could be misleading and might not be an effective approach. The SHEP project has provided different gender training to foster a mindset change for both men and women beyond traditional perspectives and encourage them to make decisions jointly for production and marketing activities. According to Mwangi et al. (2021), the SHEP project in Kenya has identified gender as a cross-cutting topic and paid substantial attention to gender across the training activities. The project gives both men and women equal chances and advocates for participating in SHEP's training activities. Along with gender mainstreaming training, the SHEP project provided training on the concept of family budgeting so that the couples were trained in their responsibilities, making plans, and making decisions jointly in horticulture production, marketing, sales allocation, and other family matters (Mwangi et al. 2021). Joint decision-making between couples in horticulture production and marketing facilitates sharing knowledge on crop variety selection, cultivation techniques, pest management, and market information. This collaboration improves household resource allocation, balances cash and food crop production, and enhances income and food security through shared responsibility.

Thus, the main hypothesis of the SHEP intervention addressed in this study is that it facilitates the transition of farm households from subsistence farming to commercialization and promotes joint decision-making practices between men and women within the households, positively contributing to improved market returns and better household economies.

2.2 Experimental research design

The SHEP project was designed to be implemented in eight *kebeles*.[1] The intervention *kebeles* were based on applications by the farmer's groups when the project was initially launched, not randomly selected. This method could introduce potential hidden bias (selection bias) when assessing its impact on income. To address the potential selection bias, we apply a quasi-experimental research design (QERD) to the SHEP project intervention. Unlike randomized control trials (RCTs), quasi-experimental design lacks randomization and uses non-random criteria for group assignment (Campbell and Stanley 1966). The concept of quasi-experiment design was originally pioneered by Donald Campbell and Julian Stanley in 1963, while Shadish, Cook, and Campbell (2002) produced a more detailed explanation. The quasi-experimental research design has been widely applied in health sciences (Waddington 2022) and social sciences (Tucker 2022).

[1] The *kebele* is the smallest administrative unit in Ethiopia, and the *woreda* is the district. Several *kebeles* are nested within a *woreda*.

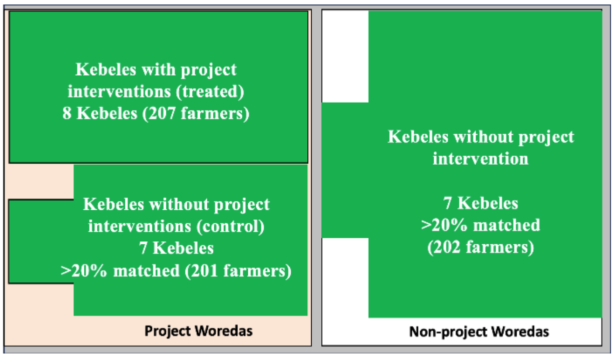
Our quasi-experimental design selects control (*kebeles* without project intervention within the intervention *woreda*) and another control group (for practicality, we call it pure control groups as they are *kebeles* without project intervention in the non-intervention *woreda*) matched with treated groups (SHEP project beneficiaries) using satellite geographic information system (GIS) data. The main research interest for which we added these two counterfactual groups (control and pure control) is that there will be peer effects or spillover effects within the intervention *woreda* even though the control *kebeles* differ from the treated *kebeles*. As a result, we expanded our assumption and added a counterfactual group, which we define as the pure control group selected from non-intervention *woreda*. These non-intervention *woreda*s are far from the intervention *woreda*s and help control the project's potential spillover. The key attributes reside in two components: agricultural and market peculiarities when considered for control and pure control *kebeles*. The agricultural peculiarities include soil properties, elevation, and irrigation availability (based on a proxy variable of distance to the nearest river network), and the market peculiarities include distance to major cities and road density. These non-random parameters are essential for horticulture production and marketing. Moreover, we also considered the Ethiopian administrative boundaries (regions, zones, *woredas*, and *kebeles*) to create the counterfactual groups.

To create the counterfactual groups, we used the following steps: 1) We divided the entire Oromia region into 1 km by 1 km parcels. We assigned a dummy of 1 to parcels that fall within the *kebeles* with the SHEP intervention; these are our "treated" parcels. We assigned a dummy of 0 to all other parcels; these are our non-treated parcels. 2) We collected the key attributes listed above at the 1km-by-1km parcel level for all treated and non-treated parcels. 3) We used the nearest neighbor matching method at the 1 km by 1 km parcel level to identify control parcels that are statistically similar to the "treated" parcels based on the key attributes using R programming software. 4) We calculated the total number of 1 km by 1km plots identified as "control" and "pure control" for each "no treatment" kebele within the intervention woredas and without intervention woredas, respectively. 5) We assigned a kebele as a "control" kebele if more than 80% of the 1 km by 1 km parcels within a kebele (which belongs to an intervention *woreda*) were statistically similar to treated parcels based on the nearest neighbor matching exercise. We assigned a kebele as a "pure control" kebele if more than 20% of the 1 km by 1 km parcels within a kebele (which belongs to a non-intervention *woreda*) were statistically similar to treated parcels based on the nearest neighbor matching exercise. (Figure 1). In addition, at the analysis stage, propensity score matching (PSM) is used to reduce bias due to covariates, allowing comparison with control farmers who are as close as possible to farmers in the project area. Thus, covariate matching was conducted at two stages: one for identifying counterfactuals and another at the time of analysis for removing sample selection bias.

Figure 1: Depiction of sampling method based on GIS data matching

2.3 Sample size

Based on our quasi-experiment sample identification, we selected 22 *kebeles* from six *woredas:*



eight treated *kebeles* (Waro Kolobo, Offolie Sadawe, Boba Roge, Buyo Kechema, Kitimnile, Girma, Gibe/Siba, and Somodo), seven control *kebeles* (Gonjo Abaye, Afoli Korti, Meti Ushanie, Ushanie Koche, Tikur Balto, Toli Kerisu, and Gudeta Bula), and seven pure control *kebeles* (Lalo Beyem, Goro Sedem, Chefe Nega, Wagtola, Unkurie, Wengecho, and Daka) (Figure 2).

Woredas	**SHEP-targeted *kebeles* (n)**	**Non-SHEP or Control *kebeles* (n)**	***Woredas***	**Non-SHEP or Pure control *kebeles* (n)**
Dedo	Waro kolobo (**33**)	Ganjo abaye (**27**)	Omonanda	Lalo beyem (**30**)
	Offolie sadawe (**39**)	Afoli korti (**34**)		Goro sedem (**30**)
Seka checkorsa	Boba roge (**25**)	Meti ushanie (**40**)		Chefe Nega (**25**)
	Buyo kechema (**34**)	Ushanie koche (**30**)		Wagtola (**22**)
Kersa	Kitimibile (**18**)	Tikur balto (**25**)	Sokoru	Unkurie (**25**)
	Girma (**24**)	Toli kerisu (**25**)		Wengecho (**23**)
	Gibe/ Siba (**25**)			Daka (**47**)
Mana	Somodo (**9**)	Gudeta bula (**20**)		
Total	**207**	**201**		**202**

Table 1: Sample size distribution across sample *kebeles* (total sample size (n)= 610)

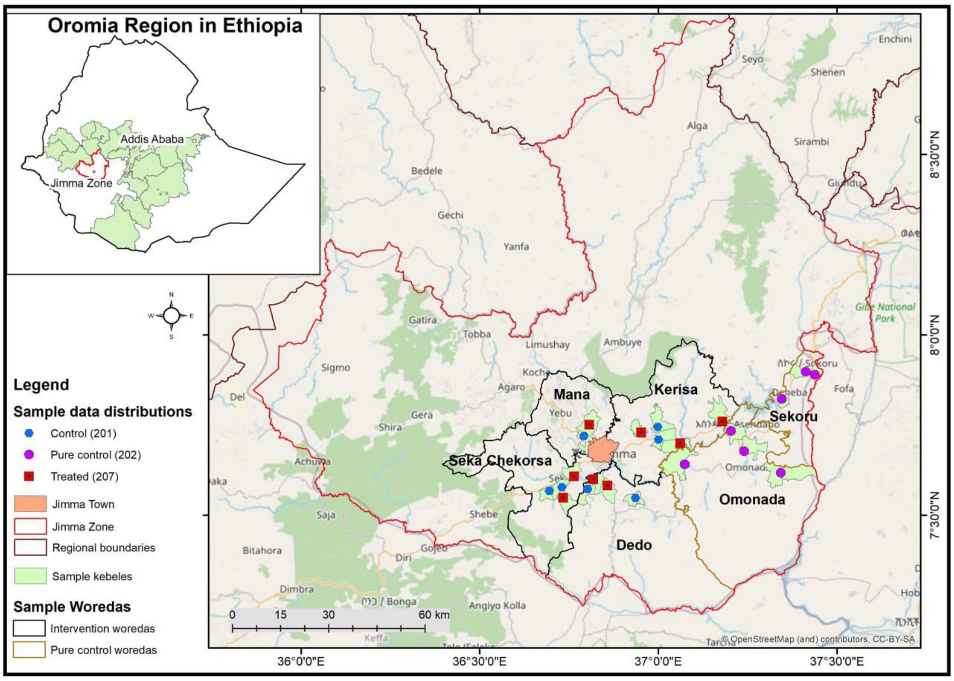


Figure 2: Map of the study areas *(Source: sketched by Authors)*

Finally, approximately 610 horticulture-growing smallholder farmers were selected using a simple random sampling method. The distributions of the sample horticulture-growing farmers are displayed in Table 1. The household survey data were collected through a structured questionnaire from December 2022 to January 2023 (Appendices 1 and 2).

2.4 Definitions and description of the main variables

2.4.1 Measuring horticulture commercialization index (HCI)

Commercialization is a metric to measure how much household crop production is geared toward market-oriented activities (Strasberg et al. 1999). Horticultural commercialization is quantified by calculating the ratio of the gross monetary value of horticulture crop production to the total sales accrued over the 12 months preceding the survey (Equation 1). The determination of this ratio necessitated the collection of unit prices for each crop from every sampled farmer, helping to convert production and sales into monetary terms. Strasberg et al. (1999) proposed that the commercialization formula remains a pertinent measurement tool that captures smallholder farmers' tendency to engage in market transactions, irrespective of sales volume. Numerous empirical studies have adopted this commercialization index, including investigations by Assaye et al. (2022), Carletto et al. (2017), and Ogutu and Qaim (2019). According to Bekele et al. (2010), the commercialization index divides farmers into two groups: those classified as commercial-oriented and subsistence-oriented. Commercial-oriented farming refers to agricultural practices that primarily produce crops for market sale. Farmers engaged in commercial-oriented farming typically aim to generate profit and maximize their income from agricultural activities.

On the other hand, subsistence-oriented farming prioritizes producing food to meet the needs of the farmer and their family rather than generating surpluses for sale in markets. Subsistence-oriented farmers often rely on traditional farming methods. We classified farmers as commercial-oriented, with an index of 0.5 or higher, and those deemed subsistence-oriented, with an index below 0.5, as follows:

$$(\mathrm{HCI})_{\mathrm{i}} = \frac{\sum_{\mathrm{j=1}}^{7} (\mathrm{Sales})_{\mathrm{ij}}\ in\ monetary\ values}{\sum_{\mathrm{k=1}}^{7} (\mathrm{Production})_{\mathrm{ik}} in\ monetary\ values} = \begin{cases} < 0.5, \text{ subsistence oriented} \\ \geq 0.5, \text{ commercial oriented} \end{cases} \quad (1)$$

where HCI_i is the horticulture crops commercialization index of the household i; $\sum Sales_{ij}$ is the summation of the gross monetary value of horticulture crop j (the sample farmers produce, on average, three horticulture crops among the seven horticulture crops (such as cabbage, onion, potato, carrot, tomato, beetroot, green paper) sold out by a household i; $\sum production_{ik}$ is the summation of the gross monetary value of total crop k produced by a household i excluding cereal and other crops.

2.4.2 Measuring gender-based decision-making

Family members in the same household may not simultaneously engage in the same activities, leading to differences in decision-making based on their respective roles. For instance, Sariyev et al. (2020) noted that income allocation decisions are often influenced by social norms, with men typically managing more significant financial transactions while women oversee smaller-scale home garden activities. The significance of decision-making intensifies when it involves a substantial portion of the population (Sariyev et al. 2020), underscoring the academic relevance of investigating who determines production, marketing, and the distribution of economic returns. In this paper, we asked the farmers four decision-making questions regarding horticulture production and marketing, with three possible answers: man-alone, woman-alone, and joint. The questions were: “Who decides to select horticulture crops to grow?,” “Who decides on agricultural inputs to use?,” “Who decides on the vegetable crop harvest to sell?,” and “Who decides on vegetable sales to allocate?” The first two questions are related to horticulture production, and the last two are related to marketing.

2.4.3 Measuring food security

Food security is a four-level ordered variable derived from nine questions using the Household Food Insecurity Access Scale (HFIAS). HFIAS is a standardized measure of a household’s perceptions of their food security status (Coates et al. 2007). The HFIAS assesses the prevalence (occurrence and frequency of occurrence) of household food insecurity situations using a set of questions that explore the uncertainty of food availability within the household, feelings of indignity from resorting to deplorable ways of obtaining food, perceptions of food deficiency in quantity and/or quality, and reductions in food intake (Coates et al. 2007). HFIAS measures include whether any household was worried their food supply would run out, whether any household member slept hungry due to inadequate food, whether any household member ate fewer times due to insufficient food, and whether any household member could not eat their preferred food due to a lack of resources (Appendix 3).

HFIAS uses nine indicators specific to a household's experience of food insecurity in the past four weeks (Annex 3). HFIAS-approved standard scoring was used, where 0 indicates non-occurrence (food insecurity situation never occurred in the household), and 1 indicates occurrence (it has three levels such as "rarely occurring" [1–2 times], 2 described it as "sometimes occurring" [3–10 times], and 3 described it as "often occurring" [> 10 times]). The frequency of occurrence for each household's food insecurity measure was aggregated to generate a HFIAS score. The aggregate HFIAS ranges from 0 to 27, which indicates that the households that answered the given nine questions "no" were scored 0—the minimum value of the score—and answered "yes" with the frequency of occurrence being "often," which is 27 (3*9), the maximum value of HFIAS. The household scores were categorized into a four-level ordered food security outcome consistent with the HFIAS guidelines (Coates et al. 2007). The four levels are: food secure (HFIAS = 0–1), mildly food insecure (HFIAS = 2–7), moderately food insecure (HFIAS = 8–11), and severely food insecure (HFIAS >11).

2.4.4 Estimation strategy/ Model specification

For data analysis, we use inferential statistics (t-tests and chi-square tests) and propensity score matching (PSM). We observe a statistical mean difference of various socioeconomic variables between treated and counterfactual groups, both control and pure control groups, indicating the existence of the selection bias. Therefore, PSM is an appropriate estimation to eliminate these selection biases between them. PSM relies on the unconfoundedness assumption, or "conditional independence assumption," which asserts that once hidden biases (confounding covariates) are controlled for, the SHEP intervention becomes random, allowing its actual effects on the outcome variable (horticulture income) to be observed. This is mathematically expressed in Equation (1):

$$\mathrm{P(Z)} = \mathrm{Pr}\{\mathrm{T} = 1|\mathrm{Z}\} = E\{T|Z\} \quad (1)$$

where T is Treatment (1 = treated (with SHEP intervention); 0 = control/pure control groups) and Z is the vector of the confounding covariates (sources of hidden bias). The conditional distribution of Z given P(Z) should be similar between the treated and control/pure control groups. In this study, we used land size for horticulture production, access to training, experience for horticulture farming, level of education of the household head, and distance to main market as covariates in PSM estimation to remove selection bias. Moreover, ensuring common support is another critical assumption of PSM. This assumption implies that any combination of farmers' characteristics observed in the treated group must also be observed in the control group. Farmers with significantly different characteristics that do not overlap between the groups will be excluded from the analysis (Bryson et al., 2002). In this analysis, about 7% (n = 44) of the total 610 sample farmers dropped and were excluded in the final analysis because of a lack of common support (Appendix 4 and 5). We applied various matching algorithms, including nearest neighbor, kernel, and radius caliper matching, as part of a robustness check. Among these, nearest-neighbor matching demonstrated the lowest mean bias after matching and produced a statistically insignificant likelihood test, indicating superior matching quality compared to the other algorithms (see Appendix 6).

We also estimate quantile regression using five quantiles (the 10^{th}, 25^{th}, 50^{th}, 75^{th}, and 90^{th} quantiles to estimate the treatment effects (effects of the SHEP intervention on horticulture income compared to control and pure control groups) (Table 5). Quantile regression accommodates heterogeneity, providing insights into effects at different quantiles at low- and higher-income levels (Buchinsky 1998; Koenker and Hallock 2001; Ogutu and Qaim 2019). The quantile regression specification is explained in Equation (2):

$$Y_i = X_i'\beta_q + \mu_{qi} \quad \text{where; } (Y_i|X_i = X_i'\beta_q) \tag{2}$$

where Y_i is horticulture income, X_i is the set of covariates, including SHEP intervention (treatment variable), the horticulture commercialization index, gender-based decision-making, and other control variables such farmers' socioeconomic, demographic, and institutional characteristics; q is a quantile with $0 < q < 1$ and β_q the parameters to be estimated.

3. Results and discussion

We completed collecting the data from the treatment and control woredas. This section presents the results of the descriptive and inferential statistical analysis.

3.1 Demographic and socioeconomic characteristics

The demographic and socioeconomic characteristics of the sample smallholder farmers are shown in Table 2. Regarding the respondents' gender, the treated group had a slightly lower proportion of females than the control and pure control groups, but this difference was not statistically significant. However, there was a statistically significant difference in the gender proportion between the treated group and the pure control group, indicating that the treated group had a higher percentage of males. In terms of the gender of the household head, the treated group had fewer female household heads than the control and pure control groups. The chi-square test results reveal a significant difference in gender distribution among household heads between the treated and control groups.

Table 2: Summary statistics of the demographic and socioeconomic characteristics (n=610)

Variables	Treated group Mean (SD)	Control group Mean (SD)	Pure control group Mean (SD)	Test statistics (Treated against control) Diff (SE)	T-value /X2-value (P-value)	Test statistics (Treated against pure control) Diff (SE)	T-value /X2-value (P-value)
Demographic variables							
Gender of the respondents (1=male; 0=female)	0.754 (0.432)	0.776 (0.418)	0.639 (0.482)	-	0.2868 (0.592)	-	**6.4010 (0.011)**
Gender of the household head (1=male; 0=female)	0.894 (0.31)	0.945 (0.23)	0.955 (0.21)	-	**3.6459 (0.056)**	-	**5.5606 (0.018)**
Age of the household head (years)	41.2 (12.7)	40.4 (11.7)	35.2 (10.4)	0.800 (1.210)	0.6635 (0.2537)	5.970 (1.150)	**5.2094 (0.0000)**
Education level of the household head (years of schooling)	2.8 (3.1)	3.1 (3.1)	3.8 (4.1)	-0.320 (0.310)	-1.0518 (0.1468)	-1.000 (0.36)	**-2.8012 (0.0027)**
Total number of families in the household	6.014 (2.304)	5.910 (2.074)	6.262 (2.252)	0.104 (0.217)	0.4790 (0.6323)	-0.248 (0.225)	1.1003 (0.2719)
Number of adult males in the household	1.8 (1.0))	1.6 (0.9)	1.7 (0.9)	0.160 (0.090)	**1.6008 (0.0551)**	0.140 (0.100)	**1.3809 (0.0840)**
Number of adult females in the household	1.6 (0.9)	1.5 (0.8)	1.4 (0.8)	0.110 (0.090)	**1.3110 (0.0953)**	0.170 (0.090)	**2.0316 (0.0214)**
Number of children under 15 in the household	2.599 (1.724)	2.746 (1.706)	3.149 (1.855)	-0.147 (0.170)	0.8642 (0.3880)	-0.549 (0.178)	**3.0953 (0.0021)**
Experience in horticultural production (year)	10.5 (8.7)	8.0 (6.4)	6.0 (4.3)	2.500 (0.760)	**3.2721 (0.0006)**	4.500 (0.680)	**6.6252 (0.0000)**
Socio-economic variables							
Horticultural farmland size (hectare)	0.64 (0.61)	0.56 (0.38)	0.49 (0.31)	0.080 (0.050)	1.61 (0.1087)	0.150 (0.050)	**3.13 (0.0019)**
Number of livestock (TLU[2])	4.3 (2.6)	3.7 (2.3)	4.0 (3.1)	0.618 (0.242)	**2.5557 (0.0110)**	0.292 (0.280)	1.0419 (0.2981)

The treated group had a slightly higher mean age of household heads compared to the control and pure control groups, but this difference was not statistically significant. However, there was a significant difference in the age of household heads between the treated group and the pure control group. The treated group tended to have a slightly lower mean education level of household heads compared to both control groups, but this difference was not statistically significant. Nonetheless, there was a significant difference in education level between the treated and control groups. The treated group had a significantly higher mean horticultural production experience than both control groups. Additionally, there was a significant difference between the treated group and the

[2] TLU stands for tropical livestock unit. The conversion factors for: Calf=0.34, Heifer = 0.75, Cow and ox = 1.0, Horse = 1.1, Donkey = 0.7, Sheep and Goat = 0.13, and Chicken = 0.013 source: Stock et al. (1991),

pure control group in terms of experience in horticulture production.

There was no significant difference in the mean total family size between the treated and control groups nor between the treated and pure control groups. The treated group tended to have slightly more adult males and females than both control groups, but these differences were not statistically significant. However, there were significant differences in the number of adult males and females between the treated and control groups. There was no significant difference in the mean number of children under 15 between the treated and control groups. However, there was a significant difference in the number of children under 15 between the treated and pure control groups.

The treated group had a slightly larger mean farmland size than both control groups, but this difference was not statistically significant. However, there was a significant difference between the treated and pure control groups regarding farmland size. The treated group had a significantly higher mean number of animals than the control group. However, there was no significant difference in the mean number of livestock between the treated and pure control groups.

3.2 Agriculture-related characteristics

Approximately 78%, 39%, and 41% of the treated, control, and pure control groups, respectively, participated in horticulture training provided by the government (Table 3). Consequently, the treated group exhibited a significantly higher proportion of households with access to horticulture training compared to both the control and pure control groups, indicating a strong association between the SHEP intervention and access to training. Notably, the treated group has also received various training packages from the SHEP project, distinct from the government-provided training.

Table 3: Summary of agriculture-related characteristics

	Treated group	Control group	Pure control group	Test statistics (Treated against control)		Test statistics (Treated against pure control)	
Variables	Mean (SD)	Mean (SD)	Mean (SD)	Diff (SE)	T-value /X2-value (P-value)	Diff (SE)	T-value /X2-value (P-value)
Agriculture-related variables							
Access to training in horticulture (1=Yes; 0=No)	0.783 (0.41)	0.388 (0.49)	0.411 (0.48)	-	**67.2768 (0.000)**	-	**60.4734 (0.000)**
Distance to the main market (minutes by foot)	72.0 (48.2)	80.4 (52.9)	84.2 (68.6)	-8.4 (5.0)	**-1.6703 (0.0478)**	-12.2 (5.9)	**-2.0817 (0.0190)**
Distance to the cooperative offices (minutes by foot)	36.2 (19.1)	45.0 (43.6)	33.5 (21.4)	-8.8 (3.3)	**-2.6629 (0.0040)**	2.7 (2.0)	**1.3444 (0.0898)**
Number of extension contacts per month	8.9 (7.7)	5 (5.2)	4.9 (5.5)	3.87 (0.65)	**5.9624 (0.0000)**	3.96 (0.66)	**5.9787 (0.0000)**

The average distance from farmers' homes to their main market for the treated, control, and pure control groups was 72, 80, and 84 minutes by foot, respectively. Significantly, the treated group had a shorter mean distance to the main market than both the control and pure control groups. Similarly, the average distance from farmers' homes to agricultural cooperatives for the treated, control, and pure control groups was 36, 45, and 33 minutes by foot, respectively. Statistical analysis reveals that the treated group had a significantly shorter mean distance to cooperative offices compared to the control group. However, it is noteworthy that the distance to agricultural cooperatives was statistically more distanced in the pure control group compared to the treated group.

The average number of extension contacts per month for the treated, control, and pure control groups was 9, 5, and 5, respectively. This figure shows that the treated group demonstrates a significantly higher mean number of extension contacts per month compared to both control and pure control groups, suggesting more frequent interactions with extension services among treated farmers.

3.3 Horticulture production practices in the study area

As depicted in Figure 3, the total number of horticultural crops produced in 2022/2023 by the smallholder farmers in the study area was seven in both SHEP target and non-SHEP *kebeles*. In SHEP *kebeles*, farmers grow horticultural crops based on the findings of market surveys, which involve visiting and assessing market demand. Potatoes were the first dominant crop produced in all woredas except Sokoru Woreda. In Sokoru *woreda*, tomatoes were the first main crop produced, followed by cabbage. .

In Dedo Woreda, the majority of farmers in the treated group produced potatoes, accounting for 61.1%. They also produced cabbage, tomatoes, and onions in proportions of 25%, 8.3%, and 5.6%, respectively. Similarly, the majority of farmers in the control group also produced potatoes (72.1%), while their production of cabbage, tomatoes, and onions stands at 21.3%, 3.3%, and 3.3%, respectively.

Potatoes are the dominant crop in Kersa Woreda, making up 46.3% and 64% of the total crops for the treated and control groups, respectively. Farmers in the treated group also produce cabbage (38.8%), onion (7.5%), tomato (5.9%), and beetroot (1.5%). In contrast, the control group grows tomatoes (18%), cabbage (10%), and green peppers (8%).

In Seka Chekorsa Woreda, the majority of both treated and control group farmers grow potatoes, accounting for 52.5% and 87.1% of their total horticultural production, respectively. Farmers in the treated group also grow tomatoes (42.4%), cabbage (3.4%), and onions (1.7%). Meanwhile, control group farmers produce cabbage (7.1%), tomatoes (2.9%), carrots (1.4%), and onions (1.4%).

In Mana Woreda, the treated group primarily grows cabbage, which accounts for 77.8% of their crop distribution, while the control group predominantly grows potatoes (75%). Treated group farmers also grow potatoes and carrots, each contributing 11.1% to the total crop output. Control group farmers grow tomatoes (10%), cabbage (5%), carrots (5%), and green peppers (5%). Overall, treated farmers in Mana *woreda* cultivate fewer horticultural crops than the control group.

The pure control group comprised two woredas such as Omonada and Sokoru. In Omonada *Woreda*, the proportions of potato, tomato, onion, green pepper, cabbage, and beetroot in this *woreda* were about 41.1%, 21.5%, 14%, 11.2%, 7.5%, and 4.7%, respectively. Green pepper production was higher in this *woreda* in the pure control group than in other woredas, followed by Kersa *Woreda*. In Sokoru *woreda*, the proportions of tomato, cabbage, potato, carrot, onion, and green pepper were about 44.2%, 29.5%, 20%, 3.2%, 2.1%, and 1.1%, respectively.

Although there are no major differences in crop types between the treatment *woredas* and the two counterfactual *woredas* (control and pure control), likely due to the market survey training provided in the treated *woredas*, there is a greater crop diversification in the pure control *woredas* (six crops in each *woreda*) and control *woredas* (five crops). In contrast, farmers in the treated *woredas* commonly cultivate four crops, except Kersa *woreda*. This suggests that the market survey training provided by the SHEP intervention in the treated areas helps farmers focus on a smaller number of crops compared to the control and pure control groups. While the differences are minimal and crop types are similar across groups, the training guides treated farmers to prioritize crops with higher market demand and better prices, encouraging them to concentrate on a limited number of crops rather than unintended diversifying, thereby increasing the total production of the selected crops.

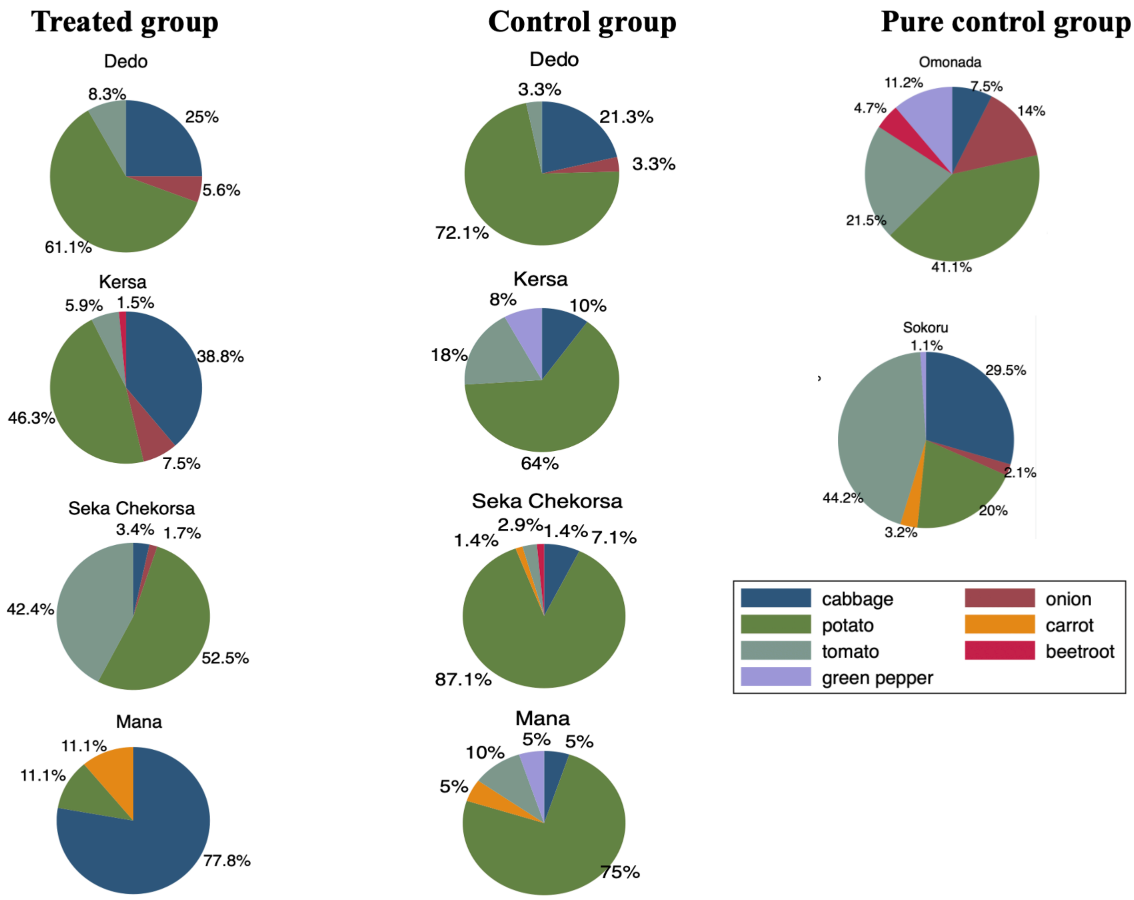


Figure 3: The proportion of horticultural crops produced across woredas.

3.4 Horticulture commercialization

The average horticultural commercialization index for treated, control, and pure control groups, regardless of *woreda*, was 82%, 66%, and 64%, respectively. In horticulture farming, approximately 92.8% of the treated group was categorized as commercial-oriented, with the remaining 7.2% identified as subsistence-oriented. Conversely, approximately 74.1% and 74.3% of farmers were classified as commercial-oriented in the control and pure control groups, respectively, while the remaining 25.9% were considered subsistence-oriented (Figure 4). The proportion of commercial-oriented farmers in the treatment group was more than that of the control group as well as that of the pure control group at the P-value<0.001 level.

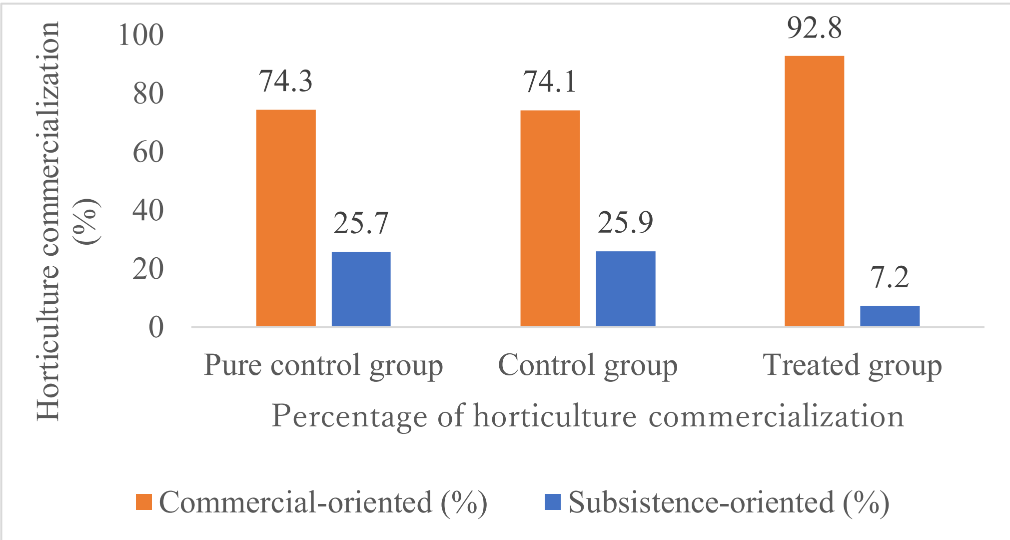


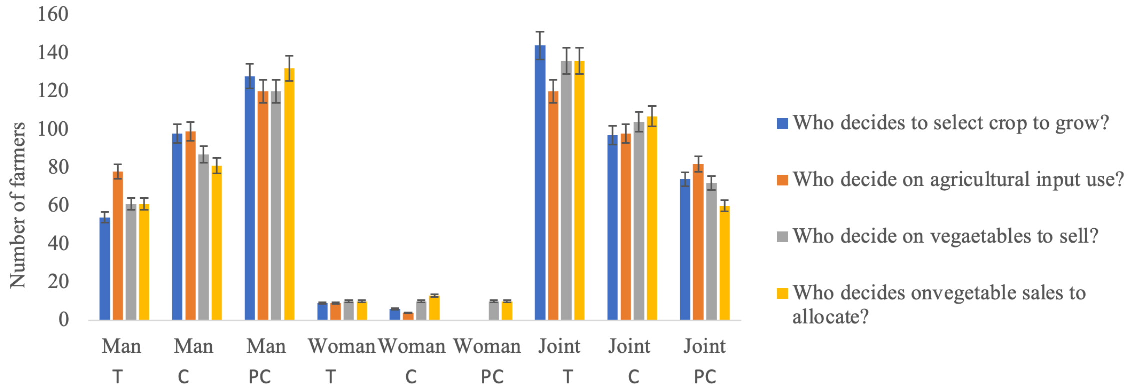
Figure 4: Horticultural commercialization index treatment groups

3.5 Household decision-making in horticulture farming

The household decision-making practices regarding horticulture production and marketing in the study areas have three arrangements: man-alone, woman-alone, and joint (Figure 5). We assessed the situation regarding household decision-making in horticulture production and marketing by asking the farmers four critical questions such as:

1. Who decides which horticulture crops to grow?
2. Who decides which agricultural inputs to use?
3. Who decides which vegetable crop harvests to sell? and
4. Who decides how to allocate vegetable sales?

As shown in Figure 5, the woman-alone decision-making group practiced less across all aspects of horticulture production and marketing than the other groups. When disaggregated by treatment, joint decision-making practices had a higher proportion of SHEP beneficiary farmers than farmers who were not beneficiaries of the project. These results can be attributed to the SHEP project encouraging farmers to make decisions jointly through training, focusing on mindset change for both men and women in the household. On the other hand, man-alone decision-making practices were more frequently observed in non-beneficiary farmers in the control and pure control groups.



Note: T = treated; C= control; PC = pure control

Figure 5: Household decision-making on horticulture production and marketing

3.6 Household and horticultural income

The treated group exhibited a significantly higher mean total agricultural income than the control and pure control groups. Additionally, the treated group demonstrated a significantly higher mean income from horticulture than the control and pure control groups. The horticultural income for treated, control, and pure control groups, on average, was 30,754 Ethiopian birr (ETB[3]) (576.8 USD), 17,842 ETB (334.6 USD), and 19,185 ETB (359.8 USD), respectively (Table 4). If we take the average of the control and pure control group horticulture income, it was 18939.5 birr. Thus, the difference between the treatment and the other groups was 11,814.5 birr (221.6 USD).

[3] ETB stands for Ethiopian birr. Converted, 1 USD was equal to 53.3180 ETB as of February 2023 at the time of data collection (Ethiopian National Bank: https://combanketh.et/en/exchange-rate/

Table 4: Disaggregated income of sample smallholder farmers

Variables	Treated (T)		Control (C)		Pure control (PC)		T vs C	T vs PC
	Mean	SD	Mean	SD	Mean	SD		
Total agricultural income (birr/year)	48,526	40,908	39,719	43,521	34,821	32,982	**	***
HH's income from Horticulture (birr/year)	30,754	33,197	17,842	34,198	19,185	23,876	***	***
IHH's income from fruits (birr/year)	11,886	15,237	14,781	19,085	6,323	8,179	**	***
HH's income from non-horticulture (birr/year)	5,885	9925	7,095	13,172	9,313	16,224	-	**
HH's Income from non-farm (birr/year)	3,583	7,250	4,246	7,478	4,665	7,131	-	-
HH's total income (birr/year)	52,108	42,531	43,966	44,079	39,487	34,257	**	***

Note: HH is household, and the units for income are Ethiopian birr

However, these mean differences do not account for selection or hidden biases between the groups. For example, the study by Fikadu, Nomura, Gebre, Payal, Takahashi, and Yabe (2024)[4] (unpublished manuscript), with the same dataset, found slightly lower horticulture income values—29,889 ETB (560.6 USD) for the treated group, 18,808 ETB (352.8 USD) for the control group, and 19,071 ETB (357.7 USD) for the pure control group—when selection bias was removed using a propensity score matching (PSM) model. This adjustment indicates that the initial mean differences were somewhat inflated by selection bias. Thus, the true impact of the SHEP intervention is more accurately captured by these adjusted values. Therefore, we took the average of the control and pure control group horticulture income, which was 18,939.5 ETB (355.2 USD). The difference between the treatment and the other groups was 109,48.5 birr (205.3 USD). We can conclude that the beneficiary farmers gained an income of 109,48.5 birr (205.3 USD) higher than the farmers without treatment. According to the national-level study by Okoth et al. (2022), the average net farm income (crop and livestock sales) was 430 USD per year in the Jimma Zone. Thus, the beneficiary farmers' mean horticultural income of 29,889 ETB (560.6 USD) was 130.56 USD higher than the average net farm income in the Jimma Zone. Finally, the quantile regression analysis post-PSM provides a deeper understanding of the SHEP intervention's impact at different quantiles in the horticulture income distribution, with values of 12,844 ETB (241 USD), 16,184 ETB (304 USD), and 22,440 ETB (421 USD) at the 10th, 25th, and 50th quintiles, respectively (Table 5).

[4] For detailed discussions, please refer to the forthcoming research paper titled "Heterogeneous Effects of Horticulture Commercialization and Gender-based Decision-making on Smallholder Farmers' Income: Evidence from a Quasi-Experimental Study in Jimma Zone, Ethiopia," authored by Fikadu, Nomura, Gebre, Payal, Takahashi, and Yabe (2024).

Table 5: Horticultural income summary after PSM estimation and treatment effects using quantile regression

Average horticulture income (ETB /year)	**Treated (T)**	**Control (C)**	**Pure Control (PC)**
After matching	29.889 ETB (560.6 USD)	18.808 ETB (352.8 USD)	19,072 ETB (357.7 USD)
Difference after matching (T-C)	11.080 ETB (202.9 USD)		
Difference after matching (T-PC)	10,817 ETB (207.8 USD)		
Treatment effects using quantile regression after PSM estimation (SHEP's effect on horticulture income)			
10th quantile	12,844 ETB (241 USD)		
25th quantile	16,184 ETB (304 USD)		
50th quantile	22,440 ETB (421 USD)		
75th quantile	Insignificant		
90th quantile	Insignificant		
Control variables	Yes		

Moreover, the treated group displayed a significantly higher mean income from fruits than the pure control group, although not necessarily the control group (Table 4). No significant difference was observed between the treated and control groups regarding household income from non-horticulture crop sales. However, there was a statistically significant mean difference between the treated and pure control groups, with the pure control group having higher income gain from non-horticulture crop sales. Furthermore, no significant mean difference existed between the groups regarding income gained from non-farm activities, even though the treated group had the lowest non-farm income. Finally, the treated group exhibited a statistically significantly higher mean total income than the control and pure control groups. In sum, in most cases, the treated group significantly showed increased income from different sources compared to the control and pure control groups, even though the effects may have varied depending on the specific type of income and the comparison group.

As shown in Figure 6, approximately 43.3%, 36.8%, and 58.1% of the total household income per year came from targeted horticulture crop sales in the pure control, control, and treated groups, respectively. This result suggests that the SHEP intervention has been advantageous in generating a higher income share from horticulture crop sales.

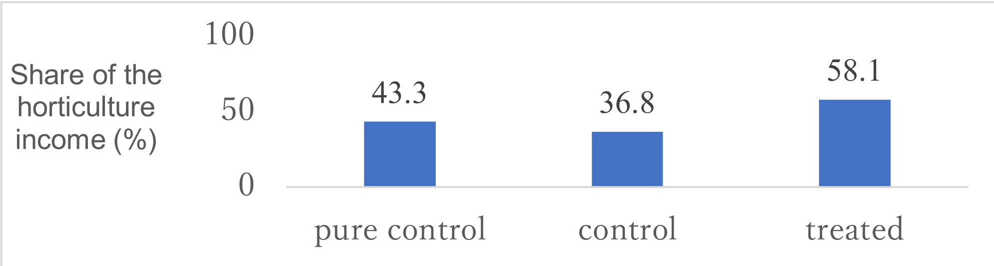


Figure 6: The share of horticulture crop income to the total household income per year

As depicted in Figure 7, joint decision-makers in the treated group had a statistically higher average horticulture income, followed by those practicing joint decision-making in the pure control and control groups. This indicates that the SHEP intervention was positively associated with households where decision-making was undertaken jointly between men and women. The finding highlights the potential benefits of joint decision-making in increasing horticultural income. Furthermore, male decision-making households in the treatment also had a statistically higher average horticulture income compared to those practicing joint decision-making in the pure control and control groups. It seems the SHEP had the greatest impact on the male decision-making households that had higher incomes compared to joint decision-making households. The male decision-making farmers appeared to receive the biggest advantage from joining the program. This could be likely due to their stronger social networks, greater likelihood of discussing with peers, and better access to market information and opportunities compared to women. However, further analysis is needed to investigate the specific reasons behind this scenario. On the other hand, female decision-making households in the treatment group did not have a statistically higher average horticulture income compared to those practicing female decision-making in the pure control and control groups. The mean incomes of female decision-making households were also lower across treatment, control, and pure control groups. Thus, the project should pay closer attention to female decision-making households.

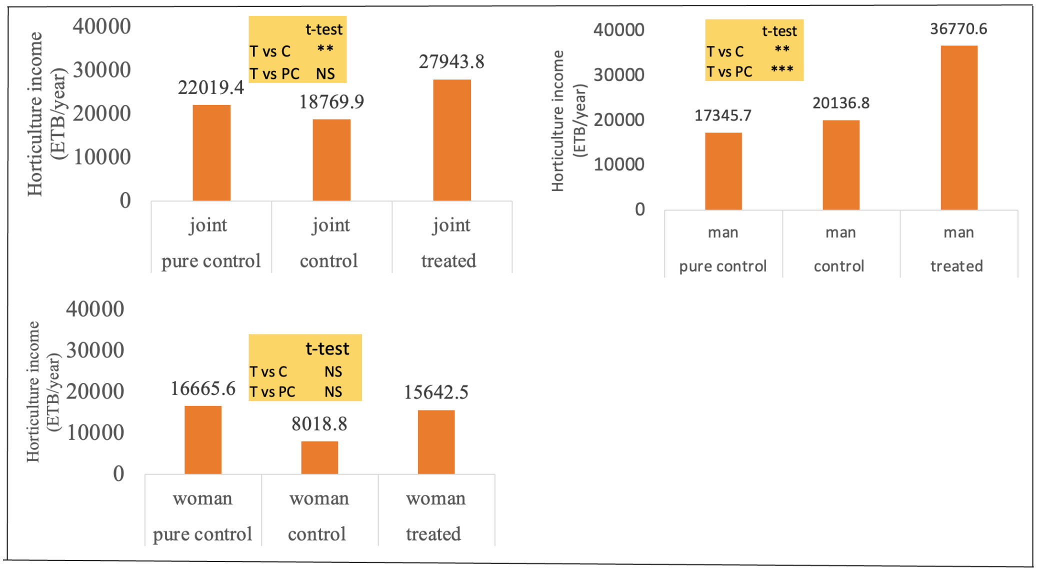


Figure 7: Horticulture income across decision-making and treatment groups

3.7 The food security situation of the smallholder farmers

We applied the Household Food Insecurity Access Scale (HFIAS), developed by the USAID Food and Nutrition Technical Assistant (FANTA) project (Coates et al. 2007). The questionnaire is included in Appendix 3. As presented in Figure 8, households in the pure control group, control group, and treated group experienced severe food insecurity at rates of about 13.9%, 13.4%, and 4.4%, respectively. Moderate food insecurity was experienced by about 10.9%, 7.9%, and 5.3% of households in the same groups. Mild food insecurity affected about 36.1%, 23.4%, and 26.6% of households, respectively. Finally, food security was experienced by about 39.1%, 55.2%, and 63.8% of households in the pure control, control, and treated groups, respectively.

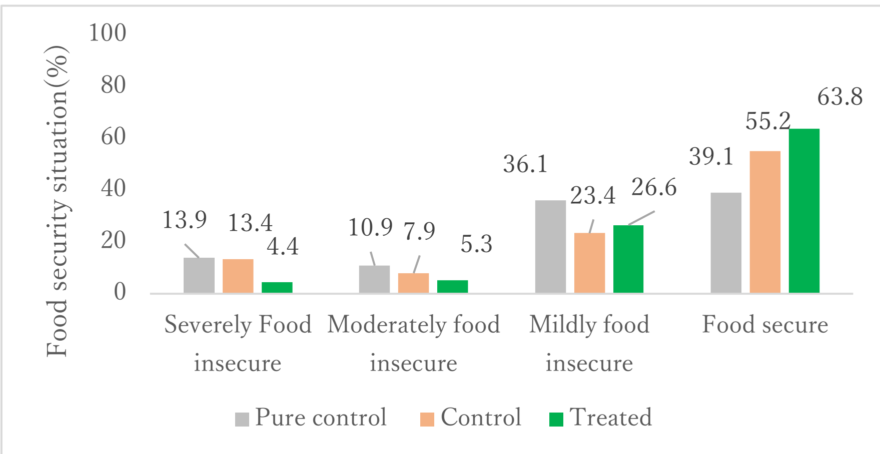


Figure 8: Food security situation of the smallholder farmers across the sample groups.

3.7.1 Household food security conditions across *kebeles*

Among the sample of 22 *kebeles*, Kitimbile, Girma, Gibe/Siba, and Toli Kerisu exhibited high levels of food security, with percentages ranging from 78% to 84%. These *kebeles* likely have reliable access to food and resources, contributing to their food security. On the other hand, *kebeles* such as Wagtola, Chefe Nega, Wengecho, and Gonjo Abaye faced severe food insecurity situations, with percentages ranging from 23% to 30% (Figure 9).

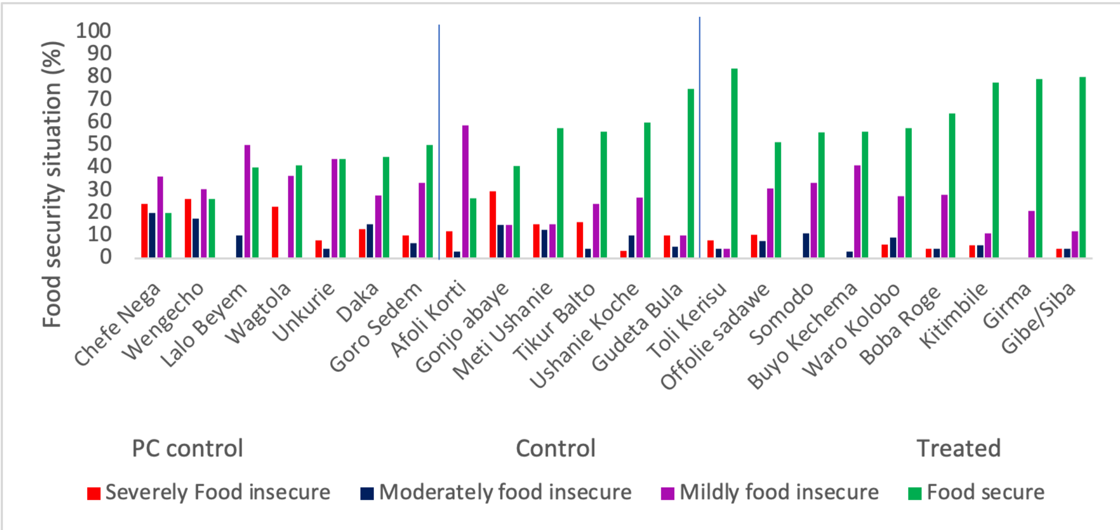


Figure 9: Household food security across *kebele*

From the left of Figure 9, among the pure control group, Chefe Nega Kebele faced significant food security challenges. Only a relatively low percentage of households were categorized as food secure (20.0%). Remarkable proportions experienced mild (36.0%) to severe (24.0%) food insecurity.

Among the pure control group:

- Wengecho Kebele faced significant food security challenges. A relatively low percentage of households were categorized as food secure (26.1%). Others experienced mild (30.4%), moderate (17.4%), and severe (26.1%) food insecurity.

- Lalo Beyem Kebele showed moderate food security, with a relatively large percentage of households categorized as food secure (40.0%). However, also a significant proportion experienced mild (50.0%) food insecurity.

- Wagtola Kebele exhibited moderate food security, with a relatively large percentage of households categorized as food secure (40.9%). However, others experienced mild (36.4%) to severe (22.7%) food insecurity.

- ♦ Unkurie Kebele had a relatively large percentage of households categorized as food secure (44.0%), while others were experiencing mild (44.0%) to severe (8.0%) food insecurity situations.
- ♦ Daka Kebele had a relatively large percentage of households categorized as food secure (44.7%). However, others experienced mild (27.7%), moderate (14.9%), and severe (12.8%) food insecurity situations. In sum, the food security situation of the household shows heterogeneous scenarios at the kebele level.
- ♦ Goro Sedem Kebele showed moderate food security, with a relatively large percentage of households categorized as food secure (50.0%) while other households experienced mild (33.3%), moderate (6.7%), and severe (10.0%) food insecurity.

Among the control group:

- ♦ Afoli Korti Kebele exhibited a high level of food insecurity, with a relatively low percentage of food-secure households (26.5%) and a significant majority experiencing mild (58.8%) to severe (11.8%) food insecurity.
- ♦ Gonjo Abaye Kebele faced significant food security challenges, with a relatively large percentage of food-secure households (40.7%) while a considerable proportion experiencing moderate (14.8%) to severe (29.6%) food insecurity.
- ♦ Meti Ushanie Kebele demonstrated moderate food security, with a majority of households categorized as food secure (57.5%) while notable percentages of households experienced mild (15%), moderate (12.5%), and severe (15%) food insecurity.
- ♦ Tikur Balto Kebele exhibited moderate food security, with a majority of households categorized as food secure (56%) while notable percentages of households experienced mild (24%) to severe (16%) food insecurity.
- ♦ Ushanie Koche Kebele showed that a majority of households were categorized as food secure (60.0%) while notable percentages of households experienced mild (26.7%) to moderate (10.0%) food insecurity. The percentage of severely food-insecure households also existed in the kebele (3.3%).
- ♦ Gudeta Bula Kebele has a high proportion of food security, with most households

categorized as food secure (75.0%) while notable percentages of households experienced mild (10.0%) to severe (10.0%) food insecurity.

- Toli Kerisu Kebele showed high food security, with most households categorized as food secure (84.0%) while the percentage of mildly and moderately food insecure households was relatively low (4.0% each) while it is noteworthy that a small proportion experienced severe food insecurity (8%).

Among the treatment group:

- Offolie Sadawe Kebele demonstrated moderate food security, with relatively large percentage of the households categorized as food secure (51.3%) while a significant percentage of households experienced mild (30.8%) to severe (10.3%) food insecurity situations.

- Somodo Kebele had moderate food security, with a relatively large percentage of households categorized as food secure (55.6%) while notable proportions experienced mild (33.3%) to moderate (11.1%) food insecurity, but no households are categorized as severely food insecure.

- Buyo Kechema Kebele exhibited moderate food security, with a relatively large percentage of households categorized as food secure (55.9%) while a notable proportion experienced mild (41.2%) and moderate (2.9%) food insecurity situations. While no households were categorized as severely food insecure, addressing mild food insecurity remains essential to ensure improved food access and stability.

- Waro Kolobo Kebele exhibited a relatively large percentage of food security, with a significant portion of households categorized as food secure (57.6%) while a notable percentage of households experienced mild (27.3%) to moderate (9.1%) food insecurity, indicating some challenges in ensuring consistent access to food resources. Additionally, it is noteworthy that a small percentage of households faced severe food insecurity (6.1%).

- Boba Roge Kebele demonstrated relatively high food security, with a majority of households categorized as food secure (64.0%). However, notable percentages of households still experienced mild (28.0%) to severe (4.0%) food insecurity.

- Kitimbile Kebele exhibited high food security, with a majority of households categorized as food secure (77.8%) while elatively low percentages of households experienced mild (11.1%) to severe (5.6%) food insecurity.

- Girma Kebele exhibited high food security, with most households categorized as food secure (79.2%), while about 20.8% of the households had mild food insecurity situations. No households experienced moderate or severe food insecurity in this *kebele*.

- Gibe/Siba Kebeles showed a high proportion of food security, with most households categorized as food secure (80.0%). Moderately low percentages of households experienced mild (12.0%) to severe (4.0%) food insecurity.

3.7.2 Household food security conditions based on decision-making

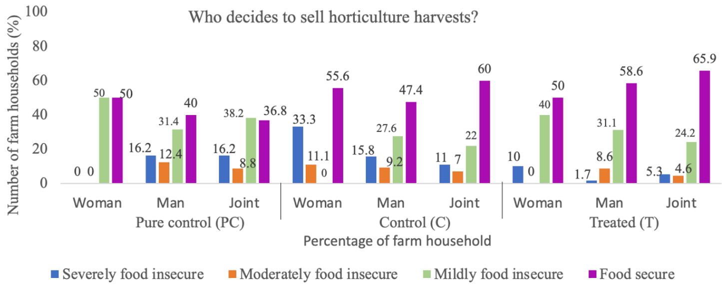
Using the household decision-making practices regarding horticulture production and marketing in the study areas, we compared how their decisions impacted household food security conditions. Here, regardless of groups, we found that joint decision households had the highest food security, while women-only decision households had the highest rates of severe food insecurity (Figure 10).

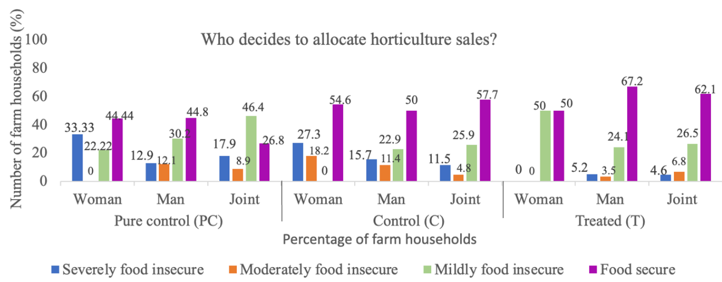
Figure 10: Gender-based decision-making on "which crop to grow" on household food security

The same trend was observed in gender-based decision-making regarding "which crop harvest to sell" and its impact on household food security (Figure 11). Among the food secure category, 58% of joint decision-making households were food secure, followed by 53% of women-only decision-making households. Notably, 17% of women-only decision-making households were classified as severely food insecure. This indicates the dichotomous situation of the women-only decision-making households: some are well managed, but others fall into food insecurity, highlighting the vulnerable condition of women in these households. Thus, the active involvement of women-only decision-making households in the project could improve food insecurity.

Figure 11: Gender-based decision-making on "which crop harvest to sell" on household food security

Among the food secure category, about 65.9%, 60%, and 36.8% of households were joint decision-makers on harvests to sell in the treated, control, and pure control groups, respectively. Similarly, in the food secure category, about 62.1%, 57.7%, and 26.8% of households were joint decision-makers on sales allocation across the same groups. In both cases, there was a statistically significant difference in proportions between the treated and control groups and between the treated and pure control groups (Figure 12). This indicates that joint decision-making was more prevalent among SHEP project beneficiary households, likely due to the project's gender-inclusive training. Households with joint decision-making on harvests to sell and sales allocation had a higher proportion of food security compared to those with female-only or male-only decision-making. The reason could be that joint decision-making between couples in agricultural households can enhance accountability and commitment to improving income and food security goals. When couples actively participate in decision-making, they tend to feel a stronger sense of ownership and responsibility for the outcomes. Also, joint decision-making can promote the exchange of knowledge and resources. When both men and women in a household participate in decisions, they bring diverse viewpoints, expertise, and assets. For example, women, who typically oversee household food management, offer valuable perspectives on the family's nutritional requirements, while men may prioritize market access and financial considerations. By integrating these perspectives, households can make more comprehensive and well-informed decisions that better meet their overall needs, thereby improving income and food security (Malapit et al., 2019).





Note: * = p < 0.10; ** = p < 0.05; *** = p < 0.01

Decision-making on harvests to sell	**Proportion test**	
	T vs C	**T vs PC**
Joint decision-making		
Food secure groups	**	***
Mildly food insecure groups	NS	NS
Moderately food insecure groups	NS	NS
Severely food insecure groups	NS	NS
Man-alone decision-making		
Food secure groups	NS	NS
Mildly food insecure groups	NS	**
Moderately food insecure groups	NS	*
Severely food insecure groups	***	***
Woman-alone decision-making		
Food secure groups	NS	NS
Mildly food insecure groups	**	NS
Moderately food insecure groups	NS	-
Severely food insecure groups	NS	NS
Decision-making on sales to allocate		
Joint decision-making		
Food secure groups	**	***
Mildly food insecure groups	NS	NS
Moderately food insecure groups	NS	NS
Severely food insecure groups	NS	NS
Man-alone decision-making		
Food secure groups	NS	NS
Mildly food insecure groups	NS	***
Moderately food insecure groups	*	***
Severely food insecure groups	**	***
Woman-alone decision-making		
Food secure groups	NS	NS
Mildly food insecure groups	**	NS
Moderately food insecure groups	NS	-
Severely food insecure groups	*	*

Figure 12: Gender-based decision-making on "harvest to sell" and "sales to allocate" on household food security across treatment groups

3.8 The effects of the National Wheat Flagship Program on horticultural production in Ethiopia (Field observations and farmers discourse)

As shown in Figure 13, about 58.2% of the sampled farmers converted their horticulture land to wheat production due to the strict national wheat policy, while the remaining 41.8% did not make the change, even though the national wheat conversion policy[5] has been implemented for all irrigation user farmers across the country. These farmers may have decided that there was still sufficient demand and profitability in horticulture crops compared to wheat. They may have chosen to continue farming horticulture crops because they already had established markets or contracts for their harvests. Historically, farmers in the study areas attach great importance to maize production rather than wheat, which could encourage them to resist the policy and continue with their existing farming methods. According to these farmers during the field survey, the main reason for this decision is that government enforcement is more unofficially relaxed if their horticulture land is not clustered. However, the survey also found that farmers are strictly compelled to grow wheat if their horticultural land is deemed suitable for clustering.

[5] The Ethiopian government launched a National Wheat Flagship Program (NWFP) to attain self-sufficiency and transition into a net exporter by the fiscal year 2025/26. This strategic initiative aims to bolster domestic wheat production while reducing the country's reliance on imports. The NWFP entails the augmentation and advocacy of irrigated wheat cultivation across a cumulative landmass of one million hectares during the 2022/23 agricultural season, with subsequent annual expansion targets set between 5% and 10% (Ethiopian Ministry of Agriculture [MoA] 2023)

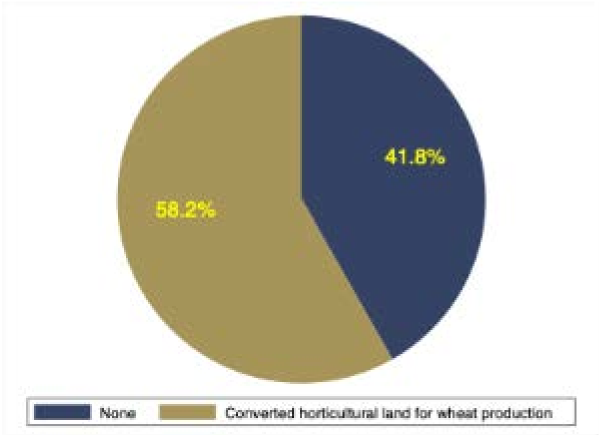


Figure 13: Horticulture land conversion to wheat production

Farmers were uncertain about switching from horticultural crops to wheat at first. Within our sample, consisting of two groups—treated and control—the farmers in the treatment group expressed uncertainty about whether the project had realized the effects they had initially hoped for. At the outset, those farmers emphasized the SHEP intervention's positive effects and reported higher incomes and improved food security as direct outcomes.

A significant challenge arose midway through the SHEP project intervention when the Ethiopian government launched a national wheat flagship program. The government's rationale for this policy centered on achieving self-sufficiency, aiming to reduce dependence on imported wheat and potentially export wheat to neighboring African countries. Thus, this policy mandated that all farmers with irrigation farmland switch from growing horticultural crops to cultivating wheat using irrigation to achieve food self-sufficiency and compensate for the imported wheat. However, smallholder farmers felt this policy was sudden and uncertain, leading them to urge the government to provide clarification. As farmers articulated, the impact of the wheat policy on individual farmers could be significant. They sincerely expressed concerns that disrupting their ongoing horticulture activities would diminish their income.

For example, one farmer's testimony highlights the stark contrast in income between horticulture and wheat farming. Before the policy, the farmer earned a substantial 80,750 birr annually from selling cabbage harvested from one hectare of irrigated land. However, after switching to wheat, the farmer's income dropped to 35,000 birr annually due to lower yields. This represents a staggering income loss of 45,750 birr annually, severely affecting the farmer's financial situation. Despite their concerns about the impact of switching from horticulture crops to wheat cultivation on their income, farmers felt compelled to comply with the policy. The government has adjusted the policy in response to farmers' inquiries, allowing them to continue producing horticultural crops during the second horticulture production season (March to June) since 2023. This decision acknowledges farmers' difficulties and aims to provide them with greater support and flexibility in executing horticulture and wheat production.

3.9 List of adaptation measures for agriculture risks (climate-smart agricultural practices)

Participating in the SHEP project encourages farmers to proactively manage agricultural risks, particularly by adapting CSA practices. Though the primary focus of the SHEP initiative may not explicitly center on CSA practices, its comprehensive training package advocates for the adoption of CSA principles. These include the utilization of disease-resistant crop varieties, adjustments to irrigation scheduling, optimization of sowing and harvesting timelines, and the promotion of horticultural crop diversification within the same season (Table 6). While the project's formal curriculum may not overtly delineate these concepts, its operational tasks inherently align with adaptation measures pertinent to horticultural risks. For instance, in scenarios where irrigation water availability is constrained, the project actively promotes the prudent utilization of existing water resources. Furthermore, the project facilitates the dissemination of relevant information regarding the selection and acquisition of inputs, including improved and disease-resistant crop varieties, fostering a conducive environment for implementing CSA practices.

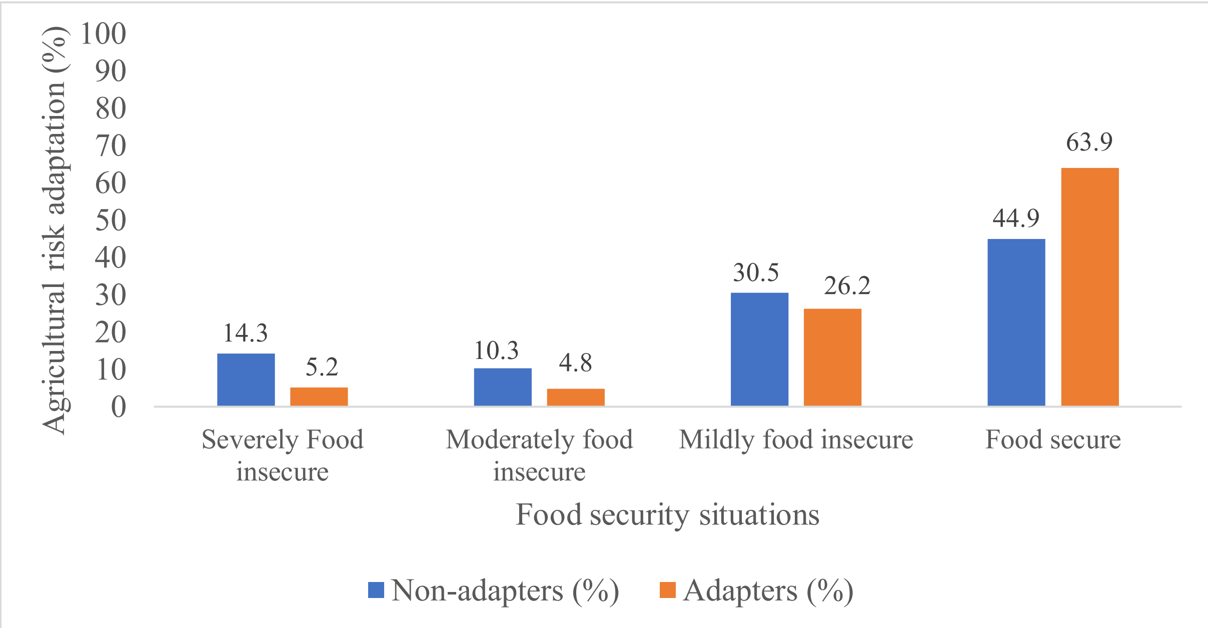
Table 6: The types of adaptation measures for agricultural risks in horticulture farming

Adaptation measures for agriculture risks	Dummy	n	%
Do you have any adaptation strategies for agricultural risk?	Yes	252	58.7
	No	358	41.3
Types of adaptation measures/ climate-smart agriculture practices			
Use disease-resistant variety	Yes	192	31.5
	No	418	68.5
Change irrigation schedule	Yes	46	7.5
	No	564	92.5
Change the sowing and harvesting date	Yes	96	15.7
	No	514	84.3
Diversify horticulture crops in the same production season	Yes	62	10.2
	No	548	89.8

Where, n=sample size

The association between agricultural risk adaptation and household food security is shown in Figure 14. Among households experiencing severe food insecurity, about 14.3% reported no adaptation strategies for agricultural risk, while 5.2% had adapted such strategies. This indicates that some severely food-insecure households have implemented measures to mitigate agricultural risks, although in a smaller proportion than those without such practices. About 10.3% of the households with moderate food insecurity were yet to adopt adaptation strategies for households, while 4.8% had done so. Similar to severely food-insecure households, a minority had taken steps to adapt to agricultural risks. Among food-secure households, approximately 63.9% implemented adaptation strategies, while about 45.0% did not. When severe food insecurity and moderate food insecurity categories were combined, almost a quarter (24.6%) of the non-CSA adapter group fell into these categories, while only 10.0% of the CSA adapter group was in the categories. This indicates that non-CSA adapters are more food insecure than the CSA adapter group. In order to improve the food security situation, the results suggest that a substantial proportion of farmers still need to apply adaptation strategies for agricultural risks.

Figure 14: The association between agricultural risk adaptation and food security



4. Conclusions

This discussion paper comprehensively analyzes the intervention of the SHEP project in Ethiopia, which provides market-oriented extension services through a series of practical trainings for horticulture-growing smallholder farmers. Beneficiary (treated) farmers have a statistically higher average horticulture income of 29,889 ETB (560.6 USD) per annum compared to control farmers with values of 18,808 ETB (352.8USD) and pure control farmers with values of 19,072 ETB (357.7 USD). Approximately 93% of the treated group was categorized as commercial-oriented, while about 74% of farmers were classified as commercial-oriented in the control and pure control groups. During the intervention, the Ethiopian government launched the national wheat flagship program to achieve self-sufficiency and reduce the volume of imported wheat; this notably affected horticulture production and thereby had negative effects on horticultural income. Despite these changes, there has been an increase in farmer incomes due to the project in the project areas, as we showed in the paper. Thus, the SHEP approach successfully increased average horticulture incomes in the treated group compared to the control and pure control areas. With recent policy relaxations, the government has allowed the cultivation of horticultural crops for one of the two seasons. Thus, farmer income from horticultural crops is likely to increase further.

Regarding household decision-making, joint decision-making practices have a higher proportion than man- or woman-only in the treated group compared to the control and pure control groups. The SHEP intervention offers training on gender empowerment in horticulture production and marketing, aiming to empower farmers and encourage meaningful collaboration within households. Unlike many women-focused empowerment programs, the SHEP approach seeks to shift the mindset of both men and women by providing them with business and life skills while highlighting the significance of joint decision-making and shared control over resources. This shows that the SHEP project intervention helps farmers adopt joint decision-making practices. Conversely, man-alone decision-making practices were more commonly observed in the control and pure control groups. Moreover, our findings show that the treated farmers were food secure while a higher proportion of the farmers in control and pure control groups faced severe food insecurity. We also found that the household food security situation was heterogeneous at the kebele level.

In the context of the SHEP project intervention, while the primary focus may not overtly prioritize CSA practices, its extensive training curriculum advocates for adapting agricultural risk adaptation strategies aligned with CSA principles. These practices include utilizing disease-resistant crop varieties, adjusting irrigation schedules, optimizing sowing and harvesting timelines, and promoting horticultural crop diversification within the same season. Our findings indicate a notable correlation between adapting these adaptation measures and a higher propensity toward food security among households. Additionally, a notable proportion of mildly food-insecure households have demonstrated proactive engagement in mitigating agricultural risks by adapting such practices.

Farmers who are non-beneficiaries of the SHEP project face severe food insecurity problems compared with project beneficiary farmers. Horticultural crops could be cash crops and subsistence crops since some overgrown or undergrown ones could be home-consumed. To overcome this situation, the government and non-government sectors need to collaborate and invest in horticultural production. Moreover, understanding the heterogeneous nature of food security situations at the *kebele* level is crucial for designing targeted interventions or context-specific approaches to address specific challenges at the *kebele* level. As a result, our comprehensive descriptive analysis shows that a market-oriented agriculture extension through SHEP improves farmers' income and food security in Ethiopia. While this study offers valuable insights into the effects of the SHEP intervention on income and food security, caution must be taken to avoid overstating the findings due to the cross-sectional nature of the dataset, which does not address endogeneity issues. Thus, we are constructing a panel dataset for the phase-II SHEP intervention for further analysis to estimate its comprehensive effects on income and food security.

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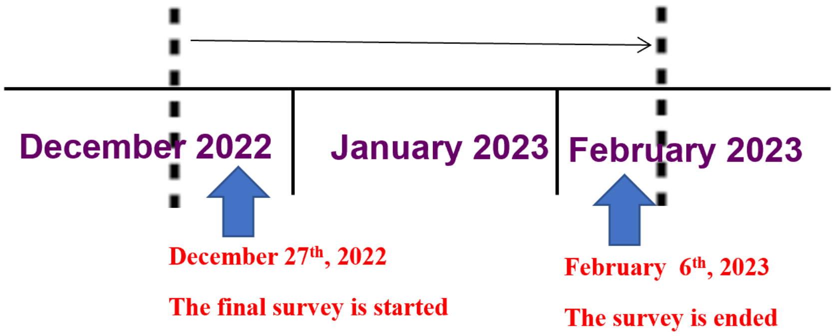
Appendices

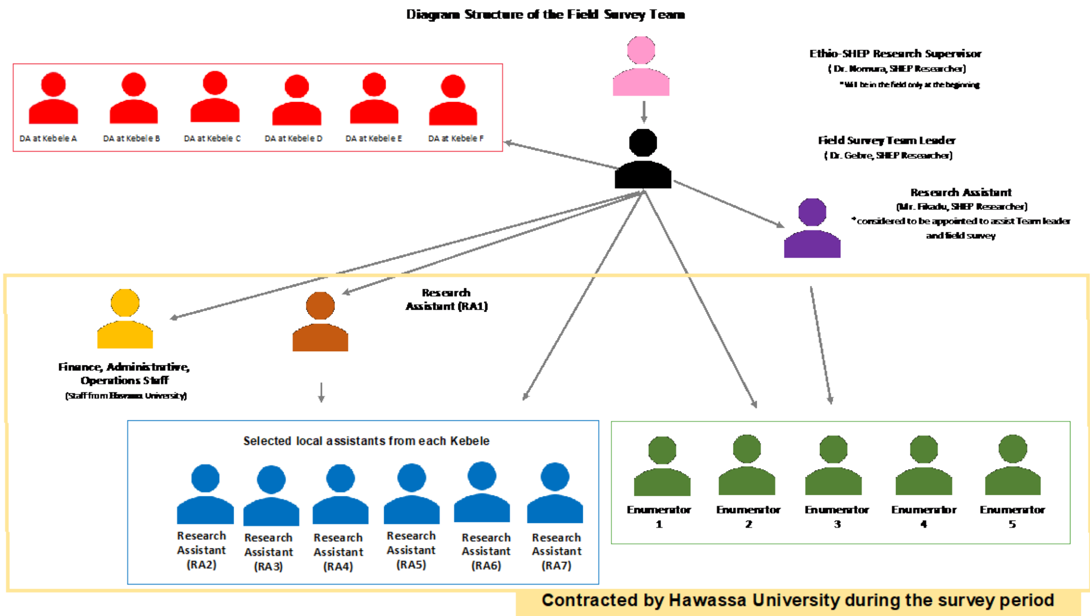
Appendix 1: Timeline of the field survey data collection



Note:

- 24/12/2022 – training for enumerators
- 25/12/2022 – pre-testing the questionnaire

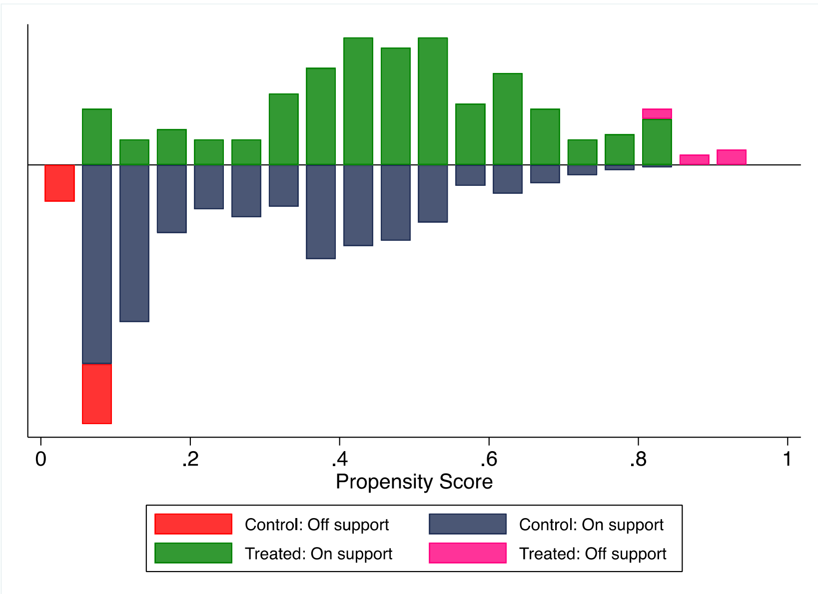
Appendix 2: Field survey implementation structure



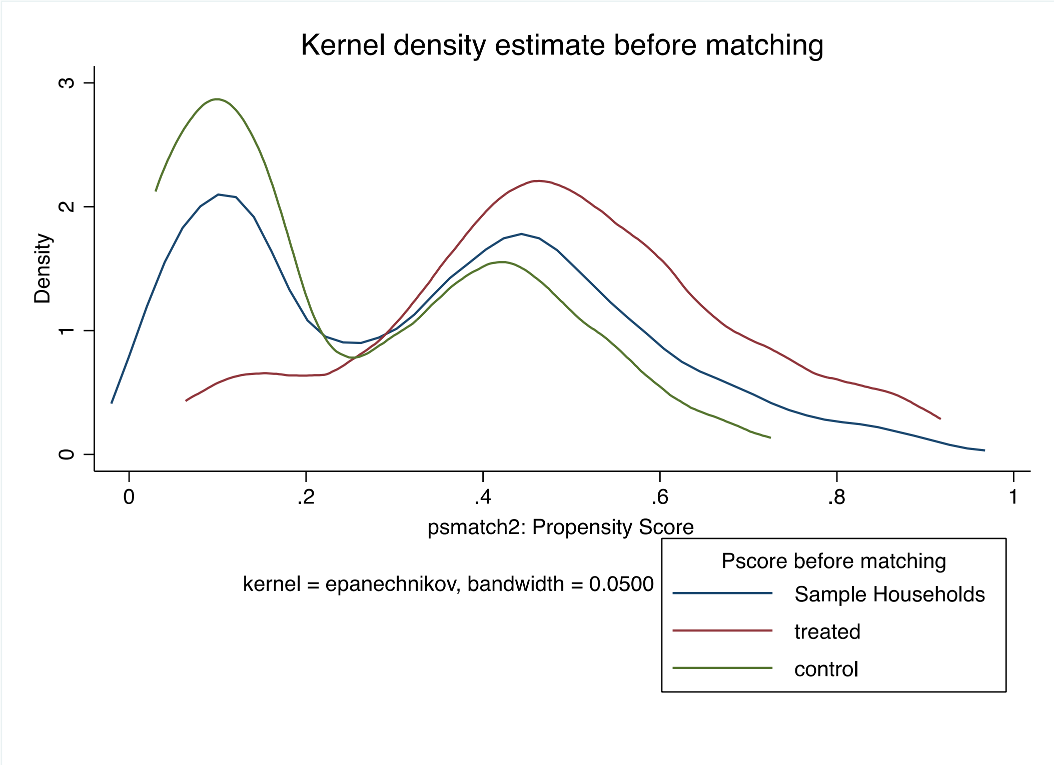
Appendix 3: Questions for measuring food security

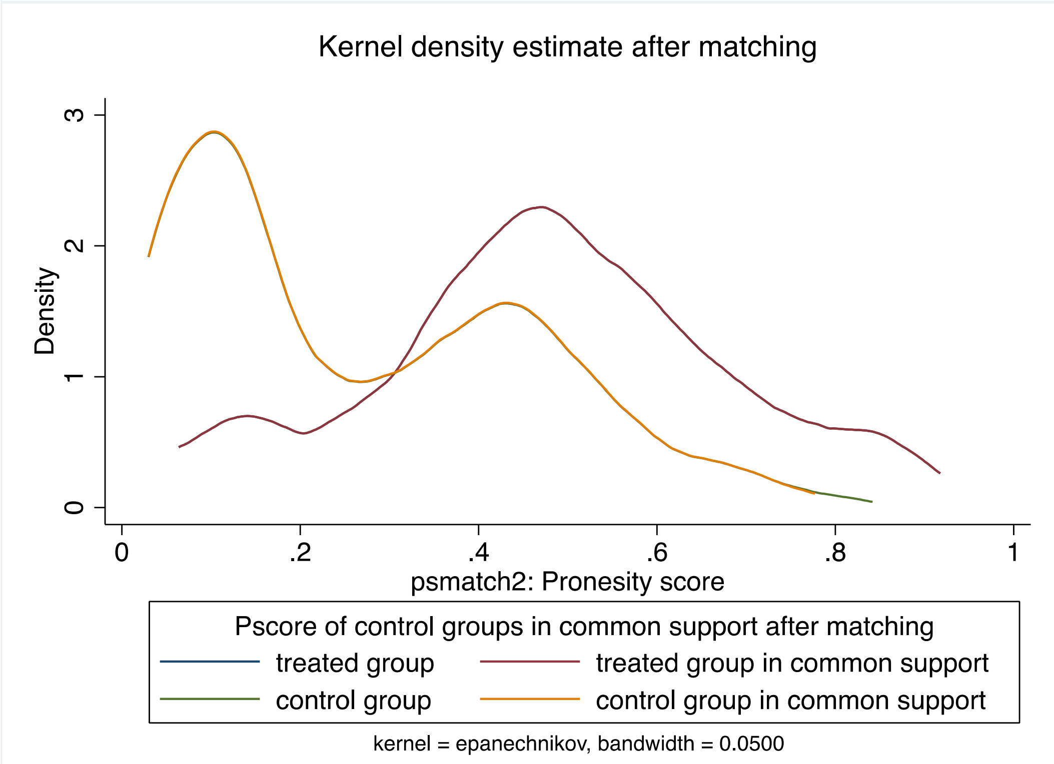
1. In the past four weeks, did you worry that your household would not have enough food?
2. In the past four weeks, were you or any household member not able to eat the kinds of food you preferred because of a lack of resources?
3. In the past four weeks, did you or any household member have to eat a limited variety of food due to a lack of resources?
4. In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?
5. In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?
6. In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?
7. In the past four weeks, was there ever no food to eat of any kind in your household because of a lack of resources to get food?
8. In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?
9. In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?

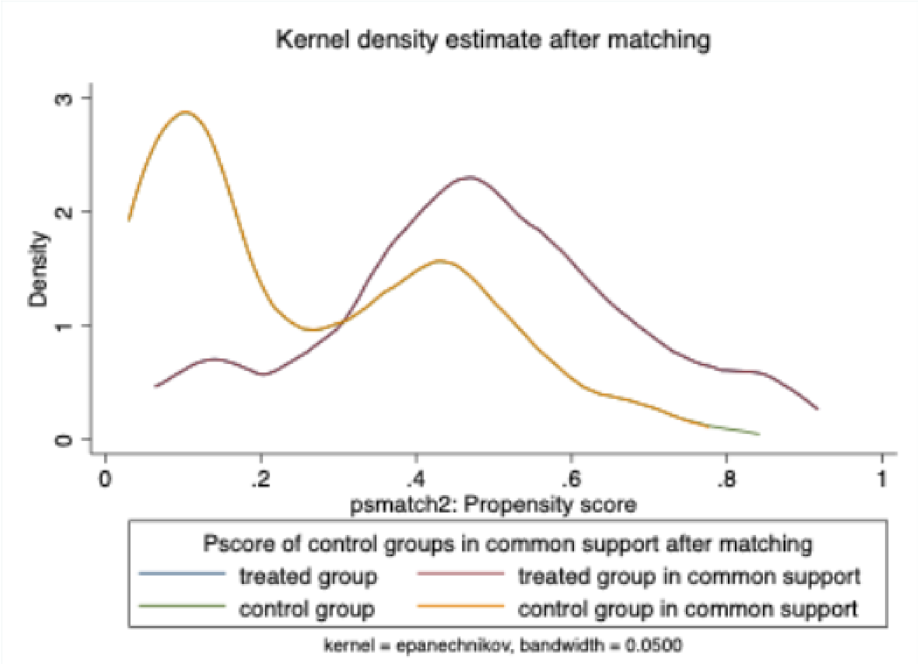
Appendix 4: Propensity score matching estimates (common support assumption) using kernel matching



Appendix 5: Common support using kernel density plot before and after matching







Appendix 6: Robust check for the hidden bias correction using different matching algorithms

Matching algorithms	Mean bias before matching	Mean bias after matching	% of Bias reduction (in range)	Value of R^2 before matching	Value of R^2 after matching	LR χ2 (p-value) before matching	LR χ2 (p-value) after matching	Off support sample
Nearest neighbor matching	38.4	5.1	48.3% - 100%	0.178	0.006	139.24 (0.000)	3.18 (0.672)	44
Kernel matching	38.4	2.2	74% - 100%	0.178	0.001	139.24 (0.000)	0.46 (0.993)	44
Radius caliper matching	38.4	5.1	48.3% - 100%	0.178	0.006	139.24 (0.000)	3.18 (0.672)	44

Abstract (in Japanese)

要　約

SHEP は、小規模園芸農家の「作って売る」から「売るために作る」への意識変革を起こし、営農や栽培スキル向上によって農家の園芸所得を向上させることを目指している。今回の研究で SHEP は小規模園芸農家の収入と食料安全保障を向上させており、特に、SHEP アプローチで取り組んでいる男女共同での意思決定は世帯の食料安全保障に正のインパクトを与えることが示唆された。評価には、GIS データを用いて園芸生産と商業化に欠かせない農業の特殊性である土壌特性、傾斜、標高、灌漑の利用可能性、市場の特殊性である主要都市までの距離と道路密度の６つの項目を基準に比較対照地域を特定した。さらに傾向スコアマッチングで共変量によるバイアスを小さくすることでプロジェクト対象地域農家に限りなく近い対照農家との比較を可能とした。調査は、エチオピアのオロミア地方における、610 件の農家を対象とした。まず、介入グループの園芸収入平均（29,889ETB、560.6USD）と食料安全保障（64%）は、他のグループより高かった。これはオロミア州ジンマの純農業収入平均である 430 米ドルよりも処理グループの園芸収入平均は 130.6USD より高いことを示している。このように、介入グループは、国の小麦フラッグシップ・プログラムの下で積極的に園芸作物を作れないという状況下でも、対照グループや純粋対照グループよりも統計的に高い園芸収入平均を得ていた。さらに、介入グループは世帯の食料安全保障が確保されている一方で、対照グループと純粋対照グループでは、深刻な食糧不安の状況に直面している農家の割合が高かった。また、プロジェクトの男女共同参画研修により、受益世帯間でより夫婦共同で意思決定が行われており、食料安全保障に貢献していることがデータから見えてきた。最後に、SHEP の広範な研修カリキュラムは、気候スマート農業（CSA）の原則に沿った農業リスク適応戦略の採用を提唱しているが、我々の調査結果は、これらの CSA 対策の採用と世帯の食料安全保障への傾向の向上との間に顕著な相関関係があることを示唆している。本研究を通じ、零細農家の所得と世帯レベルの食料保障を向上させるためには、エチオピアにおいては SHEP のようなアプローチが有効であると考えられる。

キーワード： 園芸商業化、傾向スコア、SHEP、空間データフィールド選択法
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