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Impact of small-scale irrigated vebetable production on household food and nutrition security

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ABSTRACT

In Ethiopia, typically two-thirds or more of the population depends on farming for livelihood. It is essential to increase the productivity and profitability of small-scale irrigation systems in developing countries for improving the food security and well-being of small-scale irrigators and their communities. The study analyses the impact of Small-Scale Irrigated Vegetable Production on Household Food and Nutrition Security using mixed method approach. A cross-sectional data collected from a sample of 254 farm households in four kebeles of Kombolcha district selected through multistage random sampling procedures following probability proportional to sample size technique. The primary data were collected from randomly selected respondents, focus group discussants and key informant interviewees whereas secondary data were referred from Kombolcha district office of agriculture. Descriptive statistics and inferential methods, including t-tests and Chi-square tests, were applied alongside an econometric model using Propensity Score Matching. The survey result showed 51% sample household head were participant of small-scale irrigated vegetable production. The result of Propensity score matching estimation showed that participation in small-scale irrigation based vegetable production has significant impact on food and nutrition security of participants by having 1.58, 8.81 difference in dietary intake of household's dietary diversity and food consumption score respectively when compared to non-participants. These findings highlight the need for policies that promote irrigated vegetable production to ensure food and nutrition security in rural Ethiopia.

Key words: Participation, Small-Scale Irrigation, Vegetable Production, Impact, Logit

1. Background of the Study

The majority of developing countries' economies continue to be based on agriculture. It is normally the largest source of employment. In Ethiopia, typically two-thirds or more of the population depends on farming for a living [1]. In Ethiopia, agriculture accounts for 34% of the country's gross domestic product (GDP), employs about 80% of the employees, and generates 79% of exports [2]. It is essential to increase the productivity and profitability of small-scale irrigation systems in developing countries for improving the food security and well-being of small-scale irrigators and their communities [3]. Small-scale irrigation has been shown to significantly boost productivity, food security, and income in rural areas of developing countries [4]. Irrigated farming is identified as vital in growing land productivity, improving foods safety, incomes better and growing potentialities for more than one cropping and crop diversification. [5].

With more than 105 million estimated citizens as of 2017, Ethiopia is the second-most populated country in Africa after Nigeria [6]. More than 8.1 million people need food assistance in 2019 due to intercommunal violence and displacement that comes from it, which affects the country's food and nutritional security situation [7]. Although efforts to reduce poverty and enhance human development have greatly improved people's lives, about 22 million people still live in poverty. Even though the country's Human Development Index (HDI) is improving, Ethiopia still falls in poorest countries in the world, ranking 173rd out of 189 countries [8]. Irrigation would greatly increase and boost productivity in Ethiopia, since the quantity, timing, and distribution of rain are all erratic. The eastern and central rift valleys of the nation are the main regions where vegetables are produced. The majority of the vegetables grown in the eastern region are sent to Djibouti, while smaller quantities exported to Yemen, Pakistan, Saudi Arabia, and Europe [9].

Despite the country's predicted 4.5 million ha of irrigable land, only 274,612 ha, or around 6.1 percent, is now covered by irrigation. Due to the majority of farmers' reliance on rain-fed agriculture, the country's agricultural industry is extremely vulnerable and sensitive to the effects of weather and climatic variability, which can cause partial or complete crop failure and caused food shortages [10]. Due to this reason, the yield and efficiency of the agricultural sector remains stumpy, which in turn, lead to the rampant food insecurity problem and poverty in the country and inability to meet the domestic need of the population with the country's per capital income of $590 is substantially lower. This justify that the sector does not enable the country to meet the food requirement of the people and the country remains among one of the food aid recipient countries in the world [11].

Therefore, one of the key intervention measures to increase agricultural productivity in the country's rural areas is the expansion of small-scale irrigation. This strengthens the foundation for sustainable agriculture, increases food security for underprivileged populations through irrigated agriculture, and contributes to the enhancement of human nutrition. It also helps poor farmers in surviving rainfall and water shortages [12].

The use of irrigation has the power to stabilize agricultural output and reduce the impact of erratic or insufficient rainfall. Delayed arrival of rainy seasons, early withdrawal, and uneven rainfall were obstacles in some parts of the country from which important lessons have been learned regarding the proper investigation of expanding small, medium, and large scale irrigation [13]. Ethiopia has a lot of capacity in terms of the availability of surface and ground water, as well as land that is normally good for irrigation, but the subsector is still in its infancy and the country is not profiting from it. Over nutrition from imbalanced diets also becomes a worry when wages rise and food consumption habits alter, both in developed and developing nations. Since increasing production and consumption of fruit and vegetables is an obvious

pathway to improve dietary diversity and enhance nutrition security, especially in the case of diets that are predominately high-energy foods with low levels of micronutrients, vegetables are increasingly coming into the focus of the nutrition community for their potential in combating the triple burden of malnutrition [14].

As [15] described the principal troubles of small scale irrigation are scarcity of input supply, output marketing, and credit score service, education of farmers on stepped forward crop and water control issues, even though supervision and tracking of scheme supports are crucial. However In some parts of the Kombolcha district, farmers use irrigation-based vegetable production through pumped water which is distributed by gravity through a canal system and applied to the fields using furrow irrigation, wells and reservoirs. For the deep dogged wells, the irrigator buys fuel for their generators and motor pumps to come up with water from the ground wells and also they use a generator when they lack electric power to facilitate the irrigation which is challenging and costly activity (Kombolcha district agricultural office 2022). [16] Conducted the study on the contribution of irrigated agriculture to household's income and food security and identifying the major determinants of households' food security however they didn't specify the crop to be investigated on. [17] Studied on micro irrigation-based vegetable farming for income, employment and food security in West Africa however like this study was not conducted specifically on food and nutrition security. [18] Studied on Risks in vegetables production in Kombolcha district. But this study concentrated on irrigation based vegetable production's contribution to food and nutrition security. In this area the problem of food insecurity, small-scale irrigation is common however farmers know the significance of vegetable in their diet from their indigenous knowledge their main focus is toward marketing it rather than using more for consumption.

Moreover participation of vegetable producer farmers in small-scale irrigation is influenced by different demographic, socio-economic, institutional and physical factors differently in different areas. This indicates that in order to identify the influence of different factors in different areas; location and irrigated vegetables specific research should be conducted. In Kombolcha district such research does not been conducted and identifying factors affecting vegetable producer household's participation in small-scale irrigation in the study area is important since vegetables are more grown in the area for generating income in general and for home consumption as particular. Therefore this study was proposed to estimate the impact of small-scale irrigation based vegetable production on household food and nutrition security to fill the existing knowledge gap in the study area.

2. Methodology

2.1. Description of the Study Area

Kombolcha is one of the twenty woredas in the East Hararghe zone of Oromia region, which is placed around 542 kilometres from Addis Ababa and 16 km northwest of Harar town, the capital of the Harare people Regional state. Its borders are the Harari region to the south, the Haramaya woreda to the southwest, the Dire Dawa Administrative Council to the northwest, the Ethiopia-Somali region to the north, and the Jarso woreda to the east. The Woreda's administrative centre is Melka Rafu. The highest points in this Woreda, Were Mucha, Babo, and Lalu, are between 1200 and 2460 meters above sea level.

According to the 2007 national census, this Woreda had a total population of 157,444, including 21,123 households, 70,967 males, and 77,659 women. According to this census, the Woreda's rural areas are residence to about 90.99 percent of the area's people. With up to 234.9 people per square kilometre of settlement, the Woreda people have a dense population. The climate of the Woreda is characterized by lowland and midland agro-ecological zones. Rainfall

in the Woreda is bimodal and variable, with an average annual amount of 600–900 mm. The main rainy season lasts from July to August, whereas the minor rainy season lasts from February/March to mid-May. The average minimum temperatures for each year range from 13.8 and 24.4 degrees Celsius, respectively.

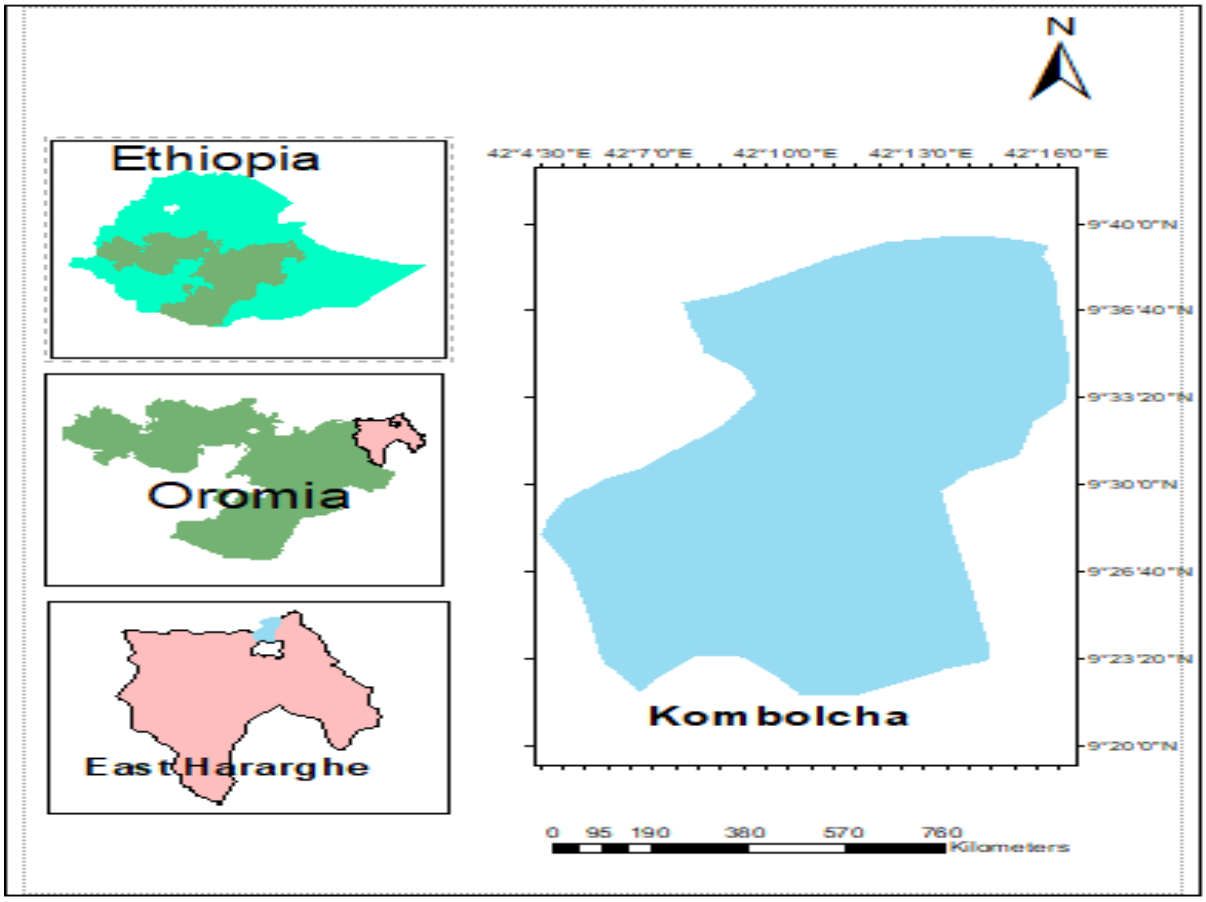


Fig 1. Map of study area

2.2. Sample Size and Sampling Techniques

Smallholder farmers of irrigated vegetable user and non-user households were the target population for the study. To select the sample for this study, multi-stage sampling method was employed. In the 1st stage Kombolcha district was selected purposively due to its potentiality in vegetable production, availability of SSI practices, its proximity and familiarity for a researcher in East Hararghe zone. In the 2nd stage, among 21 kebeles of the district, a total of 9

potential irrigated vegetable producing kebeles were identified. At third stage, among the 9 potential kebeles four kebeles were randomly selected by using simple random sampling. At fourth stage households were stratified in to strata as participant and non-participant of SSI. Finally representative sample respondents were randomly selected by probability proportional to size technique (PPS) of the number of households in each four sample kebeles.

The sample size for the study was identified by using [19] since the population is heterogeneous in terms of vegetable production. This was because; even if there is variation among farmers in terms of participation in small-scale irrigation based vegetable production, majority farmers involved in vegetable like potato and carrot (KDAO, 2022). The simplified formula is:

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq}$$

$$n = \frac{1.96^2(0.5)(0.5)5630}{0.06^2(5630-1) + 1.96^2(0.5)(0.5)} \approx 254$$

Where q=1-p, N is the population size, n is the sample size, Z is the standard cumulative distribution with a value of 1.96 that corresponds to the level of confidence, e is the level of precision, and p is the estimated proportion of an attribute present in the population with a value of 0.5 to obtain the desired minimum sample size of households at a 95% confidence level and 5% precision. The sample was chosen using a proportional sampling technique from each of the four kebeles.

2.3. Data Types, Sources and Methods of Data Collection

Both quantitative and qualitative data were gathered for this study from primary and secondary sources. Primary data sources were vegetable growers, key informants and focus group discussants (FGD) while secondary data related to small-scale irrigation based vegetable

production, general socio-economic information of the district, major types of crop produced and topography of the district were acquired from Kombolcha district office of agriculture (KDOA), published and unpublished documents such as CSA of Ethiopia.

Moreover, four focus group discussions (FGD) and eleven key informant interviews were conducted in order to supplement and triangulate the data collected through structured interview. For FGD, the discussion was intensively held at each four kebeles. During data collection, development agents of each four kebeles were consulted to identify a candidate farmers for FGD. At all selected kebeles, male and female headed farmers were included and the discussion was conducted with 6-8 group members. Furthermore, the key informant interview was also employed to draw the important information on small-scale irrigation based vegetable production in the study area. A total of eleven key informants, including four development agents (one from each kebeles), six model farmers and Kombolcha district head of agricultural office were interviewed using check list to collect the data.

2.4. Methods of Data Analysis

2.4.1. Descriptive statistics

Descriptive statistics such as mean, frequency, standard deviation and percentages were used to discuss the household demographic, socio-economic, institutional and physical characteristics. The result of analysis were presented by the table and graph. Inferential statistics like chi-square test and t-test were also employed. The chi-square test was used to see significance percentage difference between participant and non-participant households in small-scale irrigation based vegetable production in terms of dummy independent variables. On the other hand t-test was employed to see if there was statistically significant mean

difference between vegetable producer households using small-scale irrigation with respect to continuous variables.

2.4.2. Econometric analysis

Binary logit Model specification

$$p_i = \frac{e^{z_i}}{1 + e^{z_i}} \quad (1)$$

Where, P_i is the probability of participation in small-scale irrigation

$Z_i = \alpha_0 + \sum_{i=1}^{n} \alpha_i X_i + U_i$ Where, α_0 = Intercept, α_i= Regression coefficients

U_i = Disturbance term, and X_i = Pre-intervention characteristics.

The probability that a household belongs to non-participant is 1-p

$$1 - p_i = \frac{1}{1 + e^{z_i}} \quad (2)$$

$\frac{p_i}{1 - p_i} = e^{z_i}$ Taking the natural logarithm, then

$$Z_i = a_0 + \sum_{i=1}^{n} a_i X_i + U_i \quad (3)$$

Method of impact analysis

Propensity score matching was employed for a number of purposes. First, it takes into consideration sample selection bias brought on by visible variations between the treatment and control groups; it eliminates the possibility of self-selection by compiling a statistical

comparison group by comparing each observation from the treatment group to each observation from the control group that shares the same observable characteristics. A cross-sectional survey served as the foundation for the available field data. Therefore, propensity score matching (PSM) method was used to evaluate the impact of small-scale irrigated vegetable production on food and nutrition security of households. In this case estimating the effect of households' participation in SSI based vegetable production on a given outcome (Y) is specified as:

$$Ti=Y(Di=1) - Y(Di=0) \quad (4)$$

Where Ti represents the impact of the treatment, Y the result, and Di a dummy representing whether household I received the treatment or not. It should be noted that the same household cannot have both Y (Di=1) and Y (di=0) detected simultaneously Based on the household's place in the treatment, either Yi (Di=1) or Yi (Di=0) is an unobserved outcome (counterfactual outcome). Due to this, it is impossible to assess the individual treatment impact Ti; instead, one must estimate the average treatment effect of the population as a whole. In empirical investigations, two treatment effects are most typically calculated [20]. The first is the average treatment effect (ATE), which is just the distinction between the anticipated results following the use of SSI or not:

$$ATE=E(\Delta Y) =E(T1 \mid D=1)-E(Y0 \mid D=0) \quad (5)$$

[21] Highlight that because this estimate includes the effect for which the intervention was never intended, it could not be relevant to policy makers. Thus, the so-called Average Treatment Effect on the Treated (ATT), which focuses entirely on the effects on people who participate in small-scale irrigation based vegetable production, is the most essential evaluation parameter. ATT is provided by:

$$ATT = E(Y1 - Y0 \mid D=0, p(X)) = E(Y1 \mid D=1, p(X)) - E(Y0 \mid D=0, p(X)) \quad (6)$$

In this case, p(x) is the propensity score calculated on covariates X, and it is defined as: the mean difference in outcomes over the common support, correctly weighted by the propensity score distribution of participants.

For non-experimental investigations, the Conditional Independence Assumption (CIA) and the Common Support Condition (CSC) are two identifying assumptions that should be used to solve the selection biases [22]. The CIA, often referred to as the unconfoundedness assumption, holds that, given X, the possible outcomes are unrelated to the status of the treatment. In other words, the treatment assignment is "as good as random" after X has been controlled accordingly. The CIA is essential for accurately determining the program's impact since it makes sure that, although user and non-user groups differ, these variations may be taken into consideration to minimize selection bias. This enables the non-user units to create a treatment group counterfactual. The occurrence of substantial overlap in the features is required for the common support criterion.

2.4.3. Indicators used to measure the food security of sample households

Household dietary diversity score

Dietary diversity is a qualitative indicator of food intake that reflects availability to a variety of foods in the home [23]. By applying 24-hour dietary recall, information on the variety of diets consumed in households was gathered. The data gathered on dietary intake allowed for the calculation of a dietary variety score, which is determined by how many different food categories were eaten by household members over the duration of a 24-hour period. In the last 24 hours, all meals, food items, and beverages were recorded. The FAO's 2006 list of the twelve food groups was used to calculate household dietary diversity scores (HDDS). The consumed

food items were divided into the following food groups: Cereals White tubers and roots, Vegetables, Fruits, Meat, Eggs, Fish and other seafood, Pulses/Legumes, Milk and milk products, Oils and fats, Sugar or Haney, Spices, Condiments, and Beverages are all acceptable food items. Categories of Yes and No were used. If the household eaten at least one food item from each food group during 24 hours, the food group received a score of 1; otherwise, it received a score of 0, and if the household did not consume any food items from a given food group, the food group received a score of 0.

Finally, the household dietary diversity scores (HDDS) was also calculated using the results from each food group based on FAO's criteria for measuring household dietary diversity. Low household dietary diversity was considered as less than three food groups, medium household dietary diversity as four to five food categories, and high household dietary variety as more than six food groups.

Household food consumption score

Foods were divided into eight categories in order to estimate the HFCS. A popular proxy indicator for food access is the Household Food Consumption Score (HFCS), a tool identified by the World Food Programme (WFP). It is a weighted score based on the amount of food consumed and the nutritional value of the different food groups. Data was gathered on how frequently a household consumed particular foods over the period of the previous seven days. The Household Food Consumption Score (HFCS) is calculated by multiplying the frequency of each food category by the weight of each food group, then adding these results to create a composite score. According to each food group's nutrition density, the weighting of the food groups has been established [24]. According to the above justifications, the simplest estimation equation for the food consumption score employed in this investigation is:

FCS=$a \times f$(staple)+β×f(pulse)+γ×f(vegetables)+γ×f(fruit)+δ×f(animal)+$\varepsilon \times f$(sugar)+$\delta \times f$(da iry)+$\varepsilon \times f$(oil)

Where FCS stands for food consumption score, f is the frequency of food consumption = number of days for which each food group was consumed during the past 7 days,

a, β, γ, δ and ε = weight and nutritional value of each food group, respectively.

WFP, (2008) and IFPRI, (2008) state that households with insufficient food consumption have a food score of 0–28, borderline households have a food score of 28.5-42, and appropriate households have a food score of 42 or above, which is considered to be acceptable.

3. Result and discussions

3.1 Descriptive analysis

Descriptive analysis for continuous variables

This section presents the result of continuous variables for sampled respondents and Variables like education level of respondent, dependency ratio, land holding size, market distance, and annual on farm income showed the significant difference between participant and non-participant respondents of irrigated vegetable production at 1% significance level where as livestock holding size and frequency of extension contact indicates the significant difference at 5% significance level as stated in table below.

Descriptive analysis for categorical variables

The result of categorical variables for sample respondent is presented in Table below and variables like access to market information, access to credit and participation in non/off-farm activities indicates that there is a significant difference between participant and non- participant

households in irrigated vegetable production at significance level of 1%. This implies that participant households have more access to credit, market information than non- participant households and also participated more in non/off- farm income generating activities.

Impact of Small-Scale Irrigation Based Vegetable Production on Household Food and Nutrition Security

By using logit regression model, the important variables explaining propensity of participation in small-scale irrigation based vegetable production were identified. The result showed that important explanatory variables which were hypothesized to affect the participation in SSI was consumed from propensity of participation. The contribution of those variables on the dependent variable and could be those that education level of household, annual on farm income of household, land holding size, market distance, farm distance from water source, frequency of extension contact, access to credit, access to non/off-farm activities, access to market information would enhance participation in vegetable production using SSI.

Matching irrigation based vegetable production participants with non-participants

There are a few primary tasks that must be finished before starting the matching activity. The propensity of participation would be used to estimate the predicted value of participation in small-scale irrigation based vegetable production propensity score for all participant and non-participant households. The propensity score distribution of families participating in and not participating in the program (SSI) should be subject to a common support condition. The remaining observations would then be excluded if their predicted propensity scores were outside the common support region. At least, a sensitivity analysis would then be performed to determine whether the concealed bias had any impact on the estimated ATT.

To identify the region of common support, participant and non-participant households were matched. Discarding all observations whose propensity score was lower than the minimum propensity score of participants (treatment) and higher than the maximum propensity score of non-participants was the fundamental criterion for determining the common support region (control group). That means all observations outside of the overlapping region are excluded.

The estimated propensity score for treated households ranges from 0.046 to 0.999 with a mean of 0.777, as shown in the table below, while it ranges from 0.008 to 0.993 with a mean of 0.233 for control households. Therefore, for the sample households, the common support assumption is met in the range [0.046-0.993]. This means that households with the estimated propensity scores less than 0.046 and greater than 0.993 are not considered in matching undertaken. As a result of this, 29 sample households (9 participant and 20 non-participant households) were discarded and 225 sample households were identified to be considered in estimation process.

Choice of matching algorithm

The selection of the matching algorithm was made amongst the caliper, nearest neighbour, and kernel bandwidth approaches. A matching estimator, which balances more independent variables, has a lower pseudo-R^2 value, and has a large matched sample size, was selected as the best estimator of the data based on three criteria. As a result, it was determined that the nearest neighbour matching method was the best estimator for the data at hand about impact of SSI based vegetable production on household food and nutrition security of sample families. With just 29 unpaired households remaining, this estimator (NNM 5) produced the lowest pseudo R^2 (0.03) value, well-balanced covariates, and a high number of matched sample households (121 participant and 104 non-participant with a total of 225 sample households).

The next step is to ensure that propensity score and covariates are balanced after selecting the optimal matching algorithm (NN). The results of the t-test indicate that before matching, variations in household features between the participant and non-participant groups are jointly significant. The fundamental goal of the estimating propensity score is also to balance the distribution of important characteristics in the participant and non-participant groups, not to accurately forecast who will be chosen for the treatment.

The results of the covariate's balancing test are shown in the table below by contrasting the significant differences between the matching algorithm before and after matching. Some variables were significantly different for the two groups of respondents before matching. However, after some of these significant variables were matched, they were become insignificant, indicating that the covariates between participant and non-participant groups were balanced.

The less significant likelihood ratio tests and lower pseudo R^2 support the idea that after matching, the covariate distributions of both groups are the same (Table 12). The outcomes definitely revealed that the matching technique was able to equalize the features in the comparison of the participant and non-participant groups. It was performed to compare observed treatment outcomes with those of a comparison group that shared a common support in order to determine the impact of participation in small-scale irrigated vegetable production among groups of families with similar observable characteristics.

All the above test suggested that the matching algorithm chosen was relatively the best for the data at hand. Thus this study has chosen nearest neighbour (5) matching method as the best estimator and then proceed to the ATT estimation with this best choice estimator.

Average treatment effect on the treated (ATT)

This study focused on impact of small-scale irrigation based vegetable production on the household food and nutrition security. Results from ATT analysis showed statistically significant difference between participant and non-participant households in SSI based vegetable production in relation to HDDS and HFCS (Table 8). The mean dietary diversity of participants was 7.07 while those non-participants was 5.49 on average basis. There was also positive and significant mean difference in food consumption score between two groups. The average food consumption score of participant households was 67.58 and that of non-participant was 58.77 on average. The recent study also indicated that households participating in irrigation based vegetable production had a higher dietary diversity than non-participant households. In the model adjusting for covariates, vitamin C and calcium intakes were higher among households participating in irrigation based vegetable production (Baye *et al*., 2022). The result from FGD and KIIs was also indicates that households used small-scale irrigation for vegetable production were able to increase their food consumption from different food group since they can buy the needed food items using the income earned from marketed vegetables. This implies that participation in small-scale irrigation based vegetable production improves household food and nutrition security by increasing household dietary diversity score and household food consumption score.

The impact analysis of the PSM result, after controlling for pre-intervention differences of the participant and non-participant of small-scale irrigation, showed that the household dietary diversity amounting 1.58 was the pure effect of participation in small scale irrigated vegetable production and this means, participant households on average have used more diet diversity of 1.58 than the family members of non-participant and this difference was significant at 1 percent. The average difference between the food consumption scores of participant and non-

participant households is 8.81, and this difference was statistically significant at the 5% significant level. Participation in small scale irrigation based vegetable production potentially increased household food and nutrition security as measured in both household dietary diversity score and household food consumption score, controlling for pre-intervention variations using propensity score matching. This result is in agreement with the finding of Muleta *et al.* (2021).

Sensitivity analysis for the estimated average treatment effect on treated

Testing the robustness of the result is advised since there may be undetected biases against the matching estimators' results. Sensitivity testing can be used to solve the issue because it is impossible to estimate the magnitude of the selection bias from non-experimental data. The main issue of sensitivity testing is determining whether or not the treatment effect is caused by an unobserved variable. The sensitivity analysis of the outcome ATT value of HDDS and HFCS to the covariates was shown in below table (Table 9). The significance level is unaffected, as stated in the table the ATT is not sensitive to the outside changes, Sig + refers to upper bound significance level where as Sig- implies lower bound significance level. As a result, it can be concluded that the impact estimates (ATT) are not affected by unobserved selection bias.

4. Conclusions and policy implication

The logit model results showed that the contributing factors on the probability of participation in small-scale irrigation based vegetable production were education level of households, total annual on farm income, market distance, frequency of extension contact, access to credit, farm distance, access to off/non-farm activity, and market information found to be the most pertinent in the study area. The results revealed that factors such as education level, access to credit, and

access to non-farm activity influenced the participation of farmers in small-scale irrigation based vegetable production positively and significantly at 1% significant level; land holding size, and market information influenced the participation in small-scale irrigation based vegetable production positively and significantly at 5% significant level whereas, variables like market distance and farm distance affected the participation negatively and significantly at 1% and 5% level of significance respectively while frequency of extension contact and total annual on farm income were affected the participation in small-scale irrigated vegetable production positively at 10% significance level. Whereas deviated from most of previous studies, variables like age of household head, sex, family size, dependency ratio, and livestock holding size did not have effects on participation in small-scale irrigation based vegetable production of households in the study area.

The impact of small-scale irrigation based vegetable production on household food and nutrition security was analysed based on sample of matched irrigation user and non-user groups. A propensity score matching approach was used to compare user households with non-user in terms of their food and nutrition security. From nearest neighbour 5 matching method, the estimated average treatment effect on treated found that participation in small-scale irrigated vegetable production had positive impact on household's food and nutrition security of small-scale irrigation users. The participant sample households were found be more food and nutritionally secure than non-participant sample households. Therefore, the participation in small-scale irrigation based vegetable production was found to have a positive impact on participant's food and nutrition security. Hence, encouraging farmers toward participation in small-scale irrigation is necessary.

Participation in small-scale irrigated vegetable production was found to have positive impact on household food and nutrition security for the target group as investigated in this study.

Hence encouraging farmers toward participation in small-scale irrigation based vegetable production is necessary. Thus all stakeholders, especially irrigation developing bodies need to carry out more easily irrigation enabling technologies for visible impacts through the development of appropriate mechanism in input delivery, processing facilities and creating market opportunities to take out the lives of small-holder farmers from the state of food and nutrition insecurity.

Abbreviations: ATT, Average Treatment Effect on the Treated; CSA, Central statistical agency; CIA, Conditional Independence Assumption; HDDS, Household Dietary Diversity Score; HFCS, Household food consumption score; FGD, focus group discussion; KII, key Informant Interview; NNM, Nearest Neighbor Matching; PSM, Propensity Score Matching; TLU, Tropical Livestock Unit;

CRedit authorship contribution statement

Seman Ahmed: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. Muluken Gezahegn: Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. Jemal Yousuf: Validation, Supervision, methodology, investigation, Conceptualization; Ibsa Aliyi: Validation, Supervision, Resources, visualization, conceptualization.

Data availability

The dataset analysed for this study are not available publicly because the authors aimed to use for other studies and then will make it publicly available, for special cases related to this study anybody can ask from Seman Ahmed (first author).

Declaration of competing interest

The authors declare that they have no any competing financial interest or personal relationship that was influencing the work reported in this paper.

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Tables

Table 1 summary analysis for continuous variables

Variable	User=130	Non-user=124	Total =254	T-value
Age	40.39	41.35	40.86	0.82
Education	4.9	2.45	3.70	-6.165***
Family size	4.86	4.84	4.85	-0.17
Dependency ratio	0.94	1.18	1.05	2.74***
Land size	0.70	0.39	0.55	-6.43***
Total livestock(TLU)	1.93	1.63	1.78	-2.1**
Market distance	7	10.41	8.67	4.72***
Farm distance from water source	0.29 km	0.36 km	0.33 km	2.06
Annual on-farm income	104645	59952	82826	-8.03***
Frequency of extension contact	13.97	12.42	13.22	-3.089**

Table 2 Summary analysis for categorical variables

Variable		User=130	Non-user=124	Total =254	$\chi 2$
Sex of the respondents	Female	38.46	38.71	44.1	
	Male	61.54	61.29	55.9	
					0.0084
Access to market info.	yes	81.5	58.85	70.47	15.67***
	no	18.5	43.15	29.53	
Participation in non/off-farm	yes	70	17	44	72.49***
	no	30	83	56	
Access to credit	yes	37.7	9.7	24	27.3***
	no	62.3	90.3	76	

Table 3. Estimated logit model results of covariates

Variables	Coefficient	Std. Err	P>z	Marginal effect
Age of household(year)	-0.009	0.022	0.671	-0.0023

Sex of the household head(1=male)	0. 169	0. 384	0.659	0. 041
Education level(year)	0. 243***	0. 063	0.000	0. 059
Total annual on farm income(birr)	0. 00001*	0.000	0.065	2.89e-06
Land holding size(ha)	1.538 **	0. 661	0.020	0. 377
Market distance(km)	-0. 090 ***	0. 031	0. 004	-0. 022
Frequency of extension contact(day)	0. 083 *	0. 048	0. 088	0. 020
Access to credit(1=yes)	1.334 ***	0. 508	0. 009	0. 295
Family size(AE)	0. 181	0. 164	0. 269	0. 044
Dependency ratio(No)	-0. 447	0. 322	0. 165	-0. 109
Farm distance (km)	- 1.913 **	0. 766	0. 012	-0.469
Livestock holding size(TLU)	0. 184	0. 161	0. 255	0. 045
Non/off-farm activity(1=yes)	1.268 ***	0. 434	0. 003	0. 298
Market information (1=yes)	1.033 **	0. 419	0. 014	0. 252
Constant	- 4.195	1.676	0. 012	
Number of observation	254			
LR chi^2	163.55			
Pseudo R^2	0. 464			
Log pseudo likelihood	- 94.21			
Prob > chi2	0.000***			

Source: own survey, 2022

Table 4. Distribution of estimated propensity score for sample households

Groups	Mean	STD	Min	Max
Participant households	0.777	0.252	0. 046	0.999
Non-participant households	0.233	0.237	0. 008	0.993
Total households	0.511	0.366	0. 008	0.999

Source: own survey, 2022

Table 5. Performance of matching estimator

Matching Algorithm	Performance		
	Pseudo R^2	No. of matched observation	Balancing test*
Nearest neighbor (5)	**0.030**	**225**	**14**
Kernel bandwidth (0.25)	0.054	225	13
Caliper (0.01)	0.128	125	11

Source: own survey, 2022

Table 6. Propensity score and covariate balance between participants and non-participants

Variables	Before matching(N=254)			After matching(N=225)		
	Treated (n=130)	Control (n=124)	T value	Treated (n=121)	Control (n=104)	T value
Age of household	40.39	41.35	-0.82	40.39	42.61	-1.53
Sex of the household head	0. 61	0.62	-0.09	0. 61	0. 59	0.31
Education level	4.9	2.45	6.17**	4.61	4.18	1.08
annual on farm income	100,000	59952	8.04**	99226	100,000	-0.56
Land holding size	0.701	0. 39	6.44*	0.63	0. 64	0.30
Market distance	6.99	10.48	-4.72***	7.04	7.77	-1.02
extension contact	13.97	12.42	3.09**	14.05	13.31	1.46
Access to credit	0.37	0. 09	5.51**	0. 34	0. 32	0.22
Family size	4.86	4.83	0.17	4.84	4.83	0.02
Dependency ratio	0. 93	1.17	-2.75	0.93	0.94	-0.11
Farm distance	0.29	0.36	-2.06 **	0.29	0. 30	-0.14
Livestock holding size	1.92	1.63	2.10	1.88	1.84	0.24
Non/off-farm activity	0.7	0.17	10.03**	0.677	0.697	-0.33
Access to market information	0.815	0. 58	4.07***	0.801	0.8	0.03

The *, ** and *** indicates significant at 10%, 5% and 1% significance level

Source: own survey, 2022

Table 7. Test for joint significance

Sample	Pseudo R^2	LR chi^2	Prob.> chi^2
Unmatched	0.46	161.39	0.0000
Matched	0.03	10.23	0.745

Source: own survey, 2022

Table 8. Treatment effect on household food and nutrition security

Outcomes	Sample	Treated	Control	Difference	BT.S.E	T-stat

HDDS	Unmatched	7.09	4.18	2.90	0.17	16.35***
	ATT	7.07	5.49	1.58	0.50	3.85***
HFCS	Unmatched	67.72	43.16	24.56	1.97	12.43***
	ATT	67.58	58.77	8.81	3.76	2.03**

*** indicates significant at 1% level of significance

Source: own survey, 2022

Table 9. Sensitivity analysis of the estimated average treatment effect of treated

Household dietary diversity score			**Household food consumption score**	
Gamma	Sig+	Sig-	Sig+	Sig-
1	1.1e-16	1.1e-16	1.4e-10	1.4e-10
1.25	3.7e-13	0	6.6e-08	5.8e-14
1.5	8.0e-11	0	3.7e-06	0
1.75	3.8e-09	0	0.000061	0
2	6.7e-08	0	0. 000477	0
2.25	6.2e-07	0	0. 002245	0
2.5	3.7e-06	0	0. 007409	0
2.75	0.000016	0	0. 018924	0
3	0.000053	0	0.039912	0

Source: own survey, 2022