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Impact of Enset Participation in Value Chain on Smallholder Household Food Security and Income in Southwestern Ethiopia

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Abstract

Growing demand for enset means that rural smallholder farmers have excellent potential to respond on the supply side, particularly in Southern Ethiopia. Evidence is required to determine whether or not smallholder farmers participate in these new market opportunities and whether they gain anything from doing so. This study examines the effects of smallholder farmers' involvement in the Enset participation in value chain on food security and income (as determined by crop income and daily caloric intake in the Gedeo zone of Southern Ethiopia). The investigation analyzed cross-sectional data from 380 randomly chosen smallholder farmers. Impact evaluation employed the Endogenous Switching Regression (ESR) model, which takes selection bias into account. Results from the ESR demonstrate how market, institutional, socioeconomic, and demographic factors influence the decision to participate as well as the food security and income of farm households. Overall, Enset market involvement has a favorable and considerable effect on the food security and income of rural farmers, with a significant difference between groups. The improvement of household food security and income depends on policies that lower the transaction costs of accessing markets, promote trees through various media, work to build the capacity of rural institutions, encourage and support Enset associations, design appropriate support from various stakeholders, encourage market linkages among various market players, and give farmers the opportunity to enroll in basic education.

Keywords: Enset; participation in value chain; food security and income impact; endogenous switching regression; treatment effects; Gedeo zone of Southern Ethiopia; Impact evaluation; markets institutional; socioeconomic.

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1. Introduction

In Ethiopia agriculture is the most important sector and plays a significant role for the country's food security and livelihood. The sector is the largest contributor to the overall economy and fundamental to the country's development. Agriculture covers 45.5% of GDP, 85% of employment, and 94% of export in Ethiopia [1, 2]. The main crop produced in the country includes enset, cereals, pulses, oilseeds, vegetables, root crops, fruit crops, chat coffee and sugarcane [3]. From these crops enset crop is used as a staple and co-staple food and represents a potential pathway out of poverty for many smallholders in Ethiopia, particularly in Southern and South-Western parts [4]. Enset (*Ensete ventricosum*) is a perennial and monocarpic herb belonging to the banana family and originated in Ethiopia [5, 6]. Due to its drought tolerance, it is the most important traditional staple and co-staple food crop contributing to food security and income for over 25% of people in the south and southwest Ethiopia [27].

There are many underutilized crops in Ethiopia that have the potential to bring lots of prosperity in this regard. *Enset*, an edible plant, is at the top of the underutilized resources in Ethiopia. Enset (Ensete ventricosum (Welw.) Cheesman) is found in various places in Sub-Saharan Africa as a wild species [38, 44]. However, it is only grown as a food crop in Ethiopia [31, 36, and 38]. In Ethiopia, enset is a versatile crop that is widely disseminated and cultivated as a staple meal for more than 20 million people in Oromia, southern and southwestern Ethiopia [8]. It's made at elevations ranging from 1200 to 3100 meters above sea level [2]. Farmers can grow the crop in any part of the country, even in areas where cereals aren't grown. Enset is not only used as food, animal fodder, construction material, and fuel, but it is also a culturally celebrated plant with major economic (as trade item), social (different settlement patterns and its associated social relations), cultural (cultural identity, medicine, ritual) and environmental roles [11] etc. It is also a drought-resistant plant and a reliable source of food in times of crop failure [11]. The environmental functions of enset are multifarious; enset gives shade to the soil and plants underneath it and it is deep tiny roots hold the soil together and protect against soil erosion and add soil fertility [9, 11].

Having an enset in a garden or home shows better wealth status and represents a stable food supply for the family, resulting in prestige for the head of the household. For instance, in the Gedeo zone enset plants are considered as an indication of an individual household's source of wealth and the main source of food that secures an individual farmer household family in food self-sufficiency. If an individual farm household has a potential Enset plant (productive and well managed) by using indigenous knowledge, it grants the household income be secured rather than expending for food crop purchase. Apart from being consumed, enset is also marketed as a source of income in local, regional, and national markets in southern Ethiopia [19]. With limited evidence, it is unclear the extent of smallholders' participation in the enset market and benefits from participation in these market opportunities. However, the above research failed to address the impact of enset market participation on household food security and income in Ethiopia, particularly in the study area. Different researchers and scholars stated *that Enset* production can be used as responsive action in the study area because *Enset* is drought tolerating crop. However little research and development attention has been given to the question of what is the impact of enset participation in value chain on the household's food security and income.

The contribution of this paper to the existing literature is threefold. In Ethiopia, some studies have been conducted on the contribution of Enset on household income [40] and found a positive influence of this crop. Conducted their research on the indigenous knowledge of Enset (Ensete ventricosum) cultivation and management practice. [8], also focused on the production trends, agronomy, processing, and the wider food security applications of a neglected banana relative. [23], also tried to explore, Enset (*Ensete Ventricosoum*) Value Chain in Dawuro Zone, Southern Ethiopia therefore, the claimed benefits of *enset* need to be confirmed by impact analysis, and its potential uses should be exploited. Hence, analyzing the impact of participation in value chain on rural farmers' food security and income would be of policy relevance**.** Second**,** Even though numerous studies on the enset plant are being conducted [63, 56, 51, 48 and 52], the impact of enset participation in value chain on household food security and income in Ethiopia, particularly in the study area has not received enough attention in previous studies in one way or another. Thirdly, the majority of previous studies have employed PSM, double-hurdle, ordered probit, and OLS estimation techniques (for example;[67, 69,70 and 71]. But these models and estimation techniques are subject to self-selection bias, endogeneity problems, and inadequate counterfactuals. For that reason, this study employs an endogenous switching regression model, GPS which has the potential in solving the above problems. Therefore, the study aims to examine the impact of enset participation in value chain on household food security and income taking Gedeo Zone, SNNPRS, and Ethiopia, as the case study. The rest of the paper is organized as follows: part 2 provides a brief description of the methodology, part 3 presents results and discussions, and part 4 presents the conclusion and recommendation of the study.

2. Research Methodology

2.1. Description of the study area

The present study was carried out in the Gedeo zone of the Southern Nations', Nationalities' and Peoples' Regional State (SNNPRs) of Ethiopia (Figure 1). The Gedeo zone is located 369 kms south of Addis Ababa and 90 kms south of Hawassa along the Addis Ababa-Moyale international road [16] and Geographically, it is located between latitudes 5° 50′ 26″ and 6° 12′ 48″ N, and longitudes 38° 03′ 02″ and 38° 18′ 59″ E [7] with altitude ranges from 1450-3200 m above sea level. The study area is characterized by diverse topographic features within limited distance (less than 100 km), thus resulted in complex and diverse climatic conditions [1, 6]. The Gedeo Zone has a total population of 975,506, of which 486,996 were males and 488,510 were females [16]. This Zone is one of the most densely populated area in the regions (648 persons /Km^2) the average family size is 8, the national average being 4.6 whereas the average farmland size is about 0.3 hectares [16].

Rain-fed agriculture, smallholder farming, and varied agricultural production make up a large portion of the land use [33]. The zone's total area is 1347 m2, of which 94.5 percent is agricultural land (agro forestry-land used for both perennial and annual crops), followed by grassland, wetland, natural forest, plantations, and other land types [6]. Enset and enset products (enset seedlings, kocho, bula, and fiber), coffee, cereal crops, root crops, fruits, vegetables, herbs, spices, medicines, honey, fibers, fuel wood, and timber for subsistence and local markets are the main agricultural products of the region. Both a source of manure and a means of subsistence, livestock are crucial. However, issues like rapid population expansion, conventional farming practices, and limited adoption of modern technologies limit the agricultural sector's production.

The inter-tropical convergence zone, where the location is located, brings rain from both the Atlantic and Monsoon currents. As a result, the zone has a bimodal pattern with two distinct wet seasons: a short rainy season from March to May and a long rainy season from July to October [58].The research area's average annual rainfall is 1500 mm, which falls between 1200 and 1800 mm. The zone's average monthly temperature ranges from 18 to 25 °C. According to differences in altitude, the study region has been separated into three agroecological zones: the highland (Dega), midland (Woinadega), and lowland (Kola) [58, 6]. With elevations between 2500 and 3200 m asl, the highland agroecological zone occupies around 26% of the research area's surface. 65 percent of the research area is covered by the midland agro-ecological zone, which has altitudes between 1750 and 2500 m asl. The lowland agro-ecological zone, which makes up 9% of the research area, is located in the altitude range of 1750 masl.

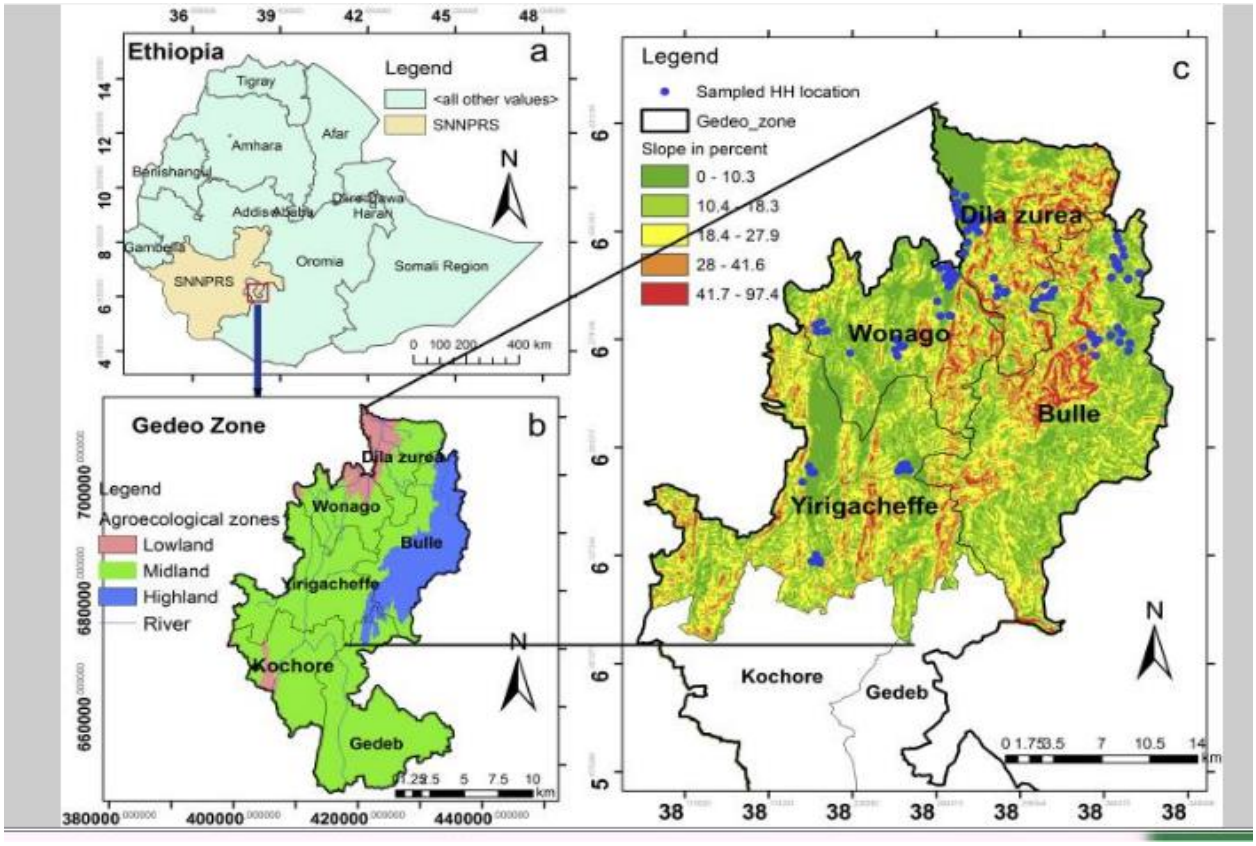

Figure 1: Map showing the study area on the map of Ethiopia (a) Location of the study area as classified by agro-ecological zone (b) and location of sampled households (The map was developed using Arc-GIS software).

2.2. Data types, sources, and methods of data collection

In this study, the required data are generated from both primary and secondary sources. Primary data were collected using a structured questionnaire that was administered by trained enumerators. For qualitative data collection, focus group discussions, key informants interview, and personal observations were employed. In addition to primary data, secondary data were collected from various sources such as records, reports, and documents of the bureau of the district agriculture and other relevant institutions. Field trips were made before the actual survey to observe the overall features of selected *districts* and *kebeles*.

2.3. Sampling methods and sample size determination

Both primary and secondary data were used in this investigation. Focus groups, formal questionnaire surveys, face-to-face personal interviews utilizing a semi-structured questionnaire, and field observations on a few randomly chosen household plots were used to gather the primary data. Key informant interviews will also be used to define realistic typologies and characterize the farming system. A multistage stratified sampling procedure was used to choose sample districts, Kebeles, and families in order to gather the data. The zone was divided into three agro-ecological zones in the initial stage according to the gradient of elevation: highland, midland, and lowland agro-ecological zones (Figure 1b). In the second stage, four districts (Bulle, Dilla zurya, Wonago, and Gedeb) from six districts in the Gedeo zone, Southern Ethiopia, were selected purposively to capture the climate variability (Figure 1c). In the third stage, using a simple random sampling technique, 15 percent of all enset-growing Kebeles in each of the four districts was chosen (Table 1). A Kebeles is the smallest administrative unit in Ethiopia, but it is larger than a village because it has about 380 households and 600 ha of land (Table 1). As a result, samples from the lowland, midland, and highland agro-ecological zones were taken from five kebeles from Dilla Zuria, five kebeles from Wonago, six kebeles from Bulle, and five kebeles from Gedeb. Finally, using the probability proportional to sample size sampling technique, a random sample of 380 households was chosen after obtaining a new list of the households from 22 kebeles households. Following [30]formula, the sample size for the study was determined as follows:

$$n = \frac{Z^2 pqN}{e^2(N-1) + Z^2 pq} = \frac{(1.96)^2(0.5)(0.5)(37000)}{(0.05)^2(37000) + (1.96)^2(0.5)(0.5)} = 380.212 \approx 380 \quad (1)$$

Where n is the sample size from a finite population, N is total size of the household population, Z is the confidence level (α = 0.05), p is the sample proportion of successes (frequency estimated for a sample of size n), where p is 0.5 which is taken for all developing countries, q = 1-p and e is level of precision (acceptable error). Thus N = 37000, Z = 1.96, p = 0.5, q = 0.5, e = 0.05. The dataset contains detailed information on households' demographic and socioeconomic characteristics, farm specific attributes, marketing, and institutional characteristics.

Table 1: Distribution of sample size across agro-ecological zones.

Agro-ecological zones	Altitude range∗ (m.a.s.l)	Name of woreda's	Woreda total kebeles	Sampled kebeles	Total HHs in sampled kebeles	Sampled HH size
Highland	>2600	Bule	21 enset producer, 10 not	6	10,142	137
Midland	1450–2600	Gedeb	21	6	8140	56
		Wonago	21	5	8,431	58
Lowland	<1450	Dilla zurya	19	5	9,620	129
Total						380

2.4. Methods of data analysis

2.4.1. Econometric framework and estimation methods

In observational data, impact estimation is difficult due to trouble in establishing counterfactuals. Observing the treatment variable in the non-controlled group had been treated or not, is impossible. This problem can be controlled in experimental data by randomly assigning the treatment sample from a given population. Though, if the treatment variable is not randomly assigned, the outcome variable for the two groups (treated and untreated) is probably affected by both observed and unobserved characteristics. The treatment is not randomly assigned in our current study since farmers are self-select for the participant and non-participant groups; thus, selection bias occurs in the outcome variables. So, there would be an efficient difference between the two groups (treated and untreated).

To solve these impact assessment estimation difficulties, econometric approaches have been developed, which include binary propensity score matching (PSM) in dichotomous treatment, generalized propensity score (GPS) matching, instrumental variable (IV), IPW (Inverse probability weighting), and endogenous switching regressions (ESR). In PSM and GPS, only observable characteristics are controlled. In contrast, IV approaches can control for both observed and unobserved variables in which the treatment effect models have one selection and one outcome equation by assuming the treatment impact can be represented by a simple intercept. But the impact of the treatment on household food security for the two groups could be different because they may have unlike characteristics [43]. Endogenous switching regression (ESR) is a two-step approach. ESR controls heterogeneity for observed and unobserved characteristics while simultaneously relaxing the assumptions in the IV approach by estimating two separate outcome equations together with the selected model. ESR has been applied largely in labor economics [32, 33] and in technology adoption in agriculture [17, 44]. For this study, we employ an ESR model to minimize the bias in selection by controlling both observed and unobserved characteristics. Inverse probability weighting (IPW) and binary propensity score matching (PSM) methods are used for robustness checks, even though these methods don't consider unobserved heterogeneity.

2.4.2. Endogenous switching regression

An endogenous switching regression model that accounts for both endogeneity and sample selection was used [17, 35]. The model uses a probit model in the first stage to determine the relationship between participation in value chain and some household and farm characteristics. In the second stage, separate regression equations are used to model the food security and income outcome conditional on a specified criterion function. To clarify the method, consider a situation where a farmer could participate in value chain or not. Let, a latent variable capturing the expected net benefits from market participation is $Di*$. The probit model of participation in value chain can be specified as:

$$Di*=\alpha' Zi+Ui \; with \; Di=\{1 \; if \; Di*>1, \quad 0 \; otherwise \qquad (2)$$

Where $Di*$ is the latent variable for participation in value chain (unobservable); Di is the dependent variable for participation in value chain equals 1, if the farmer has sold any quantity of enset produced in the market, and 0

otherwise (observable counterpart); Zi is a vector of observed explanatory variables determining market participation; the coefficient estimates is α, and a random disturbances associated with the participation in value chain is Ui.

The two food security and income regression equations where farmers face the regimes of participation or not to participate in in value chain are defined as follows:

$$Regime\ 1: Y_{1i} = \beta_1 X_{1i} + \varepsilon_{1i} if D_i = 1 \quad (3)$$

$$Regime\ 2: Y_{2i} = \beta_2 X_{2i} + \varepsilon_{2i} if D_i = 0 \quad (4)$$

Where Yi is household food security and income in regimes 1 and 2, Xi is a vector of exogenous variables of household i, expected to influence food security and income; β is the coefficient vector; D is a dummy for market participation, and, εi the residuals.

For the ESR model to be identified, it is important to use exclusion restrictions, thus as selection instruments, not only those automatically generated by the nonlinearity of the selection model of participation (2) but also other variables that directly affect the selection variable but not the outcome variable [17].

2.4.3. Conditional expectations, treatment, and heterogeneity effects

An endogenous switching regression model was used to compare the projected outcome variables of households that participated (Eq. 3a) with households that didn't participate (Eq. 3b) and to explore the expected food security in the counterfactual cases (Eq. 3c) that the treated happened to be untreated, and (Eq. 3d) that the untreated happened to be treated.

The conditional expected and average treatment effect both in actual (observed from the sample) and counterfactual situations specified as follows:

1. Actual scenarios.

$$\text{a. } E\left(\frac{Y_{1i}}{A_i} = 1\right) = x_{1i}\beta_1 + \delta_{1\eta}\lambda_{1i} \quad \text{(participant)} \quad (5)$$

$$\text{b. } E\left(\frac{y_{2i}}{A_i} = 0\right) = x_{2i}\beta_2 + \delta_{2\eta}\lambda_{2i} \quad \text{(non-participant)} \quad (6)$$

2. Counterfactual scenarios

$$\text{c. } E\left(\frac{Y_{2i}}{A_i} = 1\right) = x_{1i}\beta_2 + \delta_{2\eta}\lambda_{1i} \quad \text{(participant decided not to participate)} \quad (7)$$

$$\text{d. } E\left(\frac{Y_{1i}}{A_1}=0\right) = x_{2i}\beta_1 + \delta_{1\eta}\lambda_{2i} \qquad \text{(non-participant had decided to participate)} \qquad (8)$$

Following [25], the change in the expected food security levels of participants in farm households (the effect of the treatment on the treated) is given as the subtraction of scenario (c) from scenario (a)

$$\text{ATT} = E\left(\frac{Y_{1i}}{A_i}=1\right) - E\left(\frac{Y_{2i}}{A_i}=1\right) = x_{1i}(\beta_1-\beta_2)+(\delta_1\eta-\delta_2\eta)\lambda_{1i} \qquad (9)$$

This represents the effect of participation in enset market on households' food security and income who actually participated in enset market. In the same way, we calculate the change in the expected food security and income of the households that didn't engage in enset market, i.e., the average treatment effect on the untreated (ATU), which is the difference between scenario (d) and scenario (b),

$$\text{ATU=(d)-(b)} = E\left(\frac{Y_{1i}}{A_1}=0\right) - E\left(\frac{y_{2i}}{A_1}=0\right) = x_{2i}(\beta_1-\beta_2)+(\delta_1\eta-\delta_2\eta)\lambda_{2i} \qquad (10)$$

Where X_{1i} and X_{2i} are explanatory variables that affect enset market in equation 2 in regime 1 and regime 2, respectively, β_1 and β_2 are parameters to be estimated.

Farmers that were involved in enset market might have had more food calorie intake than households that actually did not involve regardless of their decision to participate because of unobservable factors that might potentially affect household food calorie intake. Based on [14], we calculate the heterogeneity effects as the difference between the expected outcomes, i.e.

(a)—(d) for the farm households that decide to participate.

$$BH_1\text{= (a)-(d)} = E\left(\frac{Y_{1i}}{A_i}=1\right) - E\left(\frac{Y_{1i}}{A_1}=0\right) = (x_{1i}-x_{2i})\beta_{1i} + \delta_1\eta(\lambda_{1i}-\lambda_{2i}) \qquad (11)$$

Likewise, for the farm households who decided not to participate in enset market, the base heterogeneity effect is given as the difference between (c) and (b).

$$BH_2\text{=(c)-(b)} = E\left(\frac{Y_{2i}}{A_i}=1\right) - E\left(\frac{y_{2i}}{A_i}=0\right) = (x_{1i}-x_{2i})\beta_{2i} + \delta_2\eta(\lambda_{1i}-\lambda_{2i}) \qquad (12)$$

In addition, we examine the transitional heterogeneity (TH) effect in which the impact of participating in enset market is lesser or better for the participant farm households, which is the difference between ATT and ATU (Table 2).

2.4.4. Propensity score matching (psm) and inverse probability weighting (ipw) methods

The results of the ESR model are compared with estimates from propen control group of a treated observation (Heckman and his colleagues 1998). The occurrence of bad matches that would sity score matching (Kernel matching) and inverse probability weighting (IPW). Kernel-based matching is a non-parametric analysis that uses the average weight of individuals to draw their counterfactuals in the happen from using nearest neighbor matching methods is reduced [13]. IPW is another technique for controlling confounding in observational data. In contrast to

Table 2: Conditional expectations, treatment effects, and heterogeneity effects.

Category	Participation decision		Participation effect
	To Participation	Not to Participation	
Farm household that participated	$E\left(\frac{Y_{1i}}{A_i}=1\right)$	$E\left(\frac{Y_{2i}}{A_i}=1\right)$	ATT
Farm household that did not participated	$E\left(\frac{Y_{1i}}{A_1}=0\right)$	$E\left(\frac{y_{2i}}{A_i}=0\right)$	ATU
heterogeneity effects	(a-d)	(c-b)	TH

Matching methods, IPW allocates larger weights to control groups with higher estimated probabilities of selection into the treatment [28].

Ai= 1 if households i participated in enset market

Ai= 0 if household i didn't participate

Y1i = household food calorie intake and income if the household participated

Y2i = household food calorie intake and income if the household didn't participate

ATT= average treatment effect on treated

ATU = average treatment effect on untreated

BH1 = base heterogeneity effect for the household that participated

BH2 = base heterogeneity effect for non-participant

TH = transitional heterogeneity effect (ATT-ATU)

2.4.5. Measurement of outcome variables

In this study, two different food security and income indicators (i.e. income from enset and daily calorie intake) were used to capture the different dimensions of food security and income. Other studies have also used the

same indicators for food security and income either a single indicator or a combination of two or more [5, 29, 39]. Income from enset refers to the total annual income of the household generated from all enset products including enset plant as it is. This is a continuous variable that is measured in Birr**.** The outcome variable is food security and income. Kilo calorie intake is used as a proxy measure of household food security. The households' food security status was measured by a direct survey of household consumption. The principal person responsible for preparing meals is asked how much food was prepared for consumption from purchase, stock, and/or gift/loan/wage over a while. In this study, a seven days recall method was used since such a measure gives more reliable information than the household expenditure method [18]. Therefore, the consumption information collected on the premise of the fourteen days recall methodology were converted into kilogram calorie using the food composition table manual adopted from Ethiopian Health and Nutrition Research Institute [9]. Then, to calculate the households' daily caloric intake, the entire household's caloric intake for the fourteen days was divided by seven. The household's daily caloric intake per adult equivalent was calculated by dividing the household's daily caloric intake by the family size once adjusting for adults.

2.5. Variables for impact analysis

Dependent variable

Enset participation in value chain (**EMPD**): It is dummy variable which takes the value of 1 if the household participate in enset value chain other wise 0.

Outcome variables

The outcome variables in this study include:

Food consumption in kilocalorie intake: This refers to the food index that measures food security status and it will be taken by converting 15 days consumption data obtained from survey questionnaire into daily kilocalorie intake, which could be compared to the nationally standardized average kilocalorie intake 2200 per day per head [41] To convert the data into calories adjusted for household age and sex composition involved a series of steps. Primarily different units of local measurement will be converting into a common measure for each food item. Then all food calories will be added up and converted to daily amounts. Finally, the total food calories will be computed in Adult Equivalent units for analysis.

Total income: it is a continuous variable measured in terms of birr obtained from off-farm and non-farm income. It can be calculating the sum of off-farm and non-farm income activities.

Independent variables

The independent variables of the model are those variables that are expected to influence participation in enset production and the outcome variables. The demographic, socio-economic and institutional factors hypothesized to affect the dependent variable and outcome variables will be present as follows:-

Age of the household head: Age is a continuous variable measured in years. In rural areas, agriculture is the main occupation and source of income for the rural households. By its nature agriculture needs high physical work. So for older farmers, it is difficult to perform productive agricultural work to produce surplus output.

Family size: It is a continuous variable referring to family members living under the same roof which influence seriously household's consumption and food security status. So, family size is hypothesized to have positive effect on participation enset production, value addition, productivity, food security and income.

Dependency ratio: Dependency ratio is obtained by dividing inactive labor force (age <15 and >65years) by active labor force (age between 15 and 65 years). Households with high dependency ratio might not be able to participate in enset production. Therefore, it will be hypothesized that, dependency ratio has a negative effect on participation in enset production, productivity value addition, food security and income.

Sex of the household head: It is a dummy variable which takes the value of 1 if the household is male and 0 otherwise. In developing countries, even though female headed households have less access to improved technologies, land and extension than male headed households. Relatively female headed households are in a better position enset production than male headed households.

Education level of household head: It is an essential factor for diversified activities in human life. In the study area, the main occupation of the population is agriculture. The field of agriculture is dynamic by its nature. This is due to the continuous improvement in the research findings and technological advances. To equally pace with these technological advances and to adopt the new findings, education is a basic factor. Educated households tend to adopt and practice new technologies more than less educated households. So, education level has a positive effect on participation in enset production, productivity, value addition, food security and income.

Farm land size: Large farm size is one of the factors that attract the enset producer. Thus, farm land size has a positive impact on participation on participation in enset production, productivity value addition, food security and income.

Livestock holding: It is the total number of livestock owned by the households excluding oxen. Livestock holding is measured in terms of standardized common conversion factor called Tropical Livestock Unit (TLU). These are possessed as the wealth of the households and coping mechanism during food shortage.

The number of livestock possessed ensures farmers' food security and socio-cultural status of the households. Therefore, the variable will have a positive influence on participation in enset production, productivity value addition, food security and income.

Frequency of extension contact: It is continuous variable measure in number of contact. This variable takes care of access to health extension, agricultural extension and administrative services which are usually located in the *kebeles* administration office compounds. Regular delivery of agriculture and health extension services as well as training for farm households is hypothesized to increase participation on participation in enset production, productivity value addition, food security and income.

Use of improved agricultural inputs: Agricultural inputs utilization is the major factor that helps farmers to increase farm productivity and production. The improved agricultural inputs under use in the study area will be improved enset seedling, organic fertilizer, decorticator and animal breeds. Proper utilization of these improved agricultural inputs would ensure food security. Households who utilize these technologies are expected to participate enset production more and produce more and food secure than those who are not using these technologies.

Access to Credit: This is a dummy variable taking the value of 1 if the household have access to credit and 0 otherwise. Lack of capital source for investment in agriculture sector in the rural area is the bottleneck in Ethiopia and this is even true for all less developing countries. To solve financial constraints in order to purchase agricultural inputs, there should be a credit service from government, cooperatives, financial institutions or funding organizations (NGOs). The availability of credit to purchase improved agricultural inputs is the determining factor in poverty alleviation and participation enset production and food security status of the farm households. So, access to credit has a positive effect on participation in enset production, productivity value addition, food security and income.

Distance to market: This is a continuous variable measuring the distance from home to the nearest market in kilometers. Households nearer to market center and cooperative warehouses, having access to all weather roads, market information system, transportation availability and other infrastructural facilities can have more opportunity to produce marketable products in order to maximize their income [66]. So, accessibility to market or being closer to market center is expected to have positive effect on participation enset production, productivity value addition, food security and income.

Table 3: Description of variables hypothesized to influence impact analysis.

Description of variables	Measurement	Expected sign
Age of the household head	Continuous	+
Family size	Continuous	+
Dependency ratio	Continuous	+
Sex of the household head	Dummy	-
Education level of household head	Dummy	+
Farm land size	Continuous	+
Livestock holding	Continuous	+
Extension service provision	Dummy	+
Use of improved agricultural inputs	Continuous	+
Access to credit	Dummy	+
Distance to market	Continuous	-

3. Results And Discussion

3.1. Descriptive results

The description of general variations between Enset participant in value chain and nonparticipants in terms of each variable are given in Table 4. The results show that Enset participants in value chain are distinguishable in terms of such as Family size, Education household head, Land size of household, Distance to nearest Market, Total livestock holding, access to credit, Frequency of extension contact, Amount of kocho produced, Amount

of bulla produced, average price of kocho, average price of bulla, sex of a household head, remittance, participation in social institution, productive safety nets participation, use of improved agricultural input, and mulching. As indicated in Table 4, the average Age of respondents for Enset market participants was 40.77 years, whereas it is 42.44 years for the non-participants.

A closer look at the family size in the sampled households also showed that the treatment group of households (participants in value chain) had a relatively smaller family size, accounting for about 5.96 persons than the control group of households which was found to be about 8.62 persons. This implies that, on average, Enset non- participants have relatively more family sizes than participants. The t-test results confirm that there is significant difference between the two groups at 1% probability level. However, the treatment group of households and the control group have no significant difference between participants in value chain and non-participants in terms of dependency ratio and age of the households. Participants are also distinct in terms of socio-economic factors.

Livestock holding, as a wealth variable, indicates the capacity of households to involve in income-generating activities from different sources. As shown in Table 4, the livestock holding in TLU was 7.16 for the treatment group and 1.32 for the control group. This implies that the livestock of participants in value chain was significantly higher than that of non-participants. The education level of the household head is significantly higher for participants (2.08) than non-participants (1.45), and this makes them better able to understand the importance of participation in value chain. The average land size owned by the participant in value chain of household is 0.975ha which is significantly higher than the average farmland owned by the non-participants (0.492). This is because, farmers can only allocate more land to Enset production if they have enough land, and therefore those who own more land are expected to have a comparative advantage when it comes to Enset production and participation in value chain. Non-participants were located far from output markets (14.42 Km) compared to participants (9.57 Km). This is because distance imposes transaction costs to households and determines their decision to participate in the enset market.

The t-test results confirm that there is significant difference between the two groups at 1% probability level. The average frequency of extension contact for participation in value chain and non-participants were 14.86 and 11.04 respectively. This implies that there is significant difference between the two groups at 1% probability level.

Participants in value chain have more access to institutional services such as; access remittance, access market information, participation in safety net program, participation in social institution, and use of improved input than non-participants. Those household heads participating in enset market are relatively those who got have access to Remittance (57.8 % *vs*. 21.25%), have access to market information (65.47% *vs*. 24.35%), have participation in safety net program (28.9% *vs*. 98.55%), have Participation in social institution (89.59% *vs*. 70.53%), have access to Processing kocho and bulla (56.64% *vs*. 33.33%), have access to mulching (95.95% *vs*. 47.82%) and use of improved input (96.53*vs*. 47.82%). The mean difference between the two groups is statistically significant at 1% probability level for all the above variables.

Table 4: Characteristics of the sampled households by enset participation in value chain.

	Mean value by participation in value chain			
Description of continuous variables	Participation in value chain	Non- participate in value chain	Total sample	t-value/χ2
Age of household head	40.77	42.44	41.43	0..27
Family size	5.96	8.62	7.65	11.77***
Education household head	2.08	1.45	1.73	6.56
Land size of household	0.975	0.492	0.676	8.708***
Distance to nearest Market	9.57	14.42	11.77	7.49***
Dependency ratio	0.725	0.723	0.724	0.247
Total livestock holding	4.23	3.09	3.96	2.45**
Frequency of extension contact	14.86	11.04	12.77	9.402***
Off-farm/non-farm income	2184.05	3228.5	2755.78	3.95**
Quantity of kocho produced	3663.72	414.98	1885.46	8.97***
Quantity of bulla produced	37.53	4.15	18.9	9.87***
Average Price of kocho	14.42	9.57	11.77	7.49***
Average Price of bulla	39.11	37.86	38.42	2.2*
Description of dummy variables				
Sex of a household head(m=1)	80.34	67.63	73.42	83.37***
Remittance(yes=1)	57.8	21.25	37.89	22.27***
Participation in social institution(yes=1)	89.59	70.53	78.42	131.21***
Productive safety nets participation(yes=1)	28.9	98.55	66.84	43.11***
Use of improved agricultural input(yes=1)	96.53	47.82	70	60.4***
Access to Credit (yes=1)	56.64	33.33	43.95	5.56**
Mulching (yes=1)	95.95	47.82	69.92	60.16***

Note: Statistical significance at 10% (*), 5% (**) and 1% (***) probability levels.

Source: Own survey result (2021)

Mean Difference in Income and calorie intake Indicators between participation in value chain **and Non-participant Households**

The difference in the mean of income and calorie intake between farmers who participated in the Enset markets and those who did not was tested using the t-test and the results are presented in Table 5. The analysis revealed that there were significant differences in all income and calorie intake between farmers who participated in the Enset markets and those who did not. Although causal relationships cannot be identified with descriptive statistics, smallholders who participated in Enset markets earn more crop income, and daily calorie intake than non-participants. With an average daily calorie intake of 2894.081Kcal, farm households who participated in Enset markets could enjoy significantly higher calorie intake than those who did not participate, with an average of 1454.856 Kcal. The descriptive result further shows that there is a statistically significant difference between the two groups of households at a 1% probability level in mean crop incomes which are 17268.16 Birr and 8483.97 Birr, respectively.

Table 5: Mean Difference in some Welfare Indicators between Participants and Non-participants.

Variables	**participation**	**non-participation**	**Total**	difference	t-value
Average income	17268.16	8483.97	13652.5	8784.18	3.7**
Average calorie intake	2894.081	1454.856	2131.8	1439.225	9.52***

Note: Statistical significance at 10% (*), 5% (**) and 1% (***) probability levels.

Source: Own survey result (2021)

3.2. Econometric results

The descriptive analysis in the previous section indicates significant differences in household demographic, socio-economic, institutional, and marketing influence as well as the food security and income of households between enset market participants and nonparticipants. However, to properly evaluate the impacts of market entrance and level of market participation on farm households' food security and income, econometric models are used. This section discusses results obtained from endogenous switching regression and the generalized propensity score approach.

3.2.1. Determinants of farm households' participation in enset value chain

The income and calorie intake equations are jointly estimated with the selection equation explaining farm households' market participation. The first stage (probit) results of the endogenous switching regression which estimates the determinants of a household's decision to participate in the enset market was depicted in Appendices Table 6. As was expected, out of sixteen variables entered into the model, three of them i.e. age of the household, distance to market, sex of the household, and participation in productive safety net program have a negative significant effect on market participation, while the remaining variables have positive relationships (i.e. education level, extension contact, and access to credit) significantly affected market participation of smallholder farmers. This indicates that demographic factors have little impact on enset market participation in this area. Further, institutional, socio-economic, and market issues should be of the main concern.

Age of the household head significantly and negatively influences enset market participation. There is a negative and notable association between the household head age and participation in enset market, indicating that young-headed households are more probably to participate in enset market for income-generating activities than old farm household heads [22].

Sex of the household head: Sex of the household head significantly and negatively influences enset participation in value chain. Being a male-headed household decreases the probability of participating in the enset value chain by 1.42%, all other factors held constant. This suggests that female-headed households are more market-oriented than males, hence they participate more in the market. The reason might be enset production and business are gender specific in the study area. [22], found that in Ethiopia female-headed households had a higher tendency to participate in the dairy market than male-headed households. This is because in Ethiopia females are the ones

who participate in the processing of dairy products. [68], reported that in Nigeria female-headed households had a higher probability of fish market participation than male-headed households. The gendered nature of the fish business comes from the fact that skills and tasks training for the acquisition of knowledge is gender specific in the study area.

Educational level of household head: As hypothesized educational level of household head was found to have positively and significantly affected enset market participation at a 10% significance level. The average marginal effect indicated that as the level of formal education of the household head increases by one grade, the intensity of participation increases by 5.2%. This indicates that attending formal education increases the ability to get and use the information and adopt better production practices and produce a large volume of enset

Access to Credit (ACR): As expected, this variable had a positive relationship with household enset participation decision and was statistically significant at less than a 1% probability level. Access to credit would enhance the financial capacity of the household to purchase the necessary inputs and increases output. Moreover, get hold of good transportation, post-harvest handling, and alleviating marketing problems. The marginal effect confirms that as the household access to get credit increase by 1% the probability of market participation decision increase by 15.44%. A study conducted by [10], states that in poor societies, lack of credit is a major constraint to everyone concerned with selling and buying honey.

Table 6: Probit model estimates participation in enset value chain.

Description of variables	Marginal effect	Std.err	p>/z/
Age of household head	0.0048	0.0029	0.094*
Sex of a household head	0.0142	0.0072	0.050**
Education household head	0.0526	0.0317	0.097*
Land size of household	0.0189	0.0621	0.761
Family size	0.0079	0.0124	0.524
Dependency ratio	0.0219	0.0143	0.128
Total livestock holding	0.0063	0.0090	0.487
Access to Credit	0.867	0.0436	0.005***
Frequency of extension contact	0.462	0.0628	0.459
Distance to nearest Market	0.0078	0.0048	0.106
Off-farm/non-farm income	1.001	0.0006	0.089*
Productive safety nets participation	0.0665	0.0566	0.241
Use of improved agricultural input	0.1544	0.0583	0.008***
Amount of kocho produced	6.28	0.0001	0.628
Amount of bulla produced	9.13	0.0002	0.586
Average Price of kocho	1.121	0.371	0.729
Average Price of bulla	0.1625	0.0594	0.006***
Access to market information	0.086	0.0547	0.114
-const			
Wald chi2(18)	73.38		
Pseudo R2	0.1574		
Prob>chi2	0.000		
Log Pseudolikinhood	-216.344		

Source: Results from sample survey data (2021).

Notes: ** and ***indicate significance at 5% and 1% levels, respectively.

The results of the estimation highlight that calorie intake and income are affected by different factors and at different levels of significance by the same factor. For instance, Age of the household, family size, education level, tropical livestock unit, dependency ratio, use of improved input, participation in safety net program, price of enset, and mills ratio significantly affect the calorie intake of households who did participate in the Enset value chain. Whereas, age of the household, family size, education level, sex of the household, tropical livestock unit, use of improved input, access to credit, participation in safety net program, , and the quantity of bulla and kocho produced significantly affect the calorie intake of households who did not participate in the Enset value chain. Moreover, the sex of the household, tropical livestock unit, distance to market, land, use of improved input, access to credit, price of enset, and mill1 significantly affect the income of households who participated in the Enset value chain. In addition, Land, and quantity of bulla and kocho produced significantly affect the income of households who did not participate in the value chain.

Table 7: ESR estimates for food security and income of smallholder farmers.

variables				
	Calorie intake		Income	
	With participation	Without participation	With participation	Without participation
Age of household head	18.78(4.67)***	20.811(8.68)**	282.76(419.3)	68.43(127.76)
Family size	91.37(19.4)***	41.23(17.7)**	496.59(1078.23)	84.19(350.23)
Education level	135.60(52.23)**	160.90(90.52)*	269.9(3924.9)	2070.18(2232.4)
Sex of a household head	7.021(88.66)	195.26(111.89)*	10960.9(6228.12)	552.26(2518.53)
Total livestock holding	44.482(10.90)***	67.28(16.29)***	1846.51(896.2)	227.23(348.41)
extension contact	9.135(10.65)	14.45(23.43)	587.84(1210.4)	338.18(516.57)
Distance to nearest Market	14.326(14.01)	61.25(39.8)	2940.013(1408.65)	239.77(1155.83)
Dependency ratio	67.510(23.51)***	10.02(36.57)	1071.76(2048.06)	437.18(721.45)
Land	69.307(56.74)	44.55(107.42)	60949.8(10808.2)	31177.9(8197.81)
Use of improved input	370.723(87.87)***	299.14(171.85)*	12922.32(7199.78)	1588.6(2700.9)
Access to market	320.74(137.54)**	526.98(272.18)**	17523.9(10744.6)	1245.89(5904.9)
Access to Credit	114.799(108.96)	446.49(250.30)*	23738.9(13108.4)	33.06(4909.5)
Participation in safety net	184.810(75.65)**	295.00(137.76)**	2621.45(6015.09)	2527.8(2226.3)
Quantity of bulla and kocho produced	0.0024(0.016)	0.040(0.015)***	0.23(0.66)	0.45(0.20)
Mill 1	1204.396(445.42)***	-1673.216(1041.1)	70887.2(37658.4)	6893.6(21207)
Cont.	915.17(358.45)**	1032.34(1710.91)	43715.733510.7 ()	8210.37(30252.6)

Note: Statistical significance at 10% (*), 5% (**) and 1% (***) probability levels.

Source: Own survey result (2021)

3.2.2. Endogenous switching regression-based treatment effects

The expected household food security and income outcome under actual and counterfactual conditions for enset participation in value chain was presented in Table 8. The result was obtained following conditional

expectations that result from the estimation of the switching model presented above. The treatment effects of participation in value chain on crop income reveal that farm households who participated in the Enset market would have an income loss of 22169.395 Birr had they not participated. On the other hand, non-participants would have achieved crop income of about 9864.246 Birr had they participated in the Enset value chain. The base heterogeneity (BH1) for crop income is positive indicating that if the current non- participants had participated; they would have gained less crop income (13591.81Birr) than farm households that participated. Similarly, the positive base heterogeneity (BH2) shows that participants would have gained more crop income (7573.55 Birr) than actual non-participants even if they had not participated. Overall, the transitional heterogeneity (TH) effect is positive implying that the effect is greater for farm households that did participate compared to non-participants. This highlights that there are some important sources of heterogeneity that makes the participants "better-off" than the non-participants irrespective of participation in value chain.

The average calorie intake of a typical household that sold its Enset output is 2390.407kcal but would be lower (1977.096kcal) if the household did not participate.

On the other hand, for a typical household that does not participate in the Enset participation in value chain would increase his/her calorie intake by 415.877kcal.

The transitional heterogeneity effect is positive implying that the effect is greater for the farm households who did participate relative to those who did not participate. Overall, results show the role of Enset participation in value chain in improving the income and calorie intake of the rural households, whereby the resulting increase in crop income from participation in value chain may facilitate the purchase of food and non-food items and improve food security, nutrition, and poverty reduction among smallholder farmers.

Table 8: ESR-based average treatment effects of enset participation in value chain on food security and income outcome variable.

Mean of the outcome variable	Farm households type and treatment effects	Decision stage		Average treatment effects (ATE)
		To participate	Not to participate	
Income	Farm households that Participate (ATT)	30361.28	8191.885	22169.395
	Farm households that did not participate(ATU)	16819.47	6955.224	9864.246
	Heterogeneous effects	BH1=13591.81	BH2=7573.55	TH=12305.149
Calorie intake	Farm households that Participate (ATT)	2390.407	1970.096	420.311
	Farm households that did not participate(ATU)	2191.813	1775.936	415.877
	Heterogeneous effects	BH1=198.594	BH2=194.16	TH= 4.434

Note: Statistical significance at 10% (*), 5% (**) and 1% (***) probability levels.

Source: Own survey result (2021)

4. Conclusion and Policy Implications

This study evaluates the potential impact of Enset participation in value chain on household income and calorie intake in the Gedeo zone of southern Ethiopia by utilizing cross-sectional farm household-level data collected from a randomly selected sample of 380 households using endogenous switching regression. This helps in estimating the true impact of participation in value chain on income and calorie intake by controlling for the selectivity bias. The results of the estimation highlight that calorie intake and income are affected by different factors and at different levels of significance by the same factor. For instance, age of the household, family size, education level, sex of the household, tropical livestock unit, use of improved input, access to credit, access to market, participation in safety net program, quantity of produce, and volume sold. The likelihood ratio test for joint independence of the two equations is reported in the last line of the output table. The significance of the coefficient of correlation between the participation equation and the farmers' calorie intake and income indicates that self-selection occurred in the enset participation in value chain.

The average calorie intake of a typical household that sold its Enset output is 2390.407kcal but would be lower (1977.096kcal) if the household did not participate. On the other hand, for a typical household that does not participate in the Enset participation in value chain would increase his/her calorie intake by 415.877kcal. The transitional heterogeneity effect is positive implying that the effect is greater for the farm households who did participate relative to those who did not participate. Overall, results show the role of Enset market participation in improving the income and calorie intake of the rural households, whereby the resulting increase in crop income from participation in value chain may facilitate the purchase of food and non-food items and improve food security, nutrition, and poverty reduction among smallholder farmers.

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5. Disclosure statement

The authors have not declared any conflict of interest.

6. Author Contributions

Toyiba Shafi **(**Corresponding author**)** contributed to the study, data collection, organizing, coding, analyzing and writing the manuscript**.**

Jema Haji (professor): contributed to the study by designing methodological framework, gives constructive comment on data analyses and write up of the manuscript.

Lemma Zemedu (associate professor): contributed to the study by designing methodological framework, gives constructive comment on data analyses and write up of the manuscript.

Abule Mehare (PHD): contributed to the study by giving a constructive comment to the manuscript.

Competing Interest

- The authors declare they have no competing interests.
- The authors has received research support like logistic from Haramaya university

Ethics Approval and Consent to Participate.

- This studies involving human participants
- **The needs for waiver was because of the author is from developing country (from Ethiopia) I don't have the ability to pay, that is why I need support**
- The ethics committee that approved the study were Jema **Haji (Professor)**, **Lemma Zemedu (Associate Professor), Abule Mehare (PHD)**

Availability of data and materials.

Data availability should still be stated in the manuscript along with any conditions for access.

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Consent for publication.

All of the material is owned by the authors

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