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EDITED BY

Raquel Santiago Barro,
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REVIEWED BY

Innocent Osoro Ngare,
Food and Agriculture Organization of the
United Nations, South Sudan
Habtmu Atalay Wubea,
Dire Dawa University, Ethiopia

*CORRESPONDENCE

Girma Gata

✉ girmagganebo@gmail.com

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Impact of mung bean crop market participation on asset accumulation of smallholder households in low-land areas of South Ethiopia

Girma Gata*, Berhanu Kuma and Alula Tafesse

Department of Agricultural Economics, Wolaita Sodo University, Wolaita Sodo, Ethiopia

Introduction: The study aimed at to evaluate the impact of mung bean crop market participation upon asset accumulation of smallholder farmers in lowland areas of South Ethiopia.

Methods: About 384 smallholder mung bean producer farmers were selected from the lowlands of Wolaita, Gamo and Gofa zones following multistage sampling procedures. The composite asset index development was calculated by multiple correspondence analysis whereas endogenous switching regression was used to evaluate the impact of market participation upon households' asset accumulation.

Results: Out of 384 selected mung bean farmers (74.5%) participated in mung bean markets while 25.5% did not participate in mung bean markets. The estimation result revealed that age of the head of household, numbers of family members, livestock population, perception toward social value, quantity of mung bean product, credit utilization, information accessibility, frequent training on agro-practices, road and market distance from home significantly affected mung bean market participation status. In addition, the asset accumulation of the participants was positively and significantly influenced by age of the head of household, quantity of product and distance from all-weather roads whereas information accessibility negatively affected asset accumulation.

Discussion: The farmers who participated in mung bean markets were more likely (positive) impact on asset accumulation from selling of the product. Therefore, the government and market regulatory bodies should encourage farmers through providing credit facilities, information and frequent training about the new emerging beans and developing other infrastructure facilities to increase the asset accumulation for smoothing elongated shocks in SERS, Ethiopia.

KEYWORDS

asset accumulation, ESR, market participation, MCA, OLS, probit

1 Introduction

Ethiopia's diverse climate and soil types, combined with three agroecologies, produce various agricultural crops for domestic consumption and commercialization, primarily dominated by smallholder farmers (Addis and Abirdew, 2021; Atnaf et al., 2015; Molla et al., 2022). However, it is still stagnant due to low agricultural technology adoption, weak fallback strategies, imperfect input and output markets, etc. (Atnaf et al., 2015; Rios et al., 2008; Tesfamicheal Wossen, 2015; Jankelova et al., 2017; Adhikari and Khanal, 2021; Getachew, 2019; Simion, 2018). As part of solving the sectorial

drawbacks, the agricultural policies, strategic plans, and establishment of the Agricultural Transformation Agency encourage the production of export crops by transforming from subsistence farming to commercialization through the cluster approach (Rios et al., 2008; Tesfamichael Wossen, 2015; Jankelova et al., 2017; Dinsa et al., 2022; Ogada et al., 2020).

Mung bean is one of the pulse crops in marginal lands, Rift Valley fringes, and river valley areas of Jema, Omo, and their tributaries in Ethiopia (Eze et al., 2022; Kebede, 2020; Teame et al., 2017). Beinsangul regional state, the Bale zone and East Shewa zone in Oromia regional state, the low-land areas of the Wolaita, Gamo, and Gofa zones in South Ethiopia are the major producers (Kaysha et al., 2020; Adhikari and Khanal, 2021; Tehulie et al., 2021; Dinsa et al., 2022; Kebede, 2020; Neda, 2020; Getachew, 2019; Assefa et al., 2022). MH-97-6 (Boreda), Shewa Robit, Rasa (N-26), Arbeke, MH BR-1, NLV-1, and NUL-1 mung bean varieties have been developed by different agricultural research centers and disseminated to farmers for cultivation, and the demand of the farmers has been increasing for improved varieties (Kassa et al., 2021; Dinsa et al., 2022; Baza et al., 2022).

Mung bean is the country's sixth main export item in the commodity market, alongside oil seeds and cereals, driven by smallholder farmers' commercialization efforts (Baker and Yuya, 2020). Its production and export volume have shown a steady increase over the years, with export volumes rising from 2310 tons in 2004 to 22,719 tons in 2013 and reaching 68,818 tons in 2016. Emerging varieties provide additional household income in South Ethiopia, improving food security and soil fertility, supporting construction, providing livestock feed, and serving as fuel (Gata et al., 2024; Tun and Phyto, 2019; Getachew, 2019; Kebede, 2020). All contributions make the mung bean the second low-land pulse next to common bean.

However, this newly introduced crop is trying to make inroads into the existing agricultural system and has faced greater challenges due to various factors. In addition to the potential importance of mung bean, its productivity and export share are low and less popular when compared with other exportable pulse crops in drought-prone areas. In the South Ethiopia region, smallholder farmers produced very small amount of mung bean crops, though they were endowed with favorable agroecological zones. Farmers' uncertainty due to lack of information about the new technology can change the perception of the farmers and adversely affect the probability of adoption (Emeru, 2022). Farmers are producing infinitesimal quantities, thereby challenging the smallholder farmers' market participation. Smallholder farmers are also failing to include it in their local dishes due to adverse perceptions of the nutritional value of the crop (Assefa et al., 2022; Temeche et al., 2022). The marketable surplus of the crop is very low in the country compared with other dry beans. These issues further lead to unexpected outcomes for the smallholder farmers' food security, nutrition and health status, income amount, and other welfare indicators.

There is limited research carried out on the long-term impact of welfare indicators in the area so far, though they simply came across the descriptive analysis of financial analysis (Tun and Phyto, 2019;

Wang et al., 2018) and review of market challenges (Kebede, 2020). In addition, landrace and staple crops are usually cultivated for both household consumption and commercialization purposes (Kebede, 2020; Manda et al., 2021; Getachew, 2019), such as common bean (Habte et al., 2021), chickpea (Tabe Ojong et al., 2022), maize and pigeon pea (Sequeros et al., 2021; Mmbando et al., 2015a), and moringa (Meskel et al., 2020). Many previous research studies have found the effects of various crop market participation in welfare indicators, mainly household income (Sequeros et al., 2021; Mmbando et al., 2015a; Meskel et al., 2020; Hashmiu et al., 2022; Abokyi et al., 2020; Zegeye et al., 2022; Biru et al., 2020; Rubhara et al., 2020; Sequeros et al., 2020; Brockington and Brockington, 2021). Short-term income and consumption indicators cannot easily stabilize smallholder farmers' livelihood compared with household asset possession, which is superior on average (Kassa et al., 2021; Baker and Yuya, 2020; Meskel et al., 2020; Zegeye et al., 2022; Li et al., 2020; Mmbando et al., 2015b; Dikr, 2023); however, varieties that are compatible with the harsh environments and high-value crops, such as mung bean varieties, are not given much attention.

Moreover, there is limited knowledge of the impact of mung bean market participation in smallholder agriculture. The claimed benefits of mung bean need to be confirmed by impact analysis for long-term shock smoothing. Finally, the extant literature on market participation did not address the quantitative issues, and the models employed were subjected to biased estimations (Tadele et al., 2022). Hence, analyzing the impact of mung bean market participation on small-scale farmers' welfare would be of policy relevance. Therefore, the study aimed to evaluate the impact of participating in the mung bean market on households' asset accumulation *via* the models that can handle all impact evaluation challenges in the study area.

2 Materials and methods

2.1 Study area

This study was carried out in the Gamo, Gofa, and Wolaita zones, which are the three main producers of mung bean in South Ethiopia Regional State (SERS) after being launched as the sixth export crop in Ethiopia Commodity Exchange Authority (ECX) (Ademe, 2023; Dikr, 2023; Kidane et al., 2022). In the SERS area, production, the yield of crops and private peasant holdings for *meher* season in 2022 increased to 2,359 ha, 11,805.04 quintals, 10.01 Qt/ha, and 11,344.00 households. They are endowed with natural resources such as permanent and seasonal rivers such as Zage, Masta, Maze, and Deme, in addition to nurturing human beings and the lives of study areas animals, especially Maze National Park dwellers (Chalite, 2020; Isayev et al., 2023; Eze et al., 2022). Dana Bazuwa is a hot area in the basin of the Deme River adjacent to the Kucha, Ofa, and Humbo districts (Baza et al., 2022). Mung bean is one of the major crops grown in low-land areas by rainfall and irrigation schemes for physiological requirements in the study area, like other areas in the world (Isayev et al., 2023; Komarek et al., 2020). Table 1 indicates the geographical and climatic information of the study.

TABLE 1 Geographical and climatic information of the study area.

District (<i>Woreda</i>)	Absolute location	Elevation, mean annual temperature and rainfall	Main rivers and peculiar features
Daramalo	6° 13'–6° 38' N latitude and 37° 21'–37° 39' E longitude.	1,001–3,500 m asl; 10.2–25°C; 1,401–1,600 mm	Zage and Masta rivers, tributaries of the Omo River
Kucha	6° 3'–6° 0' N latitude and 37° 3'–37° 7' E longitude.	Elevation- 800–2,250 m asl.	Dana Bazuwa (hot basin) Deme River
Demba Gofa	8° 1' 21" to 8° 1' 84" N latitude and 42° 9' 35" to 43° 9' 86" E longitude	23°C, 1,300 mm; 1,350–2,600 m asl.	Maze River Maze National Park
Zala	6° 04' 00" N to 06° 30' 00" N latitude and 36° 58' 20" E to 37° 13' 30" E longitude	18°C–32°C and 900–1,700 mm	Maze River Maze National Park
Ofa	6° 83' N latitude and 37° 71' E longitude	14°C–34°C and 850–1,450 mm	Deme River, Mani'ssa River
Humbo	6° 50' and 6° 81' N latitudes and 38° 04' E longitude	22.0°C and 1,123.15 mm	Hamasa River, East Africa's Rift Valley

Source: Own survey, 2024.

2.2 Sampling procedures, sample size, and sample size determination

Multistage sampling procedures were employed to select the sampled mung bean farmers in SERS. Among the SERS zones of the Omo and the Rift Valley areas, Wolaita, Gamo, and Gofa were selected in stage one based on large production and the first adopters of the varieties in the regional state. Next, six districts (two from each zone) were selected purposively as part of the study due to the main producers for the ECX (Tabé Ojong et al., 2022). A total of 14 sampled Kebeles. Out of 24 *kebeles*, only seven *kebeles* are found to be the major mung bean-producing *kebeles* in the Daramalo district. These are Hoya Degeze, Masta, Domoa, Shela Shubo, Shela Deda, Nenena Abaya, and Antashe. Out of 24 *kebeles*, five were identified as the main producers from the Kucha district. Masha Morka *kebele*, Dana *kebele*, peri-urban of Selam Ber, and others are the major producers of mung bean. Zala district has 34 rural and one urban *kebeles* (Simion, 2018).

Demba Gofa, which is adjacent to Maze National Park, is the producer of the crop. Out of 15 rural and four urban *kebeles*, Mancha Gogara, Sere Esho, and Busha are the main producing *kebeles* in the catchment area of Dana River in Ofa district (Tehulie et al., 2021; Assefa et al., 2022). Thus, out of the total mung bean-producing *kebeles* from six districts, three *kebeles* each were selected from Daramalo, Kucha, Zala, and Demba Gofa districts and one *kebele* each was selected from Ofa and Humbo districts and that made a total of 14 sampled *kebeles* those were selected in the third stage through simple random sampling techniques (Table 2).

In the end, from the research population (N), the 384 final sample size (n) with the error term (ϵ) of 5% value at a 95% confidence level was determined based on the previous literature (Habte et al., 2021; Tabé Ojong et al., 2022; Sequeros et al., 2021).

$$n = \frac{N}{1 + N(\epsilon)^2} = \frac{9587}{1 + 9587(0.05)^2} = 384 \quad (1)$$

The study used a proportionate or equalized sampling technique to take a sample from each district, which is specified as follows:

$$P_i = \frac{n}{N} * X_i \quad (2)$$

where P_i represents the sample from strata or *kebele* i ; n is the sample size, N is the population, and X_i is the number of households in each *kebele* i .

2.3 Data types and sources

The study incorporated both primary and secondary data types. A source of primary data was mung bean producers from each *Woreda*. The primary data survey questionnaire included the mung bean farmers' demographic, socio-economic characteristics, market participation, market-related factors, and asset indicators pertinent to the objective of the study. Secondary data types such as written documents and necessary websites to enrich the literature were also employed from six *Woreda* offices.

2.4 Data collection and analysis

The household survey was conducted using commonly employed tools such as questionnaire schedules and/or interviews to collect the primary data. Trained and oriented enumerators, such as agriculture office experts from the districts and development agents from sampled *kebeles*, were assigned and collected, and the data were collected from mung bean farmers under the supervision of the researchers. The smallholder farmer's socio-economic, demographic, and institutional characteristics, market participation, welfare indicators, and other characteristics were summarized by statistical analysis of the center of the distribution, the dispersion, and the shape of data in the first part of the results and finding section. The multivariate statistical algorithm family so-called multiple correspondence analysis (MCA) for the development of household asset accumulation index from the asset lists arranged in a questionnaire based on suitability assessments were used (De Muro et al., 2011). In econometric techniques, the endogenous switching regression (ESR) model was used to estimate

TABLE 2 Determined sample size from sample population of the study area.

Zones	Districts/ <i>Woredas</i>	Study sites/ <i>Kebeles</i>	Study population	Sample size
Gamo	Daramalo	Hoya Degeze	513	21
		Doma	520	21
		Masta	535	21
		Sub total	1,568	63
	Kucha	Masha Morka	675	27
		Dana	980	39
		Wozate	539	22
		Sub total	2,194	88
Gofa	Zala	Mella Gayla Osa	561	22
		Delle Wagesho	972	39
		Indegerra	914	37
		Sub total	2,447	98
	Demba Gofa	Lotte Gaila Chalbie	860	35
		Zanga Awande	863	35
		Docha Dambala	434	17
		Sub Total	2,157	87
Wolayta	Ofa	Mancha Gogara	461	18
		Sub Total	461	18
	Humbo	Pango Lome	760	30
		Sub Total	760	30
		Grand Total	9,587	384

the binary equation and the outcome equations simultaneously. Furthermore, due to the sensitivity character of ESR, Instrumental variables (IVs) were selected using the ordinary least square (OLS) estimation technique and binary probit model. The STATA 16 package was used to fit asset indicators in MCA and to estimate the models.

2.5 Model specification for impact evaluation

Outcomes evaluation is a major methodological challenge to cascade because it needs to control potential selection biases/heterogeneity and endogeneity problems. If we apply the classical linear regression model (CLRM) estimation technique to estimate the impact of market participation on farmers' asset accumulation, the result should be biased. Selection biases arose from the observed heterogeneity controlled by the PSM, but the problem of unobserved heterogeneity still remained. Along with PSM, the IVs are able to capture unobserved factors (Maddala, 1992; Mmbando et al., 2015b). In addition, the main limitations of Heckman's model are employed in two successive decision analyses (Willy et al., 2023; De Muro et al., 2011; Koné et al., 2019). Therefore, the current article adopts the model that can be able to handle all impact evaluation challenges, the so-called ESR for the impact of mung bean farmers' participation in the product

market upon asset accumulation, by providing both equations simultaneously (Koné et al., 2019; Di Falco et al., 2011).

In stage one of the selection equation in the ESR model, the binary probit model regression method is a suitable model for market participation estimation since it takes dichotomous code "1" (D_1) and code "0" (D_0) for households that sell their product in the mung bean market for getting benefits from the participation and for households who did not participate in this market, respectively. Therefore, assumed the rational farmers would choose to be participating in order to gain maximum utility ($D_i^* = D_1 - D_0$, where $D_i^* \Rightarrow 0$) from that of not participating. Equation 3 represents the selection or participation equation:

$$D_i^* = \beta Z_i + \eta_i; D_i = 1 \text{ if } D_i^* \geq 0 \quad (3)$$

where D_i is a binary variable that takes values equal "1" and "0" for both participation status; Z_i is mung bean farmers' characteristics those assumed to influence binary responses; β is a vector of parameters that indicates the slope change of each variable upon participation decision, and η_i is a random term.

Market participation outcome variable (in this study, the outcome variable was asset accumulation) Y_i assumed as the linear function of the variables X_i and D_i such that:

$$Y_i = \beta X_i + \delta D_i + \varepsilon_i \quad (4)$$

where δ and ε_i are the parameters to be estimated and the error terms, respectively.

The second stage consists of the estimation of both outcome equations: one for those who participate in the market or treated individuals and another for those not participating in the market or for untreated individuals represented following (Hashmiu et al., 2022; Kidane et al., 2022; Koné et al., 2019; Di Falco et al., 2011; Lokshin and Sajaia, 2004) as follows:

$$\text{Regime 1: } Y_{1i} = \beta_{1i}X_{1i} + \varepsilon_{1i} \text{ if } D_i = 1 \text{ (Market participation)} \quad (5)$$

$$\text{Regime 2: } Y_{2i} = \beta_{2i}X_{2i} + \varepsilon_{2i} \text{ if } D_i = 0 \text{ (Non-participation)} \quad (6)$$

where Y_{1i} and Y_{2i} are outcome variables for participants and non-participants, respectively; X_i is a vector of exogenous variables of mung bean farmers, expected to influence asset accumulation; β is the coefficient vector; D_i is a dummy for market participation, and ε_i is the residuals.

The selection Equation 3 error term and two regimes error terms in the outcome Equations 5, 6 are assumed to have a tri-variate normal distribution with zero mean and covariance matrix of the following form:

$$\text{cov}(\eta, \varepsilon_1, \varepsilon_2) \begin{bmatrix} \delta_\eta^2 & \delta_{1\eta} & \delta_{2\eta} \\ \delta_{1\eta} & \delta_1^2 & . \\ \delta_{2\eta} & . & \delta_2^2 \end{bmatrix} \quad (7)$$

where δ_η^2 is the variance of the error term in the selection Equation 3; δ_1^2 and δ_2^2 are the variances of the error terms in the outcome Equations 5, 6; $\delta_{1\eta}$ and $\delta_{2\eta}$ are the covariance of η , ε_{1i} , and ε_{2i} . Covariance between ε_{1i} and ε_{2i} is not defined since Y_1 and Y_2 are not observed simultaneously. The FIML method simultaneously estimates binary (the selection equation) and continuous parts of the model (the outcome equations) to yield consistent standard errors.

Based on the literature, the ESR identify the impact of eco-friendly farmers upon asset accumulation of those who participate in the mung bean market (Equation 5) with respect to eco-friendly farmers who do not participate in the mung bean market (Equation 6). Furthermore, the respective two counterfactual hypothetical cases are also examined in the following cases (Case I–Case IV):

Case I: market participants with participation in the mung bean market:

$$E(Y_{1i}/D_i = 1) = \beta_1 X_{1i} + \delta_{\varepsilon_1} \eta \lambda_{1i} \quad (8)$$

Case II: market participants have decided not to participate in the mung bean market:

$$E(Y_{2i}/D_i = 1) = \beta_2 X_{1i} + \delta_{\varepsilon_2} \eta \lambda_{1i} \quad (9)$$

Case III: non-market participants without participation in the mung bean market:

$$E(Y_{2i}/D_i = 0) = \beta_2 X_{2i} + \delta_{\varepsilon_2} \eta \lambda_{2i} \quad (10)$$

Case IV: non-market participants have decided to participate in the mung bean market:

$$E(Y_{1i}/D_i = 0) = \beta_1 X_{2i} + \delta_{\varepsilon_1} \eta \lambda_{2i} \quad (11)$$

Using these expected outcomes, we derive unbiased treatment effects: the average treatment effect on treated (ATT), which is the difference between Equations 8 and 9, and the average treatment effect on untreated (ATU), which is the difference between Equations 10 and 11.

$$\text{ATT} = E(Y_{1i}/D_i = 1) - E(Y_{2i}/D_i = 1) \quad (12)$$

$$= (\beta_1 - \beta_2) X_{1i} + \lambda_{1i} (\delta_{\varepsilon_1} \eta - \delta_{\varepsilon_2} \eta)$$

$$\text{ATU} = E(Y_{2i}/D_i = 0) - E(Y_{1i}/D_i = 0) \quad (13)$$

$$= (\beta_1 - \beta_2) X_{2i} + \lambda_{2i} (\delta_{\varepsilon_1} \eta - \delta_{\varepsilon_2} \eta)$$

The “effects of base heterogeneity” for the group of farm households that decided to participate (BH₁) is:

$$\text{BH1} = E(Y_{1i}/D_i = 1) - E(Y_{1i}/D_i = 0) \quad (14)$$

$$= (X_{1i} - X_{2i}) \beta_1 + \delta_{\varepsilon_1} \eta (\lambda_{1i} - \lambda_{2i})$$

“The effect of base heterogeneity” (BH₂).

$$\text{BH2} = E(Y_{2i}/D_i = 1) - E(Y_{2i}/D_i = 0) \quad (15)$$

$$= (X_{1i} - X_{2i}) \beta_2 + \delta_{\varepsilon_2} \eta (\lambda_{1i} - \lambda_{2i})$$

The difference between (TT) and (TU) leads to “transitional heterogeneity” (TH). Or it indicates whether the effect of participants is greater than that of the non-participants.

2.6 Variables expected to affect market participation and its impact on asset accumulation

2.6.1 Dependent variable

Treatment variables: Mung bean farmers’ market participation was measured by the binary decision of mung bean farmers whether to participate in the output market in selling crops in the survey period (1) or otherwise (0).

Outcome variable: The asset index of households is a continuous outcome variable used in the model. MCA was used to develop a household asset accumulation index based on the asset lists arranged in a questionnaire based on suitability assessments (De Muro et al., 2011).

Explanatory variables: The independent variables in this study are classified as control covariates and selection instruments. These are farmers’ demographic, socio-economic characteristics, and institutional factors.

Sex of the head of the household (SEX): The sex variable takes the value “1” if the sex of the head of the household is female and the value “0” if the sex of the head of the household is male. Being maleness was expected to influence the binary responses and outcome equations more probably when compared with their counterparts (Cazzuffi et al., 2020).

Age of the head of the household (AGE): The household’s age was measured in years. The older farmers are more participating in the mung bean market than their young farmers. According to reports, age is more likely to affect the mung bean market participation (Bezabeh et al., 2020).

Human capital (KH): It was used as a proxy of education level measured by years of schooling. The more educated farmers, the more cash crops are produced, thereby enhancing market supply for household livelihood improvement than less educated farmers (Adhikari and Khanal, 2021). Therefore, a positive relationship is expected.

A number of family members (FAZ): Mung bean production is expected to be labor intensive. If the family members in a single household are large, thus they are expected to produce a large amount of products it should supply to the market. Therefore, it is directly related to market participation (Olounlade et al., 2020).

Perception toward social value (PCA₅): The relationship between this perception and the market participation status of new market crop varieties has a positive effect hypothesis (Sánchez-Toledano et al., 2018).

Livestock population (TLU): More holdings of livestock population (TLU) in rural communities are more productive through cultivating commercial crops and thereby supplying more products to the market (Manda, 2016).

Farm size (MBFMZRATIO): Smallholder farmers with relatively large farmland have higher economies of scale and production, encouraging them to rely on market-based institutional arrangements (Mulwa et al., 2017).

Credit utilization (CRT): It is a binary variable that takes code “1” for CRT and “0” for its counterparts. The smallholder households’ input demand should be backed by finance, which gives them the power to purchase, thereby increasing the market supply.

Hence, it was hypothesized to support households to participate in the mung bean market, thereby increasing asset accumulation (Dagnew et al., 2023).

Quantity of mung bean produced in a year (MBQTY_YEAR): It is expected to be directly related to asset accumulation (Emran et al., 2021).

All-weather road proximity distance from home (DISROAD): The farther the home is from the road, the less it is to supply the farm products to the market than their counterparts (Gikonyo et al., 2022).

Center market distance from home (DISMKT): Center market distance from home takes the approximate distance measurement in kilometers. If center market distance from farmer’s residence is very near, it encourages the farmers to supply the products to the market, thus directly related to livelihood improvement strategies (Cazzuffi et al., 2020; Belete and Nigatu, 2023).

Information accessibility (INFOAC): Information accessibility, especially in producing cash crops and marketing in different means, can affect the mung bean market participation decision more likely (Belete and Nigatu, 2023).

Frequent training on mung bean agro-practices (FREQTRAIN): Frequent training takes binary codes 1 and 0 (no = 1 and 0 = there is training). It has a positive impact (Ahsanuzzaman, 2015). However, many meetings with public bodies can complicate the adoption choices of the technology, especially in situations where the improved seed varieties are not provided to the market (Silva and Broekel, 2016). Table 3 depicted types, definitions and measurement of the variables.

TABLE 3 Types, definitions, and measurements of variables.

Variable types	Definitions/descriptions	Measurement of variables
Dependent variable		
Market participation	Farmers market participation	Dummy (participate = 1; otherwise, 0.)
Outcome variable		
Asset accumulation		Index (multiple correspondence analysis)
Covariates		
Age of the head (AGE)	Age of the head of the household	Years
Sex of the head (SEX)	Sex of the head of the household	Dummy (female = 1, male = 0)
Human capital (KH)	Proxy by education level	Years of schooling
Social networks (PCA ₅)	Perception toward social value	Index (principal component analysis)
Family size (FAZ)	Number of family members	Number
Livestock size (TLU)	Number of livestock owned	Tropical livestock unit (TLU)
Farm size (MBFMZRATIO)	Farm Size to mung bean cultivation	Ratio
Road Infrastructure (DISROAD)	All-weather road distance from home	Km
Market Distance (DISMKT)	Center market distance from home	Km
Credit (CRT)	Credit utilization	Dummy (not utilize = 1, if utilize = 0)
Farm experience (TELAPSED)	Mung bean cultivation experience	Years
Production quantity (MBQTY_YEAR)	Quantity produced during the crop season	Kg
Information Accessibility (INFOAC)	Information accessibility in different means	Dummy (no accessibility = 1; yes, = 0)
Frequent training (FREQTRAIN)	Frequent training on mung bean agro-practices	Dummy (no = 1; yes = 0)

3 Findings and discussion

3.1 Summary statistics of households characteristics in terms of market participation status and asset accumulation

3.1.1 Sampled households characteristics

The result revealed that, out of 384 selected mung bean farmers, 74.5% of farmers participated in mung bean markets, while 25.5% of farmers did not participate in mung bean markets (Table 4). The mean age of the total samples, market participants, and non-participants was 48.37, 48.71, and 47.38 years, respectively. The average household size of the total samples, market participants, and non-participants was 6.794, 6.72, and 7.02 years, respectively. The mean education level of the total samples was 5.6 years of schooling. Meanwhile, the mean ratio of total land size to mung bean crop plots was 0.524 ha.

The mean livestock population for overall samples, market participants, and non-participants was 3.716, 3.85, and 3.03, respectively, and the treated and untreated groups are significantly different, as depicted in the *t*-value. This finding was also confirmed by researchers in the same study area and other regions of the country Ethiopia (Gata et al., 2024). Other researchers also confirmed that farmers who have more livestock holdings (TLU) possess basic assets and are able to handle agricultural implements for cultivation, thereby supplying more products to the market (Manda, 2016). The mean distance of the market center from farmers' homes for the total sample was 3.27 km, for market participants was 3.58 km, and for non-participants was 2.38 km. The farmers' home distance to nearby all-weather roads is a maximum of 10 km. This finding is similar to other drought-prone areas in south Ethiopia (Gata et al., 2024).

Perception toward social aspects in PCA with a mean component for market participants is greater than non-participants. Furthermore, the amount of mung bean products for participants was 1,455.50 kg, while 1,143.80 kg was for the counterparts, and the mean difference was statistically significant at <0.05 significant levels. This finding indicates that yields produced by participants are larger than the yields produced by non-participants in the study area. This finding was confirmed by Dagnew et al. (2023). A unit increase in the amount of products to market leads households to possess more wealth through market participation (Gikonyo et al., 2022; Durjoy Lal Soren, 2023).

Table 5 presents the characteristics of sampled households in terms of dummy variables and χ^2 test for market participant farmers and non-participant farmers. From 384 total samples, 273 farmers were males, while the remaining 13 farmers were females. Out of the total sampled farmers, those who utilized the financial credit were 66 farmers; however, most of the farmers (22 mung bean farmers) did not utilize the credit in the study area. Those who had access to information were 249 mung bean farmers, and the remaining did not have access to market information (37 mung bean farmers). Furthermore, 57.55% of farmers received frequent training on mung bean agro-practices, while the remaining 42.45% did not receive any training during the crop season. It also revealed the existence of statistically significant differences between both groups in cases of CRT [$\chi^2 = 17.66$ (0.000)] and information accessibility [$\chi^2 = 162.5$ (0.000)].

TABLE 4 Market participant farmers and non-participant farmers for continuous variables (t-test).

Variable	Measurement	Market participant farmers (N = 286)				Non-participant farmers (N = 98)				Pooled (N = 384)				t-value	
		Mean stat.	SDev	Minm	Maxi	Mean stat.	SDev	Minm	Maxi	Mean stat.	SDev	Minm	Maxi		
AGE	In years	48.71	12.30	25.00	80.00	47.38	12.63	25.00	77.00	48.370	12.384	25	80	-0.9189 (0.179)	
Family size	Number	6.72	2.37	1.00	13.00	7.02	2.46	1.00	12.00	6.794	2.392	1	13	1.085 (0.8607)	
Mung bean farm size	Ratio	0.52	0.22	0.13	1.00	0.54	0.25	0.20	1.00	0.524	0.226	0.13	1.00	0.704 (0.7589)	
Human Capital	In years	5.60	3.48	0.00	15.00	5.73	3.47	0.00	15.00	5.635	3.477	0	15	0.327 (0.6281)	
Tropical Livestock Unit	Index	3.85	4.19	0.00	17.26	3.03	3.79	0.00	14.68	3.716	4.104	0	17.2	-1.9109 (0.0284**)	
Bean cultivation experience	In Years	3.80	1.99	1	9	3.70	1.69	1	9	3.773	1.913	1	9	-0.4155 (0.3390)	
Infrastructure of road	Kilometer	2.310	2.560	0.050	10.00	2.07	1.32	0.10	5.05	2.251	2.311	0.05	10	-0.8829 (0.1889)	
Center market distance	Kilometer	3.580	3.890	0.400	15.00	2.38	1.71	0.38	6.00	3.270	3.499	0.375	15	-2.9506 (0.0017*)	
Perception toward social value	PCA	0.050	1.00	-1.78	1.88	-0.146	0.981	-1.783	1.88	-5.49	1.000	-1.783	1.88	-1.6780 (0.0471**)	
Quantity Produced _ Year	Kilogram	1,457.5	1,133.3	200	8,000	1,143.8	800.9	200	4,400	1,377.5	1,066.32	200	8,000	2.5308 (0.0059*)	

*** Indicates at <0.01 significant level, ** indicates at <0.05 significant level, and * indicates at <0.10 significant level. Source: Authors' Field Survey, 2024.

TABLE 5 Market participant and non-participant farmers for dummy variables (χ^2 value).

Variables	Participation status	Market participant farmers(N = 286)		Non- participant farmers (N = 98)		Pooled (N = 384)		χ^2
		Freq.	%	Freq.	%	Freq.	%	
Sex	Male	273	71.09	96	25	369	96.09	1.219 (0.269)
	Female	13	3.39	2	0.52	15	3.91	
Credit utilization	Yes, used	66	17.19	4	1.04	70	18.23	17.66(0.000*)
	Not used	220	57.29	94	24.5	314	81.77	
Information accessibility	Access to information	249	64.84	18	4.69	267	69.53	162.5(0.000*)
	No access	37	9.64	80	20.8	117	30.47	
Frequent training on agro-practices	There is training	146	38.02	75	19.5	221	57.55	19.39 (0.000*)
	No, training	140	36.46	23	5.99	163	42.45	

*** Indicates at <0.01 significant level, ** indicates at <0.05 significant level, and * indicates at <0.10 significance level. Source: Authors' Field Survey, 2024.

3.1.2 Composite asset index development

Among 53 asset indicators, 38 asset indicators were identified for composite asset index (asset weight) based on suitability assessments to fit for the MCA, whereas 10 asset indicators were excluded from the computation of the asset weight due to possession only by <10% (few) mung farmers [bee hives (5%), generator (4%), refrigerators (1%), bicycle (2%), computers (2%), remittances (7%), sofa set (15%), water pump (16%), biogas (7%), and irrigation pipe (4%)] and can bias the comparison in the study area; also four asset indicators were also excluded from analysis due to 100% not possessed by mung bean farmers, and one asset indicator was excluded from analysis due 100% possessed by all farmers (Table 6). The most deficient and best-accessed assets were excluded because they brought data outliers and failed to measure asset distribution among the farmers. Moreover, the exclusion of these variables is relevant not only because of low possession or virtually all possessed; rather, the differences in accessibility also can distort the comparison of the farmers across different study districts. Therefore, asset indicators should be removed or adjusted to better meet the fundamental properties of the MCA approach.

3.1.3 Distribution of asset accumulation over mung bean market participation

The impact indicator variable, the asset accumulation index, was computed using multiple correspondence analyses and was used as an outcome variable in the models. As depicted in Table 7, the maximum asset index (asset weight) was 2.573, and the minimum asset index was −2.206. The range asset weight was 4.779, which indicates a great uneven distribution of asset accumulation over mung bean market participants in SERS. These kinds of asset variations among rural farmers were also confirmed by Durjoy Lal Soren (2023).

The mean asset accumulation index for total mung bean farmers was 1.75, with a 0.0564 index value for treated and −0.164 for untreated groups. The *t*-value indicated the significant difference between both groups at <5% significance level [*t*-value = −1.8859 (0.0300)]. The level of assets within a community significantly affected its ability to develop and reestablish the low-land people’s livelihood improvement during an emergency and after a shock of incidents. The eco-friendly farmers’ strength depends on asset accumulation. The more they accumulate the assets, the more they shape the shocks they encounter. In addition, asset accumulation index development is important to address inequality in asset distribution (Islam and Walkerden, 2022).

3.2 Econometric analysis

3.2.1 Driving factors of mung bean market participation _ Stage I: probit model

Table 8 indicates the selection equation result of the main driving factors that are influencing mung bean farmers’ market participation status. As shown in Table 8, the Chi-square value ($\chi^2_{14} = 225.02$) and the log-likelihood ratio [LR χ^2 (14) = −104.59] confirmed the final model was appropriate with *P* < 0.000. McFadden’s pseudo *R*² given by LR Chi² (Deviance

TABLE 6 Frequency and chi-square test of final asset indicators used for composite asset index development responded by mung bean framers in low-land areas of South Ethiopia.

Asset indicators	Pooled (<i>N</i> = 384)				Participate in mung bean market (<i>N</i> = 286)		Not participate in mung bean market (<i>N</i> = 98)		Chi-square	Sig. level
	Yes		No		Yes	No	Yes	No		
	Freq.	%	Freq.	%	Freq.	Freq.	Freq.	Freq.		
Livestock	305	79.4	79	20.6	244	42	61	37	23.773	0.000***
Animal cart	51	13.3	333	86.7	28	258	23	75	11.859	0.001***
DVD player	37	9.6	347	90.4	31	255	6	92	1.865	0.172
Stove	120	31.3	264	68.8	79	207	41	57	6.8642	0.009***
Television	75	19.5	309	80.5	46	240	29	69	8.4738	0.004***
Watch	44	11.5	340	88.5	35	251	9	89	0.6711	0.413
Motor bicycle	69	18	315	82	49	237	20	78	0.5312	0.466
Mobile phone	228	59.4	156	40.6	177	109	51	47	2.9343	0.087*
Bank account	173	45.1	211	54.9	125	161	48	50	0.8199	0.365
Membership in cooperatives	70	18.2	314	81.8	64	222	6	92	12.938	0.000***
Membership in any association	144	37.5	240	62.5	118	168	26	72	6.7553	0.009***
Water sources	86	22.4	298	77.6	83	203	3	95	28.302	0.000***
Forests	43	11.2	341	88.8	40	246	3	95	8.7605	0.003***
Housing roof	112	29.2	272	70.8	97	189	15	83	12.236	0.000***
Housing floor	234	60.9	150	39.1	176	110	58	40	0.1700	0.680
Housing wall	252	65.6	132	34.4	195	91	57	41	3.2476	0.072*
Solar energy	78	20.3	306	79.7	65	221	13	85	4.0371	0.045**
Private toilet	317	82.6	67	17.4	233	53	84	14	0.9135	0.339
Radio/GPAS	183	47.7	201	52.3	134	152	49	49	0.2898	0.590
Separated kitchen	167	43.5	217	56.5	137	149	30	68	8.8783	0.003***
Chairs	344	89.6	40	10.4	257	29	87	11	0.092	0.762
Tables	310	80.7	74	19.3	233	53	77	21	0.3938	0.530
Beds/Mattress	339	88.3	45	11.7	253	33	86	12	0.0352	0.851
Shelves	134	34.9	250	65.1	100	186	34	64	0.0024	0.961
Ox	152	39.6	232	60.4	114	172	38	60	0.0359	0.850
Water sprinkler	67	17.4	317	82.6	48	238	19	79	0.3438	0.558
Watering can	172	44.8	212	55.2	129	157	43	55	0.0445	0.833
Hoe	285	74.2	99	25.8	215	71	70	28	0.5353	0.464
Plow	286	74.5	98	25.5	214	72	72	26	0.0706	0.790
Spade/shovel/rake	229	59.6	155	40.4	174	112	55	43	0.6746	0.411
Ax	287	74.7	97	25.3	215	71	72	26	0.1124	0.737
Hand mile	187	48.7	197	51.3	140	146	47	51	0.0287	0.865
Hammer	160	41.7	224	58.3	119	167	41	57	0.0016	0.968
Saw	163	42.4	221	57.6	122	164	41	57	0.0201	0.887
Wheelbarrow	93	24.2	291	75.8	72	214	21	77	0.5581	0.455
Sickle, mower	251	65.4	133	34.6	185	101	66	32	0.2284	0.633
Pickaxe	70	18.2	314	81.8	52	234	18	80	0.0017	0.967
Chemical sprayer	91	23.7	293	76.3	67	219	24	74	0.0456	0.831

***Indicates at <0.01 significant level, **indicates at <0.05 significant level, and *indicates at <0.10 significant level. Source: Authors' computation, 2024.

TABLE 7 Distribution of asset accumulation over mung bean market participation.

Participate in mung bean market (N = 286)				Not participate in mung bean market (N = 98)				Pooled (N = 384)			
Mean Stats.	Stan. Dev.	Mini	Maxi.	Mean Stats.	Stan. Dev.	Mini.	Maxi.	Mean Stats.	Stan. Dev.	Mini.	Maxi.
0.0562	1.007	−2.206	2.573	−0.164	0.972	−2.206	1.708	1.75	1.00	−2.206	2.573
t-value = −1.8859 (0.0300***)											

Statistical significance at less than 1% (***) probability level. Source: Authors' STATA Computation, 2024.

$\text{null} - \text{Deviance}_{\text{full}}$) divided by Deviance full and each model Deviance is equal to $-2 * \text{the log-likelihood for that model}$ and gave the value of 52.05%, suggests the goodness of fit of the model's adequacy. To treat the heteroscedasticity assumption, some continuous variables are computed by using composite indexes and ratios.

A total of 14 covariates, such as sex, age, CRT, human capital, information accessibility, tropical livestock unit, family size, farm size to mung bean cultivation, how far is the all-weather road from the homestead, center market distance from the residence of mung bean farmers, amount of products in kilograms within a year, frequent training on agro-practices, perception toward social value (PC₅) and mung bean cultivation experience (TELAPSED) were included into the selection equation to identify the determinates of market participation status. Age, CRT, information accessibility, tropical livestock unit, number of family members, how far is the all-weather road from the homestead, center market distance from the residence of mung bean farmers, amount of products in kilograms within a year, frequent training on agro-practices and perception toward social value (PC₅) were significantly affected mung bean market participation.

Information accessibility, how far is the all-weather road from the homestead, center market distance from the residence of mung bean farmers, amount of products in kilograms within a year, and frequent training on agro-practices were significant ($P < 0.01$), while perception toward social value (PC₅) was significant ($P < 0.05$) and age, CRT, tropical livestock unit, and a number of family members were significant at $<10\%$ significance level. On the contrary, age, livestock population in TLU, center market distance from the residence of mung bean farmers, amount of products in kilograms within a year, frequent training on agro-practices, and perception toward social value were more likely to affect mung bean market participation. This binary probit regression estimation result indicated in Table 8 is almost similar to that of the simultaneous estimation technique of ESR.

The age of the head of the household was highly likely (coeff. = 0.017) and significantly ($p > Z = 0.0650$) to affect the market participation of mung bean farmers. Holding all the other factors constant, household age increased the likelihood of participating in the mung bean market. One percentage increment in the age of the head of the household increased their likelihood of market participation by 0.30%. This means they get older and older, and they experience more participation in the mung bean market than their counterparts. This might be acquired from a lot of experience in older farmers' mung bean cultivation. This finding

was congruent with the findings in the lowlands of southern Ethiopia (Aboye et al., 2023).

Family size of households is less likely (coeff. = -0.093) and significantly influences the market participation status at $<10\%$ ($P > z = 0.0660$) significant level. A one family member addition on family decreased the likelihood of participating in the mung bean market in the study area by 1.4%, holding all other factors constant. The increasing of the family size retards the market participation. This might be most of the mung bean production required for large family sizes to smooth local dish problems for some early adopters in low-land areas. It is congruent with the finding of Haile et al. (2022).

Holding all the other factors constant, having a large livestock population in TLU is highly likely to increase the probability of participating in the market by 0.8% at $p = 0.000$. Livestock ownership was found to have a more likely (coef. = 0.052) and significant influence on participation in the mung bean market at $<10\%$ level of significance. Households that have large livestock population support them in purchasing necessary agricultural inputs and implement them through asset accumulation, thereby increasing market surplus, unlike other low-land areas in Ethiopia that practice more pastoralism. The previous studies (Gebiso et al., 2023) confirmed that livestock are mostly vital for asset accumulation.

The quantity of mung bean produced by farmers was statistically significant and more likely affecting market participation for mung bean farmers. Suppose the farmers get more output, and the probability of deciding the supply of beans to the market increases. Increasing the number of products is a significant contributing factor in participating in the output market, thereby enhancing livelihood resilience (Molla et al., 2024). In addition, the production of mung beans is mostly for sale rather than used for local dishes like other regions of the country (Sánchez-Toledano et al., 2018; Manda, 2016).

Households that did not utilize credit for agricultural business influenced the market participation less likely and significantly affected by $<5\%$ significance level than their counterparts. Holding all the other factors constant, a unit change by not utilizing credit services (CRT = 1) decreases their likelihood of participating in the mung bean market by 10.3% at $p = 0.028$. The current finding is congruent with others (Zakari et al., 2023).

Information accessibility also highly and significantly affected the binary responses at $<1\%$ ($p > z = 0.0000$). One percentage increment in no-information accessibility (base category) decreased the probability of participating in the center market by 34.5% at $p = 0.000$. Those farmers who have no information on

TABLE 8 Result of probit estimation of mung bean farmers' market participation.

Mung bean market participation	Coefficient	dy/dx	Standard error	Z	P > Z
SEX (female = 1)	−0.125	−0.018	0.438	−0.28	0.7760
Age of the head of the household (AGE)	0.017	0.003	0.009	1.850	0.0650*
Number of family members (FAZ)	−0.093	−0.014	0.051	−1.84	0.0660*
Human capital (KH)	−0.026	−0.004	0.030	−0.88	0.3800
Livestock population (TLU)	0.052	0.008	0.028	1.83	0.0670*
Mung bean farm (MBFMZRATIO)	−0.209	−0.031	0.452	−0.46	0.6440
Mung bean cultivation experience (TELAPSED)	0.083	0.012	0.056	1.48	0.1390
Amount of quantity produced _year (MBQTY_YEAR)	0.000	0.000	0.000	3.4	0.0010***
Information accessibility (INFOAC 1 = no)	−2.334	−0.345	0.230	−10.2	0.0000***
Credit utilization (CRT code 1 = no)	−0.694	−0.103	0.316	−2.2	0.0280**
Training on agro-practices (FREQTRAIN code 1 = no)	0.681	0.101	0.219	3.1	0.0020***
Perception toward social value (PCA ₅)	0.193	0.029	0.096	2.02	0.0440**
Road distance from home (DISROAD)	−0.283	−0.042	0.060	−4.69	0.0000***
Center market distance from home (DISMKT)	0.202	0.030	0.040	5.05	0.0000***
_cons	1.192		0.678	1.76	0.0790*
Number of obs = 384 Prob > χ^2 = 0.000 LR χ^2 (14) = 225.02 Wald χ^2 (14) = 149.91 Pseudo R ² = 0.5205 Log likelihood = −104.59					

***Indicates at <0.01 significant level, **indicates at <0.05 significant level, and *indicates at <0.10 significant level. Source: STATA Output, 2024.

agro-practices of the mung bean and marketing issues can make the decision to participate in the mung bean market participation decision less likely (coef. = −2.334). This finding is similar to the finding of Belete and Nigatu (2023).

An increase in the frequent training on mung bean crop agro-practices decreased a 10.1% probability of increment, *citrusparibus*. Frequent training on mung bean crop agro-practices was less likely to affect binary responses. The more training is provided for mung bean crop cultivation, the less advantage it gives the farmers in surplus supply for the market. Though it increases the managing capability of the crop, it does not have access to nearby markets or the ECX market. The finding is inconsistent with the finding of Belete and Nigatu (2023). They stated that the extension services increase the capability of farmers to manage and supply the crops to the market.

A 1% increase in perception toward social value increased the likelihood of market participation occurrence by 2.9% with a significance level of $p = 0.044$. Moreover, positive societal perceptions toward mung bean crop cultivation should be enhanced to produce a large amount of quantity, thereby increasing output supply to the market (Kassa et al., 2021; Emran et al., 2021).

Center market distance from the residence of mung bean farmers increased the likelihood of participating in the mung bean market by 3.0% at $p = 0.000$. A 1-km distance to all-weather roads decreased their likelihood of participating by 4.2%, *citrusparibus*. Farmers' home distance to all-weather roads decreased the probability of participating in the mung bean market. This could be explained by price differentials (Gikonyo et al., 2022). The farmers' willingness to supply his/her products to the market is very less due to the sparsely populated access to road facilities and the large size of farms in low-land areas that are very far from the

road. This finding is similar to the finding of Kassa et al. (2021) and Kidane et al. (2022) in market participation of maize, pigeon pea, and mung bean crops.

3.2.2 Impact of mung bean market participation on farmers' asset accumulation _Stage II: results from endogenous switching regression model

For impact evaluation in stage two, ESR was used to estimate the binary and continuous parts of the equation simultaneously (Cazzuffi et al., 2020; Emran et al., 2021). Its appropriateness is confirmed by the validity test result of selection instrument identification (IVs test). Accordingly, the IVs test confirmed the validity of market distance, frequent training on agro-practices, and CRT status, which were not jointly statistically significant causes of asset accumulation for market mung bean market participants and non-participants. As depicted in Table 9, distance to the market, frequent training on agro-practices, and CRT were statistically significant at <1% significance level, different from zero, in probit model estimation of the mung bean market participation status of the pooled samples. On the other hand, the OLS estimation showed that these covariates did not affect the asset accumulation of the non-participants group ($N = 98$). Therefore, the excluded IVs are relevant.

The overall fitness test of the model (Wald χ^2 test = 65.54), the correlation coefficient test of the model, such as the Wald test of the independent equation, also significant with χ^2 (1) = 6.59; Prob > χ^2 = 0.03, which implies that the mung bean market participation was positively correlated with asset accumulations in the study area. The inclusion of at least a few covariates in the selection equation directly affects the mung bean market participation decision but

TABLE 9 Test of the validity of the selection instruments.

Instruments	Probit_Case I	OLS_Case II
	Market participation status (code = 1/0)	(Asset accumulation by farmers that did not participate)
Distance to the market	0.0763(0.0219)***	0.0295 (0.0618)
Frequent training	0.73591(0.1570)***	−0.364 (0.2236)
Credit utilization	−1.138(0.2699)***	0.226 (0.3639)
Wald test =	$\chi^2 (3) = 47.04$ (0.0000)***	F-statics = 0.2647
Sample size	384	98

***indicates significance level at <1%. Parenthesis showed robust SE. Source: Authors' STATA Computation, 2024.

does not affect the outcome equation of the non-participant group. An exclusion restriction is based on economic theories and other previous empirical studies, such as Meskel et al. (2020) and Manda et al. (2020).

The correlation coefficients ($\rho_1 = 0.504$ and $\rho_0 = -0.304$) between participation in the mung bean market and asset accumulation exhibited both signs, and asset accumulation was significant at <5% level. This indicates that self-selection occurred among the mung bean crop participants and non-participants. Mung bean market participants would have high asset accumulation, and whether they participate in the market, they would be better off if they participated. Relatively, non-participants would have low asset accumulation but would be better off if they preferred to participate in the mung bean market. The positive correlation coefficients between outcome variables and mung bean market participation status also implied that there were both observable and unobservable factors that affected the participation and outcome, such as asset accumulation. The difference in the coefficients of the asset equation between treatment groups shows that heterogeneity influences the value of asset accumulation.

Table 10 presented the full-information maximum likelihood estimates the impact mung bean crop market participation upon asset accumulation. The asset accumulation _1 stands for participant farmers, whereas asset accumulation _0 stands for non-participant farmers. Age of the head of household (AGE) was directly affected asset accumulation _1 at <5% significant level while the amount of products in kilograms within a year at <1% significant level, and farmers' home proximity to all-weather roads at <1% significant level. Moreover, asset accumulation _1 was negatively affected by information accessibility at <1% significant level. On the other hand, accumulation _0 was directly and significantly affected by farmers' home distance from all-weather and information accessibility at <5% significant level in low-land areas of South Ethiopia.

A unit increment in the age of the head of household (AGE) results from the proportional change in an asset accumulation of mung bean market participants by 1.06% (0.0106) whereas decreases an asset accumulation of non-participants by 0.79% (−0.0079). However, it was insignificant. This result is congruent

with others (Dagne et al., 2023). In addition, the age of the household head and amount of products in kilograms within a year only influenced those who did not participate in the mung bean market as depicted in Table 10. These disparities reflect the fact that there is heterogeneity between mung bean market participants and non-participants. The more you produce the mung bean crop, the more supply to the market, thereby boosting asset accumulation by 0.02% (0.0002). It helps increase the living standard of rural households (Bezabeh et al., 2020; Kassa et al., 2021). Furthermore, a mung farmer who did not have access to information on specific crops was less likely to possess more assets than those who had access to information in low-land areas of South Ethiopia.

Finally, the average treatment effect (ATE) in terms of population of the coefficient estimate of participants' farmers in bean market participants and average treatment effect on treated (ATET) for sample impacts on asset accumulation were 0.3200 and 0.3047 and significant at $p > z = 0.0490$ for nearest-neighbor matching approach, respectively. Meanwhile, the coefficients of ATET were positive and significant at less than a 10% significance level for the regression adjustment approach. These indicate that the one who participated in the mung bean market have a greater probability of increasing asset accumulation than their counterparts.

4 Conclusion and recommendations

4.1 Conclusion

The current aimed to evaluate the impact of mung bean crop market participation on asset accumulation of smallholder households in low-land areas of South Ethiopia. Following the multistage sampling techniques, from the selected six Woredas, a total of 384 samples have been taken for the entire analysis. Based on the above-mentioned findings, the study was drawn the following conclusions:

- About 74.5% of farmers participated in the bean market, while 25.5% of farmers did not participate in the mung bean market out of 384 observations.
- The difference in asset accumulation ranges to 4.779, and it explains the wide uneven possession of households' assets in the three selected zones in SERS.
- The selection equation result revealed that information accessibility, the proximity of an all-weather road from the homestead, center market distance from the residence of mung bean farmers, the amount of products in kilograms within a year and frequent training on agro-practices significantly affected market participation at <1% significance level. Perceptions of social value and CRT were significant at less than a 5% significance level, while the age of the head of household, tropical livestock unit, and family size affected market participation at less than a 10% significance level.
- The mung bean market participation is more likely affected by the age of the household head, CRT, access to market information, tropical livestock unit, center market distance from the residence of mung bean farmers, amount of products

TABLE 10 Endogenous switching regression (ESR) estimation for asset accumulation of mung bean farmers.

Mung bean market participation (MKTPARMB, yes = 1)					Asset accumulation_1				Asset accumulation_0			
Variable code	Coeff.	Standard error	Z	P > z	Coeff.	Standard error	Z	P > z	Coeff.	Standard error	Z	P > z
SEX (female = 1)	−0.0763	0.5686	−0.13	0.8930	−0.1822	0.2652	−0.69	0.4920	0.4878	0.6526	0.75	0.4550
AGE	0.0181	0.0097	1.86	0.0620*	0.0106	0.0050	2.12	0.0340**	−0.0079	0.0087	−0.92	0.3600
FAZ	−0.0855	0.0460	−1.86	0.0630*	0.0229	0.0269	0.85	0.3950	0.0689	0.0440	1.57	0.1170
KH	−0.0295	0.0290	−1.02	0.3100	0.0179	0.0162	1.11	0.2680	−0.0356	0.0274	−1.30	0.1930
MBFMZRATIO	−0.1650	0.4561	−0.36	0.7180	0.1068	0.2797	0.38	0.7030	−0.2227	0.3974	−0.56	0.5750
TLU	0.0482	0.0276	1.74	0.0810*	0.0159	0.0149	1.07	0.2860	0.0250	0.0293	0.85	0.3950
INFOAC (code 1 = no)	−2.3668	0.2273	−10.4	0.0000***	−0.6849	0.2548	−2.69	0.0070***	1.0286	0.5005	2.05	0.0400**
PCA5	0.1598	0.1045	1.53	0.1260	0.0327	0.0565	0.58	0.5630	0.1012	0.1005	1.01	0.3140
TELAPSED	0.0542	0.0602	0.9	0.3680	−0.0265	0.0284	−0.93	0.3520	−0.0342	0.0590	−0.58	0.5620
MBQTY_YEAR	0.0003	0.0001	3.35	0.0010***	0.0002	0.0001	4.07	0.0000***	−0.0001	0.0002	−0.50	0.6150
DISROAD	−0.2646	0.0809	−3.27	0.0010***	0.0916	0.0238	3.85	0.0000***	0.2413	0.0977	2.47	0.0140**
CRT (code 1 = no)	−0.6798	0.3414	−1.99	0.0460**								
DISMKT	0.2107	0.0467	4.51	0.0000***								
FREQTRAIN (1 = no)	0.6156	0.2232	2.76	0.0060***								
_cons	1.1907	0.7208	1.65	0.0990*	−1.2588	0.3479	−3.62	0.0000***	−1.3059	0.7845	−1.66	0.0960*
/lns1 and /lns2					−0.0740	0.049377		0.134	−0.1132	0.087825		0.198
/r1 and /r2					0.55401	0.341663		0.105	−0.3140	0.386953		0.417
sigma_1 and sigma_2					0.92863	0.045853			0.8930	0.078428		
rho_1 and rho_2					0.50352	0.055041			−0.3040	0.051182		
LR test = χ^2 (1) = 6.590 Probability > χ^2 = 0.03 Log likelihood = −607.54 Wald χ^2 (11) = 65.54 Probability > χ^2 = 0.0000 Observations = 384.												

***Indicates at <0.01 significant level, **indicates at <0.05 significant level, and *indicates at <0.10 significant level. Source: Authors' STATA Computation, 2024.

in kilograms within a year and perception toward social value. The number of family members, road distance from home, and frequent training on agro-practices were less likely to affect the mung bean market participation.

- The full-information maximum-likelihood method result showed that the asset accumulation of mung bean market participants, outcome equations, was positively and significantly affected by the amount of products in kilograms within a year and farmers' home proximity from all-weather roads and age of household head, whereas information accessibility negatively affected. On the other hand, asset accumulation of non-market participants was positively and significantly affected by farmers' home distance from all-weather and information accessibility.
- The average treatment effects in both cases (population effects and treated) are 0.3200 and 0.3047, respectively. Meanwhile, the coefficients of the average treatment effect on the treated patient are positive. Thus, the farmers who participated in the mung bean market had a greater probability of increasing asset accumulation than their counterparts. However, eco-friendly farmers face various challenges in supplying their products to the market.

4.2 Recommendations

Therefore, based on these findings, it is recommended that credit facilities purchase new farm technology and implements for farmers' agricultural practices to boost its production, information accessibility of the new emerging beans, frequent training on agro-practices, and other infrastructure facilities should get another look by government and non-governmental organizations, ECX and market regulatory bodies to enhance market participation. Increasing market participation of mung bean supports rural households uplifting the improvement of livelihood through increasing asset accumulation for smoothing elongated shocks encountered by eco-friendly farmers in SERS, Ethiopia. In all cases, it is worth mentioning that this study still lacks the support of a large amount of data gathered about this specific crop over different periods to determine the dynamics. A single cross-sectional study may miss significant long-term trends, such as market dynamics, marketing volume and recorded price data of newly emerging mung bean crops, which are crucial for understanding overall market participation.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories

and accession number(s) can be found in the article/supplementary material.

Ethics statement

The studies involving human participants were reviewed and approved by Wolaita Sodo University Graduate Studies Directorate with a research permit letter of Ref. GSD_596_15. Written informed consent to participate in this study was provided by the [patient/participants' OR patient/participants legal guardian/next of kin].

Author contributions

GG: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft, Writing – review & editing. BK: Investigation, Project administration, Supervision, Validation, Writing – review & editing. AT: Investigation, Project administration, Supervision, Validation, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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