Adoption of Improved Soybean Varieties by Smallholder Farmers in Northwestern Ethiopia: Double Hurdle Model Approach

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Abstract

The study examined the major factors determining adoption and intensity of adoption of improved soybean varieties by smallholder farmers in Pawe district of Metekel Zone, Benishangul Gumuz Regional State. It employed mixed methods survey design, with concurrent triangulation as its specific strategy. A total of sample of 308 household heads (197 adopters and 111 non-adopters) were randomly selected using probability proportionate to size method from a total of 1337 households of the four sampled kebeles. The research used questionnaires, FGDs, KIIs, observations and survey of secondary data as methods of data collection. The study employed double hurdle model to analyse the data on the major factors influencing the adoption and intensity of adoption of improved soybean varieties by smallholder soybean producers. The result of first hurdle of double hurdle model revealed that adoption decisions of improved soybean varieties were determined via frequencies of extension contacts, agricultural trainings, field-day participations and annual income positively whereas distance to the market and farm size negatively. The second-hurdle result, on the other hand, depicted that adoption intensity of improved soybean

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varieties was influenced by sex of household heads, credit access, annual income and TLU positively, whereas age of household heads influenced negatively. Generally, the findings highlighted the importance of addressing constraints associated with extension contacts, participation in trainings, field day participations, facilitated credit access, and increased TLU ownership capable of improving the adoption and intensity of adoption of improved soybean varieties. This, in turn, would help to improve the income and livelihoods of rural smallholder soybean producers in Pawe District of Benishangul Gumuz Region.

Keywords:*Adoption, Soybean varieties, Double hurdle model, Determinants*

1. Introduction

Soybeans (*Glycine max.*) are one of the world's most valuable crops, serving not only as an oil seed crop and feed for livestock and aquaculture, but also as an excellent source of protein for human consumption and as a biofuel feedstock (Masuda & Goldsmith, 2009; Shea et al., 2020). Soybean is a non-native and non-staple crop in Sub-Saharan Africa (SSA) with economic promise due to its diverse uses as a food, feed, and industrial raw material. It was first brought to SSA by Chinese traders in the nineteenth century and was cultivated as an economic crop in South Africa as early as 1903 (Khojely et al., 2018). This finding revealed that soybean cultivation area and production in SSA have grown exponentially over the last four decades, from around 20,000 ha and 13,000t in the early 1970s to 1,500,000 ha and 2,300,000t in 2016. Soybean yield in SSA has been stagnant for decades at around 1.1 t ha^{-1}, much lower than the global average, marking one of the most difficult issues in the SSA soybean sector. This low level of soybean yield can be ascribed to the use of poor-performing varieties as well as the limited application of fertilizers and rhizobia inoculants in soils that have never produced soybeans. Soybeans, as a legume, have the potential to play an essential role in ensuring long-term food security for both current and future generations across the continent. Soybean farming is important in Africa, where smallholder farmers' agricultural systems dominate the food production landscape, because it provides rural households with inexpensive protein and nutrients while also providing natural fertilization for the soil (Masuda & Goldsmith, 2009; Siamabele, 2021). It is a valuable cash crop potentially capable of reducing poverty in rural areas (Usmane et al., 2020).

Grain legumes are important components of agricultural crops that are vital in improving nutrition security and income of smallholder farmers around the world (Kebede, 2020). Out of these crops, soybean has been the major legume crop with positive contribution to the livelihoods of farms worldwide (Bezabih, 2012). Soybean is becoming one of the most important commodities in the global markets and most commonly planted and used legume crop due to its valuable seed composition (Shea et al., 2020). The crop is the major source of oil and protein in the world. Its cultivation has been increasing rapidly in Africa due to the increasing demand for it by food and feed processing industries (Murithi et al., 2016; Pagano et al., 2020). Soybeans are believed to be the major legume crop to ensure sustainable food security both for the current and future generations in Africa (Siamabele, 2021). Despite its positive attributes, its productivity remained much lower than the world's average level of productivity due to use of poor-performing varieties and limited application of fertilizer and other agronomic practices (Khojely et al., 2018).

Soybeans are one of the most lucrative and important cash crop for Ethiopian farmers (Delele et al., 2022). It accounts for almost 18% of the country's total oilseed production and only 6% of the area planted with oilseeds. The country produced 101,703.81 tons of soybeans and delivered to the market excluding reserved seeds for next production season and local food consumptions. The national productivity of the crop was 2.15 tons ha^{-1} with high degree of variability across the country. Smallholder farmers in Ethiopia are increasing soybean land allocation, their production and productivity (Delele et al., 2022; Mussema et al., 2022). Soybean production levels and allocated land have increased due to increased demand in domestic and international markets, but the country's productivity remains lower than the world average. Domestic soybean productivity is lower than global productivity due to lack of good agronomic practices (Agegn et al., 2022).

Soybeans are recognized for their outstanding nutritional and functional food properties, containing an average of 40% protein (Mussema et al., 2022). Erana (2020), on the other hand, compared soybeans to other protein sources and found that they provide the most cost-effective protein, delivering 918 grams of protein per dollar, compared to chicken’s 76 grams per dollar. Soya-based foods are regarded as nutritious and healthy due to their rich nutrient composition (UNCTAD, 2016). Additionally, soybeans are highly digestible and comparable to animal protein in terms of quality (UNCTAD, 2016), with protein content ranging from 14.3% to 38% (Messina, 1999).

The soybean value chain in Ethiopia significantly contributes to rural economies, food security, and the livelihoods of market participants (Mussema et al., 2022). It creates employment opportunities in activities such as cleaning, transportation, local trading, and oil processing. In regions like Amhara (Jawi) and neighbouring areas of Benishangul Gumuz, soybean serves as a key cash crop and major source of income for farmers. It also provides an affordable protein alternative for low-income populations unable to access meat. More so, soybean oil is a vital dietary substitute for other oils in rural areas. Beyond economic and nutritional benefits, soybean cultivation promotes environmental sustainability by being intercropped with cereals, enhancing soil health (Bezabih, 2010).

Agricultural policy of Ethiopia gives high priority to increase food production and decreasing malnutrition problems through the promotion of improved production technologies among smallholder farmers in the national extension packages. As part of this, producing and consuming more soybeans is believed to improve the situation as it can provide a nutritious combination of both calorie and protein. It is also cheap and rich source of protein for poor farmers, who have less access to animal source protein, because of their low purchasing capacity. Besides, in addition to its nutrition rich potential, the crop has a great significance in improving the status of soil nutrients and farming system when grown solely and in combination with cereal crops(Sopov, 2011).

Although soybean is widely cultivated in Ethiopia, the national average soybean yield remains low at 19.98 quintals per hectare, falling below the global average of 23.1 quintals per hectare (Foyer et al., 2018). This low productivity can be attributed to several factors, including limited adoption of advanced soybean production technologies, inadequate supply of improved varieties, and suboptimal agricultural practices (PARC, 2010).

This research was aimed at bridging the gap that it has observed in the empirical literature. The case in point are the research results by Miruts (2016), Kedir (2017) and Diro (2017) to mention some. These and other research reports focused on identifying determinants of adoption of improved soybean varieties only. This study, however, examined both the factors that affect the adoption of improved soybean varieties, and intensity of the technology being adopted by the households on the one hand and its implication on the livelihoods of soybean producers and its productivity on the other as a gap that it attempted to address in addition to the methodological plurality and the empirical data produced that justifies the relevance of this research.

The general analysis provided above is also supplemented by the theoretical and/or the conceptual perspectives that simplifies the efforts in grasping the adoption status and influencing factors on farmers' decision to adopt improved soybean varieties in the study area.

2. Conceptual and Theoretical Frameworks

The research highlighted key concepts and models to be used as a lens in understanding how soybean is being accepted, cultivated, and consumed in Pawe district. In so doing, it draws onFeder et al. (1985) that saw adoption, as a process that integrates an innovation into a farmer's routine practices over time. It can be assessed at the individual level, referring to the degree of long-term use once the farmer fully understands its potential, or at the aggregate level, reflecting widespread diffusion within a region. Adoption is not permanent, as farmers may abandon previously accepted innovations for various reasons, including personal preferences, institutional factors, or the availability of better alternatives (Dasgupta, 1989). Diffusion, in this context, refers to how innovations spread across a particular region.

The research, on the other hand, sees innovation as a vision of ongoing change, providing opportunities for improvement in various sectors, including public libraries (Jenkins, 2014). Furthermore, the research explains innovation as a practice that involves continuous management and adaptation to maintain its strategic advantage (Ziemnowicz, 1942). The Innovation System Model engages multiple stakeholders to address challenges and opportunities along value chains, fostering networks that promote research, knowledge generation, and practical application (Fatunbi et al., 2016). Agricultural innovation applies new or existing knowledge in novel ways to enhance socio-economic outcomes. It encompasses technological or institutional advancements, such as ICT, agricultural inputs, or machinery, aimed at improving productivity and well-being (Dror et al., 2016).

Diffusion**,** on the other hand**,** is a social process where innovations, such as new approaches to health care, are communicated over time through specific channels within a social system (Dearing & Cox, 2018). It focuses on how new ideas spread, emphasizing the evolution or "reinvention" of innovations to better fit the needs of individuals and groups rather than persuading people to change. This process explains how innovations are adopted by populations, with the focus on modifying innovations rather than individuals (Robinson, 2009). Rooted in Rural Sociology, the Diffusion of Innovations model has faced criticism when applied to underdeveloped nations.

Soybean production has grown significantly worldwide due to its applications in food, feed, and biofuel industries. The United States, Brazil, and Argentina produce about 80% of the global supply (Cattelan & Dall'Agnol, 2018). This growth is driven by rising demand for protein-rich products and soybean's role in improving soil fertility (Fraanje & Garnett, 2020). However, challenges such as deforestation and biodiversity loss, especially in South America, remained as critical concerns (Alcock et al., 2022). Initiatives like deforestation-free supply chains and the European Union's Deforestation Regulation aim to mitigate these impacts by 2024 (European Commission, 2023).

Soybean adoption varies from region to region, influenced by economic, environmental, and social factors. In developed countries, adoption is driven by access to technology, improved seeds, and strong markets. In developing nations, barriers like limited technology, infrastructure, and training hinder adoption (Feder et al., 1985). Socio-economic factors, including market demand and government policies, also play a role. Additionally, competition with traditional crops and environmental concerns affect adoption.

Promoting awareness, market access, and research is essential for sustainable soybean production expansion at a global level.

Soybean production in Ethiopia has gained attention due to its potential to improve food security, enhance soil fertility, and provide a source of income for smallholder farmers. Feder et al. (1985) emphasized that adoption of innovations, such as soybean cultivation, depends on awareness, access to technology, and economic incentives. Historically, soybean was introduced to Ethiopia in the 1950s, initially as a soil-enhancing crop and livestock feed. By the 1980s, its significance grew with rising global demand for soy-based products. Regions like Amhara, Oromia, and Benishangul Gumuz became early adopters, utilizing soybean for both domestic consumption and export. However, limited access to improved seeds and inadequate extension services that slowed its expansion, letting its productivity to fall below global averages (Bezabih, 2010).

Pertaining to Soybeans' growing prominence, its farming has expanded in many regions through crop substitution and rotation, as farmers replace traditional crops to improve soil fertility and meet market demands (Masuda & Goldsmith, 2009). In Ethiopia, small-scale farmers have adopted soybean as a cash crop, but yields remain low due to limited access to resources and technology (Foyer et al., 2018). The national yield of 19.98 quintals per hectare is below the global average of 23.1 quintals (Foyer et al., 2018). Barriers to adoption include poor practices, limited availabilities of improved varieties, inadequate market access, and insufficient extension services. Socio-economic factors like competition with staple crops and lack of awareness also hinder adoption. Addressing these issues requires investment in infrastructure, research, and farmer education.

2.2. Models of Adoption

2.2.1. Diffusion of Innovation Model

Theory of Innovation Diffusion (DOI), developed by E.M. Rogers[4] in 1962 is found to be one of the oldest theories in social science (Rogers, 1961). It originated in communication to explain how, through a specific population or social system, an idea or product gains momentum and diffuses (or spreads) over time. The ultimate outcome of this diffusion is that people adopt a new idea, behaviour, or product as part of a social system. Adoption means a person is doing something different from what they had before, that is, using new technology learning and practicing new behaviour etc.

For (Rogers et al., 2005), adoption is a decision to use an innovation as the best course of action available and rejection is a decision not to adopt an innovation. Rogers explain diffusion as the process in which an innovation is communicated through certain channels over time among the members of social system. As expressed in this explanation, innovation, communication channels, time, and social system are the four key components of the diffusion of innovations.

The first element of diffusion of an innovation process is innovation. Rogers illustrated innovation as an idea, practice, or project that is perceived as new by individuals (Rogers et al., 2005). The technology may have been invented long ago, but if it is viewed by individuals as new, it may still be the innovation for them. The novelty characteristic of adoption is more related to the three steps of the innovation-decision process that are knowledge, persuasion and decision.

The second element of diffusion of innovations process is communication channels. According to Rogers et al., (2005), communication is a process in which participants create and share information with one another in order to reach a mutual

[4] Everett Mitchell Rogers (March 6, 1931 – October 21, 2004) was an American communication theorist and sociologist, who originated the diffusion of innovations in 1962

understanding. This communication occurs through channels between sources. According to (Rogers et al., 2005), the time aspect is ignored in most behavioral research. He argues that including the time dimension in diffusion research illustrates one of its strengths. This is because issues such as innovation-diffusion process, adopter categorization, and rate of adoptions all include a time dimension. Finally, the social system is the final element in the process of diffusion. (Rogers et al., 2005) explained the social system as "a set of interrelated units that work together to solve a problem to accomplish a common goal. Because diffusion of innovations is disseminated in the social system, it is influenced by the social system structure.

2.2.2. The Innovation Decision Model

According to Rogers et al., (2005) innovation-decision process was explained as an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation. The innovation-decision process involves five steps: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. These stages typically follow each other in a time-ordered manner.

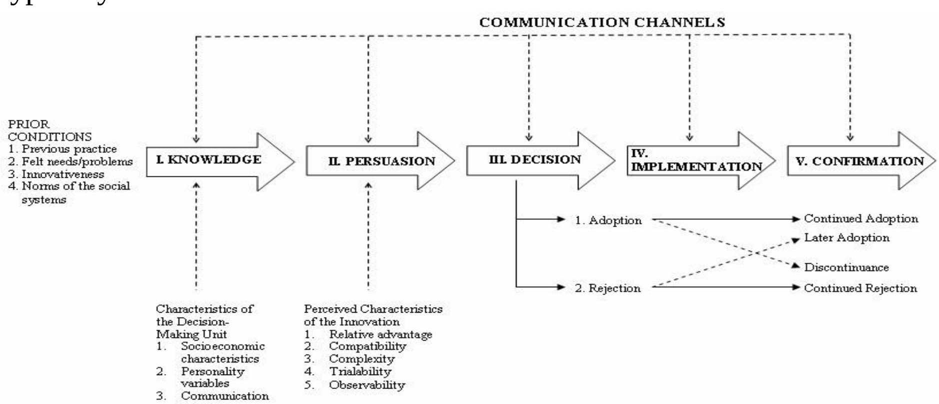

Figure 2. Innovation decision model (Rogers 2003).

3. Research Methodology

3.1. Description of the study area

This research was carried out in Pawe district, which is one of the seven districts of Metekel Zone of Benishangul Gumuz Regional State. The district is bordered by Dangure district in the West, Mandura district in the South and Jawi district of Amhara Region in North and Eastern side of the district. It is located 575km away from Addis Ababa between 36° 20'-36° 32'- longitude and 11° 12'-11° 21'north latitude. The district has 20 Kebles and the climate of the area is hot humid and characterized by unimodal rainfall pattern with high and torrential rainfall that extends from May to October. The area receives a mean annual rainfall of 1586.32 mm and has an altitude of 1120 m (Yemam, 2013).

The main economic activities of these study areas are mixed crop-livestock farming, which has been practiced by smallholder farmers. The share of agriculture is 73.9%, and livestock farming 3.8%, and others account 22.3% respectively (Pawe Agricultural District Office, 2019). The area is considered as high potential crop-livestock zone where crop activities play a significant role in the livelihood of farmers. Considering the potential of the area and the economic significance of crop production to the local community, there have been repeated efforts by governmental and nongovernmental aid organizations to improve crop productivity. Compared to other rural areas, this area is better suited to soybean crop production. Improved soybean varieties production is a popular practice in the area due to the aforementioned reasons and the economic capabilities of smallholder’s farmers (Pawe Agricultural District Office, 2019).

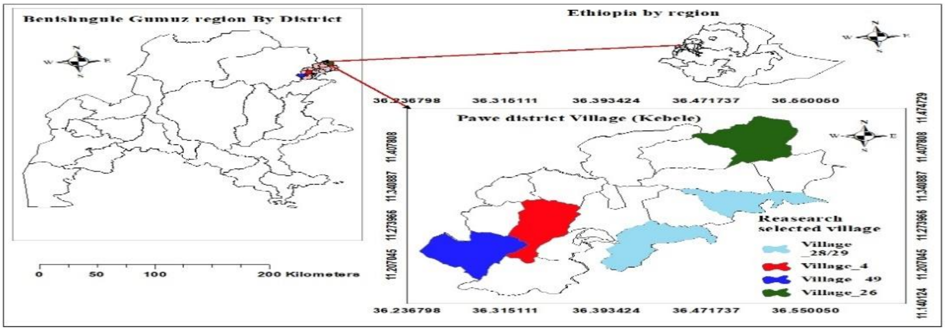

Figure 3. Map of the Study Area (Pawi Districts).
Source: Own construction

3.2. Sampling Method and size

The research employed mixed methods survey design, with concurrent triangulation as its specific strategy. It utilized both quantitative and qualitative sampling methods. Sampled respondents for this study were selected using a multi-stage stratified random sampling procedure. Pawe district was selected purposively for its wider coverage of soybean farms and its production potential. There has been also demonstrations and pre-scaling up activities carried out by PARC in collaboration with district agricultural office on different improved soybean varieties. Improved soybean varieties were also demonstrated and popularized by Pawe agricultural research center. The second sampling stages was a random selection of soybean growing kebeles of the district, followed by the selection of sample households in order to give equal chance for all observations. The kebeles were first stratified as first soybean potential and soybean growing, and those without the potential of soybean production. Identification was made through reviewing secondary data on the production potential of soybean and dissemination of the improved soybean technologies and area coverage of the crop. Then from potential soybean growing kebeles, four kebeles were selected for sampling randomly. In the third stage, total sample respondents were selected from the four kebeles using a systematic random sampling technique based on probability proportional to size for the interview purpose.

Each of the two categories' households was chosen at random. Ultimately, 308 farm household heads were selected randomly using a probability proportionate to size from a total of 1337 households in these four kebeles of whom 197 were adopters and the remaining 111 were non-adopter farm households. The total sample size (n=308) was determined by using Yamane,1967 sample size determination formula.

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size for the study, N is the total households of the study area, e is the maximum variability or margin of error which is 0.05 in this study. That is, 0.05% margin of error was used because the population under the study is less heterogeneous. 1 is the probability of the event of occurring.

Table 6: Details of Sample household's distribution of the selected kebeles.

No	Name of the kebeles	Total number of HH in the sampled kebeles	Sample household selected
1	Mender, 49	351	81
2	Mendir, 4	252	58
3	Mender, 28/29	362	83
4	Mender, 26	372	86
	Total	**1337**	**308**

Source: Own survey, 2024.

3.3. Methods of Data Collection.

In this study, both qualitative and quantitative data types from primary and secondary sources were utilized. Secondary data was collected in reviewing published sources. This information was used to compare the study with earlier researches and assess the works that do already exist in the literature. Formal and informal surveys were the two methods employed to gather primary data. Furthermore, Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) were conducted to explore qualitative data based on two sets of checklists developed for them. Overall, fifteen key informant interviews and four focus group discussions were conducted to augment the sample survey that was collected using structured and semi-structured household survey questionnaires by applying face-to-face interviews with household heads.

3.4. Methods of Data Analysis

Both descriptive statistics and econometric models were employed to analyze the data collected from primary sources.

3.4.1. Statistical analysis

The data were edited, coded, entered into the software, and cleaned to make them ready for analysis. The data was then analysed using statistical software SPSS, (STATA 14 version) and both descriptive and inferential statistics were used. Descriptive statistics was used to analyse selected demographic and socioeconomic characteristics of sample households, as it would help to frame the econometric analysis. Chi-square and t-statistic tests were employed to compare improved soybean varieties adopter and non-adopter groups concerning some explanatory variables. Accordingly, t-test is used to test the significance of the mean values of continuous variables while chi-square is used to test the significance of the values of the potential dummy variables, with a comparison of the adopters and non-adopter households.

3.4.2. Econometric Model

Econometric analyses were applied as specified in the analysis subsection. In this regard, double hurdle models were used for this study. The model helped to describe the determinant factors of adoption and the intensity of adoption relationships between dependent variables and a set of explanatory variables. The qualitative data obtained from FGDs and KIIs were simply narrated to substantiate the quantitative findings.

To detect the degree of relationships between some quantifiable explanatory variables and the dependent variables, the double-hurdle econometric model was employed. Farmers' decision to adopt improved soybean varieties is contingent upon the farmer or farm-specific attributes; therefore, their adoption is a self-selection process instead of a random-assignment process.

LetU_{iA}andU_{iN}be the farmer I's utilities from the adoption and non-adoption of the improved varieties, respectively. Farmers will decide to adopt the improved varieties when $U_i^* = U_{iA-}U_{iN} > 0$. However, farmers' utility from the adoption of improved varieties is unobserved. As suggested by (Asfaw et al., 2011), (Abdulai & Huffman, 2014) and (Kassie et al., 2014), the adoption decision can be modelled using a random utility framework and expressed as a function of the observed variables as follows:

$U_i^* = \beta x_i + \varepsilon_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..1$

$U_i = 1\ if\ U_i > o\ \&\ Ui = 0U_i^* < 0$

Where U_i^* is a latent variable representing farmer i's adoption of the improved Soybean varieties; it equals 1 if the farmer adopts and 0 otherwise.X_i is the vector of observed variables that affect the probability of adoption.

In our sample data, there are both adopters and non-adopters of the improved varieties, while the adopters have different intensities of adoption. In other words, the adoption variable equals zero when the farmers do not adopt the improved Soybean varieties, but this variable takes a positive continuous value when the farmers adopt these improved Soybean varieties. In this case, the Tobit or the double-hurdle model may be appropriate (Mason & Smale, 2013). The adoption of the improved Soybean varieties may entail a two-stage decision-making process, including whether to adopt and then how much to adopt. These decisions can be simultaneously or separately determined. The Tobit model may be applied when these decisions are simultaneously determined. Meanwhile, the double-hurdle model may be more appropriate when these adoption decisions are made separately (Tambo & Abdoulaye, 2013).The double hurdle model is considered as a generalized and improved form of the Tobit model. The model is expressed using Eq. (2) for the first stage (decision on whether to adopt or the probability of adoption) and the following function for the secondstage (decision on how much to adopt or the intensity of adoption):

$$Y_i = \beta Z_i + \varepsilon_i$$

$$Y_i = \begin{cases} Y_i^* \ if \ Y_i^* > 0 \\ 0 \ otherwise \end{cases} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.2$$

$Y_i^*$is the latent variable that denotes the farmer i's actual intensity of adoption and is measured, in this research, using the proportion of the area of land devoted to the improved Soybean varieties cultivators. Z_i is a vector of observed variables that explain the intensity of adoption. In the first stage of the model, the Probit or Logit estimation may be employed to estimate the probability of adoption (Langyintuo & Mungoma, 2008). In the second stage, several estimation techniques are suggested to estimate the intensity of adoption, including Truncated regression (Detre et al., 2011; Ricker-Gilbert et al., 2011) OLS regression (Cragg, 1971), or Tobit (1958). His article applies the Probit and Truncated regressions to examine the farmers' adoption decisions in the first and second stages of the double-hurdle model, respectively (Cragg, 1971).

Both the Double-hurdle and Tobit's model output were presented in this article for a comparison to determine which model best fits the data used for analysis. The Likelihood Ratio (LR) test was applied to investigate whether farmers make two-stage decisions simultaneously or separately. The LR test makes comparisons of the log-likelihood values from the double-hurdle model and Tobit models. The LR test will be conducted using the following equation:

$$\lambda = -2(LL_T - LL_P - LL_{TR}) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..3$$

Where, LL_T, LL_P and LL_{TR} denote the log-likelihood values for the Tobit, Probit, and Truncated models, respectively. λ is an LR statistic value with Chi-square distribution with degrees of freedom equal to the number of independent variables. λ is estimated under the null hypothesis that the Tobit model is more appropriate than the double-hurdle model. Consequently, the rejection of the null hypothesis means that the double hurdle model is a better alternative to the data.

Intensity of adoption of improved soybean technology package

For multiple practices (packages), there are two methods of measuring intensity of adoption. The first one is adoption index. This type of measurement measures the extent of adoption at the time of the survey. The second measurement is adoption quotient. This measures the degree or extent of use with reference to the maximum possible without considering time (Ilesanmi & Afolabi, 2020) and (Mihretie et al., 2022) . In this study, the first option was employed.

In order to know the intensity of adoption of soybean production technology, first the main components of the technology packages were listed based on soybean production manual, which was prepared by PARC in 2019. As package study, give equal weights for each package, it was not acceptable by many researchers because some components are easy toimplement, while others are difficult to implement. In addition, all components have not equal contributions for a specific crop production. Many scholars such as (Kebede & Tadesse, 2015), (Ogunya et al., 2017), (Ilesanmi & Afolabi, 2020), (Mihretie et al., 2022) have given weight for each packages to obtain intensity of adoption of a given technology. Therefore, this study gave different weight for each packages of soybean production technology (see Table 2). Based on the weight, soybean growing farmers' adoption intensity was calculated. Accordingly, adoption index of the technology was calculated as follow:

$\boldsymbol{AIi} = \boldsymbol{ATiRTixISi}$ ………………………………….. Equation 4

Where; ATi is the level or amount of packages (plowing frequency, seed type, crop rotation, fertilizer rate, seed rate, sowing method, and weeding frequency) of the ith farmer actually applied. RTi is the recommended level or amount of packages farmers ought to apply, ISi is the proportion of score (weight) for each package. AIi is adoption index of ith farmer.

As already explained above, researches conducted on agricultural technology adoption had been using weight to calculate adoption intensity. For instance, (Mihretie et al., 2022) used weight to calculate the intensity of adoption of tef production technology packages. The researcher was computing weight from district agricultural experts and model farmers. Kebede & Tadesse (2015) gave proportion score to calculate adoption intensity of malt-barley. Research conducted by (Ogunya et al., 2017) used weight for each package to calculate adoption intensity and level of Nerica rice varieties in Ogun, Nigeria. Ilesanmi & Afolabi (2020) also gave weight for each technology packages to calculate intensity of adoption of cocoa production technology packages in Ekiti State, Nigeria. They calculated weight from sample respondents. Hence, this study was computing proportion score (weights) of soybean production technology packages from district agricultural officers, kebele agricultural experts, development group leaders, and model farmers based on the contribution and necessities of the package for soybean production.

Table 2: Weights and methods of rating to calculate intensity of adoption

N	Packages	Recommendation	Weight	Methods ofrating
1	Seed type	Improved seed	0.35	Ratio of areacovered
3	Plowing Frequenc	3 and aboveha^{-1}	0.125	Ratio of averageplowing
4	Seed rate	Row=60Kgha^{-1}	0.125	Ratio of recommendationseed rate ha^{-1} to farmers‟actualapplication of seed ha^{-1}
5	Fertilizer	NPS 100 Kgha^{-1}	0.225	Ratio of actual application of recommendation amount NPS ofha^{-1}
7	Weeding	Manualweeding 2 and above ha^{-1}	0.175	Ratio of averageweedingfrequency
Total			**1.00**	

Source: Computed from woreda and kebele agricultural experts, development group leaders, and model farmers, 2024.

3.5. Description of dependent and independent variables

After a review of the literature and personal observations by authors, we have hypothesized different demographic, socioeconomic, psychological, and institutional factors that would affect both the adoption and intensity of adoption of improved soybean varieties. Accordingly, explanatory variables were hypothesized on determinates of improved soybean varieties adoption based on the information extracted from the theoretical literature review of previous works (Table 3).

Table 3: Variable definition and its measurement used in the Model

Definition variables	**Categories**	**measurement**	**Expected Sign**
Dependent variable			
Adoption of decision	Dummy	1= Adopter 0= non-adopter	
Adoption intensity	Continuous	Adoption index	
Independent variables			
Age of household head	Continuous	Years	+/-
Sex of the household head	Dummy	Male/female	Positive(+)
Education level of household head	Continuous	Formal schooling in years	Positive(+)
Farming experience	Continuous	Year	Positive(+)
Family labor force	Continuous	Man equivalent	Positive (+)
Farm size	Continuous	Cultivated area in ha	Positive(+)
Cost of seed	Continuous	In birr(ETB)	Negative(-)
Productivity	Continuous	Quintal in ha	Positive(+)
Number of livestock owned	Continuous	TLU	Negative(+)
Total annual income	Continuous	In birr(ETB)	Positive(+)
Distance to market center	Continuous	Minutes (min)	Negative (-)
Credit access	Dummy	Yes/no	Positive(+)
Participation in field days	Dummy	Yes/no	Positive(+)
Participation in training	Dummy	Yes/no	Positive(+)
Frequency of Extension contact	Continuous	No of days per year	Positive(+)

Source: Own construction

4. Results and Discussion

4.1. Descriptive results

Descriptive statistics analysis of the selected demographic and socioeconomic characteristics of sample households is vital, as it would help to frame the econometric analysis. Chi-square and T-statistic tests were employed to compare improved soybean variety adoption by adopter and non- adopter groups with respect to some explanatory variables. Accordingly, the t-test is used to test the significance of the mean values of continuous variables while chi-square is used to test the significance of the values of the potential dummy variables, with comparison of the adopter and non-adopter households.

4.1.1. Demographic and socioeconomic characteristics of respondents

This sub-section described the household characteristics that explain the information on demographic and socio-economic characteristics. In this study, a total of fifteen explanatory variables were identified and out of these variables twelve of them revealed significant association with the adoption and intensity of use of improved soybean varieties production. Variables such TLU, total annual income, distance to the nearest market, frequency of extension contacts, family labour force and farming experience are continuous, whereas participation in field day visiting, training, sex of household heads, education level, cooperative membership and credit access are dummy variables that show statistically significant at 1% , 5% and10% significant levels with the adoption decision. Put differently, market distance and off-farm income, did not have statistically significant relation with the adoption decision. Summary of the overall descriptive results of this study is presented in table 4 and 5 below.

TLU: Farm animals play a crucial part in rural livelihoods. They serve as a source of draft power to augment protein requirements, as well as status, currency, animal dung for organic fertilizer and fuel, a mode of transportation, and a hedge against general economic crises. Livestock found in the research region included cattle, sheep, goats, equines, and chickens. The mixed farming system (integrated crop and livestock production) is the primary agricultural activity in the study region. As a result, draft power is regarded as the primary source of production in the research area. Aside from that, it was discovered that livestock ownership has a major impact on the adoption of enhanced soybean technology. The average cattle ownership among adopters and non-adopters was 6.66 and 5.37, respectively. The p-value indicates a significant mean difference between the two groups (P <0.01). As a result, adoptive households are more likely to own livestock than non-adopter families. This finding is consistent with a study by (Bayissa Gedefa Weyessa, 2014), who found that when cattle ownership increases, adoption and intensity of adoption are likely to rise and correlate positively.

Annual income (ANUINC) is an important factor that influences the adoption of improved soybean varieties in the study area. In comparison to improved soybean adoption, the average yearly income of adopter households was ETB 41989, whereas the equivalent figure for non-adopter households was ETB 13044.54. The mean difference between the two groups was determined to be statistically significant (P<0.01).This demonstrates that respondents with higher income levels are more likely to spend above their fundamental needs, allowing them to purchase improved soybeans and related services, whereas those with lower incomes spend significant proportion of their income on basic needs.

Distance to the nearest market (DISMARK): refers to the time required to go from house to the nearest soybean market location where farmers sell their produce (soybean). Adopters and non-adopters take an average of 24.20 and 52.16 minutes to reach the nearest market. The mean difference between the two groups was found to be statistically significant (P<0.01), implying that non-adopters take longer to reach the nearest market than adopters.

The frequency of extension contact (FRQEXCONT) is one of the factors influencing the adoption of improved soybean varieties in the study area. With regard to improved soybean adoption, the average contact of adopter household heads with extension agents was 72.69, while the comparable figure for non-adopters was 58.35. The mean difference between the two groups was determined to be statistically significant (P<0.01). This shows that the frequency of extension contact has a positive and significant effect on the adoption of improved soybean varieties. The findings of this study are consistent with those reported by Negash (2007), Asfaw et al., (2011), and Dereje (2019).

Family labor force (FAMLABFORCE): The average family labor force supply in men equivalents of the sampled households was 4.75 persons, whereas adopters had 4.93 persons and non-adopters had 4.43 persons. The mean difference between the two groups was determined to be statistically significant (P< 0.05). This indicates that large families, or man equivalents, may provide a comparatively larger labor force supply for agriculture tasks related with their utilization (for example, weeding and land preparation). A labor shortage may prevent a household from adopting improved soybean varieties. The study provides similar results to the current study by Beshir et al. (2012), Asfaw et al., (2011), and Dereje (2019).

Farming experiences (FARMEXP): The average years of agricultural production experiences of all household heads, adopters, and non-adopters were 18.63 and 15.88 years, respectively. The mean difference between the two groups was determined to be statistically significant (P<0.05). The results show that technology adoption and agricultural production experiences are positively related.

Table 4: Test statistics of demographic and socioeconomic characteristics for continuous variables (t-test)

Variables	Adopter (N=197)		non-adopter (N=111)		Combined (N=308)		T- value
	Mean	Std.	Mean	Std.	Mean	Std.	
AGHH	45.06	0.64	44.63	0.9	44.90	0.51	0.655
DISMARK	24.20	0.96	52.16	3.97	34.3	1.73	8.63***
FRQEXCONT	72.69	0.65	58.35	1.19	67.52	0.72	-11.45***
FAMLABFORCE	4.93	0.11	4.43	0.15	4.75	0.09	0.99**
FARMEXP	18.63	0.68	15.88	0.76	17.64	0.47	-2.79**
FARSIZ	3.56	0.07	3.34	0.11	3.48	0.06	0.94

Variables	Adopter (N=197)		non-adopter (N=111)		Combined (N=308)		T- value
	Mean	Std.	Mean	Std.	Mean	Std.	
TLU	6.66	0.17	5.37	0.27	6.20	0.15	-4.15***
ANUINC	41989	1489.31	13044.5	895	31558	1280	-13.81***

Source: own estimation result, 2024 *** p<0.01, ** p<0.05, * p<0.1

Participation in field day visiting (PARTFILDVIST): - The majority of the respondents, 54.9%, had participated in demonstration visits, while 45.1% of the respondents did not participate in demonstration visits. From the total respondents, 85.8% were improved soybean adopters, and 14.2% were non-adopters, as they had participated in demonstration visits. On the other hand, 84.3% of respondents were improved soybean adopters, and 15.7% of respondents were non-adopters, as they did not participate in demonstration visits. The chi-square result showed that there is a statistically significant difference (P<0.01) between improved soybean adopters and non-adopters with respect to participation in demonstration visits. Participation in demonstration visits can give respondents the chance to evaluate different varieties demonstrated and decide to try them on their farm by selecting crop varieties that match others by different attributes using their judgment. As households participate in demonstration visits, they can develop improved soybean technology.

Cooperative membership(COOPMEM): - The result of this study showed that majority, 54.22% of the respondents had cooperative membership while the remaining 45.78% did not have cooperative membership. From the total respondents, 83.83% of respondents were improved soybean adopters and 16.17% of respondents who were non adopters reported they had cooperative membership. On the other hand, 40.42% of respondents were improved soybean adopters and

59.58% of respondents who were non-adopters reported that they did not have cooperative membership. The chi-square result showed that there is statistically significant difference (P<0.01) between improved soybean adopters and non-adopters with respect to cooperative membership. This implies that being a member of cooperatives is important than use improved soybean technology among adopters than non-adopters.

Training(TRAINSOY): The result of this study showed that about 53.6% of the respondents have attended training while the remaining 46.4% have not attended training. From the total respondents, 83.63% were improved soybean adopters and 16.37% of respondents who were non adopters reported they have attended trainings. On the other hand, 41.26% of respondents were improved soybean adopters and 58.74% of respondents who were non-adopters reported as they did not attend trainings. The Chi-square test confirmed that the association between training attendance and improved soybean adoption was significant (P<0.01). The finding is similar with the findings of (Abebe et al., 2018) and (Tesfaye Tegegne, 2021) who reported those farmers with access to trainings have better chance to adopt improved forage.

Sex of household (SEXHH): The findings of this study revealed that 76.3% of respondents were male-headed, while the remaining 23.7% were female-headed. In terms of improved soybean adoption status among sample respondents, 67.23% were male household heads, with the remaining 53.42% were female. On the non-adopter household side, approximately 32.77% and 46.58% of all respondents were male and female, respectively. The Chi-square test indicated that having a male household head was associated with increased soybean adoption (P<0.1). This results is in line with the study of (Mesfin et al., 2011), who noted that because of several socio-cultural beliefs and conventions, male have higher freedom of mobility and participation in various extension programs, resulting in better access to knowledge. Therefore, it is hypothesized that male farmers are more likely to adopt the package.

Credit access (ACCCREDIT): Credit is a vital institutional function for financing poor farmers who cannot buy input with their own money, especially during the early phases of adoption. The study found that 60.45% of respondents had access to credit, while 46.4% did not. According to Table 5, approximately 84.3% and 15.7% of adopters and non-adapters have access to credit services, whereas approximately 47.02% and 52.98% do not have access to credit services. The Chi-square test indicated a significant relationship between access to training and improved soybean adoption (P<0.01).

Education level (EDUHH): As shown in Table 5 below, 12.01% of improved soybean adopters completed secondary school education, compared to 3.8% of non-adopters. The mean difference between the two groups was determined to be statistically significant (P<0.01). This suggests that there is a significant positive association between education and increased soybean adoption.

Table 5: Test statistic of demographic and socioeconomic characteristics for dummy variables (chi2 -test)

Variable	Categories	Adopter (N=197)		Non-Adopter (N=111)		Total value (N=308)		Chi^2-value (probability)
		N	%	N	%	N	%	
Sex	Male	158	67.23	77	32.77	235	76.3	4.61*
	Female	39	53.42	34	46.58	73	23.7	
Education	Illiterate	37	12.01	51	16.56	88	28.57	33.23***
	Red & write	51	16.56	32	10.4	83	26.95	
	Primary school completed	72	23.4	17	5.52	89	28.89	
	Secondary school completed	37	12.01	11	3.8	48	15.59	
Training on soybean production	Yes	138	83.63	27	16.37	165	53.6	59.68***
	No	59	41.26	84	58.74	143	46.4	
Field day	Yes	145	85.8	24	14.2	169	54.9	77.47***
	No	52	37.41	87	62.59	139	45.1	

Cooperative	Yes	140	83.83	27	16.17	167	54.22	62.49**
	No	57	40.42	84	59.58	141	45.78	*
Credit	Yes	118	84.3	22	15.7	140	45.45	46***
	No	79	47.02	89	52.98	168	54.55	

Source: own estimation result, 2024 *** p<0.01, ** p<0.05, * p<0.1

4.4. Econometrics Result

4.4.1. Determinants of Adoption of Improved Soybean Variety

As shown in the model specification test, the log likelihood ratio (LR) value shows the reliability of the double hurdle model for this study. This implies that the factors that determine the adoption decision and intensity of improved soybean varieties production run in two- stages separately. The first hurdle indicates how the given variables determine the likelihood of an adoption decision for improved soybean varieties production. The second hurdle indicates how variables affect the intensity of adoption of improved soybean varieties production. As shown in Table 6, the Wald chi-square value of 104.18 is statistically significant at the 1% level of significance, indicating that the explanatory variables in the model jointly explain both the probability of adoption and the intensity of adoption of improved soybean production.

Distance to the Nearest Markets (DISMARK): it has a negative effect and statistical significance at 1% on the adoption decision of an improved soybean variety. When other variables were held constant, a 1-minute distance increase in the input market from the farmer's residence caused the adoption decision of the improved soybean varieties to decrease by 2.8%. This implies that the nearest farmers can get market information and agricultural inputs (fertilizer, certified improved seed, insecticide, and herbicide on time from the primary cooperative) more quickly than distant farmers.The result is consistent with previous studies by Gedefaw, (2019) found that distant farmers from input provider centers were affected negatively in their adoption decision and intensity of improved maize BH540.

Training on Soybean Production (TRANSOY): is significantly and positively influenced the adoption decision of improved soybean varieties at 1% significance level. When all other variables are held constant, participating in farm training increases the probability of improved soybean varieties adoption decisions by 13.3%. This suggests that farm training may enable farmers to acquire sufficient knowledge and skills for improved soybean varieties adoption, increasing the likelihood that respondents will accept the technology. The result is in harmony with the study by Gedefa, (2010), Daniel Masresha et al., (2017) and Hagos & Girma, (2018).

Frequency of Extension Contact (FREQEXCONT): it has positively and significantly influenced the adoption decision of the improved soybean varieties at 1% level of significance. The marginal effect shows that one more extension contact between farmers and agricultural extension experts increases the probability of improved soybean varieties adoption by 4.2%, ceteris paribus. This implies that frequent extension contact creates knowledge and updated information about improved soybean varieties. The result is in harmony with the study by Duressa, (2015) frequency extension contact between farmers and extension agents was positively and significantly influenced the adoption decision of Quncho tef in Wayu Tuqa district, respectively.

Field Day Participation (PARTFILDVIST): is positively and significantly influenced the adoption decision of improved soybean production at the 1% level of significance. All other variables held constant, participation in field day visits increases the probability of an improved soybean varieties adoption decision by 94.7%. This implies that the demonstration approach is one of the important approaches to transferring practical knowledge on agricultural production and technologies to farmers. When farmers conduct a new practice, they can weigh the advantages and disadvantages of the new technology, which can facilitate adoption and help them implement the new technology properly. This result showed that farmers who participate in demonstration activities are more likely to adopt new, improved technology than others. This suggests that wider demonstration would speed up the adoption of agricultural packages and hence, calls for development of the existing limited demonstration practices. Similar results were reported by Bezabih, (2012), Kedir et al., (2017) and Tesfaye Tegegne, (2021). These studies indicated that demonstration and dissemination of information through field day and demonstration activities might facilitate adoption of improved varieties.

Farm Size (FARSIZ): is negatively and significantly influenced the adoption decision of improved soybean production at 5% level of significance. All other variables held constant, but the result was unexpected because, under many adoption studies, farmers who have more land were assumed to adopt better new technologies than their counterparts. In this study, however, the finding was the inverse. Thus, model output revealed that one ha of additional land owned by sample farmers decreased their adoption decision probability by 28.6%. This implies that smallholders who have lower landholdings are more likely to strive to adopt improved soybean varieties to compensate for the limitations of crop production due to land shortages than farmers who have more land. On the other hand, farmers who have large landholdings might be rented out because of a lack of finance or awareness of how to utilize their land. The result contradicted with the work of Khonje and others., (2015).

Total Annual Income (ANUINC): it has positive and statistical significance at 1% on the adoption decision of improved soybean varieties. Provided other variables held constant, we found out that for every one unit increase in income, the adoption decision for improved soybean production increased by 2.1%. This implies that a farmer who has a better income will be more likely to adopt improved soybean varieties. This may be due to the resource-demanding nature of improved soybean production activity, particularly when the production purpose is beyond home consumption and for commercial purposes. Regarding the influence of farm income on adoption, many other studies have also found similar results. The result is in line with the finding of similar studies by Gedefa, (2010) and Beshir and others (2012).

4.4.2. Determinants of Intensity of Adoption of Improved Soybean Variety

This section focuses on factors that determine farmer's intensity of adoption of improved soybean production. As shown in the second hurdle (truncated regression), fivepredictor variables from 12 explanatory variables significantly determined the intensity of adoption of improved soybean production technology packages (Table 6).

Age of Household head (AGXHH): is negatively and significantly influenced adoption intensity of improved soybean variety at 10% level of significance. If other variables held constant, this is indicating an inverse in the relationship between age of household head and intensity of soybean adoption. The result indicates that a year increase in age of household reduces the probability of adoption intensity by 0.3%. The reason is that older farmers cannot manage the farm properly and usually rely on old farming systems. This agrees with the findings of Dube & Guveya, (2016) and Derso and others (2022), who also found that a farmer's risk-bearing ability reduces as his/ her age increases

.

Sex of Household Head (SEXHH): is positively and significantly influenced the adoption intensity of improved soybean varieties at the 10% level of significance. if other variables were held constant, the result indicated that the change in sex of the head from female to male increased the probability of adoption intensity by 3.7%. This shows that male-headed households have better access to information on improved soybean production technologies and are more likely to adopt new varieties than female-headed households, and also increase their soybean production. The result is in line with the findings of similar studies byKassa and others (2013).

Access to credit (ACCCREDIT): is significantly and positively influenced the adoption intensity of improved soybean varieties at 10% significance level. If all other variables held constant, access to credit increases the adoption intensity of improved soybean varieties by 4.5%. From this result, it can be stated that those farmers who have access to credit are in their district. The FGD discussion revealed the possible reason why farmers who need cash for their farm activities but failed to take credit is because of the fear that high interest rate will get them indebted. Those who take credits are relatively in a better economic situation and can pay the credit back. Farmers who can take credit can buy improved seeds and other farm inputs, while cash-constrained farmers cannot. This finding is congruent with Beshir, (2014), and Eba & Bashargo, (2014).

TLU: The number of livestock holdings in terms of tropical livestock units has positively and significantly influenced the adoption intensity of improved soybean varieties at 1% level of significance. When other variables were held constant, the result of the study revealed that as the livestock size (TLU) of a household increased by 1 unit, the intensity of improved soybean production would increase by a factor of 2%. This implies that a farmer who has more livestock will be more likely to influence the intensity of improved soybean varieties production. This may be due to the fact that having more livestock offers a means for a better propensity to buy improved soybean seed, and farmers who have a large number of livestock might consider their asset base as a mechanism for ensuring any risk associated with the adoption intensity of improved soybean production. The same results were reported by Burke, (2009) and Weyessa, (2014). This implies that livestock holding has an influence on the adoption of new technology in different areas.

Soybean Productivity (SOYPROD): is significantly and positively influenced the adoption intensity of improved soybean varieties at 1% significance level. If all other variables held constant, an increase in soybean output by one quintal increases the adoption intensity of improved soybean varieties by 2.8%. This was eventually expected since households that have greater production have more surpluses they can sell. The findings of this study are consistent with another study that households with a higher value of crop produced sell a higher proportion of their produce Awotide et al., 2016; Mather et al., 2011).

Table 6: Estimates of Double Hurdle Model for Adoption of Improved Soybean Production.

Variables	First hurdle (Tier1)			Second hurdle (Tier2)	
	Coef.	Marginal effect	Robust Std.Err	Coef.	Robust Std.Err
AGEHH	0.028	0.007	0.021	-0.003*	0.003
SEXHH	-0.413	-0.089	0.321	0.037*	0.035
EDUHH	0.168	0.040	0.126	-0.012	0.011
FAMLABFORCE	-0.081	-0.019	0.151	0.011	0.013
DISMARK	-0.028***	-0.007	0.005	0.001	0.001
TRAINSOY	1.133***	0.282	0.277	0.031	0.027
FRQEXCONT	0.042***	0.010	0.011	0.005	0.026
PARTFILDVIST	0.947***	0.237	0.274	0.002	0.027
ACCCREDIT	0.665	0.155	0.273	0.045*	0.023
COOPMEM	0.211	0.051	0.286	0.020***	0.004
FARSIZ	-0.286**	-0.069	0.136	0.001	0.003
TLU	0.021	0.005	0.066	0.028***	0.006
ANUINC	0.021***	0.005	0.004		
_cons	-5.939		1.303	0.186	0.154
sigma _cons	0.148		0.007		

Source: own estimation result, 2024 *** p<0.01, ** p<0.05, * p<0.1

4. Conclusion and Recommendations

The study posits its conclusive statements on determinants of adoption and adoption decision as per the lines of the double hurdle model outputs. Firstly, the study stated that determinants of adoption such as extension contacts, agricultural trainings, field days participation and annul income have a positive and significant impact on farm households' decision to adopt improved soybean varieties. In contrast, to this, however, distance to the market and farm size had negative and significant influences on the adoption decision of improved soybean varieties. Secondly, the study also revealed that sex of household heads, credit access, TLU and soybean productivity have a positive and significant effect on the intensity of improved soybean varieties adoption, but age of the household head had negatively and statistically significant effect on the intensity of improved soybean varieties adoption.

The study came up with critical implications as to how to address challenges of adoption and deepen the intensity of adoption decisions related to improved soybean varieties production. Particularly, reducing the obstacles and increase adoption and production of soybean thereby to enhance the income from this crop/technology and consequently address the poverty situation of smallholder soybean producers is critical. To this sake, the study suggests that kebele agricultural extension agents should work to increase adoption rates in a sense that they provide regular, tailored training programs on innovative soybean production technologies. Furthermore, extension agents should also actively make their services accessible to farmers by making frequent field visits and cultivating collaborative partnerships to guarantee efficient information transmissions and institutional supports.

Sectoral policymakers and/or agricultural stakeholders in should emphasize funding availability for extension services, training facilitation, field day events, and livestock resource development (TLU) and input marketing to realize the anticipated benefits from soybean productions. Collaboration between the public and private sectors is also vital for providing complete institutional support and enabling broader access to these services.

5. Research limitations and future directions

Due to limited resources, the study was limited to a description and analysis of factors influencing improved soybean varieties in Pawe district of Benishangul Gumuz regional state. As a result, the study's main limitation was its geographic area coverage within the region. This may limit the study's generalizability to a larger area or region. Even if the study had been conducted with the aforementioned limitations, this finding would serve as a foundation for future research in the study area as well as other areas with similar physical characteristics.

Abbreviations

CCT Contingency Coefficients Test
CSA Central Statistical Agency
GDP Gross Domestic Product
FGD Focus Group Discussion
KI Key Informant
ILRI International Livestock Research Institute
TLU Tropical Livestock Unit
VIF Variance Inflation Factor

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Author contributions

The author collected and analyzed both primary and secondary data. The author read and approved the final manuscript.

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Availability of data and materials

The author wants to declare that they can submit the data at any time based on the publisher's request. The data sets used and/or analyzed during the current study will be available from the authors upon reasonable request.

Ethics approval and consent to participate

All sources are duly acknowledged. The authors gave due attention to environmental and sociocultural considerations.

Consent for publication

Allauthorsagreedtomakethisoriginalresearchworkavailabletothepublic.

Competing interests

The authors declare that they have no competing interests.

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EndNote

1. 'Wereda' is an administration unit equivalent to a district, whilst 'Kebele' is the lowest administrative unit in Ethiopia