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DETERMINATION OF ADOPTION OF SUSTAINABLE INTENSIFICATION PRACTICES: THE CASE OF SMALLHOLDER VEGETABLE FARMERS IN EAST HARARGHE ZONE, OROMIA REGION, ETHIOPIA

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Abstract

Agriculture is still the leading sector in economic development of Ethiopia. Recently, farmers' adoption of sustainable intensification practices considered as the best strategy to ensure economic and environmental sustainability concomitantly. The aim of this study was to identify determinants of adoption of sustainable intensification practices in eastern part of Oromia region, Ethiopia. Using multistage sampling technique, 383 households was drawn from the study population. The study used multivariate probit model to analyse factors influencing adoption of sustainable intensification practices. The result of the model revealed that factors like Extension service, Education, Farm size, Livestock and access to training significantly an positively enhance adoption of sustainable intensification practices while access to media negatively influence adoption of sustainable intensification practices. The results of the study also indicate that there is complementarity between crop rotation and conservation tillage and a negative correlation between organic fertilizer and conservation tillage. From the result we can conclude that adoption of sustainable intensification practices are complementary and can jointly better enhance soil and environmental conservation.

Keywords: adoption, sustainable intensification practices, multivariate probit, Ethiopia.

1. INTRODUCTION

Ethiopia has a high capability, favourable climate and edaphic conditions (EHDA, 2012; Emana et al., 2015) for vegetable production because of various factors suitable to growing these crops, including topography, climate, and soil (Hunde and Nimona, 2017). Recently, vegetable production has been considered as an essential economic activity in Ethiopia that ranges from gardening smallholder farming to commercial farms and private enterprise (Rahiel

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and Gebresilasie, 2018). Vegetable production also gives an opportunity for intensive production (Kumilachew et al., 2014). That is why the area under vegetables owned by smallholders was increased from 0.39 million ha with production of 4.48 million tons in 2013 (Belew and Tedele, 2015) to 0.44 million hectares with a total production of 53 million tons which shares about 1.69% of the area under all crops at country level (Cochrane and Bekele, 2018).

In Ethiopia, input intensification has revealed an increasing trend where the proportions of farmers using fertilizer have been increased by 21 percentages between 2012 and 2019. Similarly, the share of fertilized farm area also increased approximately by 6 percentage and rates of application as measured by amount of any fertilizer use per hectare of land has doubled (Dorosh and Minten, 2020). Besides this, most of the time, the growth in agricultural production including vegetables was at the expense of environmental cost like deforestation, reduction in biodiversity (Carlos et al., 2018 ; Ahirwar et al., 2020), water pollution, land degradation, soil erosion (Ouyang et al., 2018 ; Borelli et al., 2018) and unfavorable climate change (Xiang et al., 2020). Farmers' excessive usage of chemicals, fertilizers, pesticides by the intention of sustaining certain level of productivity has been seriously damaging soil structure, soil fertility (Xiang et al., 2020), human health and other ecosystems.

Adoption of sustainable agricultural intensification practices underpin the type of environmental-friendly production that will neutralize or minimize detrimental usage of natural resources to the least possible amount, while sustaining or even enhancing the level of production. Furthermore, farmer's adoption of sustainable intensification practices (e.g., Improvements in cultivation practices, accessibility of improved yield varieties and enhancement in irrigation infrastructure (Mariyono and Sumarno, 2015)) enables farmers not only in sustaining productivity and reducing environmental burdens but also shifting from producing subsistence crops to commercial crops. Mitku (2014) and Abafita et al. (2016) mentioned that transformation of agriculture from subsistence to commercial is an indispensable pathway towards economic growth and development for several agriculture-dependent societies in developing countries.

In this context, the importance of sustainable intensification practices has been increased so as to use the existing land to enhance yields, and attain the goals of positive economic and environmental outcomes simultaneously as a guaranteed basis for long-term agricultural development and well-being improvement (Pretty et al., 2011; Rogers et al., 2013). Sustainable agricultural intensification practices (SAIPs) could realize both economic improvement and environmental protection through conserving soil fertility, reduce deforestation and produce greater production in existing cropping areas with minimum environmental pressure (Nkomoki et al., 2018; Kim et al., 2019).

In this arena, reflecting light on the determinants of adoption of multiple sustainable agricultural intensification practices and the existing correlation projected to fill the gap in the literature and enable farmers and development agents basically attain maximum level of production at a reduced amount of environmental cost.

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Hence, the objectives of this study are:

1) To identify the determinants of adoption of sustainable agricultural intensification practices of smallholder vegetable producers
2) To examine the existing relationships between sustainable intensification practices

2. OVERVIEW OF ADOPTION OF SUSTAINABLE INTENSIFICATION PRACTICES

Adoption: Despite the term adoption is among very difficult terms not only to define (CIMMYT, 1993) but also to quantify (Erenstein et al., 2012), several researchers have given various definition to it. Rogers (1962) defined adoption as a mental process through which an individual passes through several stages from hearing about an innovation to its adoption that follows awareness, interest, evaluation, trial, and adoption stages. According to Woittiez and Giller (2015), adoption is defined as the long-term assimilation of a technology or part of a technology into the set of household livelihood activities, measured in terms of well-defined and quantifiable indicators. Adoption refers to the decision to use a new technology, method, practice, etc. by a firm, a farmer or a consumer.

Sustainable intensification: Absence of definitional clarity and lack of uniform understanding among agricultural experts (Petersen and Snapp, 2015) to the term sustainable intensification made the word difficult to operationalize. To define "sustainable intensification", it is necessary to separately define and conceptualize the term "sustainable" and "intensification". The term "sustainable" and "intensification" are also defined broadly. The word "sustain" from the Latin sustinere (sus-, from below and tenere, to hold), to keep in existence or maintain, implies long-term support or permanence. As it relates to agriculture, sustainable indicates farming systems that are "capable of maintaining their productivity and usefulness to society indefinitely. Such systems must be resource-conserving, socially supportive, commercially competitive, and environmentally sound" (John, 1990).

Juma et al. (2013) defined sustainable intensification (from now onwards SI) as agricultural inputs and practices that results in higher outputs from efficient use of available inputs, while simultaneously reducing environmental damage, building resilience and improving environmental services. Sustainable agricultural intensification practices (SAIPs) may include numerous inputs and practices such as prudent usage of chemical fertilizers, improved crop cultivars, soil and water conservation, cereal-legume intercropping, crop rotation, agroforestry (Lee, 2005), organic fertilizer, intercropping, crop diversification, conventional tillage, soil fertility management practices, usage of improved seed varieties and etc. Therefore, this study used the definition given by Juma et al., (2013) as operational definition and focused on three specific sustainable agricultural intensification practices (SAIPs): organic-fertilizer, crop rotation and conservation tillage.

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3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

The study was conducted in East Hararghe zone of Oromia Regional State of Ethiopia. Oromia is the largest region in terms of population and area coverage. The Zone is geographically located between 7°32′-9°44′ North latitude and 41°10′-43°16′ East longitudes with altitude ranging from 500 to 3405 meters above sea level (PEDO, 1997). East Hararghe Zone is well known by vegetable production. According to CSA (2021), the total area allocated for vegetable cultivation in East Hararghe estimated as 544.30 ha that generated nearly about 33,175.33 quintal of vegetables. The zone has 18 administrative districts.

3.2. Sampling Technique

Multi-stage sampling technique was used to select the sample units. The first stage involved purposive sampling where three districts were purposively selected from 19 districts of the East Hararghe Zone by considering their high potentiality in vegetable cultivation capacity and participation in adopting sustainable intensification practices compared to the remaining districts of the zone. The second stage involved a stratified random sampling to stratify the list of kebeles into vegetable producers and non-vegetable producers. Then, by using simple random sampling method, three vegetable producer kebeles were selected from each district (i.e., a total of nine kebeles) proportional to size.

Depending on the list of number of vegetable producers in randomly sampled kebeles, a random selection of adopters and non-adopters from each of selected kebeles will be carried out using Probability Proportional to Size (PPS). Thus, the numbers of sample adopter and non-adopter households selected were 153 and 230, respectively. Hence, in this study, a total of 383 sample households were drawn for an interview.

3.3. Sample Size Determination

There are several methods followed by various researchers to determine the sample size of a given study. . The population of the study refers to smallholder farmers that produce vegetable in the East Hararghe zone of Oromia region. Such wide geographical coverage and large size of the population requires a lot of resources in terms of time and cost to be studied with a complete census. Accordingly, given the population size of the study area, the total sample size was determined using a formula which provides the maximum size to ensure the desired precision using the formula given by Kothari (2004) as follows:

$$n = \frac{Z^2pqN}{e^2(N-1) + Z^2pq} = \frac{(1.96)^2(0.5)(0.5)(89215)}{(0.05)^2(89214) + (1.96)^2(0.5)(0.5)} = 382.51 \approx 383$$

3.4. Data Sources and Methods of Data Collection

In this study, both primary and secondary data were used. Secondary data was gathered from several sources including East Hararghe zone agricultural office, woreda agricultural and rural development offices of the three Woredas, reports and documents of sampled kebeles and non-government organizations. These include annual, semi-annual and quarterly reports, and

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publications. Primary data was gathered from both adopter and non-adopter of SIP among vegetable producer households in the study area. Based on the requirement of each and every research objective, various types of primary data were collected.

Face-to-face personal interviews using semi-structured questionnaire was employed to collect primary data. Both open and close-ended types of questions were included in the questionnaire to collect information relevant to the purpose of the study. Data was collected from the study area during the 2021/22 production year. Data collection was conducted through a cross-sectional survey as the method involves one-time data collection and analysis, thereby save time and cost.

3.5. Methods of Data Analysis

This study included both descriptive statistics and econometric analysis to estimate the values of the unknown parameters of the population and testing of hypotheses. Descriptive statistics such as means, standard deviation, ratios, proportions, frequencies, etc. were used to capture the multidimensional behaviour of the households and farms in the study area. Inferential statistics such as chi-square, t and F tests was applied to compare households by adoption status of SIP.

Kassie et al. (2015) stated that from the works of Feder (1985) onwards, studying adoption of multiple agricultural technologies on the base of single versus joint analysis has got paramount attention. Single adoption models often analyse the decision to adopt a single technology by using univariate econometric modelling frameworks, with scant attention to the other interrelated technologies. As the farmers in underdevelopment countries encounter multiple production constraints, risk and limited resources access, they consequently opt for adopting a combination of technologies to maximize utility and deal with these constraints. Based on the constraints and utilities accompanying with the various practices, their adoption may be interdependent, either as complements (positive correlation) or as substitutes (negative correlation).

Thus, this study used the multivariate probit (MVP) modelling approach which simultaneously allows estimating interdependent multiple adoption decisions while allowing the unobserved and unmeasured factors (errors terms) to be correlated freely. Failure to capture unobserved factors and interrelationships among adoption decisions regarding different practices will lead to bias and inefficient estimates (Greene, 2008). Following Kpadonou et al. (2017) the observed outcome of SIP adoption can be modelled following a random utility formulation. Let U_n represents the utilities associated with the adoption of nth practice and U_0 otherwise. The farmer decides to adopt the nth practice if $Y_{in} = U_n - U_0 > 0$. The net utility, Y^*_{in}, that the farmer derives from the adoption of nth practice is a latent variable determined by the observed factors and the multivariate normally distributed error term (ε_i):

$$Y^*_{in} = \beta_n x_i + \epsilon_i \qquad (1)$$

Where x_i is independent variables, n is the number of practices to be adopted by farmers and β_n is coefficients to be estimated. In this case n represents choice of crop rotation (R),

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conservation tillage (C) and organic fertiliser (O). Consequently, the farmer is expected to adopt a given practice if the expected utility from its adoption involves a greater benefit compared to non-adoption. Hence, the outcome equations explaining the observable binary choices of the farmer are written as follows:

$$Y_{in} = \begin{cases} 1 \text{ if } Y_{in}^{*} > 0 \\ 0 \quad \text{otherwise} \end{cases} \qquad (2)$$

Where Y_{in} is a dichotomous observable variable represents the adoption decision of the ith farmer regarding the nth practice. In the MVP model, the error terms are assumed to jointly follow a multivariate normal distribution with zero conditional mean and variance normalized to unity, and the symmetric variance-covariance matrix is given as follows:

$$\Omega = \begin{bmatrix} 1 & \sigma_{RC} & \sigma_{RO} \\ \sigma_{CR} & 1 & \sigma_{CO} \\ \sigma_{OR} & \sigma_{OC} & 1 \end{bmatrix}$$

σ (sigma) is the pairwise correlation coefficient between the error terms of any two adoption equations to be estimated in the model. In this model, the sign and significance of the correlation coefficient, offer evidence on the nature of the relationship between adoption equations. Many scholars (e.g., Kpadonou et al., 2017) explained that positive correlation indicates complementarity between practices, while a negative correlation is understood as substitutability. The MVP model only reflects the probability of adoption of a certain SIP with no distinction made between, for example, farmers who adopt a single practice and those who adopt many practices in combination. Holding this, a study conducted by Zougmore et al. (2010) revealed that farmers who combine several practices have better benefits than those who adopt only a single or very few practices.

4. RESULTS AND DISCUSSION

This section deals with determinants of adoption of sustainable intensification practices of sampled smallholder farmers engaged in vegetable production in the study area. Multivariate probit model was selected as an appropriate model. The model is estimated using the maximum likelihood estimation at farm level observation. The overall fitness of the model was tested using Wald Chi2 -test based on likelihood ratio statistics. The result as displayed in table 1 revealed $[x^2(57) = 278.23, p = 0.00]$. Accordingly, null hypothesis that states the regression coefficients of all independent variables are together equal to zero was rejected at one percent level of significance.

As a result, the overall fitness of the model was assured and underscored that explanatory variables have jointly good power of explaining the adoption status of SAIPs in the study area. In addition to this, based on the likelihood ratio test$[x^2(3) = 41.6796, p = 0.00]$we rejected the null hypothesis (independence of the error terms) and approved the existence of correlations among the covariance of the error terms across equations of SAIPs. However, there is both negative and positive sign of correlation in the covariance of the error terms. This entails that compound application of practices are not only interdependent but also mutually dependent.

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Hence, appropriateness of the model is also again approved from this point of view i.e. multivariate probit model is preferred over single equation probit model. The result of multivariate probit model disclosed that the decision to adopt sustainable agricultural intensification practices is significantly affected by many variables.

Age of the household head was negatively and significantly affected the adoption status of conservation tillage and crop rotation. This implies that as the age of the household head increases, the likelihood of adopting these practices decreases. This is because the older farmer is mostly risk averter and they don't like to move from their early farming habit to new farming style.

Size of the household had a positive and significant influence of the adoption status of organic fertilizer and crop rotation. Family is considered as a proxy for family labour. The farmer in the study area uses member of the house hold as a complementary that cover multiple jobs on the farm. In the study area, applying organic fertilizer to the farm is the work of member of the household as the household head is most of the time busy with major and heavy task like ploughing planting and the like. In addition to this, farmer with large family member focused on securing food availability for the member of the family which indirectly pushes household head to adopt practices that enhance soil fertility and farm productivity. Hence, household head with large family size were more likely to adopt organic fertilizer and crop rotation than household head with less family size. The marginal effects indicated that a unit increase in family size increases the adoption status of organic fertilizer and crop rotation by 3.1 and 4 percent respectively. This finding is consistent with the study conducted by Teferra et al. (2019) on determinants of crop rotation in West Amhara Region,Ethiopia and they concluded in support of this finding. Similarly, Jabbar et al. (2020) also found positive and significant influence of family size on crop rotation.

The result of multivariate probit model underscored that social participation was also another variable that positively affect the likelihood of adopting conservation tillage and organic fertilizer. This may be due to the fact that farmer that act as a member in various social structure is mostly exposed to different diffusion of information regarding to farm and farming style. In the study area, farmers who participated in FGD mentioned that due to limited availability of livestock, some farmers bring organic fertilizer from the nearest pastoralist. Hence, farmer that had good participation in the social organization has by default relevant information and better linkage with surrounding society. This may enables socially active farmer easily adopt the above mentioned sustainable agricultural intensification practices.

The decision to adopt conservation tillage was positively affected by extension service at 1% level of significance. Extension services are considered as a critical component that facilitate transfer of knowledge and technologies, improve farmers' technical skills and create awareness on advantages of applying useful practices on the farm. Furthermore, development agents provide farmers with practical support and ensure disseminations of beneficial inputs among the farmers. Thus, as expected, household head that was visited by extension agent was more likely to adopt conservation tillage than the farmers who was not visited by extension agent. In contrary to this result, Darkwah et al. (2019) found negative and significant influence of extension service on the adoption status of conservation tillage arguing that access to extension services by itself is not enough to enhance adoption status of farmers. Hence, the effect of extension service is left unsettled and requires further research.

This study found that Education of the household head had a positive influence on the adoption of crop rotation, conservation tillage and organic fertilizer. This is possibly because educated farmer is more open minded and easily understand the benefits of those practises. Given that, educated farmer has the ability to easily communicate and understand the guidance of extension agent. Education help farmer in many aspects like selecting quality of farm inputs, gathering useful information and utilizing farm inputs and available information efficiently to make better decision for many problems. Due to the above reasons, it is probable that education significantly affect the adoption decision of farmer to crop rotation, conservation tillage and organic fertilizer. A one unit increase in the year of schooling increases the adoption status of SAIPs by 2.5, 2 and 0.6 percent respectively. Similar results were found in the work of Muluneh et al. (2022) and Wang et al. (2021).

Size of the land owned by the household had significant and positive effect of adoption of conservation tillage and organic fertilizer at less than one percent level of significance. This suggests that ownership of large land encourage farmer to adopt SAIPs. The result is parallel with many studies conducted before. For instance, Darkwah et al. (2019) obtained positive and significant effect of land size on adoption of SAIPs.

The possible reason is that since land is the only major asset that farmer rely on to feed their family, initially farmer with small land is not want to be risk taker by adopting unusual practices. In contrary, farmers with large farm land can easily test new inputs and practices on the land as he or she own another land to run their usual economic activities. The result showed that unit increase in the land increases the probability of adopting SAIPs by 37, 38 and 8 percent respectively. Therefore, it is likely that household with greater land size tend to adopt SAIP than household with lesser land size.

The other variable that was expected to affect adoption decision of SAIPs was ownership of livestock. As expected, this study presented possession of livestock had significant and positive effect only on the adoption of organic fertilizer and had no significant effect on the remaining practices. It is obvious that livestock is the main source of organic fertilizer, farmer that own many livestock has excess dung than farmer with less number of livestock. The marginal effect stated that a unit increase in TLU increase the probability of applying organic fertilizer by 6.5 percent. There are no arguments among scholars of the subjects concerning to the effect of livestock on the adoption of organic fertilizer as almost all studies conducted before generated identical results. For instance, the study conducted by Teferra et al. (2019) and Muluneh et al. (2022) found similar result.

According to the result in table 1, perception yield had a significant and positive influence on the farmer's position to adopt conservation tillage and organic fertilizer. The result is in agreement with the hypothesis stated in chapter three above. This suggests that the respondent that believes adoption of conservation tillage and organic fertilizer increases yield of the farm

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possibly tend to adopt those practices early before their counterpart. Perception to soil fertility had revealed significant and positive effect on the adoption decision of crop rotation and organic fertilizer. However it had no effect on adoption of conservation tillage.

In opposite to what was hypothesized in chapter three, the result underscored pertaining to access to media had a negative and significant effect on the decision to adopt crop rotation and organic fertilizer. This result is opposite to what was found by Muluneh et al. (2022) who obtained significant and positive effect of access to media on adoption of crop rotation. There was also another study for instance Darkwah et al. (2019) that found negative coefficient but no significant effect of access to media on adoption of SAIPs. Such kinds of controversy result on a single variable may be outspread from the intention to which the farmer purchased communication tools, the concerned type of information farmers' gain from media and whether the media broadcast information relevant to these practices. As far as this study concerned, the information obtained from key informants and development agents pointed out that majority of the farmers rely on development agents and rarely follow media for improving their farming practices.

Access to training significantly and positively influenced the adoption status of all SAIPs. This is because, household head that participated in training may gain better knowledge and narrow skill gaps pertaining to better farming practice. The same result was also found by Hong et al. (2017).

Table 1: Result of coefficient estimates of multivariate probit model

	Coefficient	SE	M. Effect	Coefficient	SE	M. Effect	Coefficient	SE	M. Effect
Age	-0.01	0.01	0.005	-0.08***	0.01	-0.032	-0.02**	0.01	-0.008
Sex	0.09	0.32	-0.014	-0.40	0.33	-0.165	-0.27	0.29	-0.144
HHS	0.11***	0.04	0.031	-0.03	0.04	0.001	0.08***	0.04	0.026
Social	2.17***	0.52	0.684	2.54***	0.49	0.496	-0.16	0.36	-0.103
Extension service	0.02**	0.50	0.059	1.52***	0.37	0.474	0.46	0.34	0.246
Education	0.07***	0.03	0.006	0.06**	0.03	0.020	0.07**	0.03	0.025
Fsize	1.19***	0.33	0.377	1.38***	0.27	0.386	-0.29	0.23	-0.088
Livestock	0.25***	0.07	0.065	-0.15	0.05	-0.051	0.09	0.05	0.045
Yldperc	0.83	0.41	0.257	0.81**	0.33	0.202	0.37	0.29	0.090
Fertperc	0.83	0.26	0.234	0.28	0.23	0.131	0.68	0.23	0.252
ATr	0.60***	0.18	0.184	0.52***	0.17	0.238	0.36***	0.17	0.133
Media	-1.56***	0.47	-0.276	-0.24	0.38	-0.051	-0.66**	0.31	-0.185
_cons	3.13	0.88		1.86	0.80		0.33	0.67	

Source: own computation from survey data, 2022.

NB: ***, ** and * indicate the level of significance at 1, 5 and 10 percent, respectively.

To discuss the types of relationships that exist among sustainable agricultural intensification practices, presenting the result of matrix of covariance is indispensable. It is already mentioned that from the likelihood ratio test, the independence of error terms was rejected. Regarding to significance and sign of correlation coefficient, the result in table 2 discovered that all of the three pair cases were statistically significant. Of the three pair cases, only one case was negative and the remaining two were positive. From the sign of correlation coefficient, we can

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understand that there is both complimentary relationships and substitutability between practices.

As indicated in table 2, organic fertilizer is negatively correlated with conservation tillage. This infers that farmer may consider organic fertilizer as substitute for conservation tillage. There are slight differences between these two practices in terms of enhancing farm productivity and positively influencing biology of the soil. For instance, by applying conservation tillage, farmer may save labour, equipment and fuel costs and minimize risk of exposing the farm to soil erosion, soil compaction and moisture evaporation. However, applying organic fertilizer may not save costs but both practices play a lion share in ensuring soil fertility and maintaining soil moisture. On the other hand, negative correlation may also indicates that both practices provide generally the save service with slight variation in the content of the service. Thus, the combination of these two practices from this perspective may indirectly involve the sense of positive collaboration.

The remaining pair of practices was positively correlated with each other i.e. crop rotation is positively correlated with conservation tillage and organic fertilizer is also positively correlated with crop rotation. As presented in the table 2 below, the highest negative correlation exists between organic fertilizer and conservation tillage: 43%. The next highest correlation displayed was positive correlation between organic fertilizer and crop rotation: 33%.This suggests that these practices are not mutually exclusive i.e. applying one practice could not hinder the usage of other practices; rather they are interdependent and complementary. Hence, the result from table 2 confirmed that these three practices i.e. conservation tillage, crop rotation and organic fertilizer are complementary and can better enhance soil and environmental conservation.

Table 2: Covariance of matrix for regression equations between SAIPs using MVP

	ρ^C	ρ^R	ρ^O
ρ^C	1		
ρ^R	0.22(0.098)***	1	
ρ^O	-0.43(0.104)***	0.33(0.100)***	1

Likelihood ratio test of $\rho^{RC} = \rho^{OC} = \rho^{OR} = 0$: $x^2(3) = 34.1532$ Prob $> x^2 = 0.000$

NB: ***, ** and * indicate the level of significance at 1, 5 and 10 percent, respectively.

Source: own computation from survey data, 2022.

5. CONCLUSIONS AND RECOMMENDATIONS

In Ethiopia, agricultural sector continued in leading the economic growth of the country. It is still considered as the stepping stone to ensure sustainable improvements of production and productivity of various agricultural outputs so as to realize transformation of the sector from subsistence to commercial oriented sectors along with paying due attention for conservation and sustainability of environmental resources. Hence, this study was designed to expand the borders of knowledge in adoption and to generate information on adoption of sustainable agricultural intensification practices. Multivariate probit model was employed to assess factors

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that determine adoption of SAIPs and the result of the model revealed that factors like family size, education of the household head, access to extension service, land size and livestock had positive and significant influence on the adoption of SAIPs. While other determinants like age of the household head and media had negative and significant effect on the adoption of SAIPs.

In line with the main objectives and findings of this study, the following conclusions and recommendations are made. Education, extension services and land size was found as a key variable that positively influence the adoption of SAIPs. Therefore, expanding the coverage of education and designing inclusive and participatory approach that enable farmer engaged in education should be emphasized. In relation to this, policies that aimed at increasing access of extension service to farmers should be strengthened. This should be implemented with the aim of not only boosting technical skills and knowledge of the farmers but also making farmers familiar to applications of various agricultural technologies, benefits of environmentally suitable and useful practices and other crops and natural resources management practices. Promoting engagement of children and youth in rural area in education, providing training and empowering under-employed youth and farmers so as to enable them grab the opportunities are also should be taken as another effective alternatives that minimize the risk of ever increasing land fragmentation in the study area.

None of the authors have a conflict of interest to disclose

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