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Household Demand for Inorganic Fertilizer and Its Determinants of Adoption and Use Intensity in Shashemene District, West Arsi Zone, Oromia Region, Ethiopia

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Abstract: The study was conducted from September 2019 to June 2020 to assess the determinants of inorganic fertilizer adoption by smallholder farmers and provide insights into the factors affecting its usage in agricultural practices within the region in Shashemene district, Ethiopia. A multi-stage sampling procedure was applied to select the appropriate sample size and a total of 365 sample households were selected out of 42,942 people from three kebeles'. Primary data was collected from households directly through interviews, while secondary data was from published documents, reports and other relevant materials. The collected data was analyzed using both descriptive statistics and econometric methods. Descriptive statistics were used to summarize the essential features of the data. The T-test-test and Chi square were also employed to measure the mean difference between groups in terms of continuous and categorical variables, respectively. There was a significant difference between adopters and non-adopters of inorganic fertilizer in terms of education (χ^2 = 12.86), credit access (χ^2 = 203.68) and extension service (χ^2 = 189.46). Moreover, there was a significant mean difference between the two groups in terms of age (t = -5.01) and off-farm (t = 2.3464) income, livestock in TLU (t =-3.4612), market distance (t = 3.44) and cultivated land (t = -1.69). According to the Hackman econometric model, age, sex, marital status, education status, access to credit, extension service and family size were among the factors that affected the adoption of inorganic fertilizer positively and significantly. While intensity of use of inorganic fertilizer was affected by age, education, livestock holding, credit access, extension service and farm income positively and significantly in the study area, Therefore, awareness creation, capacity building, access to credit and extension service enhancements should be in place.

Key words: Adoption · Determinants · Inorganic Fertilizer

INTRODUCTION

Livestock is a significant national resource and an essential component of Agriculture is the main livelihood source for smallholder farmers who live in the developing world, where traditional farming practices dominate [1, 2]. Socioeconomic data demonstrated that the agriculture sector dominates Ethiopia's economy. One of the main inputs that increase production is fertilizer. Therefore, using fertilizer more effectively can be seen as a more realistic solution in Ethiopia to close the large gap in food scarcity (at least in the near future). Ethiopia doesn't produce inorganic fertilizer on its own. One cannot undervalue the importance of agriculture to Ethiopia's economy, as it accounts for around 86% of all export revenue [3]. As a result, the industry contributes significantly to the national GDP more than 40% and serves as a foundation for the growth of other industries. More than 90% of Ethiopia's impoverished people work as laborers and it is the primary source of income for 85% of those who reside in the nation's rural areas. As a result, the industry plays a crucial role in enhancing the standard of living for the sizable population that is defined by poor productivity [4, 5].

A more productive agricultural sector is necessary to improve food security and slow down the rate of population growth, two goals that the government and many development stakeholders support. Oromia Region, which covers 353,690 km^2 and encompasses a variety of agro-climatic zones across the nation, is endowed with a

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comparatively high agricultural potential. However, because of the extremely low performance of the agricultural sector, the region's annual growth rate in food production is less than necessary. While there are many different and intricate reasons why agricultural output does not function well, the main ones are land holdings that are sub-economic, institutional, technological, environmental and technological [6, 7].

Together with the previously mentioned issues, a growing population has resulted in a demand for food that exceeds the region's ability to supply it. Therefore, extensive or intensive farming should be used to increase crop yield in order to achieve food self-sufficiency. Since most of the viable sites are in lowland areas that need significant investment and time to develop, the former cannot be used or be a temporary solution. Furthermore, the pressure of an ever-increasing population makes large-scale farming nearly impossible nowadays. Fertilizer is the primary component in a package of technologies that can be adopted to boost agricultural productivity per unit area, which is the only short-term solution [8]. In other words, the use of fertilizers and other inputs must intensify agriculture in order to enhance production. Fertilizer-based agricultural intensification is therefore seen as a critical element in raising agricultural production and productivity in the area [9]. The input boosts productivity and agricultural output, which may enhance the country's ability to feed itself [10].

Furthermore, Africa's high rates of poverty and low productivity are mostly caused by low input utilization and traditional production processes [11]. Many studies have been conducted on the need to improve or raise production across the continent in order to address this problem, but not much progress has been made. To meet the projected rise in food demand, increasing agricultural productivity through the implementation of modern agricultural technologies such as fertilizer and improved seeds, among others is crucial. Inorganic fertilizers have the power to improve household income, boost crop output, raise soil fertility and increase food security when properly applied to soils [12-14].

Despite the fact that inorganic fertilizer has been shown to be the most effective way to restore deficient soil nutrients for crop growth, its application in Africa has not been as widespread as it has been in developed countries. Thus, the objective of this study is to investigate the determinants of households' demand for inorganic fertilizer in Shashemene district, West Arsi Zone, Oromia, Ethiopia.

MATERIALS AND METHODS

Description of the Study Area: The study was carried out in Shashemene district, West Arsi Zone, Oromia, Ethiopia. Shashemene is situated at a latitude of 7° 12' north and a longitude of 38° 36' east. It is found in the West Arsi zone of Oromia regional state and is located 250 km south of Addis Ababa, the capital of Ethiopia and 25 km north of Hawasa, the capital of Sidama Region. This district is bordered on the south by the Sidama region, on the north by Negelle Arsi district, on the east by Kore district, on the southeast by Kofele district and on the west by Shalla district. Its climate is characterized as temperate, with annual temperatures ranging from 12°C to 27°C. It is 1,685 m to 2,722 m above sea level, with a total area of 467.18 square kilometers. More than 87 percent of the land is cultivable. The district has a population of 241,311, of whom more than 85 percent depend on agriculture for their livelihood and the majority of them are smallholders owning a plot of less than 5 hectares. The agro-climatic conditions of the district are favorable for agriculture, with two rainy seasons. It has annual rainfall ranging from 700 mm to 950 mm [15].

Types and Sources of Data: The study employed both primary and secondary data sources. The primary data was collected from a sample of rural household heads from the selected kebeles of the district. A semi-structured questionnaire was developed and interviews were conducted to capture the relevant data from the respondents. In addition, a questionnaire was distributed to the respondents and directly filled out by them. Secondary data, which included a profile of the district, was collected from different previous research works, the internet, books, different pamphlets, etc. Secondary data for this study was primarily collected from published and unpublished documents, reports and other relevant materials. Secondary data collected from such sources included agricultural inputs supplied and consumed, physical characteristics, population size, etc. These types of data were also composed of different governmental and non-governmental offices and bureaus found at district, zonal, regional and national levels.

Instrument and Method of Data Collection: Accordingly, for the data collection, seven enumerators who speak the local language fluently were recruited from the study area and they were trained. Five of the enumerators were degree graduates, whereas the remaining two were

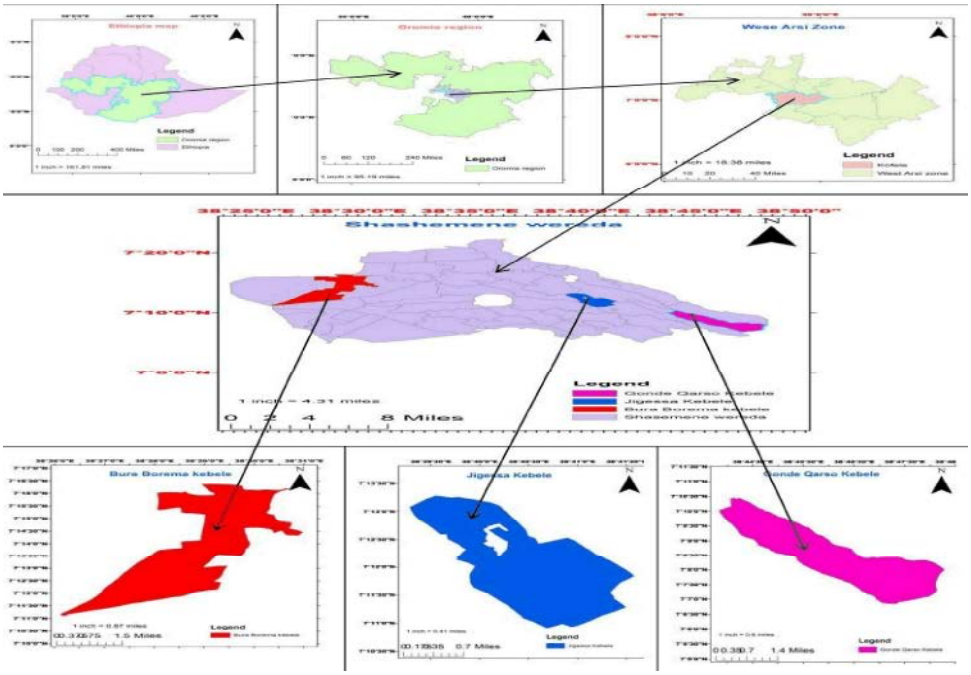

Fig. 1: Map of study Area

diploma-complete. The enumerators collected the required data under the close supervision of the researcher. The filled-in questionnaire was thoroughly checked every day.

Sampling Procedures and Sample Size: In order to select sample respondents, a multi-stage sampling technique was followed. First, depending on social and demographic location, thirty-seven kebeles under the district were grouped into three different strata. From each stratum, one kebele was selected randomly.

The sample size was taken according to the formula developed by Kothari [16].

Accordingly,

$$n = \frac{z^2 * p * q * N}{e^2(N-1) + z^2 * p * q}$$

$$= \frac{(1.96)^2 * 0.5 * 0.5 * 3500}{(0.05)^2 * 3449 + (1.96)^2 * 0.5 * 0.5}$$

$$= 346$$

where, n = desired sample size, Z = (area under normal curve for the 95 percent confidence level (Z = 1.96). e =0.05 acceptable error or the precision, P =proportion of sample population assumed to using fertilizers properly (p=0.5), q = 0.5 (the proportion of sample not using fertilizer properly).

Table 1: Sample distribution of households

S.N	Strata/Kebele	Population	Sample Selected
1	Bura Borema	1241	123
2	Jigessa	1198	118
3	Gonde Qerso	1061	105
Total	3500	350	

Method of Data Analysis: Based on objective and behavior of data type's different tools and techniques of data analysis were used. Descriptive statistics and econometric methods were employed.

Descriptive Statistics: Descriptive statistics was used in the analysis. This type of statistical analysis was used because it summarizes essential features of data using central tendencies and variability measures. It deals with presentation of analyzed numerical facts in the form tables or graphs.

Mean Deference Test Between Samples: In statistical analysis involving two samples it is imperative to test whether or not the difference between the two sample means can be attributed to chance [17]. This implies that one needs to confirm whether the samples are taken from homogeneous population or not. In this regard, statistical tests are required to check whether observable samples are likely to have come from the same population. These tests are also used to assess whether the difference between users and non-users of a given technology differ

by chance or by real differences in different socio-economic variables. The statistical tests employed for this purpose include t-test and Chi-square test.

T-test is used to check whether the mean values of different continuous variables in the two Districts are significantly different or not. In other words, independent sampling implies that the selection of one sample is in no way affected by the selection of another. T-test is based on the t- distribution and is considered as an appropriate test for judging the significance of the difference between the means of two samples when the population variances are not known [18]. In using t-test two points are considered: whether to use pooled variance that assumes equal variance of two samples or taking separate variances of two samples. Then, the computed t-value is compared with the average of the two values of the critical values (with degrees of freedom n_1-1 and n_2-1) [17].

The chi-square test was used for qualitative variables that can make the two samples different. Thus, to judge the significance of difference between the two districts in terms of qualitative explanatory variable. Chi-square test is one of the most widely used non-parametric tests. The computed value of chi-square is always positive. Hence, the chi-square distribution is positively skewed.

Econometric Method: Different studies use different models in order to identify the factors that determine and affect variables in economic activity. This study employed Hackman model for the econometric analysis.

Model Specification and Description: Regression analysis is a statistical tool for evaluating the relationship of one or more independent variables to a single or various dependent variable/s. However, in case of this study since the dependent variable is binary it incorporates inorganic fertilizer non-adopter sample respondents to include in the analysis with zero value of the dependent variable. Here is the variable adoption of inorganic fertilizer, the dependent variable failed to be continuous. Moreover, this study required to analyze the use intensity of inorganic fertilizer by the respondents in the study area. This dependent variable is a continuous variable and its explanatory variables are similar to that of the adoption of the inorganic fertilizer.

Therefore, the Hickman's sample selection model where a probit model for the inorganic fertilizer adoption equation was estimated and an OLS regression model, which is corrected for selectivity bias was specified to account for the intensity of inorganic fertilizer was estimated. In Heckman model, the first procedure was to estimate the probability of participation and estimating Inverse Mill's Ratio as a right-hand variable incorporated in intensity of inorganic fertilizer function. The probit model is specified as:

$$\text{[illegible]}_i = \text{[illegible]}_i \text{[illegible]}_i + \text{[illegible]}_i$$
$$I = 1, 2, 3 \ldots \text{[illegible]}_i \quad (2)$$

where

[illegible]_i: is a dummy variable indicating the adoption of inorganic fertilizer that is

$\text{[illegible]}_i = 1$if $\text{[illegible]}_i > 0$, otherwise, $\text{[illegible]}_i > 0$

[illegible]_i'[illegible]: are unknown parameters to be estimated

[illegible]'[illegible]: are variables determining adoption of inorganic fertilizer and

[illegible]_i: is the random error term

Second, the OLS model parameters were consistently estimated by using OLS over n observations for [illegible]_i by including the estimate of the inverse Millis ratio, denoting, as an additional regression in the equation below. The model was

$$\text{[illegible]}_i = \text{[illegible]}0 + \text{[illegible]}_i \text{[illegible]}_i + \text{[illegible]}\,\text{hi} + \text{si}$$
$$i = 1, 2, 3 \ldots \text{[illegible]} \quad (3)$$

where

[illegible]_i: is the intensity of inorganic fertilizer used

[illegible]_i'[illegible]: are unknown parameters to be estimated

[illegible] [illegible]: is an intercept term

[illegible] [illegible]: are variables determining adoption of inorganic fertilizer and

[illegible]: is a parameter that shows the impact of adoption on intensity of inorganic fertilizer

s_i: is the random error term

Multi-co linearity Test: Before taking the selected variables into the Tobit model, it was found necessary to check for the existence of multi-co linearity among the continuous variables and verifying the associations among the variables. The reason for this is that the existence of multi-co linearity affects seriously the parameter estimates. If multi-co linearity turns out to be significant, the simultaneous presence of the two variables will attenuate or reinforce the individual effects of these variables. Omitting significant interaction terms incorrectly leads to a specification bias.

Table 2: Summary of Descriptions and Measurement of the Variables

SN	Variable description	Variables	Value of the variable	Sign
1	Formal Education	FEDU	Dummy, Literate=1,illitrate=0	+
2	Age of the Household Head	AGHH	Continuous	-
3	Farm Size / cultivated land	FRMS	Continuous	+
4	Farm Income	TONI	Continuous	+
5	Off-Farm and/or Non-Farm Income	OFIC	Continuous	+
6	Market distance	DRFM	Continuous	-
7	Access to Extension Services	EXSR	Dummy, Receiving=1,not receiving=0	+
8	Access to Fertilizer Credit	FRCR	Dummy, accesses=1,no accesses=0	+
9	Dependency Ratio	DPRO	Continuous	-
10	Family size	HH size	Continuous	-
11	Number of livestock owned	TLU	Continuous	+
12	Marital Status	MST	Dummy , married =1, for others=0	+
13	Sex of the household head	SEXDM	Dummy; for male =1, for female =0	-

Therefore, Variance Inflation Factors (VIF) technique and correlation coefficient test were employed to detect the problem of multi-co linearity among continuous variables. Large VIF are indicators of multi-co linearity and those explanatory variables with VIF>10 were excluded from the regression analysis [19].

$$VIF_j = (1 - R_j^2)^{-1} \quad (3)$$

where, R_j^2 is the coefficient of multiple determinations when the variable X_j is regressed on other explanatory variables.

RESULTS AND DISCUSSION

Descriptive Statistics Result

Socio Economic Characteristics of the Respondents: Among the total sample, households 13.17% were female headed while about 86.83% were male headed. In this study, the sample respondents incorporated both the inorganic fertilizer adopters and non-adopters with no significant difference in terms of sex category (x^2=0.0002). Amongst the adopters of inorganic fertilizer, about 6.90% of the households were female headed while the remaining 73.98% were male headed. In the same way, non-adopters consisted of 1.88% female and 17.24% male household heads. As a result, the proportion of male-headed households was higher among both the adopters and non-adopters of inorganic fertilizer compared to that for female-headed households. Among the adopters of inorganic fertilizer, the higher proportion of male-headed households could be due to the exposure of the cultural values of the society. According to IFPRI [20], male heads are more likely prone to productive roles; attend community meetings and visit demonstration plots or research centers compared to female household heads. This could possibly make number of male-headed households to be more adopters of inorganic fertilizer.

Marital status result indicated that majority 89.96 percent of the household heads were married while the others remaining is 10.03 percent. The percentage of married household heads was higher among the adopters compared to the non-adopters implying that respondents who are the heads because of being married are more likely to adopt inorganic fertilizer. This could be due to the heavy concern that the married households have to improve output at minimal possible cost over the limited and competing resources [21]. Further, out of 10.03 percent others household heads 7.53 percent were adopters against 2.5 percent of non-adopters. In case of marital status, there is no significant difference among the adopters and non-adopters of the inorganic fertilizer (χ^2=1.6567).

Education status is the potential source of knowledge, which is believed to enable one to understand instructions, access and grasp information about adoption and non-adoption of inorganic fertilizer. The sample respondent's education status consisted of Illiterate (51.72%), literate (48.28%). The analysis supported that the adopters of inorganic fertilizers are better in education as compared to that of the non-adopters with significant difference (χ2=12.86). Therefore, Education could likely allow farmers to make efficient decision and be the early adopters who can take the advantage of the new technology, in this case inorganic fertilizer [22].

Credit is an important source of finance in agricultural technology adoption in the district and our country. So, having access to credit source to farmers were challenging for several different seasons of the last several years due to rules of mortgage. Now a day, few

Table 3: Summary of discreet variables

	Category		Adopters			
Variables	Frequency	Percent	Frequency	Percent	Non-Adopters	χ^2 Value
SEXDM	Male	224	70.22	53	16.61	0.0002
	Female	34	10.66	8	2.51	
	Married	234	73.35	53	16.61	1.6567
MST	otherwise	24	7.53	8	2.5	
	Illiterate	127	39.81	38	11.91	12.86***
FEDU	Illiterate	131	41.06	23	7.21	
FRCR	Yes	238	74.61	3	0.94	
	No	20	6.27	58	18.18	203.68***
EXSR	Yes	242	75.86	8	2.51	
	No	16	5.02	53	16.61	189.46***

Table 4: Demographic characteristics of the respondents (Continuous variables)

	Adopters (n=258)		Non adopters (n=61)		
Variable	Mean	SD	Mean	SD	t- value
Age	49.32	7.25	42.70	15.17	-5.01***
Farm Income	50686.78	31059.75	47335.89	29841.65	- 0.76
Off farm income	1530.04	3781.27	2909.84	5375.34	2.35**
Livestock (TLU)	3.67	1.62	2.88	1.50	-3.46***
Market distance	6.10	1.43	6.84	1.78	3.45***
Cultivated-land	1.49	0.72	1.32	0.57	-1.69*
Dependence ratio	0.48	0.12	0.49	0.12	0.50
Family size	4.60	1.97	4.30	2.10	-1.08

modifications and government support regarding mortgage is showing some opportunity to farmers to have access credit to finance agricultural inputs especially inorganic fertilizer input. The major source of credit in study area is Oromia credit and saving institution. It was found that about 75.55% of the sampled respondents had accessed to credit while about 24.45% percent of them did not access credit due to different reasons such as high interest rate. The results of credit access and use among the respondents was low with significant difference between the adopters and non- adopters of inorganic fertilize (χ2= 203.68). This could be related to the fact that inorganic fertilizer was being provided to farmers in kind and farmer's payback the debt after crop harvest.

The extension service in the area is the support delivered to farmers via agricultural experts/development agents/ about the utilization or adoption of inorganic fertilization. From the analysis, about 75.86% of the adopters of inorganic fertilizer in the study area has access to extension service while the remaining 5.02% of the adopters do not have access to the extension service. The results showed that the majority of the respondents had better access to extension services while using inorganic fertilizer justifying that the higher frequency of extension visits could have contributed towards adoption of inorganic fertilizer showing significant difference between the two groups of the dependent variable (χ2= 189.46). This also made farmers who have regular contact with agricultural experts more likely to have know-how about adoption of the fertilizers.

Descriptive Statistics Continuous Variables: The descriptive analysis result of age show that the combined average age for the sampled farmers was 48.056 years. The minimum and maximum age of inorganic fertilizer sample respondents were found to be 20 and 70 years, respectively. In terms of age, there was a significant mean difference between the adopters and non-adopters of inorganic fertilize (t = -5.0080) at 1% level.

The inorganic fertilizer adopters and non-adopters could obviously earn income from different sources. The basic category of the income in the study area is farm and off farm income. The combined annual average farm and off farm income of the respondents is 25919.95 ETB and 1793.9 ETB, respectively. The income is partly used to cover cost of fertilizer even if it is mainly to overcome other livelihood aspects of the households. In case of farm, income there was no significant mean difference with t test value of -0.76 while in case of off-farm incomes there was a significant mean difference between the adopters and non-adopters of inorganic fertilizer with t- test values 2.3464 at 5% level of significance (Table 3).

Table 5: Reasons for not demanding the inorganic fertilizers by farmers

Demand problems	Freq.	Percent	Cum.
Fertilizer price expensive	30	9.40	9.40
Not timely availability and shortage of the fertilizer	26	8.15	17.55
Lack of awareness (user/no reason)	263	82.45	100.00
Total	319	100.00	

The total number of livestock owned by the adopters or non-adopters of inorganic fertilizer in was measured in tropical livestock unit (TLU) giving different weights for different types of livestock. Accordingly, the analysis results showed that the overall average livestock holding among the farmers was about 3.52 TLU. The average livestock holding was about 3.67 TLU among the adopters and 2.88 TLU among the non-adopters. In terms of livestock holding there was a significant mean difference between the adopters and non-adopters of inorganic fertilizers (t =- 3.4612) at 1% level of significance.

In relation to market distance, overall average distance to the nearest market was 6.54 km (Table 4). In comparison, the average distance was 6.4 km among the adopters of organic fertilizer and 7.07 km amongst the non-adopters. This shows that the adopters were closer to the nearest market place compared to the non-adopters counteract with significant mean difference between the two groups (t = 3.44) at 1% statistical level. This indicated that farmers closest to the inorganic fertilizer market centers could easily access the input. According to IFPRI [20], farmers who are on a shorter distance to the market are more likely to have access to agriculture-related information through different channels. This might have compelled the farmers who are close to the market place to engage in adoption of inorganic fertilizer. On the other hand, Martey *et al.* [23] reported that distance from the inorganic market centers is one of the limiting factors of agricultural input use as it determines the transaction costs associated to it.

In relation to cultivated farm size, there was a significant mean difference between the adopters and non-adopters of inorganic fertilizers (t=-1.69) at 10% level of significance. The mean cultivated land of the household 1.46 hectares and on average, relatively, smaller land was allocated to grazing and forest/plantation lands constituting 0.096 hectares, each. On average, adopters of inorganic fertilizers own 1.49 hectares while non-adopters own 1.32 hectares, as per the number of sample respondents from each category. In addition, the farmers rented in land averaging 1.82 hectares, from incapable farmers of affording fertilizer and other farm inputs, in order to raise product and productivity of their produce.

Dependence ratio is in this case, refers to the ration of the number the inactive working members of the households to those working members. The mean of dependence ratio for adopters and non- adopters was found to be 0.48 and 0.49, respectively. This indicated that statistically there's no significant mean difference between the adopters and non-adopters of inorganic fertilizers (t= 0.5007).

Family size of the respondents of both adopters and non-adopters on average were found to be 5 and 4 persons, respectively. The analysis revealed that there is no mean significant difference between adopters and non-adopters in terms of family size (t= -1.0879).

Demand and Supply Challenges of Inorganic Fertilizer: Inorganic fertilizer use is slow to become traditional in our country and the study area specifically. In addition, to due to this fact there are still problems that can obstacle the demand and supply of the input to farmers in the study area. The respondents mentioned some of the challenging factors in the study area including expensive price, limited or untimely availability of the input and lack of awareness about inorganic fertilizer use. The result revealed that the majority of the farmers 263 (82.45%) have no know how about the inorganic fertilizer technology. Even though the majority mentioned the lack of awareness, the emphasized factors were expensive price and quantity and availability of the input. Therefore, the farmers mentioned that they were using the inorganic fertilizer with subsidy to plus debt from the government. This further makes the farmers to be challenged during the unsuccessful season of crop harvest so they fear the risk and try not to use the inorganic fertilizer.

To emphasize on the problems of inorganic fertilizer supply, the study revealed that the majority (73.98%) of the respondent answered that not timely supply of the inorganic fertilizer is leading factor to inappropriate timing of fertilizer application influencing the productivity of the crops in the study area. Moreover, less quantity (only up to and quality of Kg is allowed each household) the inorganic fertilizer supplied were the problems resulting in the demanding for additional and not certified quality less fertilizers. In attachment during the black market, the farmers were being cheated either via illegal trade or corrupted officials.

Table 6: Inorganic fertilizer supply related problems in the study area

Supply side problem	Freq.	Percent	Cum.
Not timely supplied	236	73.98	73.98
Shortage of quantity supplied	63	19.75	93.73
Low quality of fertilizer supplied	1	0.31	94.04
More than 100kg is not possible	19	5.96	100.00
Total 319	100.00		

Table 7: VIF result (multi-co linearity test)

Variable	VIF	1/VIF
FRCR	1.81	0.553
EXSR	1.71	0.583
FEDU	1.66	0.600
OFIC	1.39	0.717
AGHH	1.35	0.738
DRFM	1.28	0.780
DPR	1.20	0.831
TLU	1.20	0.834
TONI	1.19	0.837
SEXDM)	1.13	0.888
FRMS	1.07	0.931
HH size	1.03	0.971
Mean VIF	1.34	9.269

Table 8: Correlation coefficient between the explanatory variables

Variables	AGHH	SEX DM	MST	FEDU	FRMS	TLU	DPR	DRFM	FRCR	EXSR	OFIC	TONI	*HHSIZE*
AGHH	1.00												
SEXDM	0.05	1.00											
MST	0.01	-0.75	1.00										
FEDU	-0.35	0.06	-0.04	1.00									
FRMS	0.15	0.01	-0.02	-0.07	1.00								
TLU	-0.06	0.16	-0.29	-0.12	0.08	1.00							
DPR	0.16	0.18	-0.19	-0.31	0.07	0.13	1.00						
DRFM	0.16	0.17	-0.12	-0.06	0.12	0.01	0.06	1.00					
FRCR	0.18	-0.03	0.00	0.04	0.09	0.20	-0.09	-0.24	1.00				
EXSR	0.19	0.00	0.02	0.05	0.01	0.19	0.00	-0.18	0.62	1.00			
OFIC	-0.20	0.08	-0.09	0.49	-0.14	-0.08	-0.20	-0.02	-0.08	-0.09	1.00		
TONI	0.17	-0.04	0.07	-0.20	0.11	-0.11	0.09	0.29	-0.02	0.00	-0.19	1.00	
HHSIZE	-0.05	0.01	0.00	-0.02	-0.02	0.08	-0.03	-0.11	0.02	0.01	-0.01	-0.11	1.00

Econometric Analysis Results: Under this econometrics part, result of Heckman two-step sample selection model is discussed. Here, the likelihood function is significant ($\chi 2$= 5174.53 with P<0.0000) showing strong explanatory powers. Similarly, the coefficient of the Mill's ratio is found to be significant (P<0.001) which indicate presence of self-selection and hence justifying the appropriateness of using Heckman's two-stage model. In addition, multi-co linearity test was made for the independent variables using VIF and the result has shown that there is no multi-co linearity problem among or between the variables.

In addition to VIF, correlation coefficient test was conducted to see the relationship among the explanatory variables. The result revealed that there is no multi-collinarity problem (Table 9).

Determinants of Inorganic Fertilizer Adoption Decision: During the econometric analysis of the determinants of the inorganic fertilizer adoption factors including age, Sex, Marital status, Education status, access to credit, extension service and Family size were found to be significant. The factors affected an inorganic fertilizer adoption decision of the farmers significantly and positively at different levels of significance as follows.

Age of the Respondent (AGHH): As an explanatory variable affected the adoption of inorganic fertilize in the study area positively and significantly at % level. From the findings of this study as age of the respondents, increase by one more years then the probability of adopting inorganic fertilizer by farmers in the study area increases by 0.55%.

Sex of the Household Head (SEXDM): Sex of the household head is one of the variables that affect the inorganic fertilizer adoption of the study area positively at 5% level of significance. The econometric result of the study showed that being male household head increases the probability of inorganic fertilizer adoption of the sample farmers by 11.75%.

Marital Status of the Respondent (MST): The analysis result of the survey showed that the inorganic fertilizer adoption in the study area was affected positively by the marital status of the farmers at 5% statistical significance. From the result as an individual farmer becomes married then the probability of adopt inorganic fertilizer increases by 7.43%.

Education Status of the Respondents (FEDU): The education status of the sample respondent households in West Arsi zone has significant and positive effect on the adoption of inorganic fertilizer for farming at 5% statistical significance, Education could likely allow farmers to make efficient decision and be the early adopters who can take the advantage of the new technology [22] because as inorganic fertilizer adoption promotes technological change it typically favors literate farmers. Therefore, as the farmers become educated the probability of adopting the inorganic fertilize in the study area increases by 2.3%. This result is consistent with other findings in Africa, including Cameroon [24], Ethiopia [25], Malawi [26] and Nigeria [27].

Access to Credit (FRCR): Having access to credit as a farmer is of great opportunity as a citizen of a developing nation, Ethiopia. In this study, therefore, access to credit to adopt inorganic fertilize in order to boost productive under environmentally friendly situation is of great opportunity in the study area. So, having access to credit, in either cash or kind, have positive and significant effect on inorganic fertilizer adoption at 5% statistical significance. As a result, having one more access to credit opportunity increases the probability of inorganic fertilize adoption by 11.02%.

Extension Service Access (EXSR): In relation to extension services, the result showed that one additional farm visit of the agricultural development agents with farmers increased the probability of inorganic fertilizer adoption by about 11.01 percent. Therefore, extension service was found to have positive effect on adoption of inorganic fertilizer at 10% level of significance. One of the most important roles of extension service is to raise farmer's awareness about agricultural productivity through providing them important information related to adoption of agricultural technologies. According to Kassie *et al.* [28], in most cases, extension workers establish field plots where farmers get hands-on learning and can practice with inorganic fertilizer to raise productivity. This result, therefore, confirm that better information dissemination through extension workers could enhance adoption of inorganic fertilizer by improving knowledge about the advantage of the new technology. Thus, the more the frequency of meeting extension workers then the likelihood of inorganic fertilizer adoption could high. The finding was in line with Kassie *et al*. [28]. They argued that farmers who have regular contact with agricultural experts are more motivated to participate in agricultural technology adoption due to intensive information they may get from the experts.

Household Size or Family Size (HH size): The results showed that an increase in the size of the household by one member increases the likelihood of adopting inorganic organic fertilizer by about 1.2 percent. Thus, an increase in the household size tends to encourage adoption of inorganic fertilizer significantly at 10 percent probability level.

Determinants of Intensity of Inorganic Fertilizer in the Study Area: This section shows OLS estimation result of Heckman two stage model showing that Age, Education, Livestock holding, Credit access, Extension service and Farm income were explanatory variables affected the intensity of inorganic fertilizer use in the study area.

It incorporates inverse Mills ratio which is found to affect intensity of inorganic fertilize use by farmers significantly. This implies covariates that condition the intensity of inorganic fertilizer operate conditional on the probability to decide on adoption of the inorganic fertilizer.

Age of the Household Head (AGHH): Is continuous variable that affected the amount of the inorganic fertilizer used by the farmers in Shashemene area significantly and positively. From the finding as the age of the sample respondent's increase by an additional one year then the quantity of inorganic fertilizer used increases by 0.44 Quintal at 1% statistical level. This can be due to the experience the farmers achieved through their live stay and practice of the inorganic fertilizer.

Education Status (FEDU): Is clearly very crucial determinant of the quantity of the inorganic fertilizer employed by the farmers that affected the intensity of inorganic fertilizer use. This can maximize the understanding ability of the farmers to clearly decide on the amount of fertilizers used. Therefore, as the education status of the farmers increases the intensity of the inorganic fertilizer used by 0.54 Quintal at 5% statistical significance. This indicated that awareness of the educated respondents about the appropriate ratio and quantity of the inorganic fertilizer used for agricultural productivity and productivity raise could be better than those within less education category (Illiteracy category). Livestock Holdings (TLU) - the livestock holding of the sample respondents in the study area is the total holdings of the different livestock types in the standard tropical livestock unit. The livestock holdings of the farmers have a significant and positive effect on the quantity of the fertilizer used in Arsi area. The result indicated that as the total livestock holdings of the farmer increases by one more tropical livestock unit then the amount of the fertilizer used increases by 0.25 Quintal at 10% level of significance. The livestock can support the farm labor with food to work and generate income that maintains inorganic fertilizer purchase, even during unproductive years to repay credit.

Access to Credit (FRCR): The analysis result confers that the quantity of inorganic fertilizer utilized depends on the amount of money capital, "ceteris paribus", the farmers have. Here the rural farmers face credit problem during the startup of and throughout the farming activities to purchase inorganic fertilizer and other agricultural inputs. Therefore, access to credit is very critical factor that significantly resolute the quantity of inorganic fertilizer procurement. Having access to credit makes the intensity of inorganic fertilizer utilized by the local farmers increase by 2.45 quintal at 1% significance level.

Extension Service (EXSR): From the analysis, access to extension service was found to be significant and affected the intensity of inorganic fertilizer use positively. Having access to extension service increases the quantity of inorganic fertilizer used by 1.71 Quintal at 1 percent probability level. It was mentioned that it is justifiable that having support/advice from the development agents /agricultural experts at kebele level/ regarding the inorganic fertilizer use could relief believe that inorganic fertilizers are harmful via awareness creation. So, it tries to indirectly fix the problems facing farmers regarding the intensity of use of the inorganic fertilizer even though there is problem of shortage of supply.

Off Farm Income (OFIC): The results indicated that an increase in farmer's off farm income by one Birr increase use intensity of inorganic fertilizer by about 0.000014 Quintal. This shows that the household off farm income had positive significant effect on use intensity of inorganic fertilizer at 10% probability level. A household with additional income prefers to use inorganic/chemical/ fertilizer as compared to organic fertilizer, which could be substitute for each other. If farmers can afford to buy chemical fertilizers, then the inclination of using labor-intensive fertilizers such as manure decreases [29] because it is time intensive to prepare and acquire. Due to this, a household with better off farm income prefer to buy and use chemical fertilizer within short period of time, that is, little cash holding households are likely to desire less inorganic fertilizer as it is relatively cheaper compared to organic fertilizer.

CONCLUSION AND RECOMMENDATIONS

The study aimed to explore the factors that influence the adoption and intensity of inorganic fertilizer use, as well as the effect of this fertilizer on agricultural productivity. A total of 346 heads of households compose the sample. We analyzed the data that was gathered from the houses using both econometric techniques and descriptive statistics. As compared to non-adopters, the research showed a significant difference ($\chi^2 = 12.86$) in the educational attainment of inorganic fertilizer adopters. In addition to having substantial support from access to credit ($\chi^2 = 203.68$) and extension services ($\chi^2 = 189.46$), both adopters and non-adopters of inorganic fertilizer could clearly generate revenue from farm or non-farm activities. Clearly, those who used inorganic fertilizer and those who did not could make money in different ways. The determinants of the inorganic fertilizer adoption factors, including age, sex, marital status, education status, access to credit, extension service and family size, were found to be significant. Heckman's two-stage model shows that age, education, livestock holding, credit access, extension service and farm income were among the explanatory variables that significantly affected the intensity of inorganic fertilizer use in the study area.

The following points are recommended:

- The proportion of household heads was higher than that of women adopters, so raising the participation of women via capacity building and encouragement
- Awareness creation on the impacts of inorganic fertilizer use type and its ratio for appropriate soil type

- The shortage and timely supply of inorganic fertilizer problems should be solved by creating access to the inorganic fertilizer market.
- The higher price of inorganic fertilizers, as mentioned by the farmers, should require subsidies to reduce the risk of farmers purchasing inorganic fertilizers in higher price.
- Credit-provider institutions should be expanded to help rural farmers purchase inorganic fertilizers and other agricultural inputs.
- Extension services must be given to all households with the appropriate experts necessary to support agriculture and enhance productivity.

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