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RESEARCH PAPER

Determinants of Inorganic Fertilizer Use Intensity on Cereal Crop among Smallholder Farmers: The Case of Toke Kutaye District, West Shewa Zone, Oromia National Regional State, Ethiopia

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Abstract

This study was aimed at analyzing determinants of inorganic fertilizer use intensity on cereal crops among smallholder farmers in Toke Kutaye District, West Shewa Zone, Ethiopia. Cross-sectional data were collected from 156 respondents using two-stage random sampling methods. Data analyses were carried out using descriptive statistics and the double hurdle model. The result of the first hurdle reveals that out of twelve explanatory variables, sex, education, off-farm income, land size, and improved seed were determined positively, whereas age and distance from the nearest market determined smallholders' use of inorganic fertilizer negatively. The results of the second stage of the double hurdle model indicate that, out of twelve explanatory variables, sex, family size, and land size positively affected the extent (intensity) of inorganic fertilizer use, whereas age and distance of the household from the nearest market negatively affected the intensity of use. Therefore, these results implied that there is room to increase the intensity of inorganic fertilizer use in cereal crop production. Hence, farmers' capacity to purchase this input, from lower income farmers to model farmers, should be acknowledged, and it should be designed to address those who have no ability to use inorganic fertilizer on their own farms through diverse development interventions.

Keywords: Double hurdle model, Inorganic fertilizer, Cereal crops, Ethiopia

Introduction

Agriculture in Ethiopia produces around 90% of the nation's total export revenues, nearly 85% of the labor force, and about 42% of the GDP (FAO, 2016). 95% of the nation's agricultural output is produced by 15 million smallholders, demonstrating how small-holder agriculture is essential to the country's overall economy and the food security of the vast majority of its citizens. Because of this, it is believed that the expansion of the agricultural sector would serve as the last resort and an engine for the country's economy (CSA, 2018). According Liulseged (2017) Sub-Saharan Africa has the lowest cereal yields in the world, which have been stagnant at 1 ton/ha for the past 50 years as opposed to 4 tons/ha in developing nations.

Low rate of usage of inorganic fertilizer is due to a number of reasons including a thin network of agro-dealers; lack of technical knowledge on appropriate fertilizers; lack of access to finance all along the value chain which prohibits the purchases of sufficient quantities to capture economies of scale; and high transport costs due to inadequate ports, rail and road networks Liulseged (2017). These factors result in high costs, putting fertilizer beyond the reach of

most farmers (Jayne et al., 2018; Yilmaz, and Sönmez, 2017).

Using agricultural technologies will undoubtedly increase agricultural production across the country. Smallholder farmers ought to make good use of it in order to feed their families adequately and create surpluses for use as industrial inputs (Birhan et al., 2017). Low yield-improving methods, such as the use of inorganic fertilizer, have been suggested for use by smallholder farmers in Ethiopia due to the country's low agricultural output. According to data from the World Bank's 2015–16 Ethiopian socioeconomic survey, 56% of households never used chemical fertilizer on their farm plots. In addition, small-scale farmers in Ethiopia apply 104 kg of inorganic fertilizer per hectare for cereal crops (Deaton, 1995).

The intensity of use of inorganic fertilizer for major cereal crops in 2019 production period, inorganic fertilizer use intensity was 82 kg/ha. Farmers in Toke Kutaye use 98 kg/ha of inorganic fertilizer for their cereal crops which is below the blanket recommendation rate of 200kg/ha (100DAP/NPS and 100UREA) (TKNRAO, 2019). Due to this low input usage, they suffered from low productivity of cereal productions.

Policy makers of the African nations and development specialists in agricultural sector in this day are giving evidence why productivity increment is quite below the population growth and the radical divergence of income inequalities among farmers of Africa compared with other side of developing nations. As Chojnacka et al. (2019) the problem is mainly connected with knowledge for input technologies supported by essential policy intervention. For instance, African farmers consume extremely low inorganic fertilizer in the world especially when compared to Asian farmers. Inorganic fertilizer use intensity is still at low levels, and the efficiency of fertilizer use in raising output per unit of land is significantly lower in Sub-Saharan Africa than in Asia (Birhan et al., 2017). Several arguments are brought forward in the economics literature about possible reasons for the low fertilizer use in developing countries like Ethiopia.

According to Choudhuri, and Sharangi, (2018) fertilizer use in Ethiopia, as in most SSA countries, is very low due to several constraints, these constraints pointing to two groups. The first group is the market-based constraints, which suggest that farmers do not use inorganic fertilizer because of a relatively high fertilizer to crop price ratio. The second group, the non-market-based constraints, emphasizes farmer's lack of knowledge about inorganic fertilizer use as well as land degradation, which lowers the returns to fertilizer application.

Cereal crop production has been lifted well above long-term levels. Although area expansion has been considerable, yield growth has accelerated more than area expansion particularly in the last few years. However, the recent large yield increases do not seem to be explained by a sudden large increase in use of modern inputs and improved farm management. Similar stories can be told of other modern inputs: use of improved inputs did not expand in such an overwhelming rate, as the yield growth did Getachew (2011). Cereal productivity in Ethiopia is relatively low, with national average grain yields for 2016 totaling about 1.7 tons per hectare for teff, 2.1 tons per hectare for barley, 2.7 tons per hectare for wheat, 3.8 tons per hectare for maize, and 2.5 tons per hectare for sorghum. This is caused, among other things, by the extensive use of low yielding varieties combined with archaic traditional methods, which ultimately lower the average national yield of the main crop in the nation. Yiu and Pratt (2014) found that Ethiopia's grain crop output levels were lower than the average yield among least developed nations.

Smallholder agricultural production remains low; particularly for cereal crops and major contributory factors include inorganic fertilizer price, inadequate supply and knowledge of using. This problem shows that, there is the research gap in the district and it needs to examine determinants of inorganic fertilizer use and its intensity use of households on cereal crop which is not carried out yet and needs to recommend possible solutions in the study area.

Methodology

Description of Study Areas

Toke Kutaye district is located in West Shewa Zone, Oromia National Regional State, Ethiopia, which found at a distance of 126 km west of Addis Ababa and 12 km from Ambo town. It is bordered by Ambo district in East and North, Dire Inchini district in South and Liban Jawi in West. It lies between 8050'0"N 37030'0"E latitude and 905'0"N 37055'0"E longitude with elevation between 1580 and 3144 meters above sea level, the optimum temperature is 100 C to 300 C and annual rainfall ranged from 800-1200mm. The district comprises in to three agro-ecologies; namely, the lowland (27.6%) the midland (51.4%) and the highland (20.9%). There are also three types of soils in the district, these are vertisoils which is (27.3%) having black color and clay texture; the latosoils covers (47.7%) and other soils comprise of (25%) of the total land found in the district. The natural vegetation's in the district comprised of woods, bushes and remnant forests which were previously dense forest. The availability of mineral deposit sites has also confirmed. The extraction of sand stones from the aforementioned largest rivers including Indris River; gypsum and limestone and coal are among the deposits found in the district (TKNRAO).

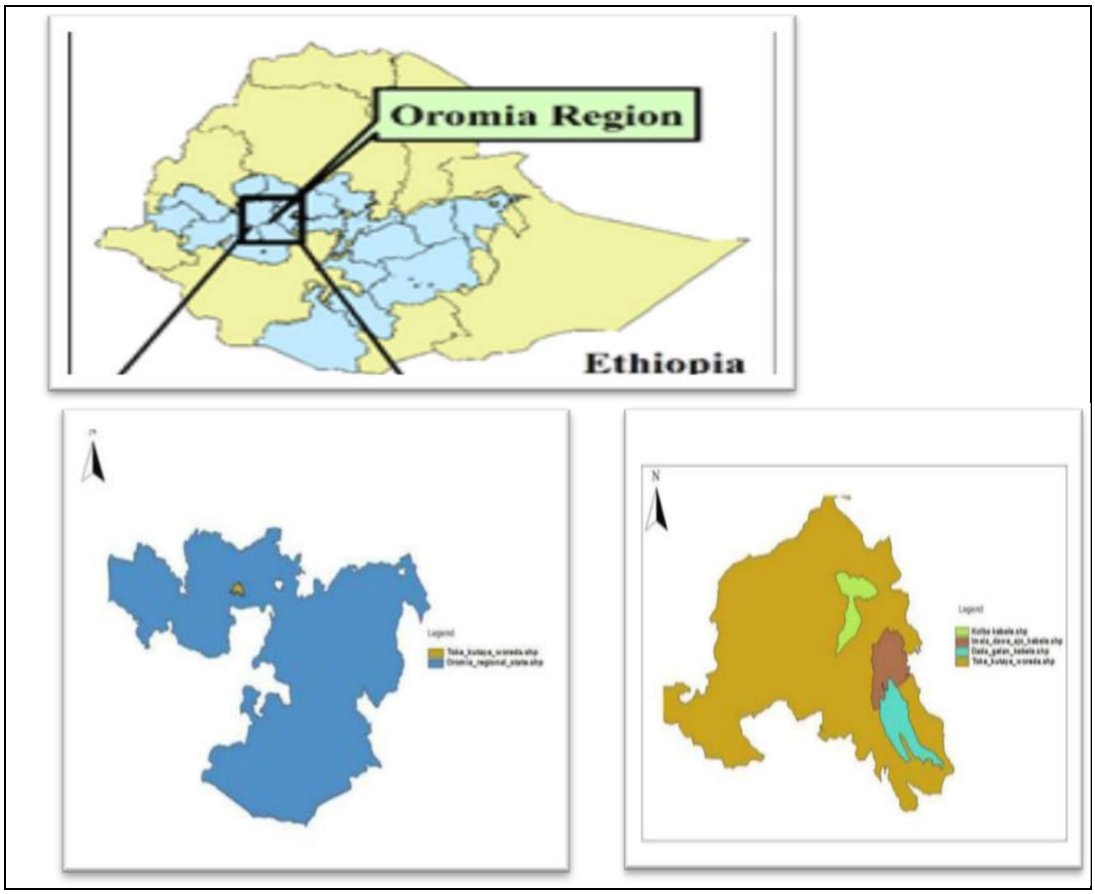


Figure 1: The Map of Toke Kutaye district

Source: Sketch from GIS, 2019

The district is known in surplus agricultural production relative to other districts of the Zone. This is due to relative favorable climatic condition even in the regional level. The proximity to Addis Ababa can also contribute to produce for the national market. Its irrigation potential and utilization is much better than other district of the zone since it has ten modern irrigation schemes and more than eighteen traditional schemes. Holota and Ambo agricultural research centers are the other good contributor for the surplus production because the district farmers used as best experience sharing for different crop varieties. The district is also known in fattening cattle and supply for Addis Ababa and nearby market (TKEDCO, 2019).

Types and Sources of Data

The study was conducted using primary and secondary data sources, which is qualitative and quantitative in its nature, and the study have employed and looked at the socioeconomic status of the sample household heads, household demographic data, and other inorganic fertilizer usage and intensity variables collectively.

Sampling Techniques and Sample Size

Multi stages sampling procedure were used to select respondents from three kebeles representative of Toke Kutaye District. In the first stage, kebeles were stratified ecologically into three as highland, midland and lowland. In the second stage, three kebeles; namely Melka nega dembi, Dada gelan and Dawe ajo were randomly selected using probability proportional to sample size (PPS). Moreover, out of the total these three Kebles, 2,514 total population 156 sample household heads were represented as sample size using Yamane (1967) formula.

For this study, the total sample size for sample household farmers was determined based on the sampling formula provided by Yamane (1967) with precision error at 8 % of (since the small holders have homogeneity characteristics).

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

$$n = \frac{2514}{1+2514+(0.08)^2} = 156 \ldots\ldots\ldots\ldots\ldots\ldots (`1)$$

Where, n = sample size,

N = Total household head of three kebele,

e = level of precision considered.

Table 1: Sample households in selected kebeles

Kebeles	*Kebles* total household	Sampled household	Agro-ecology
Dada Gelan	842	51	High land
Emala Dawe Ajo	823	49	Medium land
Melka Nega Dambi	849	56	Low land
Total	2,514	156	

Source: Own sampling design (2020)

Methods of Data Collections

Data collection methods were done through structured questioner prepared for farm households. The questioner was designed and pre-tested in the field and refined in the office before the implementation of the actual survey for its validity and content to make overall improvement of the same and in line with the objectives of the study.

Method of Data Analysis

Both qualitative and quantitative method of data analysis were used and key informants' interview and secondary document analysis were done. In relation to the quantitative data analysis, coding and feeding the collected primary data into the computer, management and analysis of data were done by using statistical packaging for social science STATA version14. Analyses of results were presented using tables and figures. Both descriptive statistics and econometric model of the data analysis were used to analyze the data collected from target respondents.

Econometric model specification

In order to justify the use of the double hurdle model, a restriction test was carried out where the log likelihood values were obtained from a separate estimation of Tobit, Probit and Truncated regression models. The test statistic has a chi-square distribution with degrees of freedom equal to the number of independent variables (including the intercept).

The double hurdle model was used for the analysis with the assumption that the determinants of inorganic fertilizer use, and its intensity were independently determined. The individual's determinants of inorganic fertilizer use are dichotomous, involving two mutually exclusive alternatives. The framework for such analysis has its root in the threshold theory of decision making in which a reaction occurs only after the strength of a stimulus increases beyond the individual's reaction threshold. This implies that every individual when faced with a choice has a reaction threshold influenced by several factors. The double hurdle model on the other hand, allow for the user and level of decision to be used by different set of factors and for the different factors to have different effect on each decision.

The study undertakes probit regression model to quantify the factors determines inorganic fertilizer user and non-user among smallholder farmers in Toke Kutaye District. The fact that the dependent variable is a dichotomous justifies the use of a binary model (Probit model). The Probit model was ideal because of its ability to constrain the utility value of the determinants to use or not use lie within zero and one, and its ability to resolve the problem of heteroscedasticity Asante et al. (2011). Accordingly, the dependent variable determinants of inorganic fertilizer use (Y) assume only two values: one if the farmers use inorganic fertilizer and zero if a farmer does not use. In double-hurdle model, on the other hand, both hurdles have equations associated with them, incorporating the effects of farmer's characteristics and circumstances. Such explanatory variables may appear in both equations or in either of them Teklewold et al. (2006). Empirical studies have also indicated that a variable appearing in both equations may have opposite effects in the two equations. The double-hurdle model, developed by Cragg (1971), has been extensively applied in several empirical studies such as Newman et al. (2001).

As already noted, in this study a double hurdle model is used to identify factors determine use and use intensity of inorganic fertilizer. The double-hurdle model is a parametric generalization of the probit model in which two separate stochastic processes determine the decision to use inorganic fertilizer or not. Probit model predicts the probability of determinants of whether an individual household use inorganic fertilizer or not. The probit model is specified as:

$$Pi = \beta 1xi + \varepsilon i \sim N(0,1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where; i= 1, 2…n

$$pi = 1 \; if \; pi^* > 0$$

$$pi = 0 \; if \; pi <= 0$$

Where: pi is a binary variable (1 if user is exist; and zero otherwise), representing the individual's participation decision on inorganic fertilizer use. To be specific, it takes 1 if a household uses inorganic fertilizer and is positive; and it is zero otherwise, xi_2 is a vector of independent variables (explanatory)variables that affect use of small holders inorganic fertilizer on cereal crops, β_1 is objective to be estimated (parameters to be estimated) is house hold to use inorganic fertilizer, εi is an error term is normally distributed with mean (0) and standard deviation of 1, and captures all unmeasured variables. To be specific, it takes 1 if a household use inorganic fertilizer and positive and it is zero otherwise. The second level of the analysis involved the truncated regression model for determination of factors that determine inorganic fertilizer use intensity. Observations on positive and greater than the optimum fertilizer use intensity are only used in the analysis;

$$Yi^* = \beta xi + \varepsilon i \sim N(0, \sigma^2) \quad \text{.....(3)}$$

$$Yi = Y^* > 0 \; and \; Pi = 1$$

$$Yi = 0 \; if \; Yo \leq 0 \; and \; Pi \leq 1$$

Where Yi is the inorganic fertilizer use intensity which depends on the latent variable Yi^* being greater than zero and conditional to the decision to use Pi fertilizer, xi is the vector of explanatory variables hypothesized to determine inorganic fertilizer use intensity, Yo is the threshold of inorganic fertilizer use intensity in the study area.

Result and discussion

This chapter presents the findings of the study and discusses the results in comparison with the results of earlier studies and is organized under two sub-sections sections.

Descriptive Results

Characteristics of sample households

The result of the survey indicates that out of 156 sample respondents, 133(85.25%) of them are inorganic fertilizer user and the remaining 23(14.74%) are non-user in 2019 production year. Group comparison of user and non-user was computed by using t-test for continuous and chi-square for dummy variables indicated in Table 2 below.

The mean livestock holding of small holder is 16.6 in the study area, whereas mean number of livestock owned by user and non-user were 19.1 and 2.52 in TLU, respectively. The mean difference of livestock owned among users and non-users is significant at 1% significance level. Livestock is kept both for generating income and traction power in the study area. Livestock has a significant influence on generating income and power of tractors; in addition, livestock used for threshing, transporting and farmers who had more livestock holding doesn't have difficulties to purchase inorganic fertilizers, in communities where agriculture is the main source of economic activity.

As survey result indicated in this study, out of total sample household, off-farm income users and non-users were 62.8% and 37% respectively. The result showed that in terms of off-farm income there is statistically significant difference between inorganic fertilizer users and non- users at 1% significance level (chi=39.4) (P=0.000). This implied that off-farm income gained trade, labor sale, remittance, salary and renting of animals serves as a means of surviving of life when the income from the on farm couldn't be as expected. On the other hand, as off-farm-income of household's increase, risk taking behavior may lead to a higher probability of using inorganic fertilizer. According to result in (Table 2) the mean difference in size of land owned among users and non-users is at 1% significance level. Farmers use their land for multiple agricultural activities especially for crop production and animal rearing. According to the result of the study area, large cultivated land size holder uses huge inorganic fertilizer because land resource had enabled them to gained high income from his/her land asset.

Table 2. Summary of continuous variables, for inorganic fertilizers users

Continuous Variables	User		Non-user		Total		t-test
	Mean	SD	Mean	SD	Mean	SD	
Age of household head	42.2	11	52	10.1	43.67	11.4	3.9***
Education	5.45	4.01	1.73	2.11	4.90	4.01	-4.3***
Number of family size	4.9	3.32	2.86	2.07	4.61	3.24	-2.8***
Number of Livestock	19	21.27	2.52	2.46	16.6	20.5	-3.7***
Extension contact	1.43	0.72	1.6	0.78	1.46	0.73	1NS
Fertilizer price	1.4	0.55	1.2	0.42	1.38	0.53	1.6NS
Distance from market	1.45	0.7	1.65	0.83	1.48	0.73	1.2NS
Land size	1.96	1.18	0.83	0.29	1.79	1.17	-4.49***

Source: Computed from survey result (2020)

Note, *** at 1% significant level and NS, not significant

Survey result in (Table 3) shows, the improved seed used by household user and non-user were 53.2% and 46.7% respectively. The chi-square result indicated improved seed used by household between user and non-user were at 1% significance level. Improved seed give high production potential for small holder farmers; thus, they used improved seed to get more productions. This modifies that using improved seed could enables farmers to use huge amount of inorganic fertilizer to get high production and income. Promoting high improved seed uses indirectly enhance inorganic fertilizer use intensity relatively.

Table 3. Summary of dummy variables for users and non-users of inorganic fertilizer

Variables		N	%	N	%	N	%	X^2
Sex	Female	11	7	5	3.2	16	10.2	3.86NS
	Male	122	78.2	18	11.5	140	89.7	
Credit	No	15	9.6	7	4.4	22	14	0.97NS
	Yes	8	5	61	39	69	44.2	
Improved seed	No	22	14	51	32.6	73	46.8	25.8***
	Yes	1	0.6	82	52.5	83	53.2	
Off-farm income	No	22	14	36	23	58	37	39.4***
	Yes	1	0.6	97	62	98	62.8	

Source: Computed from survey result (2020)

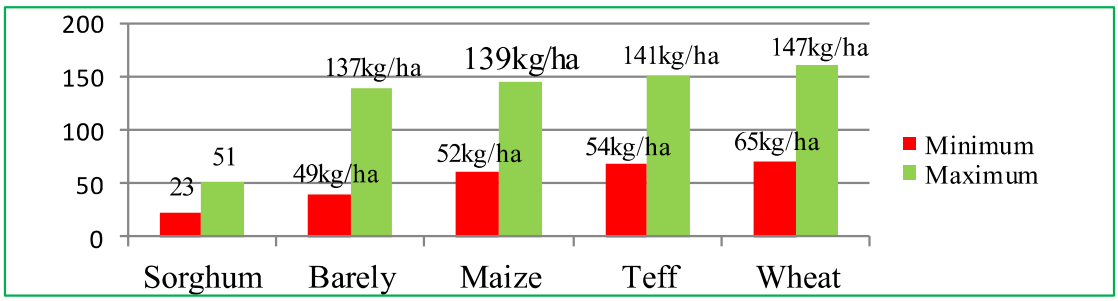
Note, *** at 1% significant level and NS, not significant

Inorganic fertilizer uses on major cereal crops in the study area

Teff land fertility matters teff production because of low inorganic fertilizer use adds fewer amounts of productions. Teff cultivation covers large area of production in the study area because of small holder's family consume at home and supply large scale of production to the market due to it has lions share in the study area. For this reason, farmers cultivate large area of teff in hectares and apply inorganic fertilizer of minimum 54kg/ha and with maximum 141kg/ha. Wheat is the second largest share of cereal crops produced by sampled household in the study area and cultivated next to teff. They produce mostly to supply to market as well as for home consumption. Farmers apply inorganic fertilizer to the wheat, minimum 65kg/ha, and maximum 147kg/ha. Maize is the third largest share of cereal crop productions in the study area, small holders produce maize majorly for family consumption at home. According to maize production in 2019, the use of inorganic fertilizer for maize production is 52kg/ha with a minimum and maximum of 139 kg/ha. Despite the fact that, the application rate and coverage gradually increased, intensity use of inorganic fertilizer is still at a low level. In the study area, there are farmers who have never been using inorganic fertilizer on their farm for maize productions.

Barely is one of the most highland cereal crop productions cultivated in the study area. Small holders cultivate crop proportionally for home consumption and commercial purpose. But they use fewer amounts of inorganic fertilizers in relation to other cereal crop productions in the area. According to 2019 production year of small holders' opinion at survey time, they used 49kg/ha minimum and 137kg/ha maximum averagely, this result shows small holders use less amount of inorganic fertilizer in the study area, due to this productivity decrease yearly.

Farmers are producing sorghum without inorganic fertilizer application mostly because culturally they believe sorghum never need inorganic fertilizer application, but they use little inorganic fertilizer which is 23kg and 51kg/ha minimum and maximum respectively. Cereal crops constitute the largest share of household's production and consumption in the study area. Major cereals crops (Teff, wheat, maize, barely, and sorghum) account for about 70 percent of area cultivation and still small holders in the study area are using low inorganic fertilizer and harvest low production and productivity (Figure 2).



Source: Own survey result (2020)

Figure 2: Inorganic fertilizer use on Major cereal crops

Econometric model results

Factors determining smallholders' inorganic fertilizer use on cereal crops

First stage double hurdle model was estimated by the maximum likelihood method. The overall model is significant at 1% significance levels (Pro>chi2=0.0000) as indicated by Log pseudo likelihood value of -24.35. This implies

the significance of explanatory variables included in the models. Result from first stage of double hurdle model indicated that the statistically significant factor determine use of small holders' inorganic fertilizer on cereal crops were Age of household head, Sex, Education, Off/non-farm income, Land size, Improved seed, and Distance from nearest market.

According to the results in (Table 4) age of household significantly and negatively determines inorganic fertilizer use at 5% significance level. As age of the sample household head increases by one year, their inorganic fertilizer use decreased by 0.3%. This analysis shows increase in age make farmers fear of risk taking to use inorganic fertilizer. This entails when the age of the household increases the probability of taking risk to use improved agricultural inputs would decrease. This result is in line with findings of Beshir, *et al*. (2012) asserted that older farmers were more conservative, and this negatively impacts on inorganic fertilizer users while young farmers tend to be more innovative.

As the result depicted in (Table 4) Sex of household head was positively and significantly affected farmhouse holds inorganic fertilizer use at significant 10% significance level. In most of the rural areas, males have access to updated information than females, because male participate on different agricultural activities than females. This makes male headed households an exposure to use inorganic fertilizer. Marginal effect results show that, being male household head significantly increase the probability of use of inorganic fertilizer by 7.3% as compared to female headed household, keeping other variables constants. This is in line with findings of Ali *et al. (*2018) hypothesized that male farmers would have a higher probability of inorganic fertilizer use than their female counterparts.

According to result in (Table 4) education of household head affect farm households' inorganic fertilizer uses positively at 10% significance level. As an individual education increase by one year, he/she is empowered with the best skills and knowledge that can effectively use farming activities as well as it enables an individual to make independent choices and to act on the basis of the decision and increase the tendency to co-operate with other people and use in group activities than uneducated farmers. Because educated farmers are better to manage their farm resources and agricultural activities than an uneducated especially on inorganic fertilizer using. Marginal effect result indicated that, as increase in education by one year, increase probability of inorganic fertilizer use by 1.2%, other things remaining constant. This is in line with the findings of Martey (2013) educated smallholders could manage their farmland triple times than uneducated.

Result in (Table 4) indicated that off/non-farm income affect farm household's inorganic fertilizer use positively at significant 5% level. It is observed that farmers who have off-farm income are less risk-averse than farmers without sources of off-farm income. Marginal effect result indicated that, increase in off-farm income rise the probability of using inorganic fertilizer use by 10.6%. Additional income earned through off/non-farm income `activities improves farmers financial capacity and increases the ability of inorganic fertilizer use. This result is in line with findings of Bazile *et al*. (2015) in off-farm activity is to get extra income that can increase the use of inorganic fertilizer when compared with other smallholder farmers who are non-user in such activity.

According to the result (Table 4) land size owned by household is at 5% significance level. Small holders who owned large land size had diversified income than small size land holders which can enable them to get more income; this enables them to use inorganic fertilizer. Marginal result indicated that, one hectare increases in land size, increase inorganic fertilizer use by 10.6% remaining other variables constant. It is consistent with findings of Abate *et al*. (2018) and farm households land allocate. n to cereal crop positively influenced the extent of farm households to purchase inorganic fertilizer.

According to result in (Table 4) improved seed used by household is positive at 5% significance level. Using improved seed by household enable them to get enough production, it increases their income through selling high value cereal crop productions. Result in marginal effect shows, one quintal increases in improved seed, and increase probability of inorganic fertilizers use by 13.8% remaining other variables constant. This result is in line with findings of Ali, et al. (2018) farmers that used improved maize seed had a high probability of inorganic fertilizer use compared to those who did not use improved maize seeds. This is attributed to the responsiveness of the improved maize seed inputs, thus becomes an important catalyst for using inorganic fertilizer. Use of improved varieties also influenced farmer's decision to use inorganic fertilizer Tesfaye *et al.* (2001).

According to result (Table 4) distance from nearest market affect inorganic fertilizer use negatively and significantly at 5% significance levels. Distance from input market is one of the major limiting factors for smallholder farmers to purchase inorganic fertilizer by going long distance to transport from cooperative center to their residence and lack transporting agent and cost. Oppositely, the nearer household residence to the market, the higher the probability of inorganic fertilizer use, due to the fact that, the time household spent is short and, need lower transportation cost and have better to agricultural input centers due to their proximity. The result indicated that, one hour increase distance of household from nearest market, it decreases 4.3% probability to use inorganic fertilizer remaining other variables constant. Inorganic fertilizer use decreases with an increase distance to the nearest market. This study is in line with findings of Akpan, (2012) result shows distance from market affects inorganic fertilizer use by small holders' farmers negatively.

Table 4: First stages of double hurdle probit estimation result

Variables	Coefficient	Robust std. err	dy/dx	p>|z|
Age	0.041**	0.017	0.003	0.015
Sex	0.849*	0.483	0.073	0.079
Education level	0.147*	0.081	0.012	0.068
Family size	0.080	0.095	0.006	0.400
Livestock	0.057	0.047	0.004	0.226
Off/non-farm income	1.245**	0.566	0.106	0.028
Land size	1.245**	0.530	0.106	0.019
Fertilizer price	-0.290	0.454	- 0.024	0.524
Improved seed	1.613**	0.709	0.138	0.023
Distance from market	-0.511**	0.236	- 0.043	0.030
Extension contact	-0.189	0.243	- 0.016	0.437
Credit	0.139	0.383	0.011	0.716
Constant	0.680	1.214	-	0.575
Numbers of observations=156 **Log pseudo likelihood=-24.35** **Pseudo R2= 0.6267** **Prob > Chi2=0.0000** **Wald chi2(12) =49.17**				
Note *, ** and * represents significance at 1%, 5%, and 10% probability level.** **Source: Computed from survey result (2020)**				

Factors determining inorganic fertilizer use intensity on cereal crops

According to the second stage of the double hurdle model in (Table 5) factor determine inorganic fertilizer use intensity on cereal crops among small holders. The overall joint goodliness of fit for second stage double hurdle model parameter estimate was assessed based on Waldichi2 (12) =456.67. The null hypothesis for the test is that all coefficients are jointly zero (Pro>chi2=0.0000). The model chi-square test applying appropriate degree of freedom indicates that the overall goodness of fit for second stage double hurdle model is significant at 1% significance levels. This indicated that jointly explanatory variable included in the model explained inorganic fertilizer use intensity. Result from second stage of double hurdle model indicated that, the statistically significant factor determines the small holder's inorganic fertilizer use intensity were Age of household head, Sex, Number of family size, Land size and Distance from nearest market.

According to result in (Table 5) age of household negatively and significantly associated with inorganic fertilizer use intensity at 5% significance level. An increase age of small holders by one year, it decreases inorganic fertilizer use intensity by 0.95 kg/ha. The assumption that small holders who are elders not consistently follow agricultural experts' advice and doesn't accept agricultural technology and change to practice soon. This is in line with findings of Akpan, (2012) older farmers were more risk averse and assessed the attributes of inorganic fertilizer use intensity than younger farmers.

According to the results in (Table 5) the sex of household is positive and significantly determines inorganic fertilizer use intensity at 5% significance level. As male headed house increase, it increases inorganic fertilizer use intensity by 29 kg/ha. The result indicated that, male headed household have more chance full to follow agricultural activities and get development agents advice as well as have no wealth resource constraint than females' small holders. Females occupied by home activities like feeding children, preparing meal, fetching water from distance, for this reason they had no time to contact with development agent. This is in line with findings of Abate *et al*. (2018) study placed emphasis on gender differences based on the presumption that male and female headed households are subjected to different binding constraints with females presumably worse off in this regard emphasizing access to information, land tenure security and understanding of inorganic fertilizer use intensity.

Result in (Table 5) shows that family size has positive and significant relation with inorganic fertilizer use intensity at 10% significance level. The model result indicated that, as family size increase in numbers, increase inorganic fertilizer use intensity by 3.97kg/ha. This result indicated that having large family sizes were better for using inorganic fertilizer intensity. This is because those household who had more family, had more labor force, in terms of paying for external labors, household purchase inorganic fertilizer and use intensively. This is in line with findings of Bamire *et al*. (2002) explained household sizes provide farm labor especially in field application and intensity use of inorganic fertilizer.

According to result in (Table 5) land size indicated that, it has positive and highly significant relation with inorganic fertilizer use intensity at 1% significance level. Thus, the use intensity of inorganic fertilizer by household is basically and highly influenced by their land holding size. According to survey results, as increase in landholding size, increases the intensity use of inorganic fertilizer by 124 kg/ha. This implies that a household who have large land size is more likely to apply inorganic fertilizer intensity to increase their production and productivity than a household who have small land size. This result is consistent with the findings of Bazile *et al*. (2015). land holding had a positive relationship with the intensity use of inorganic fertilizer.

According to result in (Table 5) indicated that, distance of small holders from the nearest market is negatively and significantly affect

inorganic fertilizer use intensity at 10% significance level. Farmers found over distance especially elders and female headed household couldn't go more distance to purchase inorganic fertilizer because of lack of transportations facility, cost and energy. Computed data result indicated that, one hour increase distance of household head from nearest market, inorganic fertilizer use intensity decreases by 12.8 kg/ha. It is consistent with findings of Akpan (2012) distance from market center, negatively influenced inorganic fertilizer use intensity.

Table 5: Second stage truncated regression estimation use intensity of inorganic fertilizer on cereal crops

Variables	**Coefficient**	**Robust std.err**	**P>|Z**
Age	0.959**	0.444	0.031
Sex	29.129**	13.784	0.035
Education	1.378	1.647	0.403
Education	1.378	1.647	0.403
Family size	3.971*	2.047	0.052
Livestock	0.317	0.288	0.272
Off/non-farm income	4.990	11.204	0.656
Land size	124.320***	7.612	0.000
Fertilizer price	5.302	9.812	0.589
Distance from market	-12.801*	7.587	0.092
Improved seed	4.349	13.615	0.749
Extension contact	5.444	9.700	0.575
Credit	-9.610	12.008	0.424
Constant	-14.896	39.027	0.703
Number of observations Censored observation=23 Uncensored observation=133 Log pseudo likelihood=-729.22		Waldi chi2(12) =456.67 Prob>Chi2=0.0000	
Note, ***, ** and * at 1%, 5%, and 10% significance probability level Source: Computed from survey result (2020)			

Summary and Conclusion

This study was conducted on examining the determinants of inorganic fertilizer use intensity on cereal crops among smallholder farmers in Toke Kutaye District Oromia Regional National State, Ethiopia. The double hurdle model was used to compute determinants of inorganic fertilizer use intensity on cereal crops among stakeholders in the study area. In the first stage double hurdle probit model was used to examine factors determine house hold inorganic fertilizer use, and result from primary stage indicated that, out of twelve explanatory variables Sex, Education, Off/non-farm income, Land size and Improved seed used by house hold were determining positively and statistically significant whereas, Age of house hold head and Distance from nearest market determine small holders inorganic fertilizer use negatively and statistically, that as Age of house hold and Distance from nearest market increase, inorganic fertilizer use decrease in the study area. Second truncated regression model was used to analyze factor determine inorganic fertilizer use intensity on cereal crops among small holders. Out of twelve explanatory variables Sex of the household head, Number of family size and Land size were positively determining extent (intensity)use of inorganic fertilizer and statistically significant whereas Age of household and Distance of household from nearest market determine negatively and significantly indicated that decrease inorganic fertilizer use intensity. Based on analysis done, Toke kutaye district has great potential for cereal crop production and however, inorganic fertilizer use intensity is still below the recommended rate. So, government and non-government organization should have to give special attention to increase inorganic fertilizer use intensity on cereal crop to increase product and productivity.

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