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

Aman Dassa (aman.rikitu@gmail.com)
Ambo University
Abera Ifa
Ambo Univesity
Efa Gobena
Ambo University agri-business and value chain management department instructor

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ABSTRACT

The study was aimed to analysis determinants of inorganic fertilizer use intensity on cereal crops among small holders in Toke Kutaye District, West Shewa Zone, Ethiopia. Correctional data were collected from 156 respondents using two stage random sampling methods. Data analyses were carried out using descriptive statistics and Double hurdle model. Result of the first hurdle reveals that out of twelve explanatory variables Sex ,Education, Off/non-farm income, Land size and Improved seed were determine positively whereas Age and Distance from nearest market determine small holders use of inorganic fertilizer negatively. The result of second stage of double hurdle model indicate that, out of twelve explanatory variables Sex, family size and Land size were positively affect extent (intensity) of inorganic fertilizer use whereas Age and Distance of household from nearest market determine use intensity negatively. Therefore, these results implied that there is a room to increase inorganic fertilizer use intensity on cereal crop productions. Hence, Farmers capacity to purchase this input beginning from lower income farmers to model farmers should be acknowledged; and should be designed the means to address those who have no ability to use inorganic fertilizer in their own farm through diverse development interventions.

Key words: Double hurdle model, Inorganic fertilizer, Cereal crops, Ethiopia

1. INTRODUCTION

1.1. Background of the Study

In Ethiopia, agriculture accounts about 42 percent of the GDP, employs about 85 percent of the labor force and contributes around 90 percent of the total export earnings of the country (FAO, 2016). About 15 million smallholders producing 95 percent of the national agricultural production which shows that the overall economy of the country and the food security of the majority of the population depend on small holder agriculture. For this reason, the growth of agricultural sector is taken as an engine and the last resort to take-off the national economy (CSA, 2018). Cereal yields in Sub-Saharan Africa are the lowest in the world, having stagnated at around 1 ton/ha for the past 50 years compared to 4 tons/ha in developing countries (Heffer and Homme, 2018).

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 (IFDC, 2015); Tamene (2017). These factors result in high costs, putting fertilizer beyond the reach of most farmers Jayne *et al.,* (2018); Abate *et al.,* (2014; Debrauw *et al.,* (2014), (FAO, 2013).

As it is specified in the above elucidation, agricultural technology use is unquestionable for agricultural production to be enhanced the nation. Smallholder farmers should as well use it properly to feed their household sufficiently and become surplus producers for commercial product as input of industry (Mellor, 2014); Abdulkadir *et al., (*2017). The productivity of Ethiopian agriculture has been low and a number of yield improving technologies like use of inorganic fertilizer have been recommended to use by smallholder farmers of the country. Data from the World Bank's Ethiopian socio-economic survey 2015/16 shows that 56 percent of households never used chemical fertilizer on their farm plots in any instance and in Ethiopia small holder farmer applies 104kg of inorganic fertilizer use intensity for cereal crop on hecktar as a result of different intervention Legesse *et al* (2019).

According to Oromia Agriculture and Natural Resource Bureau (OANRB, 2019) repot shows the use of inorganic fertilizer for major cereal crops in 2019 production, inorganic fertilizer use intensity is 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 200kg/ha (100DAP/NPS and 100UREA) (TKANRO, 2019) due to low input use, 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. 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. Therefore, the specific target put in Abuja declaration in the summit of African Union members' countries through their agriculture ministers further conferred about to increase inorganic fertilizer use intensity by six fold in 2015 in SSA (ADB, 2007).

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(Mellor, 2014); Abdulkadir *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. There is poor access to modern farming inputs which emanates from both supply and demand side constraints. Weak infrastructure and non-conducive

policy environment together with institutional problems lead to relatively high input costs and the absence or late arrival of supplies legesse (2019). Cereal yields in Africa are lower than half the world average (FAO, 2010).

According to Agbahey *et al.,* (2015) and Holden (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 Abegaz (2011). Relatively low productivity of cereals, the national average grain yield of cereals in Ethiopia is relatively low amounting to about 1.7 tone per hecktar for teff, 2.1 tone per hecktar for barley,2.7 tone per hecktar for wheat, 3.8 tone per hecktar for maize and 2.5 tone per hecktar for sorghum in 2016 (CSA, 2017). This, amongst others, is due to the widespread use of low yielding varieties coupled with unimproved traditional practices that ultimately contribute to the low national average yield of major cereal in the country. Ethiopia's cereal crop yield levels are lower than the average yield in least developed countries Yiu and Pratt (2014).

National level inorganic fertilizer use and use intensity is still lower than the recommended rate of 200 kg per ha (100 kg of DAP and 100 kg of Urea) Demeke *et al.(*1998), Fufa and Hassen (2005), Alem *et al*.(2008), Endale in (2011). According to Toke Kutaye Agriculture and Natural Resource Office annual report shows, the average of inorganic fertilizer use intensity on cereal crops of small holder in the district is 98 kg/ha which is below the recommendation rate whereas the recommended inorganic fertilizer use in the district is 200 kg/ha(TKANRO,2019). Smallholder agricultural production remains low; particularly for cereal crops and major contributory factors include inorganic fertilizer price, inadequate supply and knowledge of using. Therefore 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.

3. METHODOLOGY

3.1. Description of the Study Area

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 $8^0$50'0"N $37^0$30'0"E latitude and $9^0$5'0"N $37^0$55'0"E longitude with elevation between 1580 and 3144 meters above sea level, the optimum temperature is 10^0 C to 30^0 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 lime stone and coal are among the deposits found in the district (TKEDCO, 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. It's 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 (TKFLDO, 2019).

3.2. Types and Sources of Data

The study was accomplished using primary and secondary data sources, which is qualitative and quantitative in nature and the study have used and examined household demographic characteristics, socio-economic conditions of the sample household heads and other inorganic fertilizer use and use intensity determinants as a whole.

3.3. 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, and to make overall improvement of the same and in line with the objectives of the study.

3.4. Sampling Techniques and Sample Size

Two stage sampling procedure were used to select three *kebele* representative out of the 23 rural kebeles in Toke Kutaye District that was used for sampling techniques for this study. In the first stage, kebeles were stratified ecologically into three: Accordingly, Seven kebeles into lowland, nine kebles into mid-altitude and seven kebeles into highland since farmers in different agro-ecological zone are usually used inorganic fertilizer intensity for cereal crop production and exposed for soil fertility problem differently. In the second stage, simple random samplings were used to select three kebeles randomly since the study was focused on the inorganic fertilizer use intensity on cereal crops at district level. One *Keble* from low land (Melka Nega Dembi) one *kebele* from medium altitude, (Emala Dawe Ajo) and one kebele from highland (Dada Gelan) were selected as representative of sample *kebeles* randomly using probability proportional to sample size (PPS). Moreover, out of the total these three Kebles, 2,514 total population and 156 sample household heads were represented as sample size.

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).

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

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

Where, n= sample size,

N= Total house hold head of three kebele,

e= level of precision considered.

Table 1: Sample households in selected kebeles

Kebeles	*Kebles* total house hold	Sampled house hold	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)

3.5. Method of Data Analysis

Both qualitative and quantative 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 (SPSS) version 20.0 and 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.

3.6. Econometric Analysis

3.6.1. Specification of Econometric Model

3.6.1.1. Double Hurdle Model

The model was introduced by Cragg (1971) and assumes that a household head makes two independent and regarding sequential decisions. 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 (Miller and Hay 1981). 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 Ricker-Gilbert *et al.,* (2011).

The study under take 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:

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

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;

$$Yi^* = \beta xi + \varepsilon i \sim N(0, \sigma^2) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \,(3)$$

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

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

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.

3. RESULT AND DISCUSSION

This chapter present result and discussion in two main sections such as descriptive results and econometrics result.

3.1. Households characteristics by descriptive and inferential statistics in the study area.

The result of the survey indicates that out of 156 sample respondents, 133(85.25%) households are inorganic fertilizer user and 23(14.74%) households are non-user of inorganic fertilizer used by household 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.

3.1.2. Socio-economics of house hold characteristics

The mean livestock holding of small holder is 16.6 in the study area, where as 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 at 1% significance level with t-value (t= -3.7) and (p=0.0001). Livestock is kept both for generating income and traction power in the study area. In order to make comparison easy, depend on Strock *et al*(1991) the livestock population of sampled house hold converted in to TLU (Table appendix 2). 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 house hold, 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, off-farm-income of household's increase, risk taking behavior may

lead to a higher probability of using inorganic fertilizer. According to survey data result in (Table 2) fertilizer price for users and non-user is 1.4 and 1.2 respectively. It shows there is no significant relationship between fertilizer price perceptions and dependent variable with t-test (t=-1.62) and value of (p=0.05). Fertilizer price sometimes hinders smallholder farmers to purchase the required amount of inorganic fertilizer for their cereal crop productions. According to result in (Table 2) extension contact has 1.43 and 1.6 mean of users and non-users which is not significant and has no relation as respondents response in this study with t-test(t=1.04) and value of (p=0.85).

The result in (Table 3) indicated that sampled house hold credit accessible for users and non-users were44.3%and55% respectively with**(**chi2=0.9763) (pr=0.323) this modify that, there is no significant relation between credit accessible and non-accessible in the study area. According to result in (Table 2) distance from nearest market has a mean of 1.45 and 1.65 for users and non-users respectively. As a survey year result indicated that, there is no significant relation for t-test (t=1.21) and value of (p=0.88) in this study. Distance from nearest market should decide for smallholders to purchase inorganic fertilizer on time. The mean land size of sampled house hold was 1.79; whereas the mean of landholder users and non-users is 1.96 and 0.83 respectively. According to result in (Table 2) the mean difference in size of land owned among users and non-users is at 1% significance level with t-test (t= -4.49) and value of (p=0.0000). 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 use huge inorganic fertilizer because land resource had enabled them to gained high income from his/her land asset.

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 house hold between user and non-user were at 1% significance level (chi=25.8) with value (p=0.000). Improved seed give high production potential for small holder farmers, thus they used improved seed to get more productions. This modify 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: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 house hold 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

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)

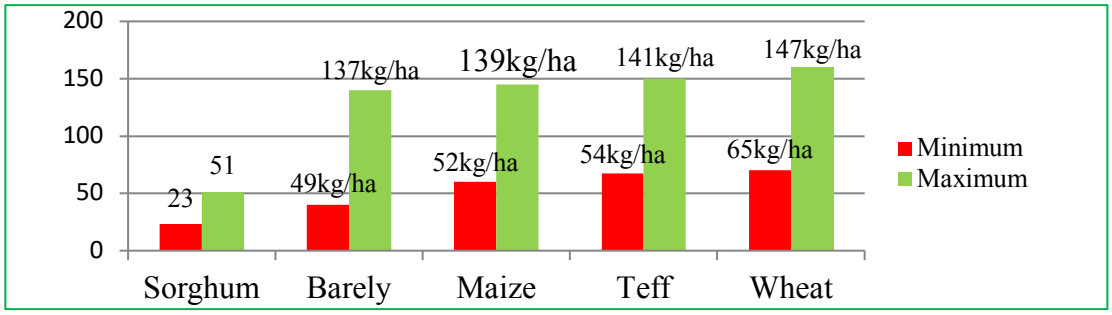
Note, *** at 1% significant level and NS, not significant

3.2.2. Inorganic fertilizer use of 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 production cultivated in the study area. Small holders cultivate crop proportionally for home consumption and commercials 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.



Source: Own sketch from survey result (2020)
Figure 1: Major cereal crops inorganic fertilizer use

4.3. Econometric model results

4.3.1. Factors determining smallholders' inorganic fertilizer use on cereal crops.

A result from first stage of double hurdle model has been estimated by the maximum likelihood method. The overall model significant at 1% significance levels (Pro>chi2=0.0000) as indicated by Log pseudo likelihood value of -24.35 and 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 house hold 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 determine inorganic fertilizer use at 5% significance level. As age of the sample house hold 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 house hold increases the probability of taking risk to use improved agricultural inputs would decrease. This result is in line with findings of Kubayo (2009), and Fufa and Rashid (2006) asserted that older farmers were more conservative and this negatively impacts on inorganic fertilizer user while young farmers tend to be more innovative.

As the result depicted in (Table 4) Sex of house hold head was positively and significantly affect farm house holds inorganic fertilizer use statistically significant at 10%. 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 shows 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 house hold head affect farm households' inorganic fertilizer use 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 findings of martey (2014) and Olwande *et al*.(2009) educated smallholders could manage their farm land 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 Negera and Bashargo (2014) 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 result in (Table 4) land size owned by house hold 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 hectares increase in land size, increase inorganic fertilizer use by 10.6% remaining other variables constant. It is consistent with findings of Ademe *et al.*(2017) and farm households land allocation to cereal crop positively influenced the extent of farm households to purchase inorganic fertilizer.

According to result in **(**Table 4) improved seed used by house hold is positive at 5% significance level. Using improved seed by house hold enable them to get enough production, it increase their income through selling high value cereal crop productions. Result in marginal effect shows, one quintals increase 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 Nambiro and Okoth,(2013) 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 Heisey *et al.*(1998). Use of improved varieties also influenced farmer's decision to use inorganic fertilizer Zegeye *et al.*(2001).

According to result in (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 house hold 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 house hold from nearest market, it decrease 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 Gebresilassie (2015) 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 5%, and 10% probability level
Source: Computed from survey result (2020)

4.3.2. 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 determine the small holders inorganic fertilizer use intensity were Age of house hold 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 decrease 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 Anago *et al.* (2020) 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 increase inorganic fertilizer use intensity by 29 kg/ha. The result indicated that, male headed house hold 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 Mensah *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 regards 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 house hold 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 findings of Negera and Bashargo (2014) 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 house hold couldn't went 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 house hold head from nearest market, inorganic fertilizer use intensity decrease by 12.8 kg/ha. It is consistent with findings of Okemute *et al*.(2006) 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
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
Improved seed	4.349	13.615	0.749
Distance from market	-12.801*	7.587	0.092
Extension contact	5.444	9.700	0.575
Credit	-9.610	12.008	0.424
Constant	-14.896	39.027	0.703
Number of observation		Waldi chi2(12)=456.67	
Censored observation=23		Prob>Chi2=0.0000	
Uncensored observation=133			
Log pseudo likelihood=-729.22			

Note ,***, ** and * at 1%, 5%, and 10% significance probability level

Source: Computed from survey result (2020)

5. Summary, Conclusion and Recommendation

5.1. Summary and conclusion

This study was conducted on examining the determinants of inorganic fertilizer use intensity on cereal crops among small holder 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 determine extent (intensity)use of inorganic fertilizer and statistically significant whereas Age of house hold 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 recommendation 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.

LIST OF ABBREVIATIONS

ADB African Development Bank
ATA Agricultural Transformation Agency
BoA Bureau of Agriculture
CSA Central Statistical Authority
COMESA Common Market for East and Southern Africa
DA Development Agent
FAO Food and Agricultural Organization
GDP Growth domestic production
GTP Growth and Transformation Plan
IFDC International Fertilizer Development
MoANR Ministry of Agriculture and Natural Resource
MoA Ministry of Agriculture
NFIA National Fertilizer Industry Agency
NPS Nitrogen Phosphorous Sulfur
PPS Probability Proportional to Sample Size
SSA Sub Saharan African
SNNPR South Nation Nationalties and People Representatives
TKNRAO Toke Kutaye Natural Resource and Agriculture Office
TKFLDO Toke Kutaye Fishery and Livestock Development Office

Deceleration

I solemnly declare that this thesis was not submitted to any other institutions anywhere for the award of an academic degree, diploma, or certificate. Brief quotations from this thesis are

allowable without special permission provided that accurate acknowledgement of source is made. In all other instances, however, permission must be obtained from the author.

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