DETERMINANTS AND PROFITABILITY OF INORGANIC FERTILIZER USE IN MAIZE PRODUCTION BY SMALLHOLDER FARMERS IN NONO BENJA DISTRICT, JIMMA ZONE, OROMIA REGION, ETHIOPIA

M.Sc. THESIS

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Determinants and Profitability of Inorganic Fertilizer Use in Maize Production by Smallholder Farmers in Nono Benja District, Jimma Zone, Oromia Region, Ethiopia

A Thesis Submitted to the Department of Agricultural Economics and Agribusiness Management, College of Agriculture and Veterinary Medicine, Jimma University, in partial Fulfillment of the Requirements for the degree of Master of Science in Agricultural Economics

By

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DEDICATION

I would like to dedicate this thesis manuscript to my parents, brothers and sisters for nursing with affection and for their wholehearted partnership in the victory of my life.

STATEMENT OF THE AUTHOR

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BIOGRAPHICAL SKETCH

The author was born from his father Dabessa Iticha and his mother Bashatu Wirtu on August 16, 1986 in Dano district, West Shoa zone. He attended his grade one to four at Dorani Oda Liban elementary school and from grade five to eight at Seyo senior secondary school. The author also attended from grade nine to twelve at Ambo comprehensive high school. He joined Hawassa University, Department of Agricultural Resource Economics and Management in 2005 and graduated with B.Sc. on June 2008. He was employed under Oromia agriculture office at Nono Benja District Agricultural Office. He has been working there for last eight years on different positions and in different sectors. He then joined Jimma University Department of Agricultural Economics and Agribusiness Management in September 2016 for his M.Sc. Study in Agricultural Economics.

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LISTS OF ACRONYMS

ADLI	Agricultural Developments Led Industrialization
AISE	Agricultural Input Supply Enterprise
ATA	Agricultural Transformation Agency
CSA	Central Statistical Agency
DAP	Diammonium Phosphate
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
FCU	Farmer Cooperative Union
FSRP	Fertilizer Subsidy Research Policy
FTC	Farmer Training Center
GDP	Gross Domestic Product
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
MoANR	Ministry of Agriculture and Natural Resource
MT	Metric Ton
NGO	Non-Governmental Organization
NPS	Nitrogen Phosphorous Sulfur
PPS	Probability Proportional to Size
SNNPR	Southern Nations, Nationalities, and Peoples' Region
SSA	Sub-Saharan Africa
VCR	Value Cost Ratio

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ABSTRACT

Inorganic fertilizer is one of the technologies that could increase crop productivity. However, farmers were still using lower than the recommended rate and yet there are a lot of farmers who are not using inorganic fertilizers at all. This study aimed at assessing determinants and profitability of inorganic fertilizer use in maize production among the smallholder farmers of Nono Benja district. Since maize is the main crop and cultivated mainly in all kebeles of the study area, it was used as a case for analysis. Two stages random sampling technique was used to select a total of 174 maize producer farmers. Primary data were collected from the sampled respondents through structured interview. For this study; descriptive statistics, econometric models, net profit and Kendall's coefficient of concordance were used. Descriptive result showed that the sampled respondents on average applied 142.8kg ha^{-1} (Sulfur blended Diammonium phosphate &Urea) which is 71.5% of the extension package recommended rate. Also, the descriptive result showed that out of the total 14 explanatory variables, 8 variables show statistically significant difference among user and non-user at 1% and 10% level. Results from Heckman's two-step procedure indicated that, age of household head, farm income and use of input credit were positively affecting the probability of using inorganic fertilizer in maize production. Education level of household head, livestock holding and frequency of contact with extension agent positively influenced both the probability of using and intensity of inorganic fertilizer use in maize production whereas perception on relative price of input-output negatively influenced both the probability of using and intensity of inorganic fertilizer use. Off-farm income positively influenced the intensity of inorganic fertilizer use. The average profit of the user sample respondents is 2,217ETB ha^{-1} after covering all costs incurred during production period. Therefore, it is necessary to give due emphasis to the indicated determinants in order to assist maize producing farmers on use and intensity of fertilizer use to boost maize productivity.

Keyword: Agriculture input, Inorganic fertilizer, Maize production, Smallholder farmers, Nono Benja, Ethiopia

1. INTRODUCTION

1.1. Background of the Study

Poor agricultural productivity is one of the main challenges to achieve food security and poverty reduction in Sub-Saharan Africa (SSA) and particularly in Ethiopia. Considering the fact that soil fertility is one of the biggest challenges, an obvious strategy is to increase fertilizer application and promote good agronomic practices to enhance productivity (Tefera *et al*., 2012). Although maize is one of the most productive crops in Ethiopia, it cannot play a significant role in ensuring food security because of various factors like poor soil fertility, low external input use and poor agronomic management (Birhan *et al.*, 2017).

Land degradation due to up slope cultivation, deforestation, flooding, soil acidity, low inherited soil fertility, limited use of technology like inorganic fertilizers are some of a major negative slowing agricultural productivity in Ethiopia (Tekalign and Hezekeil, 2015). This implies low agricultural productivity with highly increasing population of Ethiopia is the most series problem in the future. However, agricultural productivity growth has been the center of Ethiopia's development strategies since the country began the ADLI in the early 1990s. The country has consistently allocated more than ten percent of public spending on agriculture in the past ten years (Byerlee, 2011). In addition, more public spending was invested heavily in rural infrastructure and made concerted efforts toward agricultural intensification with special attention to the promotion of extension services and inorganic fertilizer use (Mogues *et al.*, 2008; Byerlee *et al.,* 2007).

Despite the Ethiopian government effort and other development agent works to transforms the agricultural sector, agricultural productivity growth remains low and the majority of farmers practice low-input, even subsistence farm rather than profitable practice. Yet, fertilizer use in the country is very low. Only 30–40 percent of Ethiopian smallholder farmers used fertilizer and those who do apply on average 37–40 kilogram per hectare, which is below recommended rate (Spielman *et al.*, 2013; Hailu, 2016). However, it is generally agreed that optimum use of inorganic fertilizer at farm level have the tendency of improving soil fertility leading to rise in agricultural productivity and increase the profitability of a given technology (Abubakar, 2014).

Inorganic fertilizer is known to boost productivity. One third of the increase in cereal production worldwide and 50% of the increase in India's grain production has been attributed to fertilizer related factors (FAO, 1999). In some areas of Ethiopia, inorganic fertilizer may be viewed as an indispensable commodity without which little or no output is obtained to meet subsistence requirement of the farm family (Mulat *et al*., 1997). Improving productivity and profitability of smallholder farming is the main pathway out of poverty in using agriculture technology for development (World Bank, 2008). Improved agricultural productivity for smallholders can reduce poverty and improve household welfare (Abraham *et al*., 2014). However, in Ethiopia increased inorganic fertilizer prices and the concomitant decrease in output prices have been the most important factors associated with use of inorganic fertilizer (Fufa and Hasan, 2006). This increased inorganic fertilizer price and decreased in crop output makes the productivity and profitability of inorganic fertilizer use in maize production low.

In Ethiopia, the average share of urea from total fertilizers remains much lower than DAP; accounting for 15% of the total fertilizer in 1980-1999 while it was 35% during 2000- 2015. That means there was no much effort to improve the fertilizer use in the country that has a variable agro-ecology and soil conditions. The unbalanced use of fertilizer in the sense of soil fertility (which is assessed according to the gap between recommended dose and type of fertilizer and its actual use in fields) became problematic in the recent years. The significant gap between the recommended dose and actual amount of fertilizer application is high in case of Urea. In Ethiopia, the unbalanced use of fertilizer implies the loss in soil fertility (IFDC, 2015).

In Ethiopia majority of an inorganic fertilizer is used for cereals production, mainly *teff*, maize, wheat, barley and sorghum. According to CSA (2015) estimates, about 90 percent of fertilizers were applied to those first three major cereal crops. Fertilizer use is concentrated on cereals followed by pulses and oil seeds respectively. During 2014/15 cropping seasons the national level amount of both Urea and DAP fertilizers applied in cereals, pulses and oil seeds were 769,940.9, 29,555.5 and 11,371.1 tons, respectively. *Teff* holds the largest share in fertilizer use among the cereals (32%), followed by maize and wheat with respective shares of 29% and 25% in 2010/11 and 2014/15 production seasons.

In Ethiopia, more than 90% of all inorganic fertilizers were used by smallholder farmers and the remaining 10% were used by private commercial farms, state farms and research centers. Four regions alone (Oromia, Amhara, SNNPRS and Tigray) accounted for more than 87.5% of the total fertilizer consumption of the country (CSA, 2015).

Inorganic fertilizers distributed to all Zones and a lot of Districts of Oromia and utilized by a lot of smallholder farmers in the region. However, the adoption and profitability of inorganic fertilizer use is different from zone to zone, from District to District and from smallholder farmers to smallholder farmers. Maize is among the major food crops widely produced and consumed by smallholder farmers in Oromia in general and Nono Benja District in particular. Therefore, this study assessed the determinants of inorganic fertilizer use and its intensity of use in maize production, evaluate the productivity and price levels making inorganic fertilizer use profitable in smallholder maize production and identify and rank the constraints of inorganic fertilizer use and its intensity of use in maize production in the study area.

1.2. Statement of the Problem

Intensification of agriculture involves an efficient use of different farm inputs among which fertilizers are the major one as these improve agricultural productivity in Ethiopia to bridge the wide gap of food shortage through improvements in soil fertility (Headey *et al.,* 2014). The recommended rate of inorganic fertilizer application in agricultural production boosts the productivity of crops and ensures food security with the role of leading towards the growth of the whole agricultural sector which ultimately leads to the overall development of the economy. On the other hand, measuring the performance of using agricultural technology is economically more important because a given technology may maximize profit at expected level or otherwise not (Sheahan, 2011).

The role of inorganic fertilizer is to improve production and productivity of crops. Regarding this, strong efforts have been carried out to promote its adoption for the last 50 years in Ethiopia (CSA, 2015). In spite of the concrete efforts made by the government of Ethiopia to promote inorganic fertilizer adoption through improved extension services and access to credit, farmers are still using under recommended amount of inorganic fertilizer and also there are a lot of farmers who are still not using inorganic fertilizers (Yirga and Hassan, 2013).

In Ethiopia, maize is the leading crop in productivity and the second in area coverage next to *teff*. Research results from high potential maize growing areas are in average 7-8 tones ha^{-1}. However, yield levels obtained by small scale farmers remained stagnant despite the availability of improved varieties. One of the main causes for this discrepancy is the low use of external inputs, leading to negative balances for NPS and Urea (Dagne, 2016). The same problem is observed in the current study area.

Even though, a lot of studies have been conducted to explain the factor affects use and intensity of use of inorganic fertilizer in Ethiopia at different places and time by using different models, the currently available knowledge about the low use and low intensity of inorganic fertilizer use is not sufficient (e.g. Tirfu, 2011; Beshir *et al*., 2012; Yirga and Hasan, 2013; Eba and Bashargo, 2014; Mengistu and Degefu, 2017).

On the other hand, before further policy emphasis is placed on increasing inorganic fertilizer use, analysis is needed on how actual use patterns compared with calculated profitability levels and to identify if and where a legitimate gap remains between the two (Tsehaye, 2008). The same author attempted to estimate a profitability of inorganic fertilizer use in Tigiray region. However, in his study he uses only price of output, price of fertilizer and quantity of yield to estimate a profitability of inorganic fertilizer use. But, his analysis has some gaps to explain a full analysis of profitability of inorganic fertilizer use, because the input is not only inorganic fertilizer, there are also improved maize seed, labor force and others.

In case of Nono Benja District there is no empirical study conducted on determinants and profitability of inorganic fertilizer use in maize production among the smallholder maize farmers. Regarding the use of inorganic fertilizer in the area a lot of farmers are still not using and the intensity of use is lagging behind the recommended levels for maize production. On the other hand, the profitability of those farmers who use inorganic fertilizer in maize production was low. Therefore, based on the above problems the current study was proposed to fill the gap by examining and addressing the determinants and profitability of inorganic fertilizer use in maize production in the study area.

1.3. Objectives of the Study

General objective of the study

The general objective of the study is to assess the determinants and profitability of inorganic fertilizer use in maize production among smallholder farmers in Nono Benja District.

Specific objectives of the study

The specific objectives of the study are:

- To assess the determinants of inorganic fertilizer use and its intensity of use in maize production among smallholder maize farmers in the study area.
- To evaluate the productivity and price levels making inorganic fertilizer use profitable in smallholder maize production in the study area.
- To identify and rank the constraints associated with use and intensity of inorganic fertilizers use among smallholder maize farmers in the study area.

1.4. Research Questions

This study tries to answer the following research questions:

1. What are the determinants of inorganic fertilizer use and its intensity of use in maize production among smallholder maize farmers in the study area?
2. Can the existing maize productivity and price level make inorganic fertilizer use profitable in smallholder maize production in study area?
3. What are the constraints of use and intensity of inorganic fertilizer use among smallholder maize farmers in the study area?

1.5. Significance of the Study

The study is significant in terms of its contribution to both theoretical and empirical evidence. The achievement of the objectives discussed above is important tool for agricultural development and household level adoption and profitability of agricultural new technology. The study is significant to improve the households' knowhow regarding the determinants and profitability of inorganic fertilizer use in maize production. This is because knowledge of the determinants and profitability of inorganic fertilizer use in maize production is very important for policy implementation and to improve fertilizer use in the future. Generally, the study attempted to provide realistic information on the overall issues of determinants and profitability of inorganic fertilizer use in maize production to smallholder farmers in Nono Benja District.

1.6. Scope of the Study

The study is restricted to one administrative District, four kebeles and 174 household heads (respondents). The data of the study was based on a cross-sectional survey which makes unable to show the dynamics in inorganic fertilizer use and the profitability over time. In addition, this study is restricted to assess the determinants and profitability of inorganic fertilizer use in maize production among smallholder maize farmers in Nono Benja District.

1.7. Limitations of the Study

The study is thus subjected to some limitations. The data are depending on the memory of the respondents, some data particularly in the quantitative data might be short of accuracy and other may be qualitative that lack measurement. Some respondents are also unwilling to give the correct response for some sensitive variables. Some secondary data at the district level was not clear and not well documented. However, for this study, different data collection methods including, random sampling and the respondent consents were used in order to minimize the limitation and to ensure the reliability of the data and to produce valid results.

1.8. Organization of the Study

The study is organized into five chapters. The first chapter contains background of the study, statement of the problem, objectives of the study, research questions, significance, scope and limitation of the study. The second chapter contains a review of related literature. Chapter three concerning the methodology of study including description of the study area, data source and type, sampling method and procedure, data gathering techniques and methodology of data analysis. The fourth chapter contains result and discussion. The last and fifth chapter contains summary, conclusion and recommendation of the study.

2. LITERATURE REVIEW

Under this topic what other authors have been studied in relation to the title selected for the study was discussed. The content of this topic discussions on the determinants and profitability of inorganic fertilizer use in maize production as an innovative farming tool and approaches, livelihood patterns as related to maize production practice and the linkage between agricultural technology use and economic performance of it. The output of this review sets the summary and conceptual framework for the review and based on different studies, journals and documents.

2.1. Concepts and Definition of Terminologies

2.1.1. Definition of inorganic fertilizer

Any substance that is added to soil, to supply one or more plant nutrients and intended to increase plant growth is fertilizer (Cooke, 1972). Fertilizers are substances, which are added to the soil to supplement the soil with those elements required in the nutrition of plants. That means, any material whether organic or inorganic, natural or synthetic, that furnishes to plants one or more of the chemical elements necessary for normal growth is fertilizer (Berhanu, 2000).

Inorganic fertilizer, often reasonably priced, consists of mineral-based nutrients manufactured for immediate application on crops. Unlike the organic variety, inorganic fertilizer does not need to decompose over time to supply nutrients to plants. Most of inorganic fertilizers contain balanced amounts of nitrogen, potassium, and phosphorous to feed plants and to foster growth. These substances often derive from chemical processes such as urea, ammonium sulfate, and calcium nitrate. Mined deposits of potash, phosphate rock, and lime can also be processed as inorganic fertilizer (www.wisegeek.com/what-is-inorganic-fertilizer.htm).

Inorganic fertilizers are usually simple chemical compounds made in a factory or obtained by mining, which supply plant nutrients and are not residues of plant or animal life. Broadly speaking, any chemical compound used for supplying one or more of the essential plant food elements are chemical fertilizer (Mcvickar, 1970). All fertilizer materials that might be present on the fertilizer market and that are sold within the same trade are called commercial fertilizers. In general, chemical fertilizers are inorganic or synthetic materials of a concentrated nature. They contain one or more plant nutrients in easily soluble and quickly available forms (Berhanu, 2000).

2.1.2. Concept of inorganic fertilizer use and trends

Adoption of a new technology at the household level has been defined as "the degree of use of a new technology in long-run equilibrium when the farmer has knowhow about the new technology and its potential" (Feder *et al.,* 1985). This implies that adoption has two separate components: a time component indicating length of time the technology has been used, and an intensity of use component indicating the appropriateness of its use. Such long-run information is seldom obtained, however, and the "adoption" of a technology is generally reduced to a binary variable indicating use of the technology or not (Kaliba *et al.,* 2000).

Inorganic fertilizer is a critical input technology for improving production and increasing crop yields. Over the past 25 years, chemical fertilizers have been the primary means of enhancing soil fertility in small farm agriculture (Byerlee *et al*., 1994). The use of chemical fertilizer in Ethiopia (primarily DAP and Urea) can be assessed in several ways in terms of total fertilizer imported, percentage of farmers using fertilizer and improved seed-fertilizer packages, percentage of cultivated land under fertilizer application, and household level estimates of fertilizer application per hectare (Spielman *et al*., 2013).

According to Rashid *et al*. (2013), cereals account for 90 percent of the country's total inorganic fertilizer use with only Oromia and Amara regional states accounted for 70 percent of total use during 2005/2006–2010/2011. The shares of the other two major cereal growing regions the Southern Nations, Nationalities, and Peoples' Region (SNNPR) and Tigray were 10 and 3 percent, respectively.

The wise usage of inorganic fertilizer is one of the best investments a farmer can fetch a high return. That means, with efficient use of inorganic fertilizer, the farmer expects a higher return on each unit of money spent on inorganic fertilizer (McVickar, 1970). Though, all of the improved farm technologies must be applied together, it is generally true that proper use of inorganic fertilizer with high yielding variety seed offer the greatest opportunity for greater and rapid improvement in farm production especially for those smallholder farmers suffering from shortage of capital and seasonal income fluctuations. Thus, investing on inorganic fertilizer and high yielding variety seed is more attractive than on fixed assets (Berhanu, 1993).

Research done by the team of researchers in IFPRI (2013) on the chemical fertilizer application trend in Ethiopia revealed that there has been an increasing trend in both planted area and fertilized area. While planted area has increased from about 7.0 million hectares in 2003/04 to 9.7 million hectares in 2010, representing a 38.6% growth, fertilized area has more than doubled from 1.12 million hectares to 2.31 million hectares during the same time. Even though; the usage is still under recommended and also there is still non-user of inorganic fertilizer in Ethiopia. Until 2013, urea and DAP (di-ammonium phosphate) fertilizers have been the only fertilizer sources that have been used in the Ethiopian agriculture for more than five decades. None of these are nationally produced Ethiopia; rather supplied by imports to meet the demand. Average inorganic fertilizer consumption in Ethiopia has risen from 132,522MT (1995/96) to 858,825MT (2014/15) period. Even though the amount of inorganic fertilizer imported increases every year, Ethiopian smallholder farmers still left far behind compared to other developing countries in fertilizer use (IFDC, 2015).

Nowadays Ethiopia starts introducing new inorganic fertilizer. Regarding the use of new inorganic fertilizers, the MoANR and the ATA have jointly worked on demonstrations on farmers' fields with the aim of testing their performance as well as creating awareness to farmers. As a result, DAP is gradually being replaced by NPS (sulfur blended DAP) for the time being and tailored blends would be produced based on the soil fertility condition of the different Districts using the already established and to be established fertilizer blending facilities, which are owned and run by the FCUs. The FCUs (farmers' cooperative union) receive the ingredients for the blends from AISE as they used for the straight fertilizers (CSA, 2015). The study conducted on agricultural growth in Ethiopia shown that an increased productivity was partly explained by a rapid uptake of a number of improved agricultural technologies. Over the period of studied, total inorganic fertilizer consumption of smallholder was increased with the share of cereal producers applying inorganic fertilizers increasing from 46 percent in 2004/05 to 76 percent in 2013/14.

2.1.3. Concept of inorganic fertilizer use in maize production

Maize is among the major food crops widely produced and consumed by smallholder farmers in Ethiopia in general and particularly in the study area. Area under maize during 2015/16 main cropping season in Ethiopia was about 2.1 million ha, which makes maize to be the second in area coverage out of cereals. During the same period, maize ranks first among cereals in terms of total production accounting for about 7.2 million tons (CSA, 2015/2016).

Based on data of 2004 to 2013, about 23% of the total inorganic fertilizer in Ethiopia were applied to maize and it reached 29% in 2015 (CSA, 2015). The overall inorganic fertilizer application in maize production has shown significant growth over the last decade. The consumption rate grew at more than 12% per annum between 2004 and 2013, in comparison to the SSA average of 3.8% (between 2004 and 2012). Ethiopia shows the fastest growth rates of inorganic fertilizer usage from SSA. However, the country needs to make every effort towards achieving the Abuja Declaration of 50 kg/ha inorganic fertilizer use from its current figures of about 34 kg/ha (Abebe *et al.*, 2015).

The farmers used improved maize seed had a high probability of using inorganic fertilizer compared to those who did not use improved maize seeds (Nambiro and Okoth, 2013). This is attributed to the responsiveness of the improved maize seed to inputs, thus becomes an important catalyst for the use of the inorganic fertilizer (Byerlee *et al*., 1998).

According to Aloyce *et al.* (2000), in Tanzania, there is no shortcut for substantial and dramatic increases in maize production without improved maize seeds and fertilizer use. However, the quantity of fertilizer that farmer were used in order to maximize his/her profits was determined by the price of the inorganic fertilizer, p(f) that is equal to the value of the additional maize produced from that unit of inorganic fertilizer i.e., the marginal value product (Liverpool *et al*, 2017).

According to Hill, (2014) study on maize response to inorganic fertilizer and inorganic fertilizer use decisions for farmers in Ghana show that by using OLS and quartile regressions, he was found that fertilizer application has a positive and significant impact on maize yields and total maize production. Having established inorganic fertilizer as a viable instrument for increasing yields, he next turned to determining policies that should increase inorganic fertilizer use rates in Ghana.

In a policy brief on Malawi's farm input subsidy program (Ricker *et al.,* 2017) discuss the effectiveness of the subsidy program at increasing inorganic fertilizer use, and further examine whether increasing inorganic fertilizer application affected maize yields. They find that female-headed households tend to use less inorganic fertilizer for maize than male-headed ones. Inorganic fertilizer use is positively correlated with the overall wealth of a household head. Farmers that plant improved varieties of maize tend to use about 50 kg more inorganic fertilizer than those that do not. The subsidy program increases total inorganic fertilizer use for maize, plots with improved varieties of maize on average produce higher yields compared to plots with traditional maize, and finally the authors find a significant and positive correlation between the amount of inorganic fertilizer application and maize yield. However, at higher rates of inorganic fertilizer use this relationship exhibits declining returns to inorganic fertilizer use.

The blended fertilizers showed that they are a promising to grow maize in the study area, whereas maize productivity for the previously existing NP fertilizers in the country was low as compared to the blended fertilizers; which indicated that maize productivity in the study sites was reduced due to high demand for external nutrient inputs rather than NP fertilizers (Dagne, 2016).

The study conducted on outcome of rich farmyard manure and inorganic fertilizers on grain yield and harvest index of hybrid maize (BH-140) at Chiro, eastern Ethiopia shown that inorganic fertilizers boost hybrid maize grain yield and harvest index significantly through improving the physical and chemical properties of the soil (Misganaw,2014). Inorganic fertilizer use considerably increases maize yield. It is also recommendable to use fertilizer for improved varieties such like maize to maximize profit. Thus, it was positively related to the probability and intensity of adoption of an improved maize variety (Bekeko, 2013).

According to Mengistu and Degefu (2017) studies on intensity of inorganic fertilizer use in maize production in West and East Hararghe Zones, the area under maize production were about 42,044 ha and 49,980 ha, respectively, during the same period. Average maize productivity in the zones were about 2.3 tons and 2.7 tones ha-1 in that order, which is below the national average of about 3.4 tones ha-1 (CSA, 2016).

2.2. Empirical Studies on Inorganic Fertilizer Use

2.2.1. Determinants of inorganic fertilizer use

Increasing the use of inorganic fertilizers at optimum is believed to be fundamental in addressing the low and declining soil fertility and improving food security in Sub-Sahara Africa (SSA). Ethiopia has the most depleted soils in Africa (IFDC, 2015). Hence, encouraging the use of inorganic fertilizer in a country is important now and in the future.

Beshir *et al*. (2012) conducted the studies on determinants of chemical fertilizer technology adoption in North eastern highlands of Ethiopia by employing the double hurdle approach. The results of the study provided empirical evidence of a positive impact of extension and credit services, age, farm land size, education, livestock, off/non-farm income and gender in enhancing the adoption of inorganic fertilizer. Physical characteristics like distance from farmers' home to markets, roads, credit and input supply played a critical role in the adoption of inorganic fertilizers as proximity to information, sources of input and credit supply and markets save time and reduce transportation costs.

Yirga and Hassan, (2013) studies conducted on determinants of inorganic fertilizer use in the mixed crop livestock farming systems of central highlands of Ethiopia by using Heckman's two-step procedure to analyses the variables. The result of their study shown that despite notable improvements in the supply of inorganic fertilizers and supporting services such as extension and credit, use of inorganic fertilizers among smallholder farmers remained disappointingly low. In their study also variables, education level of the head of the household, number of livestock owned, number of plots owned, land tenure, access to credit and extension, agro ecology and manure use influenced both the likelihood of adoption and intensity of inorganic fertilizer use.

Ketema and Bauer, (2011) studies conducted on determinants of manure and inorganic fertilizer applications in eastern highlands of Ethiopia by employing a two-stage probit model and highlighted large number of statistically significant variables. Their study showed that the decisions to use inorganic fertilizer and manure were negatively related to one another. Inorganic fertilizer is expensive in prices and inadequate in supply but less demanding of labor in its application. Manure in most of the cases is freely available but labor intensive in transportation and application. As a result, the choice between the two was mostly based on labor endowments and income levels of the farmers.

Olwande *et al*. (2009) conducted the studies in Kenya used panel data to examine determinants of fertilizer adoption and intensity of use. Using a double-hurdle model, they found that age and education of the farmer, access to credit, presence of a cash crop, distance to fertilizer market and agro-ecological potential influence the probability of fertilizer adoption. Gender of the farmer, dependency ratio, credit access, presence of cash crop, distance to extension services and agro-ecological potential were found to influence the intensity of inorganic fertilizer use. A double-hurdle model is useful in capturing intensity of adoption but it ignores the fact that adoption of fertilizer could also be influenced by related practices such as adoption of improved maize seed.

The study conducted on a factor that influences adoption of inorganic fertilizer by maize farmers in Kakamega District of western Kenya by using probit model shows that growing of cash crop, off-farm income, access to agricultural extension agents and the current use of improved maize seed positively influence the use of inorganic fertilizers in maize production. Also, a positive relationship between off-farm income and use of the inorganic fertilizer supports the hypothesis that off-farm income was used for purchasing the inorganic fertilizer among other farm inputs like the hybrid maize seed (Nambiro and Okoth, 2013).

Tedla, (2011) studies conducted on factors determining fertilizer adoption of the peasant farm sector in Tigray region, northern Ethiopia. The author was investigated influential factors which determine the probability of fertilizer adoption. He used econometric analysis, supported by the descriptive analysis tool and the random effect panel probit and panel tobit models, has shown that education level of the head of the household, adult labor, farm size, the number of plots that a household used, average plot distance from homesteads, oxen holdings, and market distance altogether had significant impact in determining the likelihood of fertilizer adoption in the region under consideration. His study shown all factors positively related with inorganic fertilizer except average plot distance from homesteads.

According to Nasrin and Bauer (2014) the factors that affecting intensity of fertilizer use among farm size groups in Bangladesh shown that farming experience and manure application did not observed any significant impact on inorganic fertilizer use intensity for all farm categories. OLS model is used for their study. Among other variables, off-farm income, labor availability, fertilizer-paddy price ratio and extension services showed that significant impact for all categories. Farmers can afford inorganic fertilizer in required amount with higher off-farm incomes, as these are the sources of liquid cash for the farmers. Marginal farmers always face difficulties in applying adequate amount of inorganic fertilizer in the field as they were constrained by financial liquidity. Also, farming is a labor-intensive work and labor cost is increasing within a time in the country which turns the coefficient significant.

Fufa and Hasan (2006) conducted a study on determinants of fertilizer use on maize in Eastern Ethiopia by using a weighted endogenous sampling maximum likelihood estimator was used in the specification of a probit and Tobit fertilizer use models indicate that fertilizer use remains very low, especially among small scale farmers in the country. The results of the study showed that the age of the farmer, farmers' expectations of rainfall conditions and farmers' perception of the price of fertilizer significantly affect the use and intensity of use of fertilizer. Increased fertilizer prices and the concomitant decrease in output prices have been the most important factors associated with use of new agricultural technologies in Ethiopia.

The study conducted by Tirfu (2011) on determinants of inorganic fertilizers use and intensity of use by smallholder farm households at Girar Jarso district, Oromia region, Ethiopia by employing the tobit model to identify factors influencing the adoption of fertilizer and intensity of its use. Accordingly, access to input credit and total livestock owned appeared to significantly and positively influence the probability of fertilizer adoption and intensity of its use, while distance from residence to input market, compost application and total farm size was negative and significant. Similarly, Eba and Bashargo (2014) conducted the study on factors affecting adoption of chemical fertilizer by smallholder farmers in Guto Gida District, Oromia Regional State, Ethiopia by employing Probit and Tobit model. The results of the study depicted that education, family size, extension contact, access to information, access to credit, farm income and off-farm activity were positively influenced the adoption of fertilizer whereas distance to market and livestock holding are negatively influenced adoption of fertilizer use. On the other hand, off-farm activity, access to information, landholding size and farming experience are positively affected the intensity use of fertilizer while family size and livestock holding are negatively determined the extent use of fertilizer.

According to Etim (2015) studies on adoption of inorganic fertilizer by urban crop farmers in Akwa Ibom State, Nigeria, shows that the factors affecting the rate of adoption of chemical fertilizer by urban crop farming households were estimated using the tobit model. The analysis reveals that the most critical factors affecting the rate of adoption and use intensity of chemical fertilizer are age and educational level of the farmer, land size under cultivation, average walking time to the nearest farm, soil fertility status of the land and accessibility to credit facilities. The study revealed that increasing the size of cultivable land is likely to increase the rate of adoption of chemical fertilizer by urban arable crop farmers. Also, results of the study showed that farmers who have acquired many years of observation and experimentation with various technologies are more likely to adopt new techniques faster than those with lesser years of farming experience. Findings further reveal that enhancing human capital plays a positive role in fertilizer adoption.

According to Ogada *et al*. (2014), the study conducted on farm technology adoption in Kenya in a case of simultaneous estimation of inorganic fertilizer and improved maize variety adoption decisions, shows that the decisions to adopt inorganic fertilizer and improved maize variety technologies are interdependent. The study also further established that plot-level, household specific factors, and market imperfection are important in influencing the likelihood of a household adopting inorganic fertilizer and improved maize varieties. Among the key factors in this regard include education level of the household head, plot size operated by the household, land tenure security, distance to the input market, and water retaining capacity of the plot, access to credit, manure adoption, expected yields and yield variability.

According to Mengistu and Degefu (2017) conducted the study on adoption intensity of inorganic fertilizers in maize production: empirical evidence from smallholder farmers in eastern Ethiopia, shown that the analyze determinants of intensity of adoption using a survey data collected from 383 randomly selected maize producing households. For the study, a two-limit tobit model was applied. The econometric result revealed that variation in districts, family size, membership to cooperatives, distance to farmer training center, and livestock holding significantly affected smallholders' intensity of adoption of DAP in maize production. On the other side, variation in district, farming experience, farm size, membership to cooperatives, dependency ratio, and annual income significantly determined the intensity of adoption of Urea.

2.2.2. Intensity of inorganic fertilizer use in Ethiopia

Tedla (2011) conducted the study on use and intensity of inorganic fertilizer use in Tigray, Ethiopia. The result of the study shows that, the intensity of fertilizer use though increased has still remained below the recommended rate of 100 kg/ha for cereal. The descriptive analysis has clearly shown that the percentage of adopters has increased by 4.27% only within the last ten years; likewise, intensity of use has increased by 10.69 kg/ha only though significant. Similarly, with in 2014/15 production season the inorganic fertilize application rate per hectare of cultivated land was 177 kg/ha for maize (CSA, 2015). However, both of these still fall below the national recommendation of about 110–130 kg/ha of N and P nutrients (or the equivalent of 150–200 kg/ha of urea and 100–150 kg/ ha of DAP), depending on the variety (higher rates are recommended for hybrids of maize) (Abebe *et al.*, 2015).

Farmers' deviation from recommended package practices was found partly due to poor extension service, lack of financial capacity of farmers to apply agricultural input according to recommendation and shortage of land (Mekuria, 2013). Similarly (Abrha, 2015) conducted the study on the factors affecting agricultural production in Tigray region, northern Ethiopia, shows that the intensity of fertilizer application was lower than the standard set at a regional level. For all types of soils, crops and agro-ecologies, 200 kg/ha or 50 kg/*tsimad* was the standard recommended in all areas of the region. For 60% of the respondents, the amount of fertilizer applied was 26.45kg/*tsimad*.

Based on descriptive analysis, the average inorganic fertilizer application rate (DAP and Urea) by the sampled famers was 118.64 kg/ha (only fertilized area considered). This implies on average sampled famers applied only 59.3% of the recommended rate (Tirfu, 2011).

2.2.3. Profitability of inorganic fertilizer use in maize production

According to Rashid *et al.* (2013), the analysis of profitability suggests that fertilizer in Ethiopia is profitable at both experimental plots and farmers' fields. All estimates of value cost ratio (VCR) at the experimental plots are higher than 2.0; but when econometrically estimated using household survey data, the VCR estimates become lower. The estimates remain greater than 2.0 only for maize in all regions. Thus, they conclude that fertilizer was profitable in Ethiopia and the low adoption is the result of other factors, such as high-risk premiums and institutional bottlenecks and this has its own implication on profitability.

In the context of yield response and profitability, the advanced question was whether or not the right kind of fertilizer is applied to the soil, which widely varies across-agro ecological zones and household farm. In this variation, the soil type essentially implies that different kinds of nutrients have been applied to maintain the soil fertility and perhaps increase the yield response and profitability. Some recent studies argued that severe organic matter depletion has potentially reduced Ethiopian agricultural GDP up to 7% (Gete *et al*., 2010).

The study conducted on factors affecting the use of inorganic fertilizer by small and medium-sized farming households in Zambia, from 1997 to 2000 shown that the limitations of the current data prevent a full-scale profitability analysis of inorganic fertilizer use. An analysis of the profitability of specific crops themselves cannot be provided. While the discussion has centered on the quantity of fertilizer application, factors related to fertilizer application and yield benefits of fertilizer application, these findings do not provide definitive indications of the profitability of fertilizer use in Zambia (Knepper, 2002).

A full profitability analysis of the use of fertilizer would require a much broader understanding of households' costs and sales of production as well as better data related to yields and response rates to fertilizer. The work by Benson *et al.,* (1997) in Malawi and FSRP (2001) in Zambia provided good references towards better understanding of the potential fertilizer profitability. The findings made to the government of Malawi by the maize productivity task force, some households at a time the most profitable use of fertilizer was not used. After conducting nationwide tests with selected farmers from across the country, fertilizer use was found to be beneficial only in some regions of the country and then at different rates of use than recommended by the government and not profitable in others.

Trials of inorganic fertilizer application conducted in various regions of Zambia using traditional farmer techniques and found that fertilizer applied to maize can be profitable given the proper conditions (FSRP, 2001). In their study, the risk of varying response rates represented a serious problem to fertilizer profitability. Unfavorable weather, poor timing of fertilizer application, overall soil fertility, and use of other herbicides or weeding were cited as significant factors affecting the variability of maize yields and profit. Other reasons fertilizer use on maize may be unprofitable include inappropriate application recommendations, lack of availability of improved seeds, inconsistent farmer management practices and lack of access to credit (FSRP, 2002). In line with this study, the determinant of the profitability of fertilizer use usually due to; weak physical infrastructure, downside crop price risk- risky, unavailability of improved seed, inefficient farm management, agronomic practices (Mulat *et al.,* 1998).

Literature of agricultural research on optimizing fertilizer use within an integrated soil fertility management framework in Ethiopia shown that fertilizer is a costly input and its efficient use is important for profitability and minimizing nutrient loss to the environment and soil acidification due to excess N application. The decision on choices of crops, fertilizers to apply and the amount of each nutrient to apply requires consideration of several factors. Agronomy of nutrient responses for different crops that the farmer plants must be considered together with the farmer's land allocation to each crop, the expected commodity values, the costs of fertilizer use and the money available for fertilizer use. Soil test information and other practices that may affect the need for nutrients must be considered (Negash and Israel, 2016).

The study conducted on analysis of inorganic fertilizer profitability and use in Kenya shown that whether or not use inorganic fertilizer on maize production, households overwhelmingly said that they were either cash constrained or did not need to use inorganic fertilizer. By confining sample to only those areas where fertilizer use is profitable and to the final four survey years, the attempts to isolate the constraints on households limiting an otherwise profitable fertilizer use decision. Only about 23 percent of the fields in this sample are not fertilized using commercial fertilizer, distance to the nearest fertilizer seller (despite its drop over time), the ratio of nitrogen to maize price, a range of information accessibility variables (i.e., own a cell phone, member of a cooperative or grower group), the choice of other inputs (i.e., manure and hybrid seeds), and education, age and sex of the household head are significant determinants of the fertilizer use decision where Profitable(Sheahan, 2011).

Low marginal physical product and high transportation costs significantly reduce the profitability of inorganic fertilizer use on maize production (Liverpool *et al.,* 2017). To increase inorganic fertilizer use in SSA, countries have several options: decrease the cost of inorganic fertilizer, increase availability of inorganic fertilizer, educate farmer on proper application and the benefit of inorganic fertilizer (Druilhe and Barreiro, 2012).

Value cost rate (VCR) estimates are available in Ethiopia on inorganic fertilizer use profitability to show the difference between productivity with and without fertilizer. Many of them are based on plot level data from the experimental stations. For instance, Mulat *et al*., (1998) presented the first set of such estimates since the government eliminated inorganic fertilizer subsidies in the 1990. Their study indicated that although VCRs were greater than two in1992 and fell far below two after the withdrawal of subsidies in 1997. Spielman *et al*., (2013) have re estimated the VCR for *teff* and maize for 2004 and 2008, and according to their estimates VCRs are 2.12 and 1.91 for maize and *teff,* respectively. In 2010, the World Bank commissioned a larger study to assess the inorganic fertilizer profitability in Ethiopia. The study indicated that, value cost rate of inorganic fertilizer in Ethiopia was at least 1.7 for all cereals in all four cereal-growing regions. However, the variation across crops and regions was high; estimates range from1.7 to 4.2 for *teff*, 2.0 to 6.5 for wheat, and 1.7 to 5.3 for maize. These needs more study to see the profitability of inorganic fertilizer use at different region of the country.

The study conducted by Tsehaye (2008) on factors affecting adoption and profitability of fertilizer marketed through cooperatives in Enderta Woreda, Tigria region of Ethiopia shown that the VCR estimation for the three major cereal crops (wheat, barley and *teff*) is above the threshold, it needs to be higher to convince farmers about the profitability of fertilizer adoption.

In Ethiopia, authors like Dajene (2008), Takele (2010) and Bayissa (2016) were used net profit analysis to estimate the profitability of agricultural commodity. Based on this evidence in the current study the net profit analysis was employed to estimate the profitability of inorganic fertilizer use in maize production.

2.2.4. Ranking of farmers' constraints of inorganic fertilizer use and intensity of use

Anang *et al.* (2013) used Kendall's Coefficient of Concordance to identify and rank tomato production constraints and identified that lack of capital and high cost of inputs as top constraints. Dogbe *et al*. (2013) and Etuah *et al.* (2013) used Kendall's Coefficient of Concordance ranking of farmers' constraints to soybean production and broiler production, respectively.

Basha (2016) used Kendall's Coefficient of Concordance ranking of farmers' constraints to potato production in Bore district, Guji zone, Oromia regional state in Ethiopia. The study identified and ranked the constraints of potatoes production. Accordingly, low uptake of improved farm inputs, weak links to markets, high transportation costs, small and weak farmer organizations, lack of information on markets and prices, lack of storage facilities and household and climate related factors limited the productivity and income earning capability of producers in order of their degree of influence.

Joseph (2016) used Kendall's Coefficient of Concordance ranking of farmers' constraints to intensity of inorganic fertilizer use among smallholder farmers in North Ghana. The author identified and ranked constraints. Accordingly, access to fertilizer, access to credit /finance, access to extension services, weather conditions, cultural factors and access to other inputs in were ordered in their degree of influence on the use intensity of fertilizer in maize production.

Therefore, through different evidences for the current study we have used Kendall's Coefficient of Concordance to analysis the constraint faced by smallholder maize farmers in use and intensity of use of inorganic fertilizer in maize production in the study area.

2.3. Conceptual Framework of the Study

Based on literature review, the following conceptual framework was designed for the current study. The framework emphasizes mainly on the relationship of dependent variable with independent variables. Although there might be some relationship among the independent variables, these relations are not dealt with in this study.

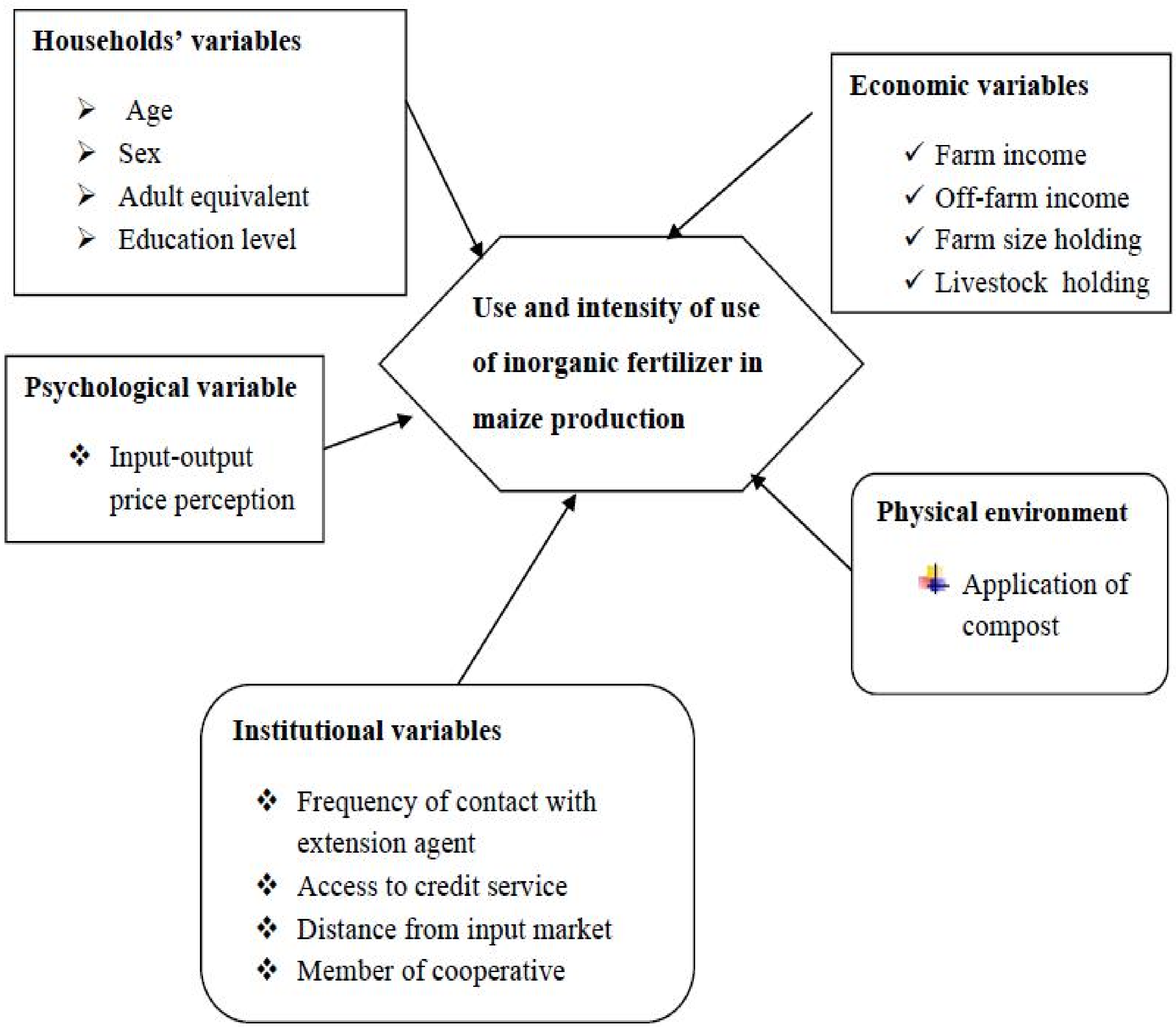

Figure 1: Conceptual Frame work of the Study

Source: Own design by reviewing related literature

3. RESEARCH METHODOLOGY

This section describes the research design and methodological steps, includes description of the study area, data sources and types, sampling techniques, data collection instruments and method of data analysis.

3.1. Description of the Study Area

This section presents the study areas, population characteristics, climate and soil characteristics and economic activities.

Location of the District

This study was conducted in Nono Benja District, Jimma zone, Oromia regional state, in Ethiopia. The District is located at a distance of 156 km North of Jimma town and 263 km West of Addis Ababa. The District is bounded by West Shoa zone from East, East Wollega zone from North, Limmu Sake and Cora Botor Districts of Jimma zone from West and South respectively. The administrative town of the District is called Alga and the second town is Benja. Nono Benja District consists of 19 rural kebeles and 2 urban kebeles. Nono Benja District lies at an approximate altitude of 1432-2500m above sea level (Nono Benja District Land Administration and Use Office, 2017).

Land use pattern of the District

The total land area of the District is 82,894.11 hectares. Regarding land use pattern during the recent years, cultivation land 34,382 hectares, pasture land 9,882.4 hectares, forest land (including bushes & shrubs) 14,775.9 hectares, Religion land 383 hectares, School and FTC land 399 hectares and the rest is others (settlement, roads etc.). Average land holding is estimated to be 3.5 hectares per household (Nono Benja District Land Administration and Use Office, 2017).

Climate of the District

Relatively the climate of the District is divided into three traditional zones, namely low land 28%, midland 43%, and highland 29%. The topography of the District is complex and consists of hills, undulating landscape and plains. The District experienced minimum and maximum temperatures of 14°C and 30°C respectively and relative humidity between 80 and 90% that falls to about 40% in the dry season. There are two distinct seasons: the rainy season starting in late March and ending in October and the dry season occurring during November to early March. The rainfall pattern is unimodal and it ranges from 780-2000mm with about 70% of the precipitation falling in a two months' period i.e., July and August. The mean annual rainfall is 1800mm. The soil of the district was fine textured heavy loamy clay soil with a pH of 6.0 (Miressa, 2015).

Population of the District

Based on (CSA report, 2013), the total population of the District is projected to be at about 101,462 of which 50,658 are males and 50,804 are females, representing a population density of 78 persons per square kilometer and an annual population growth rate estimated of 2.8%. The total households of the District are 9909 (9641 male and 268 female). Out of the total household population, 1702 is urban households.

Economic base of the District

The economic base of the residents of the District is agriculture. The majority of the population depends on agriculture for their livelihood. Individual smallholder farmers are the sole and dominant production unit. The agriculture sector is based on rain fed and is characterized by low productivity. Moreover, the agricultural sector in the District is characterized by low use of agricultural inputs, traditional farm practices and poor soil fertility. Mixed agriculture (crop production and animal rearing) is a typical practice in the District. Some of the major crops produced in the District are: maize, sorghum, *teff*, niger seed, wheat, barley and others. The area covered by these crops is 6424, 3391, 5918, 6142, 2182, 738 and 7066 hectares, respectively. The average yield per hectare of these crops are 4975, 3300,1600,1100,4000 and 6800kg, respectively. Maize is the major crop in both area coverage and production at the study area. It is produced for both consumption and marketing purpose in a District. Livestock are also kept as one part of agricultural practice in a District. Most of the farmers of the District farms for only subsistence live (Nono Benja Agriculture office, 2017/2018).

Irrigation development also is practiced in the District by smallholder farmers. According to the report of irrigation development office of the District, 2472 smallholder farmers were participated in irrigation to produce different vegetables and other crops during 2017 production season on 1034 hectares of land. However, the participation of farmers on irrigation development is low with the potential available irrigable land in the District, which is above 10,000 hectares of land (Nono Benja Irrigation Development Office, 2017).

Regarding the agricultural technology utilization, especially inorganic fertilizer and improved maize variety utilization introduced before two decades. But the utilization rate of the technology is still low. Therefore, this nature of economic practice requires encouragement of agricultural technology.

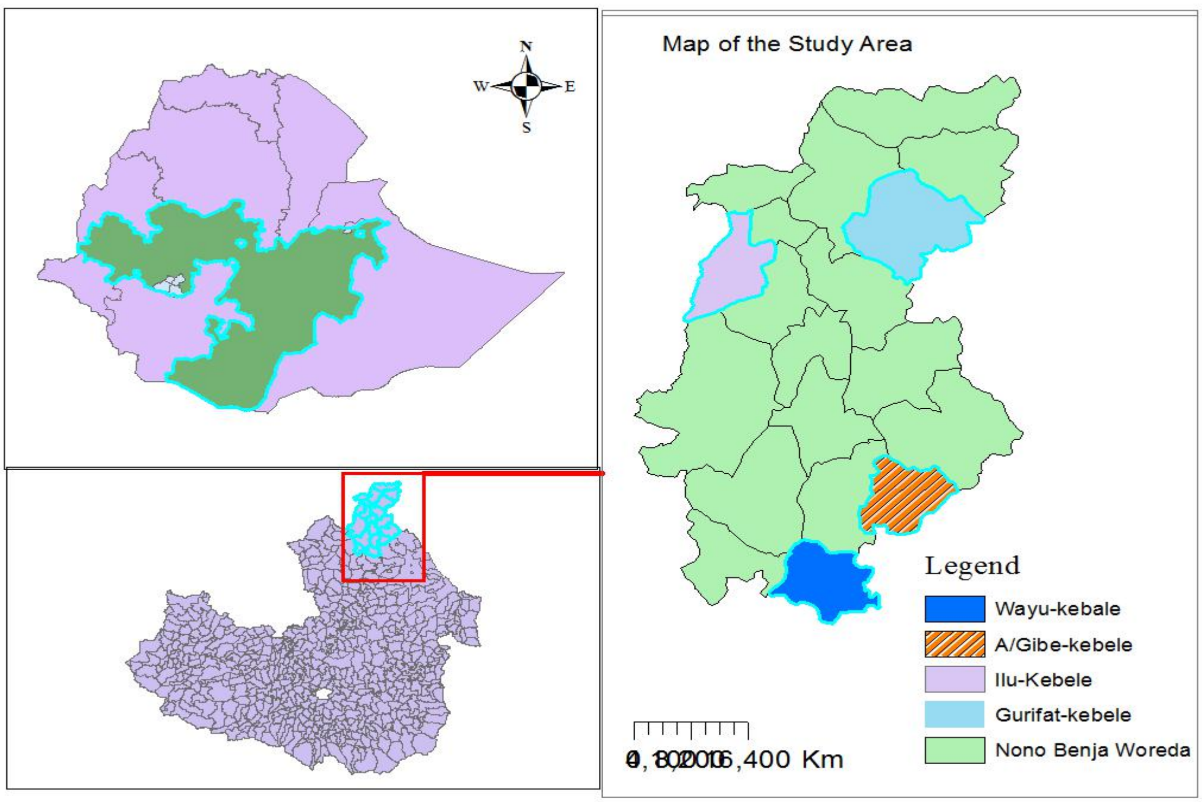

Figure 2: Map of study area
Source: Adopted from GIS

3.2. Data Sources and Types

For this study both quantitative and qualitative data were collected from both primary and secondary sources. Quantitative data was collected using structured interview schedule from the household head on different issues related the demographic, socio-economic and institution characteristics. Qualitative data was collected through focus group discussions and key informant interview from knowledgeable smallholder maize farmers. Secondary data was collected from unpublished and published materials and District Agricultural Office, Cooperative Office and Trade and Market Development Office.

3.3. Sampling Methods and Procedures

The study was used a two-stage sampling technique to select sampled respondents. First, by considering maize production uniformity in all kebeles of the District and taking into consideration the time, budget and human resource necessary for the study, from the total of 19 rural kebeles, 4 kebeles namely; Abiyu Gibe, Wayu, Gurifat and Ilu were selected randomly.

In the second stage, a list of all smallholder maize farmers in the four kebeles were obtained and stratified into two user and non-user of inorganic fertilizer in maize production. Then a total sample size of 174 individual household (114 users and 60 non-users of inorganic fertilizer in maize production) was selected randomly from the total population of 1899 of the sampled kebeles of the District and the heads of the selected households were interviewed. The sample size of 174 households' was determined based on simplified formula from Yamane (1967), applying 8% level of precision or error limit.

$n=\frac{N}{1+N(e^2)}$ $\quad n=\frac{1899}{1+1899(0.08)^2}$ $\approx$ 174, where N is household size of the study area, e is level of precision or error limit, and n is a sample size for the study. This sample size was up scaled to 174 for purposes of having sufficient numbers for analysis of the user and non-user. Then, using probability proportionate to size (PPS) the sample of user and non-user in each kebeles was selected as it is indicated in table below.

Table 1: Sampling frame of the study

Name of kebeles	Total household produce maize in the kebeles			Sample household produce maize in the kebeles		Total sample of HH
	Total HH user	Total HH non user	Total HH	Sample HH user	Sample HH non user	
A/Gibe	301	97	398	23	13	36
Wayu	314	103	417	24	14	38
Gurifat	425	98	523	32	16	48
Ilu	461	100	561	35	17	52
Total	1501	398	1899	114	60	174

Source: From sampled kebeles administration

3.4. Data Collection Methods

The primary data was collected both in quantitative and qualitative form through structured interview schedule, focus group discussion and key informant interview. The quantitative data was collected through structured interview schedule by enumerators from the sampled respondents. For this data collection eight enumerators and one supervisor were used. By giving training for them, pre testing the questionnaire on a plot and translating the language of questionnaire from English into Afan Oromo, data was collected. Focus group discussion was proceed with 4 focused groups of farmers selected from 4 sample kebeles and 1 focused group discussion with stakeholder official of the District to obtain a qualitative data. Each group consists of 8 members. Key informants interview was also employed to collect qualitative data. Accordingly, a detail interview was made with 12 key informants from four selected kebeles (8 men and 4 women) on their personal experience on use and intensity of inorganic fertilizer use in maize production. The secondary data was collected from published and unpublished materials, which include books, journals, scientific research works and office records.

3.5. Methods of Data Analysis

The quantitative data were coded and entered into SPSS20 and STATA13 versions computer program for analysis. Qualitative data was analyzed and interpreted in a narrative way. To analyze the quantitative data, descriptive statistics, econometric model (Heckman two-steps), net profit calculation and Kendall's coefficient of concordance were used.

3.5.1. Descriptive analysis

Descriptive statistics is a technique that was used to summarize information collected from a sample unit. In this study, descriptive statistics such as, means, standard deviations, percentages and frequencies were used to compare and contrast different categories of sampled units with respect to the desired characteristics. Also, inferential statistics like chi-square and t-test were employed to identify the importance and strength of association of the hypothesized variables.

3.5.2. Econometric analysis; Heckman's selection model

The choice to be selected to participate in any program may not necessarily be random as a result selectivity bias may exist. In this scenario because the sample that was included in the study was based on the selection of adopters, there could be selection bias. Thus Heckman selection model was used to control for the selection bias problem. In the Heckman's selection model, it is assumed that technology adopters are not randomly selected but there is a self-selection bias that needs to be corrected in obtaining unbiased estimates of the intensity of adoption. According to Heckman (1979), sample selection bias may arise in practice for two reasons, first there may be self selection by an individual or data units being investigated. Second sample selection decision by analysts or data processors in much the same fashion as self selection.

Selective samples may be the result of rules governing collection of data or the outcome of economic agent's own behavior. The latter situation is known as self-selection. Statistical analysis based on those non-randomly selected samples can lead to erroneous conclusions and poor policy (Heckman, 2008). The Heckman's correction, a two-step statistical approach, offers a means of correcting for non-randomly selected samples. The first stage formulates a model for the probability of adoption used to predict the probability for each individual and then in the second stage, removing the part of the error term correlated with the explanatory variables and avoiding the bias. Some adoption studies in Ethiopia and East Africa used the Heckman's selection model to identify the probability and intensity of different agricultural technologies in different locations. (e.g: Kaliba *et al*., 2000; Kurukulasuriya *et al.,* 2006; Yirga, 2007; Deressa *et al*., 2008; Jaleta *et al*., 2013; Yirga and Hasan, 2013; Atupokile, 2016). Heckman's selection model follows two-steps estimation procedure where in the first stage, an 'adoption equation', attempts to capture factors affecting adoption decision and Inverse Mill's Ratio (IMR) is obtained. In the second stage, the intensity of adoption is estimated using the IMR as one of the explanatory variables to correct selection bias. The probability of adoption was modeled by Maximum Likelihood Probit, from which the inverse Mill's ratio was estimated. The specifications for Heckman's two-step models are as follows:

1. The adoption equation: The Probit model is specified as:

$$Y_i = \beta_i X_i + \varepsilon_i,\ i = 1, 2, n \text{ --- } (1)$$

$$y_i^* = 1, \text{ if } y_i^* > 0 \text{ or } 0, \text{ if } y_i^* < 0$$

Where, y_i^* is the latent dependent variable which is not observed and Yi is a binary variable that assumes 1 if household *i*, use inorganic fertilizer and 0 otherwise.

β_i is a vector of unknown parameters in adoption equation.

X_i is a vector of explanatory variables in the probit regression model.

ε_i is random error term that are assumed to be independently and normally distributed with zero mean and constant variance.

Lambda (λ_i), which is related to the conditional probability that an individual household was deciding to adopt (given a set of independent variables) is determined by the formula.

$$\lambda_i = \frac{f(x\beta)}{1-F(X\beta)} \text{ -- } (2)$$

Where λ_i is Inverse Mill's Ratio (IMR), f (Xβ) is the standard normal probability density function and $1-F$ (Xβ) is the cumulative distribution function for a standard normal random variable. The value of λ_i is not known, but the parameters (β) can be estimated using a probit model based on the observed binary outcome (Y_i). Then it was used in outcome equation to make consistency of the model.

2. Regression (OLS): Outcome model is specified as:

$$Y_i = \alpha_i Z_i + \mu\lambda_i + \eta_i \text{ -- } (3)$$

Where, Y_i is the intensity of inorganic fertilizer use, α_i is a vector of unknown parameters to be estimated in the rate of inorganic fertilizer use equation, Z_i is a vector of explanatory variables determining the rate of inorganic fertilizer use, μ_i is the parameter that helps to test whether there is a self selection bias in the use of fertilizer, λ_i is inverse mill ratio and η_i is the error term.

Before running the Heckman model all the hypothesized explanatory variables were checked for the existence of multi-collinearity problem. There are two measures that are often suggested to test the existence of multicollinarity. These are: Variance Inflation Factor (VIF) for association among the continuous explanatory variables and contingency coefficients (CC) for dummy variables. In this study, variance inflation factor (VIF) and contingency coefficients (CC) were used to test multicollinearity problem for continuous and dummy variables respectively.

According to Maddala (1992), VIF can be defined as: VIF (Xi) = $\frac{1}{1-R^2}$ ------------------ (3)

Where R^2: is squared multiple correlation coefficients between Xi and the other explanatory variables. As a rule of thumb, if the VIF of a variable exceeds 10 (this will happen if R^2 exceeds 0.95), that variable is said to be highly collinear (Gujarati, 1995). A contingency coefficient (CC) was computed for dummy variables using the following formula.

$$C=\sqrt{\frac{x^2}{n+x^2}} \text{-- (4)}$$

Where, C is contingency coefficient, $\chi 2$ is chi-square value and n = total sample size. For dummy variables if the value of contingency coefficient is greater than 0.75, the variable is said to be collinear (Healy, 1984 as cited in Mekuria, 2013).

3.5.3. Definition of variables

Dependent variable

The dependent variables in this study are use of inorganic fertilizers which is dummy variable and intensity of inorganic fertilizers use which is continuous variable. For continuous dependent variable the potential range value was 0-200 kg per ha by considering the components of inorganic fertilizers (NPS (100 kg per ha) and Urea (100 kg per ha)). Definitions of the important concepts of use/adoption related to this specific context are:

- For this study user/adopter is defined as smallholder maize farmers who have applied any amount of inorganic fertilizer component in maize production during the survey period.
- Intensity of use/adoption refers to use/adoption index indicating farmers' level/extent of inorganic fertilizer use in maize production at the period of survey.
- Non-user/non-adopter is defined as a farmer who didn't use any amount of inorganic fertilizer component in maize production during the survey period.
- Use/adoption is thus defined as the status of use of inorganic fertilizer in maize production at a time of survey.

For multiple practices (package), there are two options of measuring adoption; (i) adoption index: measures the extent of adoption at the time of the survey or (ii) adoption quotient: measures the degree or extent of use with reference to the optimum possible without taking time into consideration. In this study, the first option was employed. Accordingly, adoption index which shows to what extent the respondent farmer has adopted the whole set of package was calculated by employing the formula of Chandara and Singh (1992) as cited in Tirfu, 2011).

$$AI = \left(\frac{e_1}{p_1} + \frac{e_2}{p_2}\right) * 100$$

Where,

e_1 = extent of use of NPS

p_1 = Potential (recommended dose of NPS)

e_2 = extent of use of Urea

p_2 = Potential (recommended dose of Urea)

Independent variables (explanatory variables)

Depending on different literature review on adoption and intensity of adoption of the new agricultural technology so far the important key explanatory variables that are expected to determine the adoption and intensity of inorganic fertilizer adoption in maize production at study area is summarized as follows.

Age of the household head: It is a continuous variable measured by year. Older farmers are more likely reject technology. They are usually risk averse. Because of this, they might tend to be reluctant in adoption of inorganic fertilizers package. Taha (2007) have reported negative relationship of age with adoption. On the contrary, younger farmers are often expected to be more knowledgeable about new events and are likely to take risk due to their longer planning horizon. They are eager to assess the advantages associated with new technologies. Therefore, it is hypothesized that increased age would have a negative impact on farmers' use and intensity of inorganic fertilizer use.

Sex of the household head: It is a biological identity nature. It is a nominal variable used as dummy represent of household head; where female headed=0 and male headed =1. Gender difference is found to be one of the factors determining adoption of new technologies. Because of many norms and socio-cultural values, male headed household has more freedom of mobility and participation in different extension programs and consequently has greater chance of access to information. Therefore, sex is hypothesized that male farmers are more likely to adopt and intensity of use inorganic fertilizer in maize production and positive sign was expected from this variable (Mesfin, 2005; Taha, 2007).

Adult equivalent: This variable is a continuous variable measured in number. A farmer with larger adult equivalent labor engaged on agricultural activities is more likely to be in a position to try to continue using a potentially profitable production enhancing inputs (Abrha, 2015). It was computed with the number of household members by age group and using conversion factor the adult equivalent was obtained. Thus, a farmer with large adult equivalent labor would have a capacity to use labor intensive agricultural inputs. Adult equivalent labor was expected to have a positive impact on farmers' use and intensity of inorganic fertilizer use.

Education level of the household head: This variable is a continuous variable representing the education level of the household head. The higher the education level, the better would be the knowledge of the farmers toward the use of agricultural new technology (Yirga and Hasan, 2013). Therefore, education level of household head was expected to have a positive influence on farmers' use and intensity of inorganic fertilizer use.

Household farm income: It is the annual income that a household gets from their farm product and it represents a continuous variable measured in Ethiopian Birr. Farmers who have got more annual farm income were investing more in agricultural activities and in new technologies (Eba and Bashargo, 2014). Therefore, a positive relationship between household head's farm income and use and intensity of use of inorganic fertilizer was expected.

Household off-farm income: It is an activity take place out of the farm activity. It is a continuous variable measured in Ethiopian Birr. Off-farm income increases the additional income of household and develops the capacity to invest in technology adoption (Beshir *et al*., 2012). Therefore, a positive relationship between household head's off-farm income and inorganic fertilizer use and its intensity of use was expected.

Perception on relative price of input-output (fertilizer-maize): The farmer's perception about the existing input and output prices is an important factor which influences his/her expected utility from investing on new technologies. It is the cost-benefit analysis in terms of farmers' relative input-output price benefit perception. If the output price is relatively good, demand for inorganic fertilizer will be high. However, it also inversely affects the demand for inorganic fertilizer use when the price of output is relatively low compared to input price (Fufa and Hasan, 2006). Therefore, a negative relationship between the household head's perception on relative price of input-output and use and intensity of inorganic fertilizer use was expected.

Farm size holding: This is the total size of farmland the farmer household own and contract for crop and measured in hectare. The relationship between farm size and inorganic fertilizer use is positive as usually hypothesized. This is because of the fact that as farm size increases the farmers' probability of technology try on their farm with tolerable risk also increases (Tirfu, 2011). Therefore, it is hypothesized that farm size holding was positively affects the household head's use and intensity of inorganic fertilizer use in maize production.

Livestock holding: This variable is defined in terms of Tropical Livestock Unit (TLU) and it is continuous variable. It may serve as a proxy for the capacity to tolerate risk of using new technology such as inorganic fertilizer and capture wealth effect (Yirga and Hassan, 2013). Livestock may also serve as proxy for sale and purchase input and own oxen which are important for farm operation. This variable is expected to have a positive influence on the household head's use and intensity of inorganic fertilizer use in maize production.

Application of compost: Compost refers to animal dung and waste plant materials; which prepared and applied by households on their plot to improve soil fertility. Regarding this variable (Tedla, 2011), using compost to the required level was probably reduce the inorganic fertilizer use. It is a dummy variable, which takes a value 1 if the household used compost and 0 otherwise. Therefore, this variable is expected to have a negative influence on the household head's use and intensity of inorganic fertilizer use in maize production.

Frequency of contact with extension agent: This variable is a continuous variable. The variable frequency of contact with extension agent represents a source of information and technical advice for smallholder farmers. This variable has a positive influence on farmer households' decision to adopted (Dawit, 2017). Therefore, in this study the variable frequently contact with extension agent is expected to have a positive influence on the household head's use and intensity of inorganic fertilizer use in maize production.

Use of input credit: This variable refers to where the farmer households use credit or not. It is a dummy variable takes 1 if the farmer households use credit and 0 otherwise. Availability and use to production credit are the major factors that determine both the overall use and intensity of use of inorganic fertilizer (Mengistu and Bauer, 2011). In this study the variable use of input credit is expected to have a positive influence on use and intensity of inorganic fertilizer use.

Distance from input market: This variable is continuous variable. This variable is used to know how far the farmer household residence from the inorganic fertilizer market. The closer the farmers' residences to the market, the more the farmers are exposed to information about the cost and benefit of the technology and the more minimization of transport cost under the study (Eba and Bashargo, 2014)). Therefore, the variable distance from input market is expected to have a negative impact on use and intensity of inorganic fertilizer use in maize production.

Member of cooperative: This variable is a dummy variable. Farmers those members of cooperative have the chance of get more information, credit than those not member of cooperative (Mengistu and Degefu, 2017). Based on this concept if the farmers are being the member of cooperatives it takes value 1 and otherwise it takes 0 values. So, being the member of cooperative is expected to have a positive influence on use and intensity of use of fertilizer.

Table 2: Definition and units of measure' of variables

Dependent variable

Variables	Type/Unit	Description
Use/Adoption	Dummy	Status of use/adoption; 1 if user &0 otherwise
Intensity of use	Adoption index	Extent of use/adoption of inorganic fertilizers component (NPS&Urea)

Independent variables

Variables	Type/Unit	Description	Expect sign
AGEHH	Discrete (Year)	Age of Household head	-
SEXHH	Dummy	Sex of the household head (1=male&0=Female)	+
ADLE	Discrete (number)	The number of adult equivalent labor available within household	+
EDLHH	Continuous (year of schooling)	Education level of household head	+
FMICMH	Continuous (birr)	The income household head obtain from their farm	+
OFFINC	Continuous (birr)	The off-farm income obtain by household head	+
PRPIO	Categorized (in degree of feeling)	The perception of household head on relative price of fertilizer and maize output (1=Low,2=Medium, 3=High, 4=Very high)	-
FARMS	Continuous (ha)	The total land hold and contract for crop by household head	+
LVSH	Continuous(TLU)	Total livestock hold by household head	+
USCP	Dummy	Application of compost on crop land by household head (if yes=1 and if no=0)	-
FCWEA	Continues (day per month)	The number of days per month extension agent contacts with the household head	+
UICRD	Dummy	Use of credit by household head(1=if yes&0=if no)	+
DFIM	Continuous(hour)	The distance household head walk from his house to inorganic fertilizer market and estimate in time	-
MCPS	Dummy	Being the member of cooperative of household head (1=yes & 0=no)	+

3.5. 4. Profitability estimation of inorganic fertilizer use in maize production

Takele (2010) studied the profitability of rice production in Fogera District of Amhara region. He employed gross profit analysis to estimate the profitability of rice production in Fogera District. To estimate the profitability of rice production at farm gates, local markets of the study areas were considered. All costs of production were estimated based on current market price. The net profit from rice production was calculated by considering all inputs and expenses required to produce rice. The unit of analysis is hectare of land. The model takes the usual gross profit formula. Also, Bayisa (2016) used gross profit (net farm income) to estimate sesame technology in drought prone areas of Ethiopia.

Therefore, for this study the gross revenue and the total cost calculations were used to analyze the profitability of inorganic fertilizer use in maize production at existing maize productivity and price level.

Net profit = TR − TC = PQ - $\sum_i^n piqi$

Where, P= Price of the maize yield at farm gate

TC= Total cost of maize production

TR= Total revenue of maize production

Q =Total maize production per hectare with inorganic fertilizer use

q_i =Quantity of input (fertilizer in kg, improved seed in kg)

p_i= Price of input at farm gate (fertilizer, improved seed, labor, oxen)

The limitation of financial profit analysis is that it does not consider the economic costs and benefits. The financial analysis estimates the profit accruing to the project entity or to participant, whereas economic analysis measures the effect of the project on national economy. In financial analysis all expenditures incurred under the project and revenues resulting from it are taken into account whereas in economic analysis attempts to assess the overall impact of improving the welfare of the society. Moreover, the price measurement is different, shadow price is used for economic analysis and market price is used for financial analysis. It measures simply the accounting cost and profits. Generally, an implicit cost is not considered in the calculation of the financial profit analysis. Therefore, in this study financial analysis was used to estimate the profitability of inorganic fertilizer use in maize production.

3.5.5. Determining and describing the extent of agreement in the ranking of constraints

The constraints of use and intensity of inorganic fertilizer use in maize production at the study area were identified and grouped into twelve various categories through pre-test and from existing literature. The constraints identified include: High cost of inorganic fertilizer, Lack of credit service, High interest rate on credit, Low return on inorganic fertilizer use, lack of uniform rain fall distribution, Perception of having fertile land, Absence of choice packaging amount, Inefficient inorganic fertilizer distribution, Distance of inorganic fertilizer marketing from residence, Late arrival of inorganic fertilizer, Poor quality of inorganic fertilizer and Lack of knowledge on inorganic fertilizer are those constraints identified at the study area and these were included in the questionnaires and presented to the sample respondents to rank in order of their importance. The data collected on these constraints were interred in computer and the mean ranks were analyzed with the help of SPSS.

This subsection used the Kendall's Coefficient of Concordance (W) in determining whether there is an agreement in the respondents' ranking of the constraints associated with use and intensity of inorganic fertilizer use among smallholder maize farmers in Nono Benja District. Following from Edwards (1964) as cited in Joseph (2016), the Kendall's Coefficient of Concordance (W) analysis was a statistical technique that is used to rank a given set of identified constraints from the most critical one up to the least critical one and then measures the degree of agreement between these constraints. The identified constraints were ranked according to the most critical to the least critical using numerals such as 1,2,3…n, in that order. The constraint with the least sum score or mean is ranked as the most critical while the one with the highest sum score or mean is ranked as the least critical. The computed total rank score is then used to calculate the W. The formula for Kendall's Coefficient of Concordance was used to test the degree of agreement among smallholder maize farmers on the constraints identified. The formula is specified as follows: $W=12\frac{[\sum T^2-(\sum T^2)/n]n}{nm^2(n^2-1)}$

Where, W = Kendall's Coefficient of Concordance, T = Sum of ranks for constraints being ranked, m = Total number of respondents, n = Total number of constraints being ranked and Σ=summation symbol (Anang *et al.,* 2011).

Hypothesis Testing for Kendall's Coefficient of Concordance

- H_o: There is no significant agreement between the rankings of constraints of use and intensity of inorganic fertilizer use among smallholder maize farmers in Nono Benja District.

- H_1: There is a significant agreement between the rankings of constraints of use and intensity of inorganic fertilizer use among smallholder maize farmers in Nono Benja District.

The value of W is positive in sign and ranges from 0 to 1. It is 1 when the values assigned by one farmer (judge) are exactly the same as those assigned by other respondents; and is 0 when there is maximum disagreement among the farmers.

4. RESULTS AND DISCUSSION

This chapter presents the results and discussion of the study. It provides the use and intensity of inorganic fertilizer use among smallholder maize farmers, the demographic and socio-economic characteristics of the sample respondents, the factors that affect use and intensity of inorganic fertilizer use in maize production, profitability of inorganic fertilizer use in maize production and rank of the constraints that hinders the sample respondents use and intensity of inorganic fertilizer use in maize production by using descriptive statistics, econometric models, profit analysis and Kendall's Coefficient of Concordance (W) analysis.

4.1. Descriptive Analysis

In order to identify the variables that vary significantly between the users and non-users inferential statistics tools such as chi-square and t-test were used in addition to descriptive statistics. The total sample size of respondents handled during survey was 174, out of which 114 were users and 60 were non-users. Out of the total sampled respondents 22 and 152 were females and males headed household respectively. From the 22 female respondents, 12 females and 10 females were users and non-users respectively and from 152 male respondents, 102 males and 50 males were users and non-users respectively. Moreover, here below the discussions of descriptive results.

4.1.1. Input use

Farmers in Nono Benja District use modern agricultural technology input like inorganic fertilizer, herbicide, pesticide and improved seed. The data for the commencement year of inorganic fertilizer use indicated that, the farmers of study area started using inorganic fertilizer in maize production in 2000/2001 production season. It was started by ten smallholder maize farmers during the period. Until 2009/2010 production season the distribution of DAP and Urea in the study area were not exceeded 500 quintals and 50 quintals respectively and in 2017/2018 it reached 7150 quintals and 4252 quintals of NPS and Urea respectively (Nono Benja District Agriculture Office, 2017/2018). Here below more about the descriptive result of inorganic fertilizer use among smallholder maize farmers were presented.

Level of inorganic fertilizer use

Inorganic fertilizer is the major agricultural new technology that improves crops production and productivity. In the study area, during 2017/2018 production season from the total sampled respondents 65.5% and 57.5% was applied NPS and Urea in maize grows respectively. On the other hand, from the total sampled respondents 34.5% and 42.5% was non-user of NPS and Urea in maize grows respectively (Table 3). The corresponding figures show that, the respondents prefer NPS more than Urea and there are some smallholder maize farmers who applied only NPS on their maize farm in the study area.

Table 3: Category of sample respondent by inorganic fertilizer application in maize grows

Category of sample household	NPS		Urea	
	N	%	N	%
User of inorganic fertilizer	114	65.5	100	57.5
Non-user of inorganic fertilizer	60	34.5	74	42.5

Source: Own survey result of 2017/2018 production season

Application amount for user of inorganic fertilizer in maize production

Any agricultural new technology like inorganic fertilizer has its own recommendation rate of application. However, the average application amount was below the recommended rate of 100 kg ha^{-1} for both diammonium phosphate (DAP) and Urea for the major cereals in Ethiopia (Yirga and Hassan, 2010). The same problem was observed in the study area regarding the intensity of inorganic fertilizer application rate in maize production.

In the study area, the extension recommended rate of inorganic fertilizer application in maize production is 200 kilograms per hectare (100 kilograms of NPS per hectare and 100 kilograms of Urea per hectare). As it was illustrated in table 4 below, the sample respondents are using less than the extension recommended rate of inorganic fertilizer in maize production. The descriptive results indicated that the average inorganic fertilizer (NPS and Urea) application rate by the total users sampled respondents were 142.8 kilograms per hectare (only fertilized area was considered). The corresponding figure implies that the sample respondents on average applied 71.5% of the recommended rate. In general, the result of this study depicts that the use of fertilizer in maize production falls below the recommended rate. Moreover, there is a wide gap between NPS and Urea application rates compared to the 1:1 ratio which was recommended by extension package in the study area. The results have shown that the average dose of NPS and Urea applied by the user sample respondents was 82.8 kilograms per hectare and 60.1 kilograms per hectare respectively (which is 1.4:1 ratios). The result of this study is consistent with research findings carried out by (Mengistu and Degefu, 2017).

Table 4: Application rate of components and inorganic fertilizer per hectare (N=114)

Inorganic fertilizer	Mean	Std. D
NPS in kg/ha	82.85	15.18
Urea in kg/ha	60.08	30.71
Extent of (NPS+Urea) use kg/ha	142.79	39.18

Source: own survey result of 2017/2018 production season

Application rate of inorganic fertilizer in maize production by sample respondents vary across kebeles. All sample kebeles applied more NPS than Urea. From the sampled kebele, Ilu kebele applied an average of 95.5 kilograms of NPS per hectare which was the highest average relative to other kebeles and Wayu kebele applied averagely 75 kilograms of NPS per hectare which was relatively the least from the sample kebeles. Average application rates of Urea for all sample kebeles were low. Moreover, secondary data collected from the District Agricultural and Cooperative offices and the result of focus group discussion and key informants interview is made clear that, since the last five years back the use of fertilizer, application ratio of NPS to Urea has been changed. However, still now the application rate and use ratio of fertilizer in maize production had a wide gap in the study area (Table 5).

As it was observed from focus group discussion that proceed with the experts of the District stakeholder officials, in some kebeles of the Districts' the smallholder maize farmers were stopped the use of Urea in maize production at all. This evidence indicated that, the use of unbalanced inorganic fertilizer (NPS and Urea) in maize production which leads to low maize production and productivity in the District. In general, the result of the study indicated that the use of Urea was more in problematic than the use of NPS in the District. This might be arising from the lack of the financial liquidity to purchase inputs, lack of knowledge on the benefit of urea, farmers' perception that urea could 'dry the land' and late arrival of urea are those combinations of problems that could make the use of urea in the study area low.

Table 5:Application level of inorganic fertilizer in maize production by sample kebele (kg/ha)

Name of sample kebele	NPS			Urea		
	N	Mean	St.D	N	Mean	St.D
Abiyu Gibe	23	78.48	13.18	21	59.13	31.39
Wayu	24	75	10.43	18	51.12	28.96
Gurifat	32	77.97	15.44	32	59.68	31.7
Ilu	35	95.57	10.83	29	65.86	30.71

Source: own survey result of 2017/2018 production season

Classification of the sample respondents by intensity of inorganic fertilizer use

Regarding the intensity of inorganic fertilizer use in maize production, the sample respondents were classified as follows. From the total sample respondents, 34.5% are non-user of inorganic fertilizer in maize production. On the other hand, depending on the results calculated from the adoption index, intensity of inorganic fertilizer use in maize production indicated that 13.23%, 2.87%, 23.56%, and 15.5% of the sample respondents were classified into very low, low, medium and high rate of inorganic fertilizer users in maize production respectively. From the total sample respondent only 10.3% was used the recommended rate of inorganic fertilizer in maize production. This result implies that, at the study area, almost 90% of the sampled farmers were used less than the recommended rate of inorganic fertilizer (Table 6).

Table 6: Classification of sample respondents by the level of use of inorganic fertilizer

Classification of adopter in kg per ha	N	Percent (%)
Non adopter(0 user)	60	34.5
Very low adopter<=100	23	13.24
Low adopter(101-133)	5	2.9
Medium adopter (134-167)	41	23.56
High adopter(168-199)	27	15.5
Recommended level adopter and above(>=200)	18	10.3
Total	174	100

Source: Own survey result of 2017/2018 production season

4.1.2. Household head's demographic characteristics by use and intensity of inorganic fertilizer use

Age of household head: In the current study, the age of the sampled respondents ranges from 22 to 75 years. The total average age of the sample respondents was 44.45 years. The average age of non-adopters was 45.20 years whereas the average age of adopters was 44.05 years. Therefore, the result of the analysis shows that, there was no statistically significant mean difference among adopters and non-adopters (Table 7).

Education level of household head: In the study area, the education level of the sampled respondents ranges from 0 (illiterate) to 10th Grade. The total average education level of the sample respondents was 1.6 grades (schooling years). The average education level of non-user sample respondents was 0.75 grades (schooling years) while that of the user sample respondents was 2.05 grades (schooling years). Hence, the analysis shows that, there was statistically significant mean difference among non-adopter and adopter at 1% level of significance (Table7). This result implies that the schooling year of the user sample respondent was higher than the schooling year of non-user sample respondent. Moreover, the result implies that having education level of smallholder maize farmers improve the ability of use and intensity of inorganic fertilizer use in maize production. However, the result of this study showed that the education level of the sampled respondents in the study area was low. The result of this study is agreed with the research finding by (Croppenstedt *et al*., 1999; Mekuria, 2013).

Adult equivalent labor: Household's labor was the major source of farm labor in the study area. Inorganic fertilizer use in maize production was labor intensive business. Based on Storck *et al.,* (1991), household size was converted into adult equivalent labor, to facilitate comparison among the non-user and user of inorganic fertilizer in maize production. In the study area, adult equivalent labor of the sampled respondents ranging from a highly labor constrained which comprises 2.3 labor to a highly labor endowed households with a maximum of 9.5 adult labors. The total average adult equivalent labors owned by sample respondents were 5.175 in number. On average, non-user sample respondents had 5.17 adult equivalent labors whereas user sample respondents had 5.18 adult equivalent labors. Hence, the analysis indicated that, there was no statistically significant mean difference among user and non-user (Table 7).

Table 7: Sample household head demographic characteristics by the use and intensity of inorganic fertilizer use in maize production (for continuous explanatory variable)

Variables	User(N=114)		Non-user(N=60)		T-value	Total sample(N=174)	
	Mean	Std. D	Mean	Std. D		Mean	St.D
Age of household	44.05	6.66	45.20	5.85	-1.124	44.45	6.40
Education level	2.05	1.82	0.75	1.14	5.033***	1.6	1.73
Adult equivalent	5.18	1.33	5.17	1.34	0.0430	5.175	1.33

Source: Own survey result of 2017/2018 production season. *** Significant at 1% level

Sex of the household head: In this study, the sample respondents were composed of both male and female headed households. According to the survey result, about 12.6 percent of the sample respondents are headed by females and the rest 87.4 percent are headed by male. The result of this study shown that from non-adopter sample respondent 16.67 percent and from the adopter 10.5 percent were females headed while from non-adopter sample respondent 83.33 percent and from the adopter sample respondent 89.5 percent were male headed. Hence, the result of the analysis shows that, there was no statistical significant difference in sex of household head among the users and non-users (Table 8).

Table 8: Sample household head sex category by use and intensity of inorganic fertilizer use in maize production (for dummy explanatory variable)

Variable		Non-user		User		X^2 -Value	. Total sample	
		N	%	N	%		N	%
Sex of household head	female	10	16.67	12	10.5	1.34	22	12.6
	male	50	83.33	102	89.5		152	87.4
	Total	60	100	114	100		174	100

Source: Own survey result of 2017/2018 production season

4.1.3. Household socio-economic characteristics by use and intensity of inorganic fertilizer use

Farm size holding: Land is a basic resource, as it is a base for any economic activity especially in rural and agricultural sector. In the study area, the farm size holding of the sampled respondents ranges from 1 to 11 hectares and the average farm size holding of total sampled respondents were 3.46 hectares. The average farm size holding of non-user sample respondent was 3.11 hectares while that of the user was 3.64 hectares. Hence, the analysis shows that, there was statistically significant mean difference among non-users and users at 10% level of significance (Table 9). The result of this study implies that the user sample respondent have more chance of use and intensity of use of inorganic fertilizer in maize production than non-user sample respondent. This is due to that they have held a large farm size which creates the opportunity of shifting cultivation for them. The result of this study is agreed with the research finding by (Dawit, 2017).

Livestock holding: Livestock production is one of the major components of agricultural sector in the study area. Livestock is the smallholder farmers' relevant source of income, food and draught power for crop production in Ethiopian agriculture in general and particularly in Nono Benja District. Hence, households with large livestock holding can have good access for more draught power and it is one of the main cash sources to purchase inputs like inorganic fertilizer. Based on Storck *et al.,* (1991), the livestock population number was converted into Tropical Livestock Unit (TLU), to facilitate comparison of livestock holding among the sample respondents. The maximum livestock holding by sample respondent was 21.01 TLU while the minimum was 0 TLU and the total average of livestock holding by sample respondents were 6.5 TLU. It was observed that the non-users and users sampled respondents had 4.6 TLU and 7.5 TLU respectively. Hence, the analysis has shown that, there was statistically significant mean difference among non-users and users at 1% level of significance (Table 9). This mean difference implies that the users have more chance of obtaining financial income by selling their livestock to purchase inorganic fertilizers and more chance of access to oxen power for crop land cultivation than non-user. In addition, users could use farm animals to transport their produce to the local markets and inputs from suppliers' center. The result of this study is agreed with the research finding by (Tirfu, 2011).

Farm income: Farm income refers to the total annual earnings of the respondents from sale of agricultural production. This is believed to be the main source of capital for purchasing inorganic fertilizer. In this study farm income was includes both incomes from the sale of crop and livestock production. Accordingly, the maximum annual farm income of the sample respondent was 35,000 ETB while the minimum was 1,200 ETB and the total average annual farm income of sample respondents was 7907.3 ETB. The average annual farm income for non-user sample respondents was 3682.83 ETB and for user sample respondents was 10130.7 ETB. Hence, the analysis shows that, there was statistically significant mean difference among users and non-users at 1% level of significance (Table 9). The result implies that users have got more farm income than non-users and this high farm income motivate the smallholder maize farmers to use inorganic fertilizer in maize production. The result of this study is consistent with research finding by (Mekuria, 2013).

Off-farm income: Off-farm income is an additional source of income for smallholder farmers. Off-farm income has its own influence on the decision to use agricultural new technology. In this study, the maximum annual off-farm income of the sample respondent was 16,000 ETB while the minimum was 0 ETB and the total average annual off-farm income of sample respondent was 1,280.61 ETB. The average annual off-farm income for non-user sample respondent was 114.08 ETB and for user sample respondent was 1,894.58 ETB. Hence, the analysis indicates that, there was statistically significant mean difference among users and non-users at 1% level of significance (Table 9). The result implies that users had got more off-farm income than non-users and this off-farm income increases additional income of the user respondent which leads to develop the capacity to invest in agricultural new technology like inorganic fertilizer use. However, the result of this study implies that participation of the respondents in off-farm income activity was poor in the study area, even though it is initiated them for use of agricultural new technologies like inorganic fertilizer. The result of this study is consistent with research findings by (Eba and Bashargo, 2014).

Frequency of contact with extension agent: The major sources of agricultural information for farmers are extension agents. Frequency of contact with extension agent makes the farmers being aware of new technologies and how they can be applied. In this study, the frequency of extension agent contact with the sampled respondents for information and technical advice were ranges from 0 to 4 days per month and the total average frequency of extension agent's contact with sample respondent was 1.7 days per month during production season. The average frequency of extension agent contact with non-user sample respondents was 1.02 day per month while with users was 2.05 day per month. Hence, the analysis shows that, there was statistically significant mean difference among users and non-users at 1% level of significance (Table 9). The result implies that users were contacted more with DA than non-users and a continuous contact with extension agent enhances the exposure of smallholder maize farmers on the use and intensity of inorganic fertilizer use in maize production. The result of this study is agreed with the research findings by (Tsehaye, 2008; Dawit, 2017).

On other hand, the report of respondents shown that 40.2% of the sample respondent was got information for agricultural farm from training prepared by District and other bodies rather than from DA(Appendix table 3). Also, the same idea was raised during focus group discussion and key informant interview that conducted at each kebele level regarding DA. As the group and key informant were raised the development agent could not give proper technical advice for them. They pointed out that most of a time the development agents (DAs) were spent their time in urban rather than staying at the employed rural kebeles and giving extension services. This results into low agricultural production and productivity and less than the recommended rate of agricultural technologies like inorganic fertilizer and improved maize seed application of the smallholder maize farmers of the study area.

Distance from input market: In this study, the sampled respondent travel ranges from 0.15 to 3 hours and on average the total sample respondent was travel 1.15 hours. The average non-user sample respondent was travel 1.23 hours while users was travel 1.10 hours with statistically insignificant mean difference among the groups (Table 9). The result implies that in the study area during survey time, distance of inorganic fertilizer market had no more influences on the use and intensity of inorganic fertilizer use in maize production.

In addition to this in the study area, the average distance that the respondent walks to sell their output was 1.35 hours (one hour and thirty-five minute) (Appendix table 4). This implies that both input and output market centers have relatively the same distance from the residence of sample respondents in the study area.

Table 9: Households' socio-economic characteristics by use and intensity of use of inorganic fertilizer (for continuous explanatory variables)

Variables	User(N=114)		Non-user(N=60)		T-value	Total sample(N=174)	
	Mean	Std. D	Mean	Std. D		Mean	Std.D
Farm size holding	3.64	2.051	3.11	1.314	1.8*	3.46	1.84
Livestock holding	7.48	3.18	4.60	2.24	6.25***	6.50	3.23
Farm income	10130.7	5899.8	3682.82	3389.68	7.87***	7907.29	6008.42
Off-farm income	1894.58	2814.5	114.08	383.25	4.87***	1280.61	2438.15
Contact with extension agent	2.05	1.03	1.02	1.15	6.013***	1.7	1.18
Distance from input market	1.10	0.44	1.23	0.728	-1.43	1.15	0.56

Source: Own survey result of 2017/2018 production season. *** & *significant at 1% & 10%

Perception on relative price of input-output: Cost of production was one of the factors that affect the use of agricultural new technologies like inorganic fertilizer. In the current study, the perception of the sample respondents on cost of the maize production with the application of inorganic fertilizer (the relative price of inorganic fertilizer and maize output) was collected and analyzed as follows. The result of the current study indicated that from the total sample respondent 3.4%, 16.1%, 29.9% and 50.6% of the farmers had perceived that the cost of production was low, medium, high and very high respectively. This implies that more than half of the sampled respondents argue that the cost of production was very high and the return from maize farming with inorganic fertilizer is not encouraging. From non-user sample respondent 3.33%, 1.67%, 21.67% and 73.33% of farmers had perceived that the cost of production was low, medium, high and very high respectively. Out of the user sample respondent 3.5%, 23.7%, 34.21% and 38.6% of farmers had perceived that the cost of production was low, medium, high and very high respectively. Hence, a chi-square ($\chi2$) analysis indicated that there was statistically significant difference in perception on relative price of fertilizer-maize among users and non-users at 1% level (Table 10). The result of the study implies that, non-user respondents had perceived very high cost of production more than user respondents. Moreover, inability to cost-benefit analysis, low production, inadequate road and low price of maize output were those makes the maize famers use and intensity of inorganic fertilizer use difference. The result of current study was harmony with the research finding carried out by (Fufa and Hassan, 2006).

Table 10: Respondents' perceptions on the relative price of input-output (for categorical variable)

Variable		Non-user		User		χ2	Total sample	
		N	%	N	%		N	%
Perception on relative price of inorganic fertilizer and price of maize output	Low	2	3.33	4	3.5	23.29***	6	3.4
	Medium	1	1.67	27	23.7		28	16.1
	High	13	21.67	39	34.21		52	29.9
	Very high	44	73.33	44	38.6		88	50.6
	Total	60	100	114	100		174	100

Source: Own survey result of 2017/2018 production season. *** Significant at 1% level

Application of compost: Farmers of the study area takes different actions to increase the fertility of their farm land. They used traditional means to increase the fertility of their farmlands among which the use of animal dung is the major one. Also, a few farmers in study area were prepared and used compost to improve the fertility of their farm lands. The result of this study revealed that from the total sample respondents, 14.37% was prepared and applied compost to their farmland while 85.63% of the sample respondents were not applied compost to their farm land. In addition to this, from non-adopter sample respondents 18.33% was applied compost to their farmland and 81.67% was not applied compost to their farmland while from adopter 12.3% was applied compost to their farmland and 87.7% was not applied compost to their farmland. Hence, in comparison among the non-user and user there was statistically insignificant difference in application of compost (Table 11).

Member of cooperative society: Cooperative societies are one of the important institutions in rural and agricultural sectors. The result of the current study showed that from the total sample respondents 40% was member of cooperative society whereas 60% of the respondents were not a member of cooperative society. Out of non-users, sample respondent 35% was a member of cooperative society whereas 65% was not a member of cooperative society. From user sample respondents 44.74% was a member of cooperative society whereas 55.26% was not a member of cooperative society. According to the chi-square ($\chi2$) analysis there was statistically insignificant difference in member of cooperative society among users and non-users (Table 11).

Use of input credit: In the study area, there are formal and informal source of credit service. From the formal source of credit service; Oromia saving and credit institution is the most known institution and most of a time the smallholder maize farmers in the study area have got credit from this institution. The results of the current study indicated that from total sample respondents 62.6% was reported lack of used to input credit and 37.4% was reported having uses to input credit for purchasing of agricultural inputs like inorganic fertilizer and improved maize seed. Out of non-user sample respondents 6.7% was users of input credit whereas 93.3% was non-users of input credit. From user sample respondents 46.6% were users of input credit whereas 53.4% were non-users of input credit. Hence, the chi-square ($\chi2$) analysis shows that, there were statistically significant difference in use of input credit among users and non-users at 1% level of significance (Table 11). The result of the study implies that adopter sampled respondents were used more input credit than non-adopter sample respondents. Moreover, as it was understood from the result of the study almost all of the non-adopter respondents were non-user of input credit while half of adopters were user of an input credit. The result of the current study is harmony with the research findings by (Tirfu, 2011; Dawit, 2017).

On other hand, regarding the use of input credit focus group discussion were conducted by researcher. During the focus group discussion, the groups were raised two main ideas. The first point raised on focus group discussion was the concern of credit institution especially Oromia credit and saving institution was focused on resource poor farmers and it gives input credit for resource poor farmers only. Other farmers were not got input credit by the assumption that they are better off to buy input like inorganic fertilizer on cash basis. However, as it was observed from focus group discussion and key informant interview, the reality that exists in the study area indicated that all the farmers need credit to buy inorganic fertilizer. The second point raised on focus group discussion by group was even they use credit on agricultural inputs, due to the high interest rate of input credit they were not benefited from the input credit. Therefore, these two main points widen a gap between the use of inorganic fertilizer and credit use in the study area even significant association was existed between inorganic fertilizer use and use of input credit.

Table 11: Households' socio-economic characteristics by use and intensity of use of inorganic fertilizer (for dummy explanatory variables)

Variables		Non-user		User		$\chi 2$	Total sample	
		N	%	N	%		N	%
Use of compost	Yes	11	18.33	14	12.3	2.66	25	14.4
	No	49	81.67	100	87.7		149	85.6
Member of cooperative society	Yes	21	35	51	44.74	1.53	72	41.4
	No	39	65	63	55.26		102	58.6
Use of credit	Yes	4	6.7	53	46.6	28.30***	65	37.4
	No	56	93.3	61	53.4		109	62.6

Source: Own survey result of 2017/2018 production season. *** Significant at 1% level

4.2. Econometric Model Results

In the previous section, it was dealt mainly with description of the sample respondents and test of the existence of association between the dependent and explanatory variables to identify factors determining use and intensity of use of inorganic fertilizer in maize production. However, identification of these factors alone is not enough to stimulate policy actions unless the relative influence of each factor is known for priority based intervention. Accordingly, an econometric Heckman's selection model was employed.

Before running the Heckman two-step model, the hypothesized explanatory variables were checked for multicollinarity problem. The result of VIF indicated that values for continuous variables were found to be small for all variables which are less than ten (Appendix table 5).

This shows that there is no serious multicollinarity problem among continuous variables. Hence, all of them were included in the model. Similarly, contingency coefficients (CC) were computed in order to check the degree of association among dummy variables. The results of the analysis indicated that there was no serious multicollinarity problem of association among dummy variables which is less than 0.75(Appendix table 6).

Also, the model goodness of fit was checked by chi-square test and the result indicated that the overall goodness of fit for Heckman selection model was statistically significant at a probability less than 1% level (Appendix table 7). This shows that jointly the independent variables included in the selection model regression explain the extent of fertilizer use.

4.2.1. Determinants of inorganic fertilizer use in maize production

In this sub section, we treat results concerning demographic, socio-economic and other factors that determine the use of inorganic fertilizer in maize production behavior of household heads. The model output of heckman selection model; probit/ adoption equation shows that seven variables were affects the probability of inorganic fertilizer use in maize production. These variables are: age and education level of household head, total livestock holding, farm income, household head perception on relative price of input-output, frequency of contact with extension agent and use of input credit. On the other hand, under this section since the coefficient cannot report directly, the marginal effect is calculated and used to report the probability of use of inorganic fertilizer in maize production (Appendix table 8).

Age of the household head (AGHH): Contrary to prior expected age of household heads was found to be statistically significant variable at 10% ($p<0.093$) level with a positive relationship. This implies that, the increase in age of sample respondents had a positive influence on use of inorganic fertilizer in maize production. The result of the study indicates that, the increase in the age of household head by one more year would leads to the increase in the probability of inorganic fertilizer use in maize production by 0.5%. This might be related the reason that older farmers might gained knowledge. Moreover, older farmers may accumulate more wealth than younger and so older ones may still be intensive in inorganic fertilizer use even as they grow older. The result of this study was consistent with research findings by Beshir *et al*. (2012) and Sisay (2016) whom showed that a positive association between inorganic fertilizer use and age of household head.

Education level of household head (EDLHH): In this study, as a prior expectation education level of household head was found to positively and significantly influence the probability of inorganic fertilizer use in maize production at 1% (P<0.000) level of significance. The result of this study indicated that, the increase in the number of years of formal schooling of the head of a household by one more schooling year would lead to increases the probability of inorganic fertilizer use in maize production by 4.01%. This implies that, having education level of smallholder maize farmers will improve the ability to use information, process and interpret information concerning agricultural technology. The result of this study was consistent with the finding by Eba and Bashargo (2014), who stated that adoption of inorganic fertilizer was positively associated with level of farmers' education.

Livestock holding (LVSH): Livestock holding was in line with the prior expectation and found to be statistically significant variable at 1% (P<0.005) level with positive relationship. The result implies that, the increase in livestock holding (in tropical livestock unit) of the head of household by one more TLU would lead to the increases in the probability of inorganic fertilizer use in maize production by 2.6%. This implies that, as livestock value increases the income of the smallholder maize farmers increases which leads to increases the purchasing power of inorganic fertilizer of the smallholder maize farmer. Since the area is bordered by the Gibe river which means the availability of grass and water were high, both crop and livestock production are integrated and are connected to each other. On the other hand, this could be due to the fact that households with more number of livestock holding do minimize the capital constraints to purchase agricultural inputs as well as capacitate their risk taking behavior to use agricultural new technology like inorganic fertilizer. This study was consistent with the research findings by Ketema and Bauer (2011) and Yirga and Hassan (2013). Their results suggested that improving herd size (e.g. improving access to veterinary service) will have positive impact on raising adoption and expected use of inorganic fertilizer.

Farm income (FMICMH): As prior hypothesized farm income was found to be positively and statistically significant at 5% (P<0.010) level of significance in influencing on the use of inorganic fertilizer in maize production. Accordingly, as farm income of the head of household increase by one ETB would lead to the increase in the probability of inorganic fertilizer use in maize production by 0.001%. The result of the study implies that, smallholder farmers who got income from their annual agricultural production could invest his/her proportion of income to buy inorganic fertilizer as well as purchasing other agricultural inputs. Moreover, smallholder maize farmers with higher annual farm income tends to use inorganic fertilize in maize production. The result of this study was consistent with research findings carried out by (Mengistu and Degefu, 2017). They stated that availability of more farm income reduces financial limitation for the purchase and use of inorganic fertilizers.

Perception on relative price of input-output (PRPIO): Household heads' perception on cost of production (the relative price of inorganic fertilizer and maize output) had the expected negative and statistically significant impact on inorganic fertilizer use in maize production at 1% (P<0.005) level. The result of the study implies that, being perceive of very high cost of production of the head of household would lead to the decreases in the probability of inorganic fertilizer use in maize production by 5.6%. This result implies farmers' perception that the currently very high cost of inorganic fertilizer and very low price of maize output decreased use of inorganic fertilizer in maize production. In general, the result implies that most of a time smallholder maize farmers think about the cost of inorganic fertilizer relative to price of maize output; rather than thinking how to improve the maize productivity. The result of this study was consistent with the research findings by (Fufa and Hasan, 2006).

Frequency of contact with extension agent (FCWEA): Frequency of contact with extension agent was a positively and statistically significant variable at 1% (P<0.006) level of significance in affecting the use of inorganic fertilizer in maize production. The result of the study revealed that, the increase in the frequency of extension agent contact with the head of household by one more day per month would lead to the increase in the probability of inorganic fertilizer use in maize production by 4.4%. This result implies that frequency of contact with extension agent was enhanced the exposures of farmers on adoption practices, increases the probability of acquiring updated information on the new agricultural technologies. This study was consistent with research finding carried out by (Dereje *et al.,* 2016). Extension was proven to have the highest impact on inorganic fertilizer use.

Use of input credit (UICRD): Use of input credit was a positively and statistically significant variable at 5% (P<0.014) level in affecting the use of inorganic fertilizer in maize production. The result of the study indicated that, being user of input credit of the head of household would leads to an increase in the probability of inorganic fertilizer use in maize production by 10.5%. From this result, it can be stated that those farmers who have use formal credit are more probability of inorganic fertilizer uses in maize production than those not using formal credit. In other words, farmers who have use credit are more likely use inorganic fertilizer. Moreover, households who need and getting formal credit for purchasing of inorganic fertilizer was increase the probability growing of maize than those not use. The result also indicated that credit is very helpful in relieving capital constraints faced by smallholder maize farmers for using inorganic fertilizer and other purchased input. This result was consistent with the finding by (Tsehay, 2008; Tirfu, 2011; Ketema and Bauer, 2011; Jaleta *et al*., 2013).

Table 12: Parameter estimates of Heckman's two steps for the likelihood of inorganic fertilizer use in maize production (Probit estimation) and its marginal effect.

Variables	Coef.	Std. Err.	T-ratio	Marginal effect
Age of household head	0.103	0.063	1.68*	0.005
Sex of household head	0.226	1.257	0.18	0.011
Education level of household head	0.801	0 .214	3.74***	0.040
Adult equivalent labor	-0.021	0.256	-0.08	-0.001
Farm size holding	-0.228	0.169	-1.35	-0.011
Livestock holding	0.517	0.185	2.79 ***	0.026
Farm income	0.001	0.001	2.53**	9.68e-06
Perception on relative price of input-output	-1.122	0.402	-2.79 ***	-0.056
Off-farm income	0.000	0.0003	0.42	5.61e-06
Use of compost	0.054	0.688	0.08	0.003
Frequency of contact with extension agent	0.893	0.323	2.77***	0.044
Member of cooperative society	-0.702	0.754	-0.93	-0.035
Distance from input market	-0.582	0.483	-1.20	-0.029
Use of input credit	2.094	0.855	2.45**	0.105
cons	-5.259	3.611	-1.46	

Number of obs =174 Wald chi2(13) =138.32 Prob > chi2 = 0.0000

Log likelihood = -529.4703

Note: ***, ** and* shows the values of statistically significant at 1%, 5% and 10 probability level of significance respectively.

Source: Own survey data result of 2017/2018 production season.

4.2.2. Determinants of intensity of inorganic fertilizer use in maize production

The intensity of inorganic fertilizer use in maize production has estimated according to the model put in the methodology party. We note that the dependent variable of the model is the intensity of inorganic fertilizer use in maize production. Hence, the regression coefficients measure the unit of inorganic fertilizer use change in maize production for a unit change in the explanatory variable.

In this subsection the covariant that we used to analyze the adoption of inorganic fertilizer are also used to identify the factors that affect the intensity of inorganic fertilizer use. However, Heckman Model has been suggested that the covariates in the selection function should contain one or more variables related to the probability of selection equation, but excluded from outcome equation (Briggs, 2004). Accordingly, the variable age of household head has been excluded from the intensity of inorganic fertilizer use (outcome equation) and used only on corresponding adoption of inorganic fertilizer (selection equation). The correlation of this variable with other variables in the intensity of inorganic fertilizer use equation is tested and the test result revealed that this variable doesn't have correlation with any one variable in the intensity of inorganic fertilizer use equation.

In outcome equation of the model, six (6) variables are found to be significant determinants of household head intensity of inorganic fertilizer use in maize production. These are: education level of household head, livestock holding (TLU), perception on relative price of input-output, off-farm income, frequency of contact with extension agent and Inverse mill ratio (LAMBDA) (Table 13).

Inverse mill ratio (LAMBDA): According to the model output inverse mill ratio (Lambda) for the intensity of inorganic fertilizer use was significant, indicating that selection bias would have been resulted if the intensity of inorganic fertilizer use had been calculated without taking into account the decision to use inorganic fertilizer. That is selection effects become important, the Inverse mill ratio is significant at 5% ($P<0.034$) level. Hence, this justifies the use of heckman's two-step procedure. The positive sign suggested that the error terms in the adoption equation and intensity of adoptions are positively correlated. This shown that those unobserved factors that determine household use of inorganic fertilizer in maize production are likely to be positively associated with household intensity of inorganic fertilizer use in maize production.

Education level of household head (EDLHH): The variable has positive and statistically significant affect on household head's intensity of inorganic fertilizer use in maize production at 1% (P<0.000) level of significance. The coefficient of variable shows that as the household head gets one more of formal education in school of year, the intensity of inorganic fertilizer use in maize production was increases by 4.94 kg, keeping other variables constant. The results of a regression analysis indicated that educated household heads has an influence on incremental use of inorganic fertilizer in maize production. As the education level of the household head increased, the intensity of inorganic fertilizer application in maize production also increased. This is presumably arises from a better understanding of the usefulness of inorganic fertilizers and it may also imply better crop management. The result of this study was harmony with the research findings by (Tedla, 2011; Yirga and Hassan, 2013).

Livestock holding (LVSH): This variable is positively and statistically significant association with household head's intensity of inorganic fertilizer use in maize production at 5% (P<0.017) level of significance. The coefficient of the variable shows that as the household head's livestock holding increase by one more TLU, the intensity of inorganic fertilizer use in maize production was increases by 1.87 kg, keeping others variables constant. This may lead to improve the extent of inorganic fertilizer use in maize production of smallholder maize farmers. The positive relationship indicates that households with larger livestock holding may have the opportunity to get financial by selling their livestock which lead to increases purchasing power of inorganic fertilizer. Also, it has the opportunity to plough at any time with minimum labor cost, especially for oxen. The result of this study was consistent with the research finding by (Mengistu and Degefu, 2017).

Perception on relative price of input-output (PRPIO): This variable is negatively and statistically significant association with household head's intensity of inorganic fertilizer use in maize production at 1% (P<0.002) level of significance. The coefficient of the variable shows that, being perceive of very high cost of production of the head of household decreases the intensity of inorganic fertilizer use in maize production by 7.35 kg, keeping other variables constant. The negative relationship indicated that the household's perception on cost of production (very high cost of inorganic fertilizer and very low price of maize output) reduces the amount of inorganic fertilizer uses in maize production. This might be due to the smallholder maize farmers observe cost of one quintal of inorganic fertilizer relative to price of one quintal of maize output rather than observing how much quintal of maize product he or she can produce by applying one quintal of inorganic fertilizer in maize production at recommended rate. The result of this study was consistent with the research finding carried out by (Muthyalu, 2013). This situation may happen due to the fact that most of a time smallholder farmers were not calculate their cost benefit.

Off-farm income (OFFMINC): Is another economic factor that was positively and statistically significant in affecting the respondents' intensity of inorganic fertilizer use in maize production at 5% (P<0.049) level of significance. The coefficient of the variable indicated that as the head of household get one more income in ETB from off-farm income the intensity of inorganic fertilizer use in maize production was increases by 0.002 kg, keeping other variables constant. This might be because of off-farm income was additional source of income for smallholder farmers and the cash generated from these activities increases the purchasing power of agricultural new technology like inorganic fertilizer and improve maize seed and it develops the capacity of invest on agricultural new technologies. The result of this study was consistent with the research finding carried out by (Beshir *et al.,* 2012).

Frequency of contact with extension agent (FCWEA): This variable had a positive and statistically significant influence on the respondents' intensity of inorganic fertilizer use in maize production at 1% (P<0.000) level of significance. The coefficient of the variable indicated that, as the frequency of extension agent contact with the head of household increase one more day per month the intensity of inorganic fertilizer use in maize production was increases by 6.5kg, keeping other variables constant. The result implies that frequency of contact with extension agent for technical advice and information enhances the household head intensity of inorganic fertilizer use in maize production. It is also important in applying the recommended level of inorganic fertilizer in maize production. In addition this implies that, extension agent have an important role to play in creating awareness among smallholder farmers as well as educating them on intensity of inorganic fertilizer use in maize production. The result of the study was agreed with the research finding by (Yirga and Hassan, 2013).

Table 13: Parameter estimates of Heckman's two step for Intensity of inorganic fertilizer use in maize production (kg ha^{-1}) (OLS estimation)

Variables	Coef.	Std. Err.	T-ratio
Sex of household head	0.906	7.400	0.12
Education level of household head	4.941	0.888	5.56***
Adult equivalent labor	-1.090	1.909	-0.57
Farm size holding	1.968	1.206	1.63
Livestock holding	1.876	0.784	2.39**
Farm income	0.000	0.001	0.92
Perception on relative price of input-output	-7.353	2.385	-3.08***
Off-farm income	0.002	0.001	1.97**
Use of compost	-2.069	6.606	-0.31
Frequency of contact with extension agent	6.483	1.272	5.10***
Member of cooperative society	-5.521	5.146	-1.07
Distance from input market	2.079	4.992	0.42
Use of input credit	7.019	4.537	1.55
Cons	112.407	15.722	7.15***
Inverse mill ratio (Lambda)	16.513	7.795	2.12**
Number of obs = 174 Wald chi2(14) =138.32 Prob > chi2 =0.0000			
Censored obs = 60 Uncensored obs = 114			

Note: ***'and ** show the values of statistically significant at 1% and5% probability level of significance respectively.

Source: Own survey datat result of 2017/2018 production season.

4.3. Profitability of Inorganic Fertilizer Use in Maize Production

Before proceeding to the calculation of the profitability of inorganic fertilizer use in maize production the underlying assumption must be explicit. Hence, the following points were considered in the calculation of profitability of inorganic fertilizer use in maize production.

- Farm activities undertaken on one hectare of maize land during 2017/2018 production season were considered.
- Average maize productivity using inorganic fertilizer and both harvested (at green and dry period) were considered.
- Price received/paid by users' respondent was different from sampled kebele to sampled kebele. Due to that, average price received/paid was considered at farm gate.
- Transportation cost was the average cost for donkey and cart that was paid for both input and output marketing during 2017/2018 production season was considered at farm gate.
- Since each farmer has maize plots with different soil fertility status, flooding status, the opportunity cost of each farm will vary so the opportunity cost given by each farmer was considered as it is.
- For interest rate calculation a 17% interest rate per month was considered which is available at Oromia credit and saving institute (OCSI)
- The price of pair of oxen/per day was estimated based on rental value in average in each kebeles.
- Labor cost was calculated based on the price or wage of labor in average in each kebele.
- The use of farm manure was excluded as they do not have a direct monetary cost and most of the smallholder maize farmers couldn't use it.

4.3.1. Gross income of maize production by using inorganic fertilizer

The average yield of maize by using inorganic fertilizer for those users sampled respondents were 29 quintal per hectare with a standard deviation of 8.44(Table 14). This average maize productivity is below the national average of about 36.6 quintal per hectare (CSA, 2016/2017). Maize producers generate income from sales of maize product. In this study the average gross income generated by the user sampled respondents was 14,471.87 ETB per hectare with the standard deviation of 4016.98 (Table 14).

Table14: Profit analysis of maize production using inorganic fertilizer per hectare

Elements of revenues and costs	Mean	St. D
A. Revenue		
Maize productivity in quintal per hectare	29.100	8.440
Price of maize in birr per quintal	497.315	21.820
Total revenue that households gets from maize birr per hectare	**14,471.870**	**4016.980**
B. Cost		
1.Material input cost		
Amount of seed that households used in kilogram per hectare	18.697	2.300
Price of seed in birr per kilogram	46.174	3.380
a. Total cost of maize seed in birr per hectare	**863.310**	**135.730**
Amount of NPS used by household in kilogram per hectare	82.850	15.180
Price of NPS in birr per kilogram	14.412	0.096
b. Total cost of NPS in birr per hectare	**1,194.040**	**144.310**
Amount of Urea used by household in kilogram per hectare	60.080	30.700
Price of Urea in birr per kilogram	10.479	0.030
c. Total cost of Urea in birr per hectare	**629.570**	**328.940**
1.1. Total material input cost(a+b+c)	**2,686.920**	**414.58**
2.Opportunity cost of land rent(birr/ha)	**1,500.650**	**105.340**
3.Animal power cost		
Amount of oxen required to plow one hectare (in oxen day per hectare)	8.000	0.000
Rental rate of pair oxen (price per pair of oxen day)	60.846	3.620
Frequency of plowing by household head	4.013	1.060

d. Total cost of oxen power required for plowing(in birr per hectare)	**1,953.400**	**115.760**
e. Animal power cost required for transport(birr per km)	**151.690**	**8.150**
3.1. Total animal power cost (d+e)	**2,105.090**	**115.050**
4. Labor cost		
Amount of labor required to plow a hectare (person day per hectare)	8.000	0.000
Labor wage to plow (wage per person day)	37.990	5.570
Frequency of labor required to plow a hectare by household	4.050	1.060
f. Total labor cost required for plowing(birr per hectare)	**1,230.880**	**178.250**
Amount of person required to weed (person day per hectare)	17.090	1.900
Frequency of weeding by household head	3.350	2.010
Labor wage to weeding(wage per person)	32.318	4.370
g. Total labor cost required for weeding (birr per hectare)	**1,850.260**	**344.840**
Amount of person required to harvest(person per day)	12.160	1.630
Labor wage to harvest (wage per person day)	19.762	7.310
h. Total labor cost required for harvesting(birr per hectare)	**240.310**	**1.230**
Amount of labor required to winnowing (person day per hectare)	24.857	3.420
Labor wage to winnowing (wage per person day)	35.210	3.120
i. Total labor cost required for winnowing (birr per hectare)	**875.230**	**2.410**
4.1. Total labor cost(f+g+h+i)	**4,196.140**	**273.950**
5. Cost of pesticide	**446.400**	**82.7420**
6. Interest rate on input credit(NPS, Urea &improved maize seed (birr/ha)	**1,319.720**	**309.510**
Total cost in birr per hectare (1.1+2+3.1+4.1+5+6)	**12,254.920**	**1209.690**
Net profit (revenue-cost)	**14,471.87-12,254.92=2,216.95**	

Source: Computed from own survey result of 2017/2018 production season

4.3.2. Cost of maize production using inorganic fertilizer

The results from table 14 above indicated that cost per hectare of various inputs used for maize production. The average total cost per hectare used for maize production by those users of inorganic fertilizer in maize production was 12,254.92 ETB ha^{-1} with a standard deviation of 508.12. Labor cost (wage value of labor) was the element taking maximum share in total cost (34.3%) followed by material input cost like maize seed, NPS and Urea (22%) and animal power cost (17.2%). Opportunity cost of land (rental value of land) takes the share of (12.1%) out of the total cost and value of other costs like cost of pesticide and interest rate on input credit shares (14.4%) from the total cost of production. These costs are summarized as follows:

Labor cost

Maize production by using inorganic fertilizer was labor intensive farm activity. From the labor cost weeding labor was ranked first. Out of the total labor cost 44.1% of the cost expenditure goes for weeding labor and followed by plowing labor cost 29.33%, winnowing labor cost 20.85% and harvesting labor cost 5.72% in the cost component for maize production.

Material input cost

Out of the material input cost, the percentage share of NPS was about 44.5% and followed by improved maize seed 32.1% and Urea 23.4% in the cost of material input for maize production.

Animal power cost

From animal power cost, the share of oxen power for a plow was the higher, with a share of 92.8% cost and the share of animal transporting cost was 7.2%.

Others cost (pesticide and interest rate on input credit)

Cost of pesticide was based on amount of yield obtained by user sample respondent and from yield amounts; the amount that the respondents want to store was taken for this calculation. Accordingly, out of the total others cost, the cost of pesticide takes the share of 22.3% (446.4 ETB) and the interest rate on input credit for user sample respondents was takes a share of

74.7% (1,319.72ETB) per hectare. Smallholder maize farmers obtained credit from Oromia credit and saving institute (OCSI) and the interest rate on input credit was about 17% per month. In this study, the interest rate of credit was calculated from the credit taken for material input like NPS, Urea and Improved maize seed by user sampled respondents for one hectare of maize land.

4.3.3. Net profit

Based on the formula put in the methodology section the revenue and cost calculated, in the current study the total revenue that sample respondents those users of inorganic fertilizer in maize production had got 14,471.87 ETB hectare^{-1} whereas the total cost that the user sample respondents incurred for maize production by using inorganic fertilizer was 12,254.92 ETB ha^{-1}. Therefore, net profit of sample respondents was calculated as follows (14,471.871-12,254.92=2,216.95 ETB ha^{-1}). The average net profit of sample respondents those users of inorganic fertilizer in maize production were 2,216.95ETB ha^{-1} after covering all costs incurred during maize production. This result shown that, use of inorganic fertilizer in maize production in Nono Benja District was profitable. In the study area through the calculation of profit even though the existing maize productivity and price level makes on average the use of inorganic fertilizer in maize production profitable, the net profit obtain by sampled producer was low or poor.

On the other hand figure 3 below gives the kernel density estimate of the distribution of user sampled respondent by their respective profit per ha. The figure of kernel density estimation of the distributions of the user sampled respondents by their profit per ha indicate that, most of the user sampled respondents were profitable and distributed at the profit area. Also, the distribution indicates that some farmers were more profitable from inorganic fertilizer use in maize production. This might be due to high productivity of them relative to others. Though farmers on average make positive profit, inorganic fertilizer use is not always reflect profit as some considerable smallholder maize farmers are still making some loss in maize production (Fig.3).

Therefore, the low or negative profit is arise due to improper use of inputs like inorganic fertilizer and improved seed, poor agronomic practice, poor price of maize product, difficulties in selling surplus product because of weaknesses in the private sector in maize marketing and transport; inadequate credit for farmers to purchase improved seed and inorganic fertilizer; and in general low profit is raised from a combination of low yields and poor marketing strategies. This idea indicated that, productivity and price of maize are the major determinants of profitability of inorganic fertilizer use in maize production. An inorganic fertilizer brings about increase in output which subsequently leads to increase profit. Hence, enhanced profit could be achieved through using agricultural new technologies properly in crop at recommended rate, applying at appropriate time and practicing the best agronomic management.

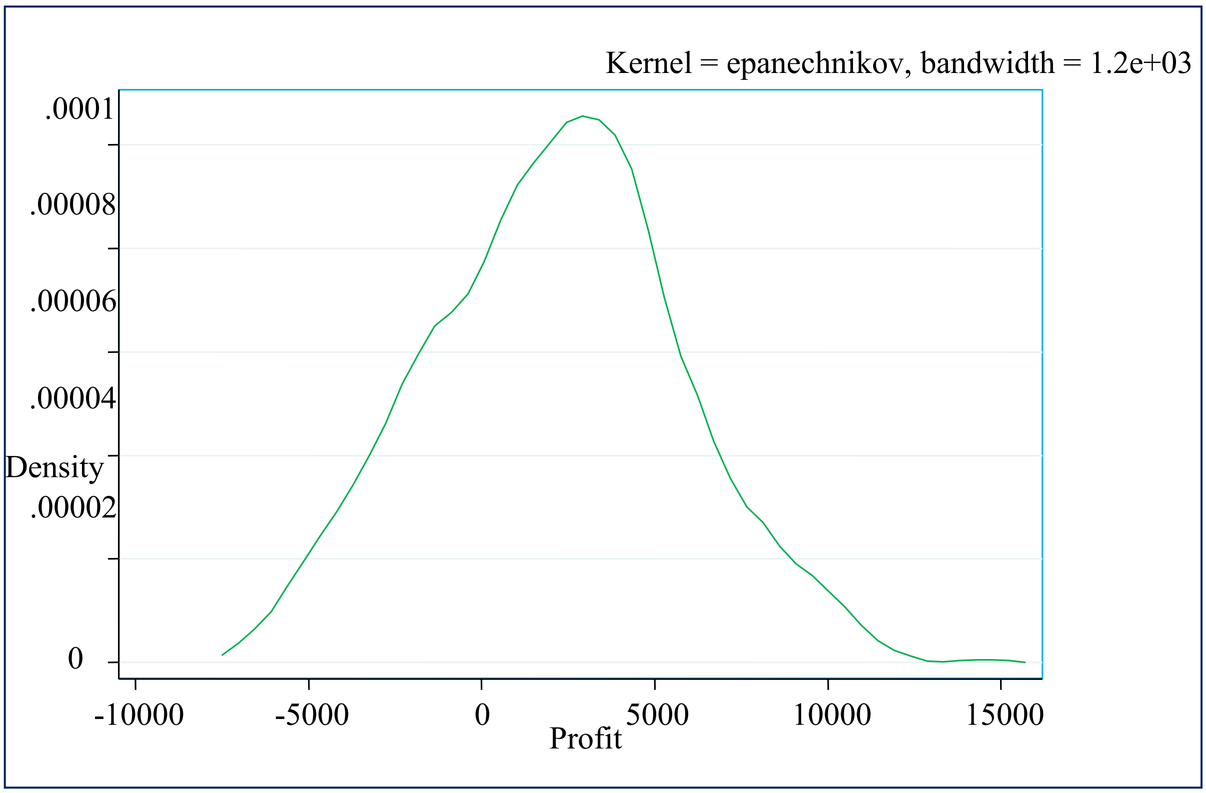

Figure 3: Kernel density estimate of distribution of respondents by their respective profit

Source: Own source of survey data 2017/2018 production season

4.4. Ranking of Constraints Associated with Use and Intensity of Inorganic Fertilizer Use

There are numerous constraints that hamper the use and intensity of inorganic fertilizer use among smallholder maize producers in Nono Benja District. Some of these constraints were identified and consolidated for the sake of this study. The constraints that were identified includes: High cost of inorganic fertilizer, Lack of credit for input, High interest rate on credit, Low return on inorganic fertilizer use, lack of uniform rain fall distribution, Perception of having fertile land, Absence of choice packaging amount, Inefficient inorganic fertilizer distribution, Distance of inorganic fertilizer marketing from residence, Late arrival of inorganic fertilizer, Poor quality of inorganic fertilizer and Lack of knowledge on inorganic fertilizer use. Under this subsection those constraints and their mean ranks and total weight score sum of ranks were presented in table 15 and appendix table 9 respectively.

The result of the Kendall's coefficient of concordance is presented (Table 15). The coefficient of concordance calculated was 0.680 (68%). The value indicates the degree of agreement in general to the rankings of the constraints. Hence, the Kendall's coefficient of concordance (W) analysis shows that 68% of the respondents were in agreement with each other on the ranking of the constraints in the study area. The result in table 15 also shows that there is agreement among the ranking and it is fairly high; since Kendall's coefficient of concordance (W) is 0.680 (68%). The result was asymptotically significant at 1% level of significance and had a chi-square value of 1301.109. Thus, we rejected the null hypothesis (H_o), which states that there was no agreement among the respondents over them ranking of the constraints of use and intensity of inorganic fertilizer use. Hence, H_1 was accepted and there was agreement among the respondents on the ranking of the constraints. Therefore, the main constraints put into the following categories based on the identification and rankings by the sampled respondents.

High cost of inorganic fertilizer: High cost of inorganic fertilizer was found to be the most important constraint to use and intensity of inorganic fertilizer use in maize production according to the ranking of respondents. Despite the high cost of inorganic fertilizer, the smallholder maize farmers in the study area tend to produce maize without using inorganic fertilizer or using less than the recommended rate. These ways of production practice of smallholder maize farmers have a negative consequence for the incremental of maize production and the constraint was ranked at first by sampled respondents.

Lack of credit for input: Lack of credit for input use was found to be the second ranked most constraint by sampled respondents in the study area. Credit has its own influence on inorganic fertilizer use and its intensity of use. Lack of credit use for input like for inorganic fertilizer and improved seed has a negative influence on the increases of maize production. In the study area many farmers' were complained of not having opportunities to use credit of any kind to enhance their farming activities. This makes the production and productivity of crops in the area too low.

High interest rate on credit: High interest rate on the credit was the third ranked most constraint by sampled respondents in the study area. The sample respondents of the study area was raised the interest rate on credit was high. Due to this most of the smallholder maize farmers were reluctant to use of input credit. This implies high interest rate on credit has a negative influence on the use and intensity of inorganic fertilizer use in maize production which leads to low maize production and productivity consequently low income and low profit.

Low return on inorganic fertilizer use: Low return on inorganic fertilizer use was the fourth ranked by sampled respondents and the most constraint that influence the use and intensity of inorganic fertilizer use in maize production. This constraint was highly raised from a point of view of low farm gate price and low maize yield. Hence, this constraint has a negative influence on the use and intensity of inorganic fertilizer use in maize production in the study area.

Lack of uniform rain fall distribution: Lack of uniform rain fall distribution was the fifth ranked constraint by sampled respondents and the most constraint that faced the smallholder maize farmers of the study area. The sample respondents of the study area raise this constraint accordingly; the rain was started late and stopped early in the area since the last five-year ago. This constraint makes the smallholder maize farmers of the study area lose of their product. Due to that, some of the smallholder maize farmers of the study area reluctant to use and intensity of inorganic fertilizer use in maize production because of they lost their production.

Perception of having fertile land: Perception of having fertile land was the sixth ranked constraint by sampled respondents and the most constraint encountered the smallholder maize farmers in the study area. The sample respondents of the study area had perceived his or her land was fertile and no need of additional fertilizer for it or it needs little inorganic fertilizer due to it was some extent fertile. This perception of having fertile land and use and intensity of inorganic fertilizer use in maize production have a negative relationship which leads to low maize production and productivity in the study area. In reality the land of all smallholder maize farmers of the study area were need additional fertilizer at extension recommended rate.

Absence of choice packaging amount: Absence of choice packaging amount was the constraint ranked at seventh by sampled respondents. This constraint was raised from a point of view of availability and choice of packaging amount. In the study area, this constraint makes production and productivity of maize low due to lack of the choice package amount and availability of technology like inorganic fertilizer and improved maize seed in maize production.

Inefficient inorganic fertilizer distribution: In the study area, inefficient inorganic fertilizer distribution was a constraint ranked at eighth by sampled respondents. This constraint was raised especially on cooperative society committees those distribute inorganic fertilizer at each kebele level. The sample respondents pointed out service of cooperative's committee members who are assigned for the sale (distribution) of inorganic fertilizer are not frequently available, as a result obtaining of inorganic fertilizer sometimes delayed. Hence, farmers shouldn't miss planting time; they are forced to sow crops without inorganic fertilizer use. Moreover, they also complain about unfair marginal profit added on the inorganic fertilizer price by the cooperatives. This makes the use and intensity of inorganic fertilizer use in the study area too low.

Distance of inorganic fertilizer marketing from residence: Distance of inorganic fertilizer marketing from residence was a constraint ranked at ninth by sampled respondents, and they were reported that the constraint is related with the road accessibility was poor in the study area. This constraint makes the use and intensity of inorganic fertilizer use to low and it leads to low production and productivity of maize in the study area. Especially this constraint was influences the use of Urea in the study area. Because Urea arrive in the area during rainy season and during that period accessibility of the road to rural kebeles was highly in problematic. This makes some smallholder maize farmers of the study area to apply NPS without Urea and to use less than the recommended rate of inorganic fertilizer in maize production.

Late arrival of inorganic fertilizer, poor quality of inorganic fertilizer and lack of knowledge on inorganic fertilizer application was ranked at 10th, 11th and 12th respectively by sampled respondents. These constraints are low level of influences on the use and intensity of inorganic fertilizer use in maize production; according to the rankings by respondents. In general, the result of this study was consistent with research finding (Tirfu, 2011; Basha, 2016; Joseph, 2016).

Table 15: Rankings of constrains of use and intensity of inorganic fertilizer use by respondent

Constraints	Mean Rank	Overall rank
High cost of inorganic fertilizer	1.41	1st
Lack of credit for input use	2.36	2nd
High interest rate on credit	3.79	3rd
Low return on inorganic fertilizer use	5.24	4th
lack of uniform rain fall distribution	5.29	5th
Perception of having fertile land	6.81	6th
Absence of choice packaging amount	6.84	7th
Inefficient inorganic fertilizer distribution	7.94	8th
Distance of fertilizer marketing from residence	8.45	9th
Late arrival of inorganic fertilizer	8.89	10th
Poor quality of inorganic fertilizer	10.34	11th
Lack of knowledge on inorganic fertilizer use	10.64	12th

Note: Kendall’s W=0.680, M=174, n=12, X2 =1301.109, Asympt.sign=0.000, df=11

Source: Own survey result of 2017/2018 production season

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary

This study was conducted in Nono Benja District. Inorganic fertilizer technology was introduced about two decades ago in the District. However, in the area a lot of smallholder farmers are still not using inorganic fertilizer in maize production and intensity of inorganic fertilizer use was less than the recommended rate and the profitability of those farmers who use inorganic fertilizer in maize production was low. Hence, this study was conducted to assess the determinants and profitability of inorganic fertilizer use in maize production among smallholder farmers in the study area.

In the current study, two stages random sampling procedure was employed. First, by considering maize production uniformity in all kebeles of the District and taking the time, budget and human resource necessary for the study, from the total 19 rural kebeles, four kebeles were randomly selected to represent the whole kebeles of the District. Second, a total 174 (114 user and 60 non-user) smallholder maize farmers were randomly selected.

Both quantitative and qualitative data were collected from both primary and secondary sources and used for the current study. The data was collected through structured interview schedule, focus group discussion and key informant interview. Four method of data analysis were employed for this study. Namely, descriptive statistic, econometrics (Heckman's selection model), profit calculation and Kendall's coefficient of concordance were employed to analyze the collected data.

The result of descriptive analysis indicated that, the average fertilizer application rate by the total user sampled respondents were 142.8 kg ha^{-1}. An average dose of NPS and Urea applied by the users' sampled respondent were 82.8 kg ha^{-1} and 60 kg ha^{-1} respectively. Also, the result of descriptive shown that out of the total 14 explanatory variables, 8 variables were statistically significant difference among adopter and non-adopter at 1% and 10% level of significance.

The result from Heckman two-step models indicated that in the selection equation (probit) a total of 14 explanatory variables included in the model and 7 explanatory variables were found statistically significant in influencing the decision to use of inorganic fertilizer. Accordingly, age and education level of household head, livestock holding, farm income, frequency of contact with extension agent and use of input credit were found to be a positive and significant affect on the decision to use, whereas household head perception on cost of production (relative price of input-out) has a negative and significant affect on the decision to use of inorganic fertilizer. In the heckman two steps; outcome equation (OLS) a total of 14 explanatory variables included in the model and 6 explanatory variables were found statistically significant in determining the intensity of inorganic fertilizer use. Accordingly, education level of household head, livestock holding, off-farm income, frequency of contact with extension agent, were found to be positively and significantly determine the intensity of use, whereas household head perception on cost of production (relative price of input-out) has a negative and significant affect on the intensity of fertilizer use in maize production.

In the study area, the profit analysis shows that inorganic fertilizer use in maize production was profitable at existing productivity and price level of maize product. The average profit of sample respondents those users of fertilizer in maize production were 2,216.95ETB ha^{-1}.

In the rankings of the constraints by respondents in the study area, the result of Kendall's coefficient of concordance shows that 68% of the respondents were in agreement with each other on the ranking of the constraints of use and intensity of fertilizer use in maize production. Accordingly, High cost of fertilizer, Lack of input credit, High interest rate on credit, Low return on fertilizer use, Lack of uniform rain fall distribution, Perception of having fertile land, Absence of choice packaging amount, Inefficient fertilizer distribution, Distance of fertilizer marketing from residence, Late arrival of inorganic fertilizer, Poor quality of fertilizer and Lack of knowledge on fertilizer were the major constraints that the farmers agreed as the most pressing constraints they faced in their farming.

5.2. Conclusions

In the study area, the level of use and intensity of inorganic fertilizer use in maize production observed is an indication of the existence of considerable potential to improve smallholder maize farmers' productivity with minimum cost compared to the development and utilization of agricultural technology.

Inorganic fertilizer is important in agricultural based economies demand for substantial efforts improving agricultural production and productivity consequently enhancing the profit. However, factors like households head demographic (age and education level) and socio-economic factors (livestock holding, farm income, off-farm income, perception on relative price of input-output, frequency of extension agent contact, use of input credit) greatly affected the use and intensity of inorganic fertilizer use in maize production and consequently production and productivity of maize. The profitability of inorganic fertilizer use in maize production was estimated and it was profitable on average. However, the profit was low. Though it was making on average profit, the profit of inorganic fertilizer use in maize production was low. The constraints of use and intensity of inorganic fertilizer use in maize production were also identified and ranked by the respondents in the study area. Hence, it is better if the concerted efforts made to promote the use of inorganic fertilizer at recommended rate in maize production to enhance maize productivity and profit through overcoming the factors and constraints. These require strengthening the institutional support provided to this sector, such as credit service, cooperative union, research and extension service.

5.3. Recommendations

On the basis of the current study, the following recommendations are suggested for future intervention strategy to overcome the factors determining the use and intensity of inorganic fertilizer use.

- Most of the smallholder maize farmers in the study area, still not using an inorganic fertilizer in spite of inorganic fertilizer use started last two decade in the area. So, due attention is required from the Oromia Agriculture and Natural Resources Bureau in creating awareness and mobilizing farmers on the use of inorganic fertilizer so that farmers can improve their agricultural productivity and livelihood.

- Uses of inorganic fertilizers are less than the recommended levels in maize production. Hence, smallholder maize farmers of the study area should have to increase use levels of the inorganic fertilizers in order to optimize the productivity of the maize.

- Age of household head had a significant positive influence on use of inorganic fertilizer in maize production. Older farmers use inorganic fertilizer faster than younger farmers. Hence, it is better if the local government arrange experience sharing and provision of short term training programs in each kebeles so as to share the rich knowledge of old farmers to young and inexperienced farmers.

- Education level of household head had a significant positive influence on use and intensity of inorganic fertilizer use in maize production. Hence, it is better if appropriate policies designed to provide adequate and effective basic educational opportunity to rural farmers in general and to the study area.
- The size of livestock holding had a significant positive impact on use and intensity of inorganic fertilizer use in maize production. So, it is better if the farmers and government body play their party in strengthening the existing livestock production system through providing improved health services, better livestock feed (forage), using high yielding breeds and disseminating artificial insemination in the area.
- Farm income had a significant positive influence on use of inorganic fertilizer in maize production. So, it is better if the smallholder farmers of the study area increase their crop and livestock productivity through using agricultural new technologies. Also, the attention is required from Oromia Agriculture and Natural Resources Bureau, Oromia Trade and Market Development Bureau and Oromia Cooperative Bureau through provision of awareness creation on agricultural new technology and facilitating the market strategy that enhances farm income.
- Frequency of extension agent contact with household head had a significant positive impact on use and intensity of inorganic fertilizer use in maize production. Hence, it is necessary to strengthen farmers training centers for enabling them to properly demonstrate available technologies and at the same time to capacitate farmers on technology utilization through provision of training for the smallholder farmers and strengthening the existing extension services.
- Use of input credit had a significant positive influence on use of inorganic fertilizer in maize production. Therefore, due attention is required from the Oromia Agriculture and Natural Resources Bureau, Oromia Cooperative Bureau and Oromia credit and

saving institution through collaboration work in extending use of input credit for all farmers rather than selective way and revising the existing interest rate of input credit.

- Off-farm income had a significant positive influence on intensity of inorganic fertilizer use in maize production. So, it is better if the smallholder farmers of the study area participate in off-farm income sources in addition to farm income. Also, the District Agriculture and Natural Resources Office and District Cooperative Office should have to support the farmers through provision of awareness on the importance of off-farm income especially during idle labor.

- Household heads' perception on cost of production (relative price of fertilizer-maize) had a significant negative impact on use and intensity of inorganic fertilizer use in maize production. So, it is better if smallholder maize farmers of the study area work on improvement of their maize productivity through using inorganic fertilizer in maize production properly and practicing best agronomic management rather than only observing the cost side of inorganic fertilizer. Also, due attention is required from the Ministry of Agriculture and Livestock, Oromia Agriculture and Natural Resources Bureau and Oromia Cooperative Bureau in collaboration work on awareness creation on cost-benefit analysis of fertilizer use in maize production` and reasonable cost of fertilizer and price of maize output.

- In spite of low productivity and poor price of maize output, the use of inorganic fertilizer in maize production in the study area was profitable. However, the profit was low. Hence, it is better if the smallholder maize farmers of the study area give attention for proper use of inorganic fertilizer in maize production and to practice best agronomic management to enhance more profit from maize production.

- In the study area, the constraints of use and intensity of inorganic fertilizer use were identified and ranked by the respondents. Accordingly, High price of fertilizer, Lack of input credit, High interest rate on credit, Low return on fertilizer use, Lack of uniform rain fall distribution, Perception of having fertile land, Absence of choice packaging amount, Inefficient fertilizer distribution, Distance of fertilizer marketing from residence, Late arrival of fertilizer, Poor quality of fertilizer and Lack of knowledge on fertilizer were ranked in order of their influences. So, it is better if the smallholder maize farmers, District Agriculture and Natural Resources Office, District Cooperative Office and National Bank play their party to overcome those constraints.

- The study was limited to smallholder maize farmers in four kebeles of Nono Benja District on use and intensity of use of inorganic fertilizer in maize production. Therefore, further study recommended that in the future should look at the use and intensity of use of inorganic fertilizer for other kebeles and crops in the district.

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7. APPENDICES

Appendix Tables

Appendix Table 1: Conversion Factor used to calculate Adult Equivalent (AE)

Age category(years)	Male	Female
<10	0.6	0.6
10-13	0.9	0.8
14-16	1.0	0.75
17-50	1.0	0.75
>50	1	0.75

Source: Storck, *et al*. (1991)

Appendix Table 2: Conversion Factor for Tropical Livestock Unit (TLU)

Animal category	Tropical Livestock Unit (TLU)
Ox/Cow	1
Weaned	0.34
Calf	0.2
Heifer	0.75
Horse/mule	1.1
Donkey	0.7
Poultry	0.02
Goat/sheep	0.13

Source: Storck, *et al*. (1991)

Appendix Table 3: Distribution of respondents by their source of information in farming

Characteristics		Respondent	Percent
source of information for farmer	From never where	27	15.5
	From field day	15	8.6
	From training	70	40.2
	From fellow farmer	7	4.0
	From developmental agent	45	25.9
	From cooperative	1	.6
	From demonstration	9	5.2
	Total	174	100.0

Source: Own survey result of 2017/2018 production season

Appendix Table 4: Distance from output market (hour)

Characteristics	N	Minimum	Maximum	Mean	Std. D
Distance travel to sell product in hour	174	.10	3.50	1.3491	.88598

Source: Own survey result of 2017/2018 production season

Appendix Table 5: Variance inflation factor for continuous explanatory variables

Variables	Collinearity Statistics	
	Tolerance	VIF
AGEHH	.858	1.166
EDLHH	.671	1.490
ADLE	.873	1.146
FARMS	.861	1.161
LVSH	.744	1.345
FMICMH	.676	1.479
OFFMINC	.722	1.385
CWEA	.723	1.383
DFIM	.903	1.108

Source: survey data model output

Appendix Table 6: Contingency coefficient for dummy variables

Variables	SEXHH	PRPIO	USCP	MCPS	UICRD
SEXHH	1.0000				
PRPIO	-0.0331	1.0000			
USCP	0.0572	0.0470	1.0000		
MCPS	0.1670	-0.1462	-0.1311	1.0000	
UICRD	-0.0292	-0.1641	-0.1114	0.2352	1.0000

Source: survey data model output in 2017/2018 production season

Apendix Table 7: Heckman selection model -- two-step estimates (regression model with sample selection)

Heckman selection model -- two-step estimates Number of obs =174 Uncensored obs =114

(Regression model with sample selection) Censored obs =60

Wald chi2 (13) =138.32 Prob > chi2 =0.0000 Log likelihood = -529.4703

	Coef.	Std. Err.	z	P>z	[95% Conf.	Interval]
ADIOIF						
SEXHH	.9064934	7.400048	0.12	0.903	-13.59733	15.41032
EDLHH	4.941024	.8880747	5.56	0.000	3.200436	.681618
ADLE	-1.090258	1.90955	-0.57	0.568	-4.832907	2.652391
FARMS	1.967986	1.206468	1.63	0.103	-.3966484	.33262
LVSTH	1 .875981	.7838078	2.39	0.017	.3397458	3.412216
FMICMH	.0003923	.0004243	0.92	0.355	-.0004393	.001224
PRPIO	-7.353238	2.38497	-3.08	0.002	-12.02769	-2.678783
OFFMINC	.0017246	.0008758	1.97	0.049	8.05e-06	.0034412
USCP	-2.069068	6.606701	-0.31	0.754	-15.01796	10.87983
CWEA	6.483196	1.271539	5.10	0.000	3.991025	8.975367
MCPS	-5.521059	5.146	-1.07	0.283	-15.60703	4.564914
DFIM	2.079553	4.992324	0.42	0.677	-7.705222	11.86433
UICRD	7.019709	4.536704	1.55	0.122	-1.872068	15.91149
_cons	112.4077	15.72231	7.15	0.000	81.59254	143.2229
ADIF						
AGEHH	.1030268	.0612674	1.68	0.093	-.0170551	.2231088
SEXHH	.2265081	1.257359	0.18	0.857	-2.237871	2.690887
EDLHH	.8011621	.214349	3.74	0.000	.3810458	1.221278
ADLE	-.0213731	.2561678	-0.08	0.934	-.5234527	.4807065
FARMS	-.2281278	.1692423	-1.35	0.178	-.5598366	.103581
LVSTH	.517217	.1856958	2.79	0.005	.1532598	.8811742
FMICMHH	.0001934	.0000764	2.53	0.011	.0000436	.0003432
PRPIO	-1.122155	.4024845	-2.79	0.005	-1.91101	-.3332997
OFFMINC	.000112	.0002687	0.42	0.677	-.0004147	.0006386
USCP	.053886	.6878315	0.08	0.938	-1.294239	1.402011

CWEA	.8926507	.3227442	2.77	0.006	.260083	1.525218
MCPS	.7017826	.7544708	-0.93	0.35	-2.18051	.776953
DFIM	-.5817271	.4832537	-1.20	0.229	-1.528887	.3654327
UICRD	2.09442	.8550759	2.45	0.014	418502	3.770338
_cons	-5.259603	3.610994	-1.46	0.145	-12.33702	1.817814
Mills(lambda)	16.51393	7.795506	2.12	0.034	1.235022	31.79284
rho	0.74334					
sigma	22.215902					

Note: ***’ ** and* show the values of statistically significant at 1%, 5% and 10 probability level of significance res

Source: Own survey result of 2017/2018

Appendix Table 8: Average marginal effect

. margins, dydx (Age Sex EDLHH ADLE LHS LVSTH FMICMHH RPFTM OFFMINC USCP CWEA MCPS DFIM UFCRD)expression(normal(xb(ADIF)))

Average marginal effects Number of obs = 174

Model VCE : Conventional

Expression : normal (xb(ADIF))

dy/dx w.r.t. : Sex EDLHH ADLE LHS LVSTH FMICMHH RPFTM OFFMINC USCP CWEA MCPS DFIM UFCRD Age

Variables	**Delta-method**					
	dy/dx	**Std. Err.**	**z**	**P>|z|**	**[95% Conf. Interval]**	
Age	.0051582	.0028398	1.82	0.069	-.0004077	.0107241
Sex	.0113405	.062891	0.18	0.857	-.1119236	.1346045
EDLHH	.0401114	.0065284	6.14	0.000	.027316	.0529067
ADLE	-.0010701	.0128148	-0.08	0.933	-.0261866	.0240465
LHS	-.0114216	.0080209	-1.42	0.154	-.0271422	.0042991
LVSTH	.0258952	.007256	3.57	0.000	.0116738	.0401166
FMICMHH	9.68e-06	3.54e-06	2.73	0.006	2.74e-06	.0000166
RPFTM	-.0561823	.016935	-3.32	0.001	-.0893743	-.0229904
OFFMINC	5.61e-06	.0000134	0.42	0.676	-.0000207	.0000319
USCP	.0026979	.0344252	0.08	0.938	-.0647743	.07017
CWEA	.0446919	.0132835	3.36	0.001	.0186567	.0707271
MCPS	-.0351358	.0370817	-0.95	0.343	-.1078147	.0375431
DFIM	-.029125	.0233092	-1.25	0.211	-.0748103	.0165602
UFCRD	.1048602	.0379138	2.77	0.006	.0305506	.1791699

Source: Own survey result of model output in 2017/2018 production season

Appendix Table 9: Ranking of the constraints hinder use and intensity of inorganic fertilizer use in maize production by sampled respondents

List of constraints in fertilizer use	Rank	TWS	Rank scores of constraints											
			1	2	3	4	5	6	7	8	9	10	11	12
High price of fertilizer	1	242	142	19	3	4	2	2	1	1	0	0	0	0
Lack of credit for input	2	410	18	126	7	15	2	2	1	1	0	1	0	1
High interest rate of credit	3	657	4	6	133	5	3	2	5	4	2	3	4	3
Low return on fertilizer use	4	879	1	2	5	105	9	12	10	9	5	6	5	5
lack of uniform rainfall distribution	5	912	3	11	11	11	105	8	5	4	3	3	7	3
Perception on fertile land	6	1185	1	1	2	3	4	108	18	6	13	3	5	10
Absenceofchoicepackaging	7	1187	1	3	1	8	16	12	109	6	7	4	5	2
Inefficientfertilizerdistribution	8	1382	0	1	6	4	5	4	7	116	10	8	6	7
Distanceoffertilizer marketing	9	1481	1	2	3	5	8	5	6	8	112	14	7	3
Late arrival of fertilizer	10	1548	2	3	3	6	8	14	4	3	3	114	4	10
Poor quality of fertilizer	11	1798	1	0	0	3	2	4	3	8	10	8	124	11
Lackofknowledgeon fertilizer	12	1853	1	0	0	6	5	5	6	9	6	10	7	119

Source: Own survey result of 2017/2018 production season

Appendix 10: Survey questionnaire of the study

This survey questionnaire is prepared for the study entitled **Determinants and profitability of inorganic fertilizer use in maize production** by smallholder farmers in Nono Benja district, Oromia regional state of Ethiopia.

General Instructions to Enumerators

Make brief introduction to each farmer before starting the interview.

Please ask each question clearly and patiently until the farmer understands your point right.

Please fill up the questionnaire according to the farmers reply (do not put your own opinion).

Please do not try to use technical terms while discussing with farmer and do not forget to record the local unit.
Please collect data of 2017/2018 crop season.
During the process put the answers of each respondent both on the space provided and encircle in choose.

I. General Information
1. Name of the District: ______________________________

2. Kebele: ____

3. Village (Garee Misooma): __________________________

4. Name of the respondent________________________Phone number__________________

5. Adopter's of inorganic fertilizer ____Non adopters of inorganic fertilizer _____

6. Date of interview___/____/____

7. Name of the enumerator______________ Sign. _______

II. Household demographic characteristics

1) Could you list all the members of your household?

No	Name	Relation to head(**code2a**)	Age(in year)	Sex(1=male 2=female)	Occupation (**code 2c**)	Education level (in Year of schooling)
1						
2						
3						
4						
5						
6						

7						
8						
9						
10						
11						
12						
13						
14						
15						

Code 2a: 1= head 2= husband /wife 3=daughter 4=son 5= others and
Code 2c: 1=farming 2=trade 3= others

III. Economic variable

1. Land holding size

1.1) Would you tell us some detailed information about your land holding size during 2017/2018 crop season in hectare?

Land allocation /use type	Cultivation land		Grazing land		Forest/shrub/bush land		Fallow land		**Total land**	
	Amount	Unit(**Code2b)**	Amount	Unit(**Code2b)**	Amount	Unit(**Code2b)**	Amount	Unit(**Code 2b)**	**Amount**	**Unit(Code 2b**
Own land										
Share in land										
Share out land										
Rented out land										
Rented in land										
Total land										

Code2b: 1. Hectare 2. Fachasa 3. Sanga 4. Others specify (ask equivalence to hectares)
1.2) Have you rented out land during 2017/2018 crop season)? (1. Yes 2. No)________

1.3) If yes, what is the size of the land you rented out? **(Ha)** ____________

1.4) If yes, how much rent did you receive in2017/2018 crop season? **(Birr)** _________

1.5) Have you rented in any plot in 2017/2018 crop season)? (1. Yes 2. No)___________

1.6) If yes, what is the size of the land you rented in? **(Ha)** ____________

1.7) If yes, how much rent did you pay in 2017/2018 crop season? **(Birr)** _________

2) Crop production

2.1) Could you please list all the plot size you have and crops that you produced during 2017/2018 crop season and give details?

Crop produced(**code3b**)	Plot size		Total crop output		Total quantity sold		Price received	
	Area	Unit(**code2b**)	Output	Unit(**code 4b)**	Quantity sold	Unit(**code4b)**	Price per unit (Birr)	Unit(**code 4b)**

Code2b: 1. Hectare 2. Fachasa 3. Sanga 4. Others specify (ask equivalence to hectares)

Code 3b:1. Maize 2. Sorghum 3.Teff 5. Nugi 6. Wheat 7.Barley 8. Bean 9.Millet 10. Others

Code4b: 1. Kilogram 2. Quintal 3. Others (ask its equivalence to KG)

2.2) Could you list all your plots that you allocated to maize production and indicate the maize production and marketing practices during 2017/2018 crop season?

Type of maize plot	Maize plot size		Total output		Total sold		Price received	
	Area	Unit **(Code2b)**	Amount	Unit**(code 3c)**	Amount	Unit**(code 3c)**	Price	Unit**(code 3c)**

Code2b: 1. Hectare 2. Fachasa 3. Sanga 4. Others specify (ask equivalence to hectares)

Code3c: 1. Kilogram 2. Quintal 3. Others (ask its equivalence to KG)

2.3) Could you give information on the following maize plot during 2017/2018 crop season in relation to plot size and amount harvested?

No	Type of maize plot	Maize plot size		Amount of maize harvested					
		Area	Unit(**Code2b**)	In green harvested		In dry harvested		Total harvested	
				Amount	Unit**(code 3c)**	Amount	unit**(code 3c)**	Amount	Unit**(code 3c)**
1	With inorganic fertilizer								
2	With compost								
3	With both fertilizer								
4	Without both fertilizer								
5	Total maize plot								

Code2b: 1. Hectare 2. Fachasa 3. Sanga 4. Others specify (ask equivalence to hectares)

Code3c: 1. Kilogram 2. Quintal 3. Others (ask its equivalence to KG)

2.3.1) From a green harvested of maize production on maize plot with inorganic fertilizer how many quintals did you sell? _____and how many birr did you received? _________

2.3.2) From a dry harvested of maize production on maize plot with inorganic fertilizer how many quintals did you sell? _____and how many birr did you received? __________

2.3.3) From a total harvested of maize production on maize plot with inorganic fertilizer how many quintals did you sell? _____and how many birr did you received? __________

2.4)During 2017/2018 crop season, did you use the following inputs/did you have the following costs for inputs on maize plot with inorganic fertilizer?

Plot name_______,Plot size____in (**Code2b)**, Total production from specific plot______in Kg							
Types of input		Did you use these inputs? 1=Yes 2=No	Amount of input used			Total payment in cash (Birr)?	Total value of payments in kinds (Birr)?
			Amount	Unit**(Code4d)**	Cost		
Inorganic fertilizer	NPS						
	Urea						
Pesticides							
Improved maize seed							
planting material							
Transport for production							
Transport for sale							
Oxen rent							
Others							

Code2b: 1. Hectare 2. Fachasa 3. Sanga 4. Others specify (ask equivalence to hectares)
Code4d: 1. Kilogram 2. Quintal 3. Liter 4. Number 5. Others specify

2.5) What was the price of one quintal of inorganic fertilizer (NPS+Urea) did you paid during 2017/2018 crop season? 1. NPS _______Birr 2. Urea _______Birr
2.6) Did you use all of the inorganic fertilizer purchased in 2017/2018 season? 1. Yes 2. No
2.7) Which type of maize seed did you use with inorganic fertilizer during 2017/2018 crop season? 1) Local maize seed 2) Improved maize seed

2.8) If you use improved maize seed during 2017/2018 crop season, how many kg did you use? ___Kg and how many birr did you paid to buy improved maize seed? _____Birr.

2.9) Did you face labor shortage during 2017/2018 crop season for maize production?
1) Yes 2) No

2.10) During which farm operation do you face labor shortage? 1) Land preparation 2) land packing (before plantation) 3) Plantation 4) Weeding 5) Harvesting 6) Threshing 7) Transportation

2.11) If yes (in question number 2.9), how did you solve labor shortage problem? 1) By hiring 2) asking for cooperation (Debo) 3) Assistance from relative 4) Combination of all 5) Others

2.12) If you are hired the labor during 2017/2018 crop season to solve labor shortage problem, for which maize plot did you hire? 1) Maize plot with inorganic fertilizer 2) Maize plot with compost 3) maize plot with both inorganic fertilizer and compost 4) Maize plot without both fertilizer 5) For all

2.13) If the labor is hired by you during 2017/2018 crop season, based on the type of labor hired given fill the amount you paid and the number of days it takes for maize plot operation?

No	Type of labor hired for maize plot	Number of worker hired in		How many days they did the work in total?		Total payment in cash(birr)	Total payment in kind in the form of crop		
		Male	Female	Male	Female		Crop**(code 3b)**	Amount	Unit(**Code 5b**
1	Labor for plow								
2	Labor for weeding								
3	Labor for harvest								
4	Labor for winnowing								
5	Others								

Code 3b:1. Maize 2. Sorghum 3.Teff 5. Nugi 6. Wheat 7.Barley 8. Bean 9.Millet 10. Others

Code5b: 1. Kilogram 2. Quintal 3. Others (ask its equivalence to KG)

2.14) If you are used your family labor during 2017/2018 crop season for maize production, please list the type of work on maize plot, number of day and sex category that you use?

Type of work on Maize plot	How many hh members age>15		How many days did they work in total		How many hh members age<15		How many days did they work in total?	
	Male	Female	Male	Female	Male	Female	Male	Female

3) Livestock holding

3.1) Did you have a livestock? (1.Yes 2.No)_______

3.2) If yes in question no 3.1 please could you list all livestock do have in number?

Category	cows	Oxen	Calves	Weaned calfs	Heifers	Goats	Sheep	Poultry	Donkey	Horse	Mule	Others (specify)	**Total tal**
Quantity in number													

3.3) During 2017/2018 crop season from where did you get income source to purchases inorganic fertilizer? 1. From selling own livestock 2. From selling own crop product 3. From off farm income 4. If from others specify__________

4) Could you get income from your agricultural production? 1. Yes 2.No

4.1) If the answer of question number 4 is yes, how much income did you get annually from your agricultural production? ________in birr

4.2) What is your annual expenditure from your agricultural production? _____in birr

5) How do you perceive the trend of fertilizer price? 1) Affordable 2) un affordable

5.1) If un affordable how did you cope up the price change? 1) Start using other alternative like compost 2) reduce the amount of fertilizer to be used 3) continue as usual 4) other coping mechanism specify)_______

5.2) How did you perceive the cost of inorganic fertilizer relative to price of maize product in 2017/2018 crop season? 1. Very low 2. Low 3. Medium 4. High 5. Very high

5.3) When did you apply inorganic fertilizer, how did you perceive the cost of maize production compared to the return? The return is 1) very low 2) low 3) medium 4) high 5) very high

6) Did you have any off- farm income? 1. Yes 2. No

6.1) If yes in question no 6, would you please give us the details of the off-farm activities, the expenditures and income?

Specify the kind of work	Total expensive from off farm income in birr	Total revenue from off farm income in birr	Total off farm income in birr annually

6.2) If yes in question no6, how many birr do you get from off-farm income annually? __

6.3) If the answer of question no 6 is yes, for what purpose do you use your off-farm income?

1) To purchase inorganic fertilizer 2) To purchase cloths for the family 3) To pay School fee 4) to settle debts 5) to buy food and grains for the Family 6) others (specify_________

7. Inorganic fertilizer

7.1) Did you use inorganic fertilizer in maize production in 2017/2018 crop season?

1. Yes **2. No**

7.2) If no, what are the reasons for not applying? 1) The land is fertile enough 2) Perceiving that it is not profitable 3) shortage of cash 4) expensiveness 5) absence of access to credit 6) unavailability of fertilizer 7) uncertainty of crop yield 8) others (Specify) __________

7.3)If yes (in question no 7.1), tell me your maize plot coverage and the amount of inorganic fertilizer you used in maize production during 2017/2018 crop season?

Area of maize plot covered (Sanga/tsimad)	Amount of inorganic fertilizer used(kg)	
	NPS	Urea

7.4) When did you aware of fertilizer use for the first time? In the year___________ E.C.

7.5) when did you start using inorganic fertilizer? In the year_____________E.C.

7.6) Did you stop using of inorganic fertilizer in between? 1) Yes 2) No

7.7) If yes (question no 7.6), please rate on the following three point scale;-

1. 1-2 year 2. 3 year 3. 5 year and more than

7.8) What is your perception about the importance of inorganic fertilizer use in maize and other agricultural production? Rate your feeling on the following scale; - 1) very low 2) low 3)medium 4) high 5) very much important

8) Did you have applied compost to your maize production land during 2017/2018 crop season? 1. Yes 2. No

8.1) If the answer of question no15is yes, did you apply inorganic fertilizer with compost to your maize plot land during 2017/2018 crop season? 1. Yes 2. No

IV. Institution variables

1) Did you get advisory services from extension agents on inorganic fertilizer use for maize production? 1) Yes 2) No

2) If the answer of question number 1 is yes, how many days per month did you contact with extension agents during the 2017/2018 crop season? _______in number of days

3) Did you visit extension agent yourself? 1) Yes 2) No

4) If yes, when did you visit? 1) During plantation for technical advice 2) During input

Provision to obtain inputs 3) it depends (any time when there is technical problem)

5) Who are your other sources of information on maize production with inorganic fertilizer and how often did you use/ have contact with them?

No	Other sources	How often you use them				Rank
		Never	Rarely	Often	Very often	
A	Field day					
B	Training					
C	Fellow farmer					
D	Developmental agent					
E	Cooperatives					
F	NGOs					
G	Demonstration					
H	Other					

6) Are you a member of cooperative society? 1) Yes 2) No

7) If yes, when did you first became member of cooperative society? Year: _____/____/____

8) What services do you get being a member of the cooperative society?

1. Inorganic fertilizer 2. Credit in cash 3. Improved maize seed (Freely, on credit base)

4. Other farm inputs on credit base 5. Marketing of maize output 6. Other (specify) ___

9) Is inorganic fertilizer available on time in your area? 1) Yes 2) No

10) Concerning the distance from input market, how far did you travel to buy inorganic fertilizer? __ in hour

11) How far do you travel to sell your agricultural product? ___ in hour

12) Is a credit available in your area? 1) Yes 2) No

13) Do you use a credit in 2017/2018 crop season? 1) Yes 2) No

14) If the answer of question no 13 is yes, for what purpose do you use a credit?

1) For buying agricultural input like inorganic fertilizer 2) For buying house furniture 3) For buying cloth 4) For buying crop for consumption 5) If other specify________

V. Constraints in using fertilizer

Rank your feeling about the determinants of inorganic fertilizer use intensity in maize production from the following list.

No	Determinants of inorganic fertilizer use intensity	Rank the problem in priority
1	High inorganic fertilizer price	
2	Late arrival(not available on time of inorganic fertilizer)	
3	Lack of credit for use of inorganic fertilizer	
4	Flexibility of rain fall	
5	Distance of fertilizer marketing from the residence	
6	Poor quality of inorganic fertilizer	
7	Inefficient inorganic fertilizer distribution	
8	Lack of knowledge on inorganic fertilizer use	
9	High interest rate of credit	
10	Absence of choice available to purchase inorganic fertilizer due to packing amount	
11	Low return on inorganic fertilizer use	
12	Perception of having fertile land	
13	others	

Check List for conducting focused group discussion

1) In your peasant association/district when did inorganic fertilizer use started?

2) Can you remember how many farmers started using inorganic fertilizer in your locality? Is their increasing or decreasing in number from time to time? Why?

3) Is there any farmer who does not use inorganic fertilizer in your peasant association? Why?

4) What is the practical level of inorganic fertilizers package used by most of maize producer farmers household currently? Why they use under recommended level?

5) Are those farmers who have started using inorganic fertilizer continued to use inorganic fertilizer? 1) Yes 2) No

6) If no, why do they discontinue?

7) What do you think are the major constraints that protect farmers from using fertilizers?

8) What do you suggest to overcome these constraints?

9) Do you think that the existence /presence of fertile land have an effect on fertilizer use?

10) How do you see the availability of fertilizer timely in your peasant association?

11) Is there a shortage of inorganic fertilizer supply?

12) Can we say there is lack of knowledge in fertilizer use in your peasant association?

13) Can an inorganic fertilizer purchasing (distribution) center be a problem for the locality?

14) What is your perception about fertilizer use in maize production in relation with rainfall?

15) Do you think the use of compost/manure have influence on the use of inorganic fertilizer?

16) Do you think a given maize productivity and price level makes inorganic fertilizer use profitable for smallholder farmers?

17) Inorganic fertilizer use in maize production profitability study

	Activity	Local variety	Hybrid
1	Maize yield kg/ha with inorganic fertilizer		
	Price of maize birr/kg		
	Total revenue		
2	VARIABLE COST		
	Seed (kg/ha)		
	Price Birr/Kg		
	Total cost of maize seed Birr/ha		
2.1	**Opportunity cost of land**		
2.2	NPS (kg/ha)		
	Price Birr/Kg		
	Total cost of NPS Birr/ha		
	Urea (kg/ha)		
	Price Birr/Kg		
	Total cost of Urea Birr/ha		
2.3	Oxen required to plow hectare (oxen day/ha)		
	Frequency of plowing		
	Rental rate of pair oxen (price/oxen day)		
	Total cost of Oxen power required for plowing (birr/ha)		
	Animal power cost for transport to home (birr/ha)		
2.4	Person required to plow (person day/ha)		
	Labor wage to plow(wage/person day)		
	Frequency of plowing		
	Total labor cost required for plowing(birr/ha)		
2.5	Person required to weed (person day/ha)		
	Frequency of weeding		
	Labor wage to weeding (wage/person day)		
	Total labor cost required for weeding(birr/ha)		
2.6	Person required to harvest (person day/ha)		
	Labor wage to harvest (wage/person day)		
	Total labor cost required for harvesting (birr/ha)		
2.7	required to winnowing (person day/ha)		
	Labor wage for winnowing (wage/person day)		
	Total labor cost required for winnowing(birr/ha)		
2.8	**Cost of pesticide**		
2.9	**Interest rate on input credit**		

Checklist for Key Informant Interview

1) What is a demand, supply and distribution of inorganic fertilizer the last five years, look like?

2) What is trend of inorganic fertilizer price for the last five years in relation with maize product?

3) What the extent of the use of inorganic fertilizer look like?

4) What the extent of the use of compost/manure look like?

5) What is the availability of inorganic fertilizer on time in your area look like?

6) What is the level of inorganic fertilizer application on major in maize production?

7) The use of inorganic fertilizer what seems that about the use of all farmers household?

8) How did you see a maize productivity with fertilizer and without fertilizer in your area and other crops?

Crop type	Maize	sorghum	Teff	Wheat	Nugi	Barley	Millet	Bean	**Others**
Hectare									
Productivity with fertilizer(Qt/ha)									
Productivity without fertilizer(Qt/ha)									

9) What is the return on maize production with inorganic fertilizer during last five year?