Determinants of Adoption of Improved Agricultural Technology and Its Impact on Income of Smallholder Farmers in Chiro District West Hararghe Zone, Oromia National Regional State, Ethiopia

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The importance of agricultural technology in enhancing production and productivity can be realized when yield increasing and technologies are widely been used and diffused. Standing from this logical ground, this paper aimed at identifying the factors affecting agricultural technology adoption decision and examining the impact of adoption on household’s income in chiro district west Hararghe zone, Oromia national regional state, Ethiopia. Both primary and secondary data was used; primary data was collected through structured questionnaire administered on 97 randomly selected smallholder farmers and secondary data was collected from published and unpublished document related to this topic. For data analysis purpose both Probit and Ordinary Least Square (OLS) regression models were employed. From the total 97 respondents 80 of them were adopted improved agricultural Technology while the left were not adopted improved agricultural technology in the study area. The regression result revealed that agricultural technology adoption has a positive and significant effect on household income by which adopters are better-offs than non-adopters. The probit regression result revealed that gender of the household head; access to irrigation, credit service; extension service and income of the household head significantly affect adoption of improved agricultural technology in the study area. From these finding researchers recommend that government should encourage small scale irrigation, credit service and extension service in the study area.

Key Words: Adoption, Technology, Probit, Chiro

INTRODUCTION

Background of the Study

Agriculture is the art and science of cultivating plants and the raising of animals for food, others human needs or for economic gain. One of the overarching goals of Ethiopian agriculture development programs and policies is increasing agricultural productivity for accelerated economic growth. Particularly, majority of the poor in Sub-Saharan Africa depend on agriculture for survival thus, agricultural sector has been recognized as a key fundamental for spurring growth, overcoming poverty, and enhancing food security. Productivity increases in agriculture can reduce poverty by increasing farmers' income, reducing food prices and thereby enhancing increments in consumption (Diagne, 2007).

Agricultural technology adoption is very essential in reducing poverty and ensuring food security (Besley and Case, 1993). According to Gemeda (2001) in developing countries, improving the livelihoods of rural farm households via agricultural productivity would remain a mere wish if agricultural technology adoption rate is low. Hence, there is a need to adopt the proven agricultural technologies so as to heighten production as well as productivity and thereby the living condition of the rural poor. Furthermore, for developing countries, the best way to catch developed countries is through agricultural technology and adoption (Foster and Rosenzweig, 2010). According to Besley and Case (1993) purport that, adoption of improved seed varieties has long been taken as a solution to heighten agricultural income and diversification. Commensurately, agricultural productivity can be ensured either by producing higher per unit of land using agricultural inputs or by expanding the area under cultivation. Adoption and proper utilization of yield increasing technologies, in Asia, have resulted with what
we call it Green Revolution (World Bank, 2008) where its replication in African countries is paramount importance for increasing productivity. As part of developing countries in general and Sub-Saharan Africa in particular, Ethiopia is an agrarian country that predominantly relied on subsistence agriculture. According to Ministry of Finance and Economic Development (MoFED, 2003), since 1990s as a national strategy, Ethiopia has espoused Agricultural Development-Led Industrialization (ADLI) which predominantly advocates smallholder agriculture and their transformation in to commercial agriculture by employing agricultural technologies. Supporting this, Ministry of Agriculture and Rural Development (MoARD, 2010) inferred that majority of the country’s total production is been produced by smallholder farmers; and the sector contributes 90% of the foreign earnings and 70% of the raw materials for industry.

Although the sector contributes this much, due to insufficient rate of production and productivity, persistent poverty and drought are actually the main manifestations. To trim down and make poverty history, the country has designed and been implementing different poverty reduction papers including Sustainable Development and Poverty Reduction Program (SDPRP), the Plan for Accelerated and Sustained Development to End Poverty (PASDEP) and Growth and Transformation Plan (GTP). Basing from the logical ground of limited arable land size and understanding the priceless importance of agricultural technologies, in Ethiopia, procurement and distribution of agricultural inputs more particularly improved seed varieties and chemical fertilizer have been the central patterns of the above-mentioned poverty reduction papers. Therefore, the general objective of this paper is to identify the factors affecting households’ agricultural technology adoption decision and to examine the impact of adoption on farm income of household around the study area.

Statement of the problem

The adoption of agricultural technologies is necessary condition for the achievement of agricultural productivity increase and poverty reduction among the farming households. Though traditional agriculture prevails in developing countries in general and in Ethiopia in particular, some progress has been made in using improved agricultural technologies and inputs.

Neil and Lea (2011) point out that the majority of existing literature on agricultural adoption is focused on Green House (GH) technologies such as irrigation, adoption of farm capitals and machineries which needs a time series data to determine adoption of technology across space and time. Many researchers like Fribourg (2009) focused on aggregate level of adoption agricultural technologies among group of farmers.

Diagne (2006) assessed the impact on agricultural technology adoption on rice yields to Cote d’Ivoire. The results show a positive and significant increase in yield particularly on the female farmers. In contrast however, a study conducted by Hossain (2003) in Bangladesh reveals that the adoption of improved varieties of rice has a positive impact on the richer households but had a negative effect on the poor.

The adoption decision of farmers is usually determined by various factors. Factors affecting the adoption of improved wheat technologies are not known. The rate and intensity of adoption as well as the impact on the new technologies on yield and farmers income have not been known in the study area.

This study focuses on agricultural technology adoption specifically on improved seed varieties and Chemical fertilizers and its impact on household’s income. It also focuses on individual adoption which can measure degree of use on long run. The study investigates positive impact of Agricultural technology adoption on both male and females.

OBJECTIVES OF THE STUDY

General objective of the study

The general objective of the study is to analyze adoption of agricultural technologies and its impact on livelihood’s income.

Specific objectives of the study

The specific objectives of the study are:
- To determine factors affecting agricultural technology adoption of farmers.
- To identify role of agricultural technology adoption on income of households.

Research Questions

- What are the major factors affecting agricultural technology adoption by the farmers?
- What are the roles agricultural technologies for farm income?

Significance of the Study

This study provides awareness about importance of agricultural technology adoption for farmers in chiro districts West Hararghe zone, Oromia Regional state, Ethiopia. The study also expects to assess factors affecting technological adoption in the study area. This study generates valuable information about producers and which may also help policy makers to take relevant decisions and intervene in production. It also provides baseline information for further researchers in the study area.
Scope and Limitation of the Study

This study was undertaken Chiro woreda of West Haraghe Zone Oromia Regional State, Ethiopia. The study was emphasized on Agricultural technology Adoption, Specifically on improved seed varieties and Chemical fertilizer adoption and its role on the household’s income. The study was carried out on Agricultural Technology Adoption and its impact on household’s income it is confined to a single district; the findings shall contribute deepen the knowledge for awareness and attitude towards agricultural technology adoption in general and the study area in particular. So that it will be used to stimulus for further research to refine the conceptual and methodology of the present study.

Empirical Studies on the Adoption of Agricultural Technologies

Concepts of Agricultural Technology

Throughout the world’s history of economic development, the catalyst of growth has been technological innovation (Dantwala, 1996). It is, therefore, natural for economic writers to give emphasis on technological progress while discussing economic situations. There are many definitions given for technology in economic literature.

According to Singh (1986) technology is a stock concept broadly means a body of skills and knowledge as well as collection of all available techniques of carrying out economic activities. He also defined technology as the proportions in which land, labor, and capital are combined into the production of a unit of output. Technological change, on the other hand, is a flow concept and when new techniques become available as a result of research or experience, it is the technology that changes.

According to Ruttan (1960), technological change is defined as the change in the parameters of a production function or the creation of new production functions. Technological change reduces the amounts of productive inputs necessary to produce any given level of output; it can also change the input proportions that are used to produce that output at the lowest cost (Maurice and Phillips, 1986).

Technological change involves an improvement in the state of knowledge—the knowledge of how to organize factors of production more efficiently. In terms of the production function, any given set of inputs in the relevant range can produce more output after the improvement in technology.

Technological change leads to a shift of isoquant map toward the origin, because a given level of output can be produced with fewer inputs. This downward shift in the isoquant means that with given input prices, each level of output can be produced at a lower cost (on a lower isoquant curve) than was possible before the change in the level of technology (Maurice and Phillips, 1986).

In general, technology either affects the levels and/or proportions of inputs used in the production of a certain level of output or it raises output produced with a given levels of input combinations.

Impact of Agricultural Technology

Research evaluation refers to judging, appraising, or determining the worth, or quality of research. This is often done in terms of its relevance, effectiveness, efficiency, or impact (Horton et al, 1993). Hence, research impact is an evaluation that deals with the effects of the research output on the target beneficiaries. Impact also implies a behavioral change in target population due to the technology (Anandajayasekeram et al., 1996).

According to Echeverria (1990), impact refers to the physical, social, and economic effects of new cultivation and post-harvest methods on crop and livestock production, distribution, and use and on social welfare in general. Impact assessment can be carried out to study the impact of a particular innovation/ technology, on a research program, or on a research program plus complementary services (such as extension, marketing, etc). Impacts can also be measured at the individual household level, target production level, as well as national and regional levels (Anandajayasekeram et al., 1996).

In discussing impact of any research program, one can identify two broad categories of interpretation. In the first category, some people look at the direct output of the activity and call this impact, e.g., a variety, a breed, or a set of recommendations resulting from a research activity. Most of the biological scientists belong to this category. The other category goes beyond the direct product and tries to study the effects of this product on the ultimate users. This one looks at the fit of the program within the overall R&D of the country. Most social scientists, donors, planners and policy makers belong in this category. This second type of impact deals with the actual adoption of the research output and subsequent effects on production, income, environment and/or whatever the development objective may be (Anandajayasekeram et al., 1996).

The impact or the potential of any improved technology under real farm situations is generally assessed from the magnitude of the differences in the mean yields, net economic returns or benefit-cost ratios of the improved technology and those of the traditional or existing farmers’ practices (Kiresur et al., 1996).

Importance of Technology in Agriculture

Technology is one of the important forces, which alter the economy. Technological innovation is a force which causes economic decay in one region and growth and
prosperity in another (Singh, 1986; Dantwala, 1996). Technological changes in agriculture have much importance to the general economic progress as well as to the farming community of most countries. It is relatively more important for densely populated countries of Asia, Africa, and Eastern Europe (Singh. Et al., 1986).

Ensuring food security for all is a major challenge facing agricultural technology generation efforts. According to Dantwala et al., (1999), food security for the world in 2025 is possible and probable if the right things are done starting now. However, the task will not be easy and represents an enormous challenge to the global community and particularly to the agricultural community. Meeting future requirements will require sustainable intensification of complex production systems, appropriate national and international policies, and continued investments in agricultural research. Without these conditions prospects for future are less bright.

Technological change can act on poverty through two channels (Singh et al., 2001). First, it can help reduce poverty directly by raising the welfare of poor farmers who adopt the technological innovation. This can be through increased production for home consumption, more nutritious foods, higher gross revenues from sales, lower production costs, lower yield risks, lower exposure to unhealthy chemicals, and improved natural resource management. Secondly, technological change can help reduce poverty indirectly through the effects which adoption has on the price of food; employment and wage effects in agriculture and in other sectors of economic activity, lower costs of agricultural raw materials, lower nominal wages of employers (as a consequence of lower food prices), and foreign exchange contribution of agriculture to overall economic growth.

Technological change leads to increased output and higher disposable income. It also changes the farmers' resource allocation behavior by changing the potential yield outcomes. It also allows diversion of resources like labor and capital to non-agricultural sectors and raises the national output (Singh, 1986; Ahmed et al., 2001). Technological progress helps in lessening the drudgery of work both in farms and farm homes. Besides producers, technological change benefits consumers via increased production and restraining spiraling prices.

Technological changes also have spillover benefits. Technology spillovers are benefits generated by the adoption of an innovation outside the mandate area of the research institutions making the discovery (Traxler and Byerlee, 2001). Agricultural R&D investments in one country may affect investment decisions in other countries through R&D spillovers. In summing up, the importance of technological change to both producers and consumers, and to the community at large is enormous. The overall role of technology in agriculture is rooted in general economic progress, feeding the teeming million, alleviating poverty, increasing production and ultimately income, adjusting resource allocation behavior, and lessening the drudgery of work.

**Empirical Literature review**

The focus in the econometric literature is traditionally on endogeneity or self-selection issues and motivated primarily by applications to the evaluation of labor market programs in observational settings. Individuals who choose to enroll in a training program are by definition different from those who choose not to enroll. These differences, if they influence the response, may invalidate causal comparisons of outcomes by treatment status, possibly even after adjusting for observed covariates (Imbens and Woodridge, 2008).

Consequently, different methods have been developed and used in the literature to assess the impact of programs, policies and adoption of improved agricultural technologies on poverty reduction or welfare however, the results have been mixed. For instance, Mendola adopted the Propensity Score Matching (PSM) methods to assess the impact of agricultural technology adoption on poverty in Bangladesh and observes that the adoption of high yielding improved varieties has a positive effect on household wellbeing in Bangladesh. In the same way, Kijima. (2008) conducted a study on the impact of New Rice for Africa (NERICA) in Uganda and found that NERICA adoption reduces poverty without deteriorating the income distribution.

Traditionally, according to Foster and Rosenzweig (1996), and Kohli and Singh (1997) agricultural technology adoption decision was seriously been determined by imperfect information, risk, uncertainty, institutional constraints, human capital, input availability and infrastructural problems. As a remedy for such traditional conception, Sasakawa Global 2000 (SG-2000) program is been in place and intended to work with smallholder farmers and their respective agriculture ministry’s so as to increase agricultural production and productivity by employing agricultural technologies that could best keep soil fertility.

Following the advent of SG- 2000, the determinants of agricultural technology adoption decision of farm households turned to be mainly social networks and learning (Bandiera and Rasul, 2002); and adoption would be in place through farmers’ own and neighbors’ experience (Foster and Rosenzweig, 1995). In a certain country, chemical fertilizer adoption can be determined by economic, social, physical and technical aspects of farming (Abay & Assefa, 2004); and these aspects influence the type of crops to be grown and the production method to be used (Sassenrath Schneider et al., 2012).

According to Yanggen et al., (1998), in Africa in general and SSA in particular, fertilizer use capacity is being
RESEARCH METHODOLOGY

Description of the study area

Chiro district is found in West Hararghe Zone of the Oromia National Regional state at about 325 km East of Finfine, the capital city of Oromia regional national state. The capital town of the district is Chiro, which is also the capital town of the Zone. The district is divided into three major agro-ecological zones. These are Lowland with 22 kebeles, Midland with 13 kebeles and highland altitude with 4 kebeles. The district bordered with Miesso in the North, Gemmechis in the South, Guba-koricha in the West and Tulo in the East. Mixed farming, both crops and live stocks production, is the dominant practice in the district covering 98% and the rest is of pastoral production system with a share of 2%.

Type and Method of Data Collection

Both primary and secondary data was used in this research. A primary data was collected through structured questionnaire administered on randomly selected smallholder farmers in 2018 cropping year; Primary data was collected by interview and supplemented by focus group discussion and secondary data was collected from the office of agriculture and finance of the district.

Sample size and Sampling techniques

Appropriate sample size depends on various factors relating to the subject under investigation including time, cost and degree of accuracy (Gupta, 2002). From total target population, household was selected by using Slovenes formula (Yamane, 1967). Therefore by Slovenes formula the proportion of sample size determined by

\[ n = \frac{N}{1 + N \times \varepsilon^2} = 97 \]

Where \( N \) = number of HH in the area, \( n \) = number of sample size to be selected, \( \varepsilon \) = level of significance.

A Primary data was collected through structured questionnaire administered on 97 randomly selected smallholder farmers in 2018 cropping year; 97 from two kebeles of chiro woreda.

For validity of the data and reliability of the collected data, purposefully, the questionnaire was pre-tested by my advisor. Firstly, two kebeles those are conducive to agriculture was selected purposively from the study area. Secondly, of the total, two kebeles 97 householders was selected using simple random sampling. Thirdly villages' sample size was determined proportionally from the already defined sample size from which adopters and non-adopters was identified; and finally, final respondents were selected randomly from the list of the farm households from each targeted villages.

Method of Data Analysis

In this paper, regardless of the intensity and quantity of technologies being used, a farmer was taken as an adopter if he or she sows any improved seed variety and uses chemical fertilizer; either independently or together with their indigenous seeds and manure. The dependent variable, technology adoption, has a binary nature taking the value of 1 for adopters (chemical fertilizer and improved seed varieties independently) and 0 for non-adopters. In this regard an econometric model employed while examining probability of farm households' agricultural technology adoption decision was the probit model. Often, probit model is imperative when an individual is to choose one from two alternative choices, in this case, either to adopt or not to adopt chemical fertilizer and improved seed varieties. Hence, an individual makes a decision to adopt chemical fertilizer and improved seed varieties of the utility associated with that adoption choice (V1i) is higher than the utility associated with decision not to adopt (V0i). Hence, in this model there is a latent or unobservable variable that takes all the values in (-\( \infty \), +\( \infty \)). According to Koop (2003) these two different alternatives and respective utilities can be quantified as: \( Y^i = V^i1 - V^i0 \) and the econometric specification of the model is given in its latent as:

\[ Y^i = \begin{cases} 1, & Y^i1 \geq 0 \\ 0, & Y^i1 < 0 \end{cases} \]

Where \( Y^i \) takes the value of one (1) for adopters and zero (0) for non-adopters.

\[ Y^i = X^i \beta + u_i \]

Where \( u_i \) is a normally distributed error term.

From this unobserved or latent model specification, therefore, the utility function depends on household specific attributes \( X \) and a disturbance term \( (u) \) having a zero mean: \( U1(X) = \beta 1X + u10 \) for adopters. As utility is random, the \( i^{th} \) household was adopt if and only if \( u11 > U10 \).
On the other hand, to examine the impact of agricultural technology adoption on household’s income, Ordinary Least Square (OLS) regression model was employed. The rationale is due to the continuous nature of the dependent variable, household’s income. Furthermore, according to Gujarati (2006), with the assumption of classical linear model, OLS estimators are with unbiased linear estimators with minimum variance and hence they are Best Linear Unbiased Estimators. Hence, its specification is given below using similar independent variables used and described in the probit model above.

\[ Y = \beta_0 + \beta_iX_i + U_i \]

Where: \( Y \) is the dependent variable (farm income), \( X_i \) is a vector of explanatory variables, \( \beta_i \) is a vector of estimated coefficient of the explanatory variables (parameters) and \( U_i \) indicates disturbance term which is assumed to satisfy all OLS assumptions (Gujarati, 2006).

\[ HH\ Inc. = \beta_0 + \beta_1 GEN + \beta_2 AGE + \beta_3 EDUC + \beta_4 LANDSZ + \beta_5 IRRIG + \beta_6 LANDSZ + \beta_8 CREDIT + \beta_8 EXTENS+ \beta_9 ASSOCI+ \beta_10 TLU + \beta_11 ORGFERT + u \]

**Description of Variables used in the Analysis (both in Probit and OLS models)**

The variables used for the analysis and their theoretical expectations about the sign and magnitude of these variables on the adoption decision of agricultural technologies more particularly chemical fertilizer and improved seed varieties as well as its impact on household’s income is discussed below. These variables were chosen based on the available literature reviewed.

- **Gender of household head (GEN):** It is a dummy variable 1 if gender of the household head is male and 0 otherwise. Male-headed households would have better opportunity to adopt both chemical fertilizer and improved seed varieties since they are exposed to new information and tend to be risk takers.

- **Age of household head (AGE):** It is a continuous variable measured in numbers; as age increases households’ probability of adopting chemical fertilizer and improved seed varieties was expected to decrease; where younger farmers were expected to adopt unlike elder farmers. The coefficient hypothesized in the final result both for chemical fertilizer and improved seed varieties was negative.

- **Education (EDUC):** It is a continuous variable measured in number of years of schooling; where the educated farmers are believed to acquire, analyze and evaluate information on different agricultural inputs and market opportunities. Positive was the coefficient expected from the final result both for chemical fertilizer and improved seed varieties adoption.

- **Land Size (LANDSZ):** This is a continuous variable measured in hectare. Those with large land size could use chemical fertilizer and improved seed varieties mainly to increase productivity. On the other hand, those with large land size could not be in a position to adopt chemical fertilizer since they could use fallowing system. Besides, large land size holders may not use improved seed varieties so long they could use their own indigenous seed. On the other side, small land size holders may use chemical fertilizer and improved seed varieties so as to heighten production and productivity and thereby satisfy their annual household consumption needs. Hence, the coefficient was not determined or hypothesized in prior.

- **Irrigation Use (IRRIG):** It is a dummy variable 1 if farm households did use irrigation practices and irrigation water 0 otherwise. If there is irrigation water, farm households would be probable to adopt chemical fertilizer and improved seed varieties since the presence of water can best be taken as guarantee for crop failure and the resultant shock. Hence, both for chemical fertilizer and improved seed varieties adoption, positive sign was expected from the final probit estimation result.

- **Access to Credit (CREDIT):** It is a categorical variable; representing 1 if household has had credit access and 0 otherwise. Credit access reduces liquidity problems that household could face while intending to purchase agricultural inputs; and hence paves the way for timely application of inputs thereby increase the overall productivity and farm income (Mpwawenimana, 2005). Hence, from the final estimation result, access credit was expected to have a positive sign both for chemical fertilizer and improved seed varieties adoption decision.

- **Extension Agents’ Contact (EXTENS):** It is a categorical variable representing 1 if households were visited by extension agents and 0 otherwise. Farmers’ visited by extension agents are believed to be exposed for different, new, updated information used to adopt chemical fertilizer and improved seed varieties thereby increase and double agricultural production that finally could increase farm income (Wondimagegn, 2011). Hence, both for chemical fertilizer and improved seed varieties adoption decision, extension agents’ contact will expect to have a positive sign or coefficient from the final probit estimation result.

- **Membership to an Association (ASSOCI):** It is a categorical variable; 1 represents if a household was a member of a certain farmers’ association or cooperatives and 0 otherwise. Membership to an association let farmers to access inputs easily with an affordable price that is pertinent to increase agricultural production and thereby farm income, hence, farmers can easily adopt chemical fertilizer and Improved Seed Varieties on time through an affordable price as well as through credit that will be returned back soon after harvesting. Due to this, while determining chemical fertilizer and Improved Seed Varieties, membership to an association will expect to have a positive coefficient.
RESULT AND DISCUSSION

Factors affecting chemical fertilizer and improved seed variety adoption

Presence of irrigation practices and irrigation use was found to be statistically significant in determining adoption of chemical fertilizer and Improved Seed varieties, respectively, at 5 and 1% significance level. Farmers who have an irrigable land and who use irrigation water, keeping other things constant, have 9.8% and 23.6% higher probability of adopting chemical fertilizer and Improved Seed Varieties. Farmers’ reluctance in adopting agricultural technologies mainly stems from erratic nature of rain fall and lack of irrigation water where the technology is in question for increasing yield rather believed to damage the productive potential of crops sown. Due largely to this reason, if farmers get irrigable water, their probability of adopting the intended technology was found to be high (Table 1).

It is worth to note that, access to credit is one best option whereby smallholders could be instigated in diversifying their economic base; and it is statistically significant at 10% and 1% significance level, respectively, in determining the adoption decision of chemical fertilizer and Improved Seed Varieties. In line with this, farm households that have credit access, keeping other things constant, have 9.9% and 24.5% higher probability of adopting chemical fertilizer and HYV unlike the credit rationed farmers respectively. As a liquidity factor, the more farmers have access to source of finance, the more likely to adopt agricultural technologies that could possibly increase crop yield (Table 1).

Organic fertilizer usage was negatively related to adoption of chemical fertilizer and positively related to adoption of Improved Seed Varieties and statistically significant and and 1% level of significance in adoption of Improved Seed Varieties keeping other things constant, the probability of adopting Improved Seed Varieties, will increase by 0.9% (Table 1).

Tropical Livestock Unit that households do possess has a negative and positive relationship for adopting chemical fertilizer and Improved Seed Varieties respectively. The presence of Tropical Livestock Unit would be an impediment to adopting chemical fertilizer where farmers do prefer utilizing manure without incurring product and transportation cost. In such scenario, farmers would prefer to use their animals’ manure by transporting through their own pack animals when need to arise or on time. Unlike this, the contribution of Tropical Livestock Unit for adopting Improved Seed Varieties is positive; this might be due to the conduciveness of the land for productivity of Improved Seed Varieties since farmers do use manure as proxy for chemical fertilizer. The magnitude of negative and positive sign indicates that, as Tropical Livestock Unit increases by one unit, keeping other things constant, the probability of adopting chemical fertilizer and Improved Seed Varieties would decrease and increase by 1.6% and 2.2% respectively (Table 1).

The Logit regression result reveals that contact with extension workers positively affects adoption of chemical fertilizer and statistically significant at 10% level of significance. The magnitude of positive sign show that, farmers who are visited by extension agents, keeping other things constant, have 11.1% higher probability of adopting, chemical fertilizer unlike non-visited or non-contacted farmers.

Income was found to have a positive and significant relationship with chemical fertilizer adoption decision which is statistically significant at 1% level of significance.

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Table 1: Factors affecting Agricultural Technology Adoption Results from Probit Model.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Chemical fertilizer</th>
<th>IMPROVED SEED VARIETIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>Coef</td>
<td>SE</td>
</tr>
<tr>
<td>Gender</td>
<td>0.068</td>
<td>0.0256</td>
</tr>
<tr>
<td>Age</td>
<td>-0.019</td>
<td>0.012</td>
</tr>
<tr>
<td>CREDIT</td>
<td>0.471</td>
<td>0.253</td>
</tr>
<tr>
<td>EDU</td>
<td>-0.068</td>
<td>0.056</td>
</tr>
<tr>
<td>IRRIG</td>
<td>0.697</td>
<td>0.306</td>
</tr>
<tr>
<td>ETraccon</td>
<td>0.497</td>
<td>0.277</td>
</tr>
<tr>
<td>Income</td>
<td>1.553</td>
<td>0.241</td>
</tr>
<tr>
<td>L Size</td>
<td>-0.038</td>
<td>0.0209</td>
</tr>
<tr>
<td>ASSOC</td>
<td>-0.14</td>
<td>0.215</td>
</tr>
<tr>
<td>FSIZE</td>
<td>0.078</td>
<td>0.466</td>
</tr>
<tr>
<td>ORG Fert</td>
<td>-0.023</td>
<td>0.011</td>
</tr>
<tr>
<td>TLU</td>
<td>-0.007</td>
<td>0.047</td>
</tr>
</tbody>
</table>

Source: Model output and own estimation result.2019, *, ** and *** significant at 1%, 5% and 10% respectively.
Income could best be taken as an important ingredient of adopting chemical fertilizer in such a way that farmers could easily afford fertilizer cost; and these farmers are mostly exposed to new and updated information since they move from one town to another and contacted with different people with different background. Due to this reason, income, have 41.8% higher probability of adopting chemical fertilizer.

The most factors affecting chemical fertilizer and Improved Seed Varieties adoption decision are irrigation use, income and credit access. Hence, compared with indigenous seed, Improved Seed Varieties have higher water intake requirement; and for fruitfulness of chemical fertilizer, there has to be sufficient rainfall and irrigable water. Datar and Del Carpio (2009) argued that use of irrigation practices is an important breakthrough to adopt and produce high yielding and profitable crops. Due largely to this fact, unless there is water, farm households would become too reluctant in adopting these technologies; as if Improved Seed Varieties could not be productive and chemical fertilizer would damage the productive potential of crops sown. Hence, farmers do not want to be risk takers and invest their resource in a barren land. The finding corroborates with the findings of Ransom et al. (2003); Kandji et al., (2006) and Paudel and Matsuoka, (2008).

It is worth to note that, access to credit is one best option whereby smallholders could be instigated in diversifying their economic base and adopt all imperative yield increasing technologies. As a liquidity factor, the more farmers have access and source of finance, the more likely to adopt agricultural technologies that could possibly increase crop yield.

Impact of Agricultural technology adoption on household’s income

Table 2 below shows the impact of agricultural technology adoption mainly chemical fertilizer and Improved Seed Varieties on household’s income. The OLS regression model was considered as impact measurement and analysis and its estimation result is shown here under.

The regression model hypothesis stating the positive impact of agricultural technology adoption on farm income is accepted at 5% significance level. Household income was found to be determined positively by gender (given male headed households do have a better farm income), land size, access to credit, membership to an association and TLU. Validating the hypothesis, chemical fertilizer adopters were much better to get birr 26672.022 than their non-adopter counterparts. Furthermore, still validating the null hypotheses, HYV adopters were found to be earners of birr 4717.575 much better than their counter parts. Hence, the result is as expected with my hull hypotheses in such a way that, agricultural technology adopters can really produce high valued and marketable crops that accelerate additional income and further motivate farm households to adopt technologies again and again (Table 2).

| Variable          | Coefficient | Standard err | t-ratio | P>|t|  |
|-------------------|-------------|--------------|---------|------|
| Constant          | -4098.418   | 7533.117     | -0.54   | 0.587|
| Improved Seed Varieties | 4717.575    | 2328.241     | 2.03    | 0.044**|
| Chemical fertilizer | 6672.022    | 2722.107     | 2.45    | 0.015**|
| Gender            | 6246.228    | 2823.037     | 2.38    | 0.018**|
| Age               | -61.795     | 105.934      | -0.58   | 0.597|
| EDU               | 281.8286    | 558.1144     | 0.50    | 0.614|
| CREDIT            | 2902.156    | 1367.957     | 2.12    | 0.035**|
| ASSOC             | 2213.214    | 1204...256   | 1.84    | 0.067|
| IRRIG             | 75.15914    | 2490.294     | 0.03    | 0.976|
| EXTCON            | 1880.734    | 1687.631     | 1.11    | 0.266|
| F SIZE            | -2150.71    | 1689.8       | -1.27   | 0.204|
| L SIZE            | 4567.513    | 5293.694     | 0.86    | 0.389|
| ORGFERT           | 4053.782    | 1091.148     | 3.72    | 0.000 *|
| TLU               | 6766.944    | 314.8419     | 21.49   | 0.000*|
| Number of obs     | 97          |              |         |      |
| Adj R-squared     | 0.1538      |              |         |      |
| Root MSE          | 37367       |              |         |      |

Source: Model output and own estimation result. *, ** represent significant at 1% and 5% respectively

Improved seed varieties and fertilizer are able to increase production and to improve the household’ income when farmers adopt them. In assessing the impacts of agricultural technologies, it is important to estimate the extent to which farmers have adopted technologies and estimate the resulting productivity gains. Farmers are concerned with the benefits and costs of particular technologies. The partial budgeting method is used to assess the impacts of the improved wheat technologies adopted by farmers'.

Table 2: Impact of Improved Agricultural Technology on Smallholder Farmer's Income

| Variable          | Coefficient | Standard err | t-ratio | P>|t|  |
|-------------------|-------------|--------------|---------|------|
| Constant          | -4098.418   | 7533.117     | -0.54   | 0.587|
| Improved Seed Varieties | 4717.575    | 2328.241     | 2.03    | 0.044**|
| Chemical fertilizer | 6672.022    | 2722.107     | 2.45    | 0.015**|
| Gender            | 6246.228    | 2823.037     | 2.38    | 0.018**|
| Age               | -61.795     | 105.934      | -0.58   | 0.597|
| EDU               | 281.8286    | 558.1144     | 0.50    | 0.614|
| CREDIT            | 2902.156    | 1367.957     | 2.12    | 0.035**|
| ASSOC             | 2213.214    | 1204...256   | 1.84    | 0.067|
| IRRIG             | 75.15914    | 2490.294     | 0.03    | 0.976|
| EXTCON            | 1880.734    | 1687.631     | 1.11    | 0.266|
| F SIZE            | -2150.71    | 1689.8       | -1.27   | 0.204|
| L SIZE            | 4567.513    | 5293.694     | 0.86    | 0.389|
| ORGFERT           | 4053.782    | 1091.148     | 3.72    | 0.000 *|
| TLU               | 6766.944    | 314.8419     | 21.49   | 0.000*|
| Number of obs     | 97          |              |         |      |
| Adj R-squared     | 0.1538      |              |         |      |
| Root MSE          | 37367       |              |         |      |
Table 3. The partial budget analysis for adopters and non-adopters of improved seed varieties

<table>
<thead>
<tr>
<th>Variety</th>
<th>IMPROVED SEED VARIETIES /Fertilizer</th>
<th>Local seed/fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (kg/ha)</td>
<td>1636.00</td>
<td>1287.00</td>
</tr>
<tr>
<td>Gross benefit (Birr/ha)</td>
<td>3190.20</td>
<td>2509.65</td>
</tr>
<tr>
<td>Fertilizer and its application</td>
<td>139.30</td>
<td>74.30</td>
</tr>
<tr>
<td>Seed</td>
<td>367.50</td>
<td>292.50</td>
</tr>
<tr>
<td>Transport</td>
<td>9.50</td>
<td>3.00</td>
</tr>
<tr>
<td>Total cost that vary (birr/ha)</td>
<td>516.30</td>
<td>369.80</td>
</tr>
<tr>
<td>Net benefit (Birr/ha)</td>
<td>2673.90</td>
<td>2139.85</td>
</tr>
</tbody>
</table>

Source: Own estimation result, 2019

Table 3 shows the partial budget analysis for adopters and non-adopters of improved seed varieties. Adopters obtained net benefit of 2673.90 birr/ha and the non-adopters obtained 2139.85 birr/ha. The adopters have gained additional net benefit of 534.05 birr/ha with the additional variable cost of 146.50 birr/ha (Table 3).

CONCLUSION AND RECOMMENDATION

Conclusion

This research paper examined the factors affecting chemical fertilizer and Improved Seed Varieties adoption by the rural household’s chiro district, Ethiopia. The probit regression result showed that income, gender, irrigation use, access to credit, contact with extension workers and income were found to be positive in determining chemical fertilizer adoption decision. Besides, income, extension contact, organic fertilizer usage and TLU were statistically significant in influencing chemical fertilizer adoption decision. Presence of irrigation practices and irrigation use was found to be statistically significant in determining adoption of chemical fertilizer and Improved Seed Varieties. Irrigation use, income and credit access are the most factors affecting chemical fertilizer and Improved Seed Varieties adoption decision are the regression model hypothesis stating the positive impact of agricultural technology adoption on farm income is accepted at 5% significance level.

Household income was found to be determined positively by gender (given male headed households do have a better farm income), land size, access to credit, membership to an association and TLU.

Recommendation

To increase and instigate the likelihood of adopting modern agricultural technologies by smallholder farmers, policy makers should put emphasis on overcoming credit market failures, irrigation problems by introducing drip and pipe irrigations, securing land ownership status of farm households and empowering female headed households to be participants and agents of change by considering a comprehensive and an integrated development of the countries where their involvement is pertinent in all endeavors of the country’s overall development.

For a research output to bring benefits, it has to be adequately disseminated to ultimate beneficiaries at a wider scale (coverage). This can be done through extension agents, as they are employees deployed very close to farmers.

The results of the study reveal that extension agents, besides their technical jobs, are burdened with other activities like effecting loan disbursement and repayments, input distribution, and administrative activities. Hence, the efficiency of extension system should be improved by upgrading practical farming knowledge of development agents through subsequent training programs that are in line with the dynamic agricultural and technological environment.

The household income on adoption and intensity of adoption was positively significant on the decision to adopt chemical fertilizer and improved seed varieties. Therefore, the source of income generation to farmers such as crop, livestock and off-farm activities should be encouraged to hasten the adoption of new agricultural technologies.

Making credit available to farmers is an important way of increasing the adoption of agricultural technologies and hence increasing the level of production. The needs to repay loans and meet other financial obligations compel farmers to sell their output immediately after harvest, at the time when prices are low. The repayment time of credit should be adjusted and the output prices should also be remunerative. This can be realized through improving infrastructure, encouraging postharvest handling techniques, promoting cooperatives marketing, and promoting micro-finance institutions.

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