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FARMER'S DECISION TO PRACTICE CROP ROTATION IN ARSI NEGELLE, ETHIOPIA: WHAT ARE THE DETERMINANTS?

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ABSTRACT

Though Ethiopia is an agrarian country, imbalance between the population growth and the agricultural production growth rate is one of the pronounced national problems that the country is facing. In addition, the agricultural sector in the country is characterized by inadequate resource endowment, traditional methods of cultivation and husbandary practices, limited access to land, credit and agricultural innovation. Crop rotation is one of the responses to enhance productivity and improve soil fertility. However, the adoption of this practice by smallholder farmers is limited. Therefore, the major concern of this study is to empirically examine factors influencing adoption of crop rotation by smallholder farmers in Arsi Negelle district of Ethiopia. In the process of the study both primary and secondary data were used. In this study, stratified sampling procedure was used to select 160 sample households from three kebeles (74 household who are practicing crop rotation and 86 non-adopters). The required data were collected using interview through structured questionnaire. Logistic regression analysis was used to identify factors influencing adoption of crop rotation and results of the regression analysis indicate that educational level of the household, farming experience and extension contact were the most important factors influencing decision of the farmer to practice crop rotation. Hence, emphasis should be given to improve the human capital through education and providing extension service to bring the non adopter into the board.

Keywords: Crop rotation, Adoption, Determinants, Logit, Arsi Negelle, Ethiopia.

1. INTRODUCTION

Ethiopia's socio-economic feature is predominantly rural and agriculture is a key driver of the country's long-term growth and food security. About 85% of the population is in rural parts of the country and agriculture directly supports 83 percent of the population, constitutes 41 percent of Gross Domestic Product (GDP), and 90 percent of export value (EEA (Ethiopian Economic Association), 2012). However, complex and widespread poverty, food insecurity, low productivity, famine and degradation of natural resources are among the challenges facing the country (David *et al.*, 2011). The agricultural sector in Ethiopia uses low capital intensive agricultural technologies that results in low productivity and income that constrain farmers' capacity (Dinar and Hassan, 2008).

According to IFPRI (International Food Policy Research Institute) (2010), the country also faces a wide set of soil fertility issues that require approaches that go beyond the application of chemical fertilizers, the only practice applied at scale to date. Chemical fertilizer faces significant constraints in terms of low availability of credit and limited reach of distribution networks in contexts where appropriate application can enhance yields. Topsoil erosion (soil erosion in the country accounts eight percent of the global total (Tekalign, 2008); acidity of the soil (covering over 40 percent of the country), significantly depleted organic matter due to widespread use of biomass as fuel, depleted macro and micro-nutrients, depletion of soil physical properties and soil salinity are among the core constraints that the country is facing. Generally in Sub-Saharan Africa, low and declining soil fertility due to net nutrient extraction by crops is responsible for low agricultural productivity and food insecurity (Yirga and Hassan, 2010)

The problem is much higher in Central Rift Valley of the country; as it is a closed basin, relatively small changes in land and water use can have far-reaching consequences for the ecosystem (Ayenew, 2004). The current population growth rate in the region appears to be greater than the agricultural production rate contributing to the food insecurity and environmental degradation. (Getachew and Ranjan, 2012). As a result of rapidly growing population and lack of proper land use management systems in the valley, naturally vegetated areas are increasingly being converted to agricultural land and an abundant livestock population has also played its part in the loss of vegetation and grass cover through overgrazing of range lands (Legesse *et al.*, 2004). This increased the frequency of cultivation on a specific landholding which diminished fallowing.

Additionally, the low external agricultural inputs use and environmental degradation such as soil nutrient mining and soil moisture stress caused low yielding of the traditional rain fed farming. (Meshesha *et al.*, 2010).

One way to tackle this problem is to adopt modern, scientific, cost effective and environmentally friendly production method and practicing crop rotation is one of them. Crop rotation can literally be defined as growing crops in a planned sequence on the same field. The principle is to grow annual crops on a different piece of land each year, ensuring that they do not return to the same spot for at least 3 years.

According to CEFS (Center for Environmental Farming System) (2006), Crop rotation has a long history. Farmers in ancient cultures as diverse as those of China, Greece, and Rome shared a common understanding about crop rotations. They learned from experience that growing the same crop year after year on the same piece of land resulted in low yields, and that they could dramatically increase productivity on the land by cultivating a sequence of crops over several seasons

Crop rotation has many agronomic, economics and environmental benefits. According to EU Directorate General for the Environment (2012) it improves soil structure with higher levels of organic matter and better water provision resulting in higher yields in the long-term. It also enhances pest and disease control so can decrease both costs and environmental impacts as producers use fewer inputs to fight pests, and it creates a more balanced nutrient cycle at the field level and helps farmers to use fewer inputs to maintain nutrient availability. This results in lower costs and increased profit margins. Crop rotation also reduces greenhouse gas emissions as better nutrient management through crop rotation decreases nitrogen fertilizer use. Reduced synthetic fertilizer use also leads to reduced greenhouse gas emissions from the manufacturing process and transportation. It also reduces water pollution by limiting the input of large applications of synthetic fertilizers which decrease water pollution caused by nitrogen, increased ability to store carbon crop rotation practices can lead to higher soil-carbon content through increased crop cover periods (using catch crops), reduced tillage intensity and frequency.

However, most of farmers around the district do not utilize this practice. In considering this fact, the study has tried to look factors that are hindering farmers to adopt this practice in Arsi Negelle district. Past adoption studies conducted in Ethiopia have shown that, a factor which is found to enhance adoption of a particular technology in one locality at one time was found to hinder it or irrelevant to adoption of the same technology in another locality. Therefore, this study analyzed factors affecting farmers' decision to practice crop rotation. Knowledge of the extent and causes of such factors will guide policy makers to help increase of agricultural production by designing more effective and efficient institutional support service.

2. METHODOLOGY

2.1. Description of the Study Area

Arsi Negelle district is located in west Arsi Zone of Oromia National Regional State at about 226 km from Addis Ababa with area of 1838 km^2. Geographically, the district is located from 38^0 25' E to 38^0 54' E longitude and 07^0 09' to 07^0 42' N latitude. It has borderlines with Southern Nations Nationalities and Peoples Regional State, Adami Tulu, Shasemene and Siraro districts and Arsi zone. Except for the South-Eastern part, most of the district's elevation is between 1500 and 2300 metres. The district is rich in natural lakes. The major rift valley lakes of Abijata, Langano and Shalla are partly in Arsi Negelle accounting for about 32% of the total area of the district.

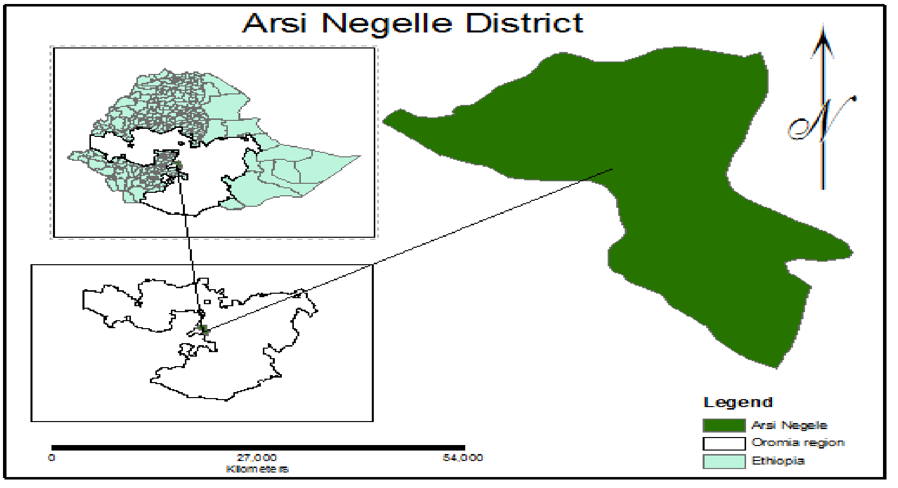
The topography of the area is gentle slope or flat and the soils of the area are lightweight, friable loam and clay loam. The main crops grown in the area include wheat, maize, teff, barley, sorghum, onion and potato. Annual crops accounted for 95% of all croplands in in the district.

Andosol soil type covers about 52.2% of Arsi Negelle, while *Nitosols* cover the remaining 47.8%. About 80% of the district is sub-tropical, while 20% belongs to the temperate agro-climatic zone. The temperature of the area ranges from 16^{o}c to 25^{o}c and annual rainfall ranges between 500-1150 mm.

Livestock are also an important component of the farming system and a source of intermediate products in the district. The area is intensively cultivated and private grazing land is unavailable.

Communal pasture and straw from crops are the main source of feed for livestock production. Cereal crops mainly wheat residue are mostly stacked and fed to livestock during dry season. According to CSA (Central Statistical Agency) (2012), Arsi Negelle district has a total population of 303,223 of which 150,245 are male and 152,978 are females. The average family size for the district was 5.2 (5.3 for urban and 5.1 for rural).

Figure-1. Location of the study area in Oromia State



2.2. Method of Sampling

Three kebeles were randomly selected and households residing in selected kebeles were stratified as adopter and non-adopter of crop rotation. Accordingly, data was collected from both strata using the same interview schedule at the same time. To give equal chance in selection of the study units from each concerned strata, probability proportional to size was applied. Consequently, the total sample size 160 households were drawn via sampling frame (74 household adopters and 86 non adopters).

2.3. Method of Data Analysis

The dependent variable in this case, is dichotomous in nature and takes value of zero or one; where zero represents non adopters and one shows adopters. Crop rotation is, therefore, a non-continuous dependent variable, which doesn't satisfy the key assumption in linear regression analysis; that is, a continuous value for dependent variable. Moreover, if we incorrectly specify the model as linear, the statistical properties derived under linearity assumption will not, in general, hold. That is, Crop rotation is heteroscedastic and that the R^2 is smaller value. Hence, an alternative non-linear regression model, which satisfies the condition required by a dichotomous dependent variable, is used. As such the study will make use of a non-linear regression model or logistic probability unit (logit for short) to examine the kind of relationship that exists between adoption decision and the various socio-economic and demographic factors..

Although a variety of qualitative econometric models, such as Linear Probability Model (LPM), Logit, Probit and Tobit Models can be used to establish the relationship between household characteristics and a dichotomous response variable; the Logit and Probit models are usually the most commonly used ones. Gujarati (1995) states that one can easily use the cumulative distribution function to model regression where the response variable is dichotomous. Moreover, for historical and practical reasons the cumulative distribution function that are most commonly chosen for studies involving dichotomous variables are Logit and normal, which corresponds to the Logit cumulative distribution function and the normal/probit cumulative distribution function, respectively. The advantages of these models over the Linear Probability model are that the probabilities are bound between 0 and 1. Moreover, they best fit to the nonlinear relationships between the response and the explanatory variables. The models specify a functional relationship between the probabilities of being food insecure to various explanatory variables. The independent variable that determines food insecurity can be expressed both qualitatively and quantitatively.

Gujarati (1995) also pointed out that in principle one can substitute the probit model for logistic model, as their formulations are quite comparable; the chief difference being that the logistic has slightly flatter tails than the cumulative normal distribution, i.e. the probit curve approaches the axes more quickly than the logistic curve. Therefore, the choice between the two is one of (mathematical) convenience and availability of computer programs. On this score, the logit model is generally used in preference to probit. In the same vein, Hosmer and Lemeshew (1989) stated that the logistic distribution has got advantage over the others, in the analysis of dichotomous outcome variables, because it is extremely flexible and easily used model from mathematical point of view and results in meaningful interpretations. Hence, the logistic model is selected for this study although both logit and probit models may give similar result.

Following the well-known exposition of Gujarati (1995), the Logit model is specified as follows:

$$P_i = \mathrm{E}(Y = 1/X_i) = \frac{1}{1+e^{-(\beta_o + \beta_1 X_i)}} \quad (1)$$

For ease of exposition, equation (6) can be expressed as:

$$P_i = \frac{1}{1+e^{-Z_i}} \quad (2)$$

Where: $Z_i = \beta_o + \beta_1 X_i$

If P_i is the probability of being adopter then the probability of non adopter is given by 1- P_i, which is expressed as follows:

$$1 - P_i = \frac{1}{1+e^{Z_i}} \quad (3)$$

Therefore, this can be written as:

$$\frac{P_i}{1-P_i} = \frac{1+e^{Z_i}}{1+e^{-Z_i}} = e^{Z_i} \qquad (4)$$

Where $P_i/(1-P_i)$ is simply the odds ratio in favor of adopter; the ratio of the probability that the household will be adopter to the probability that it will be non adopter.

Now if one takes the natural log of equation (9) above it is possible to arrive at a log of odds ratio, which is linear not only in X's but also in the parameters,

$$L_i = Ln\left(\frac{P_i}{1-P_i}\right) = Z_i = \beta_o + \beta_i X_i \qquad (5)$$

Where:

P_i is the probability of being adopter ranging from 0 to 1

Z_i is a function of n-explanatory variables (X_i) and is expressed as:

$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \text{-------} + \beta_n X_n$

β_0 is the intercept or constant term,

$\beta_1, \beta_2, \beta_3, \beta_4,$ -------β_n are the slope of the equation in the model (parameters to be estimated),

L_i is log of odds ratio,

X_i is a vector of relevant household characteristic.

If the disturbance term (U_i) is introduced, the logit model becomes:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \text{-------} + \beta_n X_n + U_i \qquad (6)$$

3. RESULTS AND DISCUSSION

3.1. Socio-Economic Characteristics of the Sample Respondent

The average age of sample farmers was 42.40 years with a range of 22 to 70 years. The majority of the household heads (48.55 %) were found in the age range of between 36 to 50 years and nearly 30 percent were younger than 35 years. The family size of the sample farmers ranges from 1 to 13 with an average of 5.76 person per household. The majority of the households i.e., 43.7% have 4-6 family members. Only 6.52 % of the household heads were illiterate while, 63.043% have attended formal education and 30.435% of the sample household heads were able to read and write even though they did not attain formal education. The survey also revealed that 4.3 % of the sample household never married and 89.1 % were married.

Land, the main resource needed by farmers to earn their livelihoods, is the primary and dependable means of living for the rural people of the country as a whole. The reported minimum land holding in the study area was 0.50 ha. While the maximum size of farm land holding was 7.00 ha. The average land owned by the farmers in the study area is 1.8125 ha. Respondent farmers on average own livestock of 8.069 TLU ranging from 00 to 81.107 TLU and nearly half of the respondents have livestock units not more than 5 in TLU units whereas, nine percent of the respondents possess more than 20 units of livestock in TLU.

A few farmers in the study area have engaged themselves in various off/non farm activities parallel with the main farming activities during the farming season. The survey indicated that 18% of the respondents are engaged in off/non farm income generating activities. The main activities were selling of firewood, hired in other farm and selling local drink.

The survey result showed that about 44 percent of samples farmer had access to credit from either sources which used it to purchase farm inputs like seed, oxen, simple farm implements, and to purchase food grains and medicines or finance school expenses. Almost all of the sample respondents reported that they received extension services though the frequency differs. About 65% of respondents had indicated that they had extension contact on weekly basis. While nearly quarter of the sample respondent had contact with extension workers twice a month.

3.2. Econometric Output

Prior to the logit model estimation, a test was made for multicollinearity among the explanatory variables using the Variance Inflation Factor (VIF) and the values of VIF for all variables entered into the model were below 10, which indicate the absence of multicollinearity among the explanatory variables. In addition, Breusch-Pagan test was also used to detect the presence of hetroskedasticity and the test indicated that there was no problem of hetroskedasticity in the models.

Table-1. Maximum likelihood estimates of the logit model

Variables	Coef.	Std. Err.	Marginal Effect (dy/dx)
Education	0.1537561*	0.080314	.0603551
Family Size	-0.0475019	0.056165	-.0186463
Experience	0.0230038**	0.011359	.0090298
Off/Nonfarm Income	-8.13E-06	6.39E-05	-3.19e-06
Cultivated Land	-0.0846651	0.081024	.0332343
Extension Contact	0.3079225**	0.15496	-.1208712
Training	-0.119122	0.236844	-.0465252
Distance to Market	0.0465177	0.075193	.01826
Distance to Health	-0.0519553	0.065619	-.0203944
Plot- Home Distance	0.0376107	0.117389	.0147636
Number Of Holydays	0.0541547	0.040593	.0212578

As expected, education, which refers to formal education measured in years of schooling of the farmer, was positively influencing the probability of adoption of crop rotation (significant at 10% level). This is because educated farmers have more exposure to the external environment and accumulated knowledge through formal learning which might enable them to pursue production strategy that leads to better efficiency and resource allocation through making use of available knowledge. This means the change in education of the head of the household head by one year, increases the probability of using the crop rotation by the 6 percentages.

Extension service, measured as a discrete variable of the frequency of contacts with extension workers in a year, also positively influenced adoption of crop rotation (significant at 5% level). Extension service had a substantial contribution to motivate the probability and intensity of using modern production technology and adopting improved practices. The higher the linkage between farmers and development agents, the more the information flows and the technological (knowledge) transfer from the latter to the former. Those farmers who have frequent contacts with development agents are likely to adopt better than others.

Experience which was taken as a discrete variable measured in number of years the farmer spent in the agriculture also found to determine the decision of farmer positively. This means that an increase in the year that the household head spent in agriculture increases the likelihood for the household to adopt crop rotation. This is possible because experienced farmers would acquire knowledge and skills that are required for prudent decision.

4. SUMMERY, CONCLUSION AND RECOMMENDATION

Given the very high population growth rate and continued degradation of natural resources, the opportunity to increase production through area expansion is very limited in Ethiopia. The greatest potential for increasing agricultural productivity is likely to come from increasing yields through efficient and wide spread applications of improved agricultural inputs and related technologies. In pursuit of this, various extension /projects have been implemented in the country with varying degree of comprehensives and coverage during the last three decades. However, the vast majority of the farmers in the country continue to use traditional production techniques. In fact, the proportion of farmers who use yield augmenting improved inputs is very limited.

This study has provided primary information on the factors affecting the farmers' decision to practice crop rotation in Arsi Negelle district of Ethiopia. A total of 160 households were considered for this study from three kebeles of the district. In addition, secondary data obtained from relevant institutions were used. The demographic and socio-economic characteristics of the households and the institutional access were analyzed before econometrics analysis. logit model was used to identify factors influencing farmers decision regarding crop rotation. Probability of adoption of crop rotation appears to be significantly and positively influenced by education, extension service and farming experience.

The study has shown that human capital positively affects the decision to adopt crop rotation. Education and farming experience are crucial factors to determine farmers' decision. This underscores the importance of human capital development through improving farmers' access to education. Thus government has to give due attention for training farmers through strengthening and establishing both formal and informal type of framers' education, farmers' training centers, technical and vocational schools.

The result of the econometric model showed that access to extension service is a very important variable that positively influenced the decision to practice crop rotation. Since extension services are the main instrument used in the promotion of demand for modern technologies, appropriate and adequate extension services should be provided. This could done by designing appropriate capacity building program to train additional development agents to reduce the existing higher ratio of farmers to development agents as well as to provide refreshment training for development agents.

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