Factors affecting use of organic fertilizer among smallholder farmers in Sekela district of Amhara region, Northwestern Ethiopia

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Abstract: The imbalance between the population growth rate and the agricultural production growth rate was one of the prominent national problems in Ethiopia. In order to meet the food requirements of the growing population, agricultural production and productivity have to be increased. This could be realized among others through utilizing both organic and inorganic fertilizer. This study aims to identify factors affecting the use of organic fertilizer use among smallholder farmers. Primary data were collected from 155 sample respondents that are selected using a combination of both simple random and stratified sampling techniques. To analyze the data, both descriptive statistics and econometrics model were applied. The result of Logit model indicates that status of education, steep slope land, access of extension service, availability of composting material, fertility of farmland, sex and health status of household head influenced use of organic fertilizers. Based on the result, this study recommended future intervention strategies should be put in place to promote the use of organic fertilizer use and hence enhancing production and productivity of crops in the study area.

Subjects: Agriculture & Environmental Sciences; Soil Sciences; Food Additives & Ingredients

Keywords: Adoption; organic fertilizer; logit model; Amhara region and Northwestern Ethiopia

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PUBLIC INTEREST STATEMENT

Organic fertilizers have enormous potential for soil fertility improvement and cost reduction as compared to chemical fertilizer. Study on identifying impediments and the underlying causes associated with less use of organic fertilizer among smallholder farmers would greatly help local government, development workers and smallholder farmers in assisting their effort of ensuring the needs of food to the growing population of Ethiopia. The findings of this research will also assist district agricultural office in designing future programs and strategies of enhancing agriculture production and productivity of the area via promoting utilization of local available resources.
1. Introduction

The prevalence of malnutrition is increasing and around 815 million of the world population have been undernourished. Malnutrition is the highest in Africa where agriculture is the dominant sector and where there is huge yield-gap (Tigabu & Gebeyehu, 2018). Agricultural technology adoption has a role of increasing productivity and rural farm income and hence considered as one means of securing food and nutrition and thereby a fundamental instrument for sustainable development and poverty reduction.

A number of studies empirically investigated the adoption decisions and the contributions of agricultural technologies (organic and inorganic fertilizers) and for improving the income of the stallholder farmers (FAO, 2017). However, the low adoption rate of modern agricultural inputs, such as fertilizer, is often suggested as the major reason for much of the stagnation in agricultural productivity across Sub-Saharan African Countries (Wossen, Gatiso, & Kassie, 2018). Ethiopia’s agricultural sector accounts about 40% of the national GDP. The sector is important in improving the livelihoods of the bulk of the population. Despite its importance, the agricultural sector in Ethiopia is characterized by low production and productivity (Gelgo, Mshenga, & Zemedu, 2017). To improve this, the adoption of organic fertilizer played a paramount role through maintaining soil fertility. As soil fertility has a direct deprecation on production and productivity of agricultural crops over the last years especially in developing countries where agriculture remains one of the largest sectors in the economy (Mengistu, 2011). Maintaining soil fertilizer by utilizing modern chemical fertilizer is expensive for most smallholder farmers. Due to this switching, organic fertilizer may improve soil quality and reduce the cost of input usage which enhances the efficiency of production of crops (Chen, Zeng, Ying, & Fan, 2018).

According to FAO estimate, 44% of the population in Ethiopia is underfed with 47% of the children suffering from malnutrition (FAO, 2014). Furthermore, the proportion of a population living below 1 US dollar a day is 39%. The causes for food insecurity and poverty may include demographic trends, recurrent drought, widespread land degradation, shrinking and fragmentation of landholdings, inappropriate policies, poor infrastructure, inefficient agricultural practices and others (FAO, 2015). Lack of adequate nutrient supply, the depletion of soil organic matter and soil erosion are major obstacles to sustained agricultural production (Tura, Kenea, & Kaso, 2017).

The key to a prolonged increase in agricultural production is to improve productivity, which can be achieved through either user of modern agricultural technologies or enhancing the efficiency of production or both (Sisay, Jema, Goshu, & Abdi, 2016). Significant characteristics associated with use of organic agricultural production practices such as use of compost, organic fertilizer and conservation tillage may provide better information to support policies that promote adoption of these practices (Fatimid, 2015). Development programs in Ethiopia over the past two decades have included several new technologies. Among the most recently introduced are improved seed, pesticides, improved farm storage techniques, methods of small-scale irrigation and fertilizer usage (Melesse, 2018). Smallholder farmers have low habit to use organic fertilizer (Mengistu, 2011). Due to this problem, the productivity of crop is not improved over time (Teenagers, 2014). Studies such as Obisesan, Akinlade, and Fajimi (2013), Benjamin (2015), Combarry (2016) and Gelgo et al. (2017) were conducted on fertilizer technology adoption. However, there are few sufficient empirical studies in Ethiopia particularly in the study area on organic fertilizer user. Therefore, this study aims to identify factors affecting the use of organic fertilizers among smallholder farmers in Sekela district of Amhara, northwestern Ethiopia.
2. Methodology

2.1. Description of the study area
The study was conducted in Sekela district of Amahara regional state (Figure 1), northwestern Ethiopia. The district is located between 10°59′25″ N latitude and 36°55′30″ E longitude. The district is bounded with the Mecha district in the north, YilmanaDensa district in the northeast, Burie district in the south, JabTehinan district in the southeast, Awi zone in the west and Quarit district in the east, at 460 km from Addis Ababa and 178 km from Bihar Dar. The area is the origin of River Abay. Based on Ethiopian (CSA, 2014) national census, the district has a total population of 138,691 of whom 69,018 are men and 69,673 women; 6,779 are urban inhabitants while 23,129 are rural inhabitants. A total of 29,908 households were counted in this district, resulting on an average of 4.64 persons in a household and 29,093 housing units for 32 kebeles (smallest administrative unit).

2.2. Sampling size and techniques
The study was conducted based on cross-sectional data that were collected from representative smallholder farmers. A total of 155 household heads samples were estimated based on sample size determination formula of Yamane (1967). Multi-stage sampling techniques which involve a combination of simple random and stratified sampling methods were used to select smallholder farmers. In the first stage, stratified sampling techniques were used to stratify 32 kebeles into 2 urban smallest administrative units and 30 rural-smallest administrative units and selected smallholder farmers which were the target of population of the study. In the second stage, four smallest administrative units among 30 kebeles were selected using simple random sampling technique. In the third stage, simple random sampling proportion to their total population size was used to select 155 household heads from the sample frame. As a result, a list of all smallholder farmers in 2018/19 production year was compiled with the help of the extension workers and the heads of these four smallest administrative units.

2.3. Methods of analysis
In order to analyze the data, both simple descriptive statistics and econometrics techniques were applied. Simple descriptive statistics such as mean, standard deviation, frequency and inferential statistics techniques such as t-test, and chi-square test were applied and Logit econometrics model was used using STATA 14 as a tool of analysis.

2.4. Binary logit model specification
The categorization of firms into “user” and “non-user” is based on the dichotomous outcome of the user decision, which characterizes the dependent variable (Y). Thus, a firm is defined as a “user” where $Y_i = 1$ or

![Figure 1. Location map of the study area](image-url)
as a “non-user” where \( Y_i = 0 \) \cite{Ullah2015}. For such types of dependent variable, either Probit or logit model are appropriate where the choice of either of them is a matter of preferences \cite{Greene2000}. This study applied binary Logit model \cite{Arslan2014; Kalinda2014; Obayelu2016 and Fikru2009} and the specification is given below:

\[
P\left( Y = \frac{1}{X} \right) = G(\beta_0 + \beta_1 x_1 + \ldots + \beta_k x_k) = G(\beta_0 + X\beta)
\]

where \( G \) is a function taking on values strictly between zero and one: \( 0 < G(z) < 1 \) for all real numbers \( z \), \( x \) is independent variable, \( y \) is response variable. This ensures that the estimated response probabilities are strictly between zero and one, i.e. \( x\beta = \beta_1 x_1 + \ldots + \beta_k x_k \), which is a non-linear function and its probabilities lie between zero and one.

In the Logit model, \( G \) is the logistic function:

\[
G(z) = \frac{\exp(z)}{1 + \exp(z)} = \Lambda(z)
\]

which is between zero and one for all real numbers \( z \). This is the cumulative distribution function for a standard logistic random variable \cite{Greene2003; Jeffrey2013}. Variables, measurements (unit), nature of variables, expected sign and their descriptions are specified in Table 1:

### 3. Result and discussions

#### 3.1. Descriptive statistics result

As indicated in Table 2, from the total 53 sample of non-users, 26.42% were illiterate while the remaining 73.58% were literate. Whereas among users, 27.45% and 72.55% are illiterate and literate, respectively. From the total 155 samples, 27.1% were illiterate and 72.9% literate. From 76 total non-users, 31.58%...
Table 2. Descriptive statistics of dummy variables for organic fertilizer user

| Dummy variables                        | Non-user user | %    | User | %    | Total sample | %    | chi 2-value |
|----------------------------------------|---------------|------|------|------|--------------|------|-------------|
| Status of education                    |               |      |      |      |              |      |             |
| illiterate                             | 14            | 26.42| 28   | 27.45| 42           | 27.1 | 0.019       |
| literate                               | 39            | 73.58| 74   | 72.55| 113          | 72.9 |             |
| Total                                  | 53            | 100  | 102  | 100  | 155          | 100  |             |
| Access to credit:                      |               |      |      |      |              |      |             |
| no access                              | 24            | 31.58| 18   | 22.78| 42           | 27.1 |             |
| have access                            | 52            | 68.42| 61   | 77.22| 113          | 72.9 | 1.516       |
| Total                                  | 76            | 100  | 79   | 100  | 155          | 100  |             |
| Access to extension service            |               |      |      |      |              |      |             |
| Have no access                         | 23            | 33.33| 19   | 28.79| 42           | 27.1 |             |
| Have access                            | 46            | 66.67| 47   | 71.21| 113          | 72.9 | 2.881*      |
| Total                                  | 69            | 100  | 66   | 100  | 155          | 100  |             |
| Proportion of steep slope land         |               |      |      |      |              |      |             |
| Non gentle slope                       | 17            | 25.76| 25   | 28.09| 42           | 27.1 |             |
| For gentle slope                       | 49            | 74.24| 64   | 71.91| 113          | 72.9 | 0.104       |
| Total                                  | 66            | 100  | 89   | 100  | 155          | 100  |             |

(Continued)
| Dummy variables                                      | Non-user user | %    | User | %    | Total sample | %    | chi 2-value |
|------------------------------------------------------|---------------|------|------|------|--------------|------|-------------|
| Perception of farmers about the quality of farm land |               |      |      |      |              |      |             |
| No fertile land                                      | 15            | 24.59| 27   | 28.72| 42           | 27.1 | 0.320       |
| For fertile land                                     | 46            | 75.41| 67   | 71.28| 113          | 72.9 |            |
| Total                                                | 61            | 100  | 94   | 100  | 155          | 100  |             |
| Health status of household head                      |               |      |      |      |              |      |             |
| Un healthy                                           | 15            | 24.19| 27   | 29.03| 42           | 27.1 | 0.441       |
| For Health                                           | 47            | 75.81| 66   | 70.97| 113          | 72.9 |            |
| Total                                                | 62            | 100  | 93   | 100  | 155          | 100  |             |
| Sex of the household head                            |               |      |      |      |              |      | 0.985***    |
| Female                                               | 20            | 27.03| 22   | 27.16| 42           | 27.1 |            |
| Male                                                 | 54            | 72.97| 59   | 72.84| 113          | 72.9 |            |
| Total                                                | 74            | 100  | 81   | 100  | 155          | 100  |             |

Note: ***, * indicate 1% and 10% significant level, respectively.
have no access of credit and 68.42% have credit while 22.78% of users have no credit and 77.22% of users have access of credit. Access of credit and non-existence of credit have no significant relationship with organic fertilizer user decision. 33.33% non-user smallholder farmers have no extension service while 66.67% non-users have extension service, and 28.79% and 71.21% are user with no access and access of extension services, respectively. The probability of using extension service has no significant relationship with organic fertilizer user decisions. 25.76% non-users have no gentle slope farmland but 74.24% non-users have gentle slope land and from users, 28.09% and 71.91% have non-gentle and gentle slope land, respectively. In this result, non-gentle slope land and gentle slope land have no significant relationship with organic fertilizer user. From the total of 42 samples, 24.19% non-user and 28.72% users have no percept that their land is fertile while 75.41% and 71.28% non-users and users believe that their land is fertile in sequence. In addition, those categories of smallholder farmers have no significant relation with that of organic fertilizer user decision. Moreover, among 113 total samples, 70.97% users and 75.81% non-users' health status are good while the rest 27.1% total samples' health status are not good, i.e. 24.19% and 29.03% for non-users and users, respectively. Furthermore, being female and male have a significant relationship at 1% significant level with user of organic fertilizers. From here 27.03% non-users and 27.16% users are females while 72.84% users and 72.97 non-users are male from the total 155 sample respondents.

Table 3 results show that the average age of household head is 48 and 35 for non-user and user with standard deviation of 2.06 and 1.11, respectively. The smallholder farmers' farm size in hectare for users and non-users are 1.36 and 1.59 with standard deviation of 0.15 and 0.08, respectively. There is mean difference off-farm size between users and non-users at 10% statistical significance level. The average number of livestock for users and non-users are 9.42 and 7.82 with standard deviation of 8.36 and 0.54, respectively. The average numbers of labor in man equivalent for user and non-user smallholder farmers are 4.37 and 4.18 with standard deviation of 0.34 and 0.22, respectively. The mean availability of composting materials to organic fertilizers sources are 205.90 and 390.03 for non-users and users with standard deviations of 35.82 and 64.85, respectively, while their total mean is 328.26. This result indicates that there is a mean difference between non-user and users of availability of composting materials of organic fertilizers at 5% level of significance.

3.2. Econometric result

Before Logit model result on Table 4 is explained, the overall model fitness result should be explained using LR Chi-²(12) with a value of 25.21 which is statistically significant at 5% level of significance indicating that the model is acceptable for interpretation.

![Table 3. Descriptive statistics for continuous variables of organic fertilizer user (OFU)](https://doi.org/10.1080/23311932.2019.1669398)

| Continuous variables                               | Non-user | User | Total sample |
|----------------------------------------------------|----------|------|--------------|
|                                                    | Mean st.dev | Mean st.dev | Mean st.dev |
| Age household head (year)                          | 48 2.056  | 35 1.108 | 39 1.125 |
| Farm size (hectare)                               | 1.360* 0.147 | 1.589 0.077 | 1.512 0.071 |
| Livestock access (TLU)                            | 9.423 1.039 | 7.825 0.621 | 8.361 0.541 |
| Number of labor (in man equivalent)               | 4.365 0.342 | 4.184 0.218 | 4.245 0.185 |
| Availability of composting materials (index)     | 205.904** 35.820 | 390.029 64.845 | 328.258 45.192 |

Note: **, * indicate at 5% and 10% significant level, respectively.
Source: own survey result (2019).
Being literate has negative effect on the use of organic fertilizer application at 5% statistical level of significance. The result shows that illiterate farmers have applied organic fertilization to their farm more as compared with those literate one with a probability of 9.9%. The negative result might be due to the fact that farmers who attended formal education level have more tendency of having more diversified income sources which can be used for supplementing expenditure for chemical fertilizer whereas farmer who did not attend formal education have less income sources and hence used their organic fertilizers for their farming. This result contradicts with the finding of Tura et al. (2017) and Chen et al. (2018) in their respective studies.

Access to extension service has a positive influence on the use of organic fertilizer at 10% statistical significance level. The result shows that farmers who have access to extension service have applied more organic fertilizer with a probability of 76% as compared with those who did not have access. The result suggested that access to extension service has a positive influence on the farmer’s user decision and intensification organic fertilizer in their farmland. This result is similar with the result of Tura et al. (2017), Ali, Awuni, and Danso-Abbeam (2018) and Gelgo et al. (2017) in their respective studies.

Availability of steeply slope land has affected the use of organic fertilizers negatively and significantly at 10% level of significance. The result implies that the proportion of steep slope land decreases the probability of organic fertilizers by 10.1% which indicates that sloppy land are more vulnerable to erosion and which led washing out of manure and compost from the farmland and hence farmers prefer to use organic fertilizers on the gentle land.

Availability of composting materials has positively affected the use of organic fertilizer at 5% level of statistical significance. This finding is similar with the result of Gelgo et al.’s (2017) result which explained the impact of organic fertilizer use on smallholder farmers’ income. The result shows that availability of composting materials increases the probability of use of organic fertilizers by 0.4%.

| Variables                              | Odds ratio | Std.Err | Z     |
|----------------------------------------|------------|---------|-------|
| Age of house holdhead                  | 0.9941     | .0280   | −0.21 |
| Status of education                    | 0.0988**   | 1.0618  | −2.18 |
| Labor in the family                    | 0.8852     | .1441   | −0.85 |
| Number of livestock                    | 0.9238     | .0527   | −1.50 |
| Farm size                              | 0.6807     | .5739   | −0.67 |
| Access to compose material             | 1.0036**   | .0017   | 2.07  |
| Access to credit                       | 0.7465     | .9099   | −0.32 |
| Access to extension service            | 4.7679***  | .9306   | 1.68  |
| Proportion of steep slope land (status)| 0.1009***  | 1.3811  | −1.66 |
| Perception of farmers to fertility of farmland | 12.3939*** | 1.3241 | 1.90  |
| Health status of household head        | 6.5054***  | 1.07663 | 1.74  |
| Sex of house head                      | 62.5150*   | 1.6111  | 2.57  |
| Cons                                   | 0.2674     | 0.5397  | −0.65 |
| LR Chi-²(12)                           | 25.21**    |         |       |

Note: * *, **, *** indicate 10%, 5% and 1% significant level, respectively.
Source: own survey (2019).
Perception of farmers about the quality of farmland has positively influenced the use decision of farmer and is statistically significant at 10% level. The result implies that if status of land fertility changes from fertile farmland form to infertile one, then the probability of user increase by 39.4% of organic fertilizer to upgrade the quality of his/her farmland. This result is similar with Chen et al.’s (2018) result which explains in the perceptions, risk attitude and organic fertilizer investment influence soil fertility positively.

Sex of household head has positively influenced use of organic fertilizer and is statistically significant at 1% level. The positive sign indicates that male-headed households were more likely to use organic fertilizers by 51.5% than female-headed household head. This finding is consistent with Gelgo et al. (2017).

Health status of household head has positive influence on use of organic fertilizer and is statistically significant at 10% level. The result implies that better health status of household head would increase the probability of use of organic fertilizer by 50.5% which could be due to the fact that use of organic fertilizer needs too much labor-intensive works that are directly related to the health status of the farmers.

4. Conclusions and recommendations
The result indicates that status of education, proportion of steep slope land affected organic fertilizer use negatively whereas access of extension services, availability of composting materials, perception of farmers about the fertility of their farmland, health status of household head and sex of household head had influenced use of organic fertilizers positively in the study area. As the result shows, extension services were the main instrument in the promotion of organic fertilizer use. So, appropriate and adequate extension services have to be provided in line with current agricultural development policies of the country. This could be 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. Future intervention strategy promotion has to be developed by increasing technologies such as organic fertilizers use. So, expansion of composting materials allows more farmers to use high amount of organic fertilizer to increase production of crop and to raise crop and livestock product.

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