

Commercialization of Smallholder Pulse Producers in East Gojjam Zone, Ethiopia

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Abstract

This study examines pulse producers' commercialization using a cross-sectional data obtained from 385 randomly and proportionately selected sampled households from East Gojjam zone, Amhara National Regional State of Ethiopia. Data were analyzed using descriptive statistics and econometric model to characterize sample households and identify factors affecting pulse output commercialization. The mean commercial index for the sample households was 0.345 which indicates that on average a household sold 34.5% of his/her total pulse produce. As a result, farm households' output commercialization levels fall in semi-commercial farming system. Two limit Tobit model result indicated that farm households' crop output commercialization was positively and significantly influenced by access to improved seed, cooperative membership, land size, access to market information and pulse yield and was negatively and significantly influenced by family size and livestock owned. Based on the findings, improved seed/new varieties should be released and accessed to smallholder farmers, deliver market information timely, land owned allocation should be intensified so that smallholder producers can increase their crop output commercialization, strengthening the existing farmers' cooperatives and finally cut and carry livestock feeding system should be practiced in order to manage farm land properly.

Keywords: Pulse, commercialization, Tobit model, East Gojjam zone

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1. Introduction

Agriculture is main economic pillars of the Ethiopian economy and the overall economic growth of the country is highly dependent on the success of the agriculture sector. The sector represents 38.5% of the GDP of the country and about 72.7% of the population gains their livelihood directly or indirectly from agricultural production (NPC, 2016). Moreover, Ethiopian agriculture is dominated by smallholder farming which accounts for 85% of households farming less than 2 ha and 40% less than 0.5 ha (FAO, 2014).

Agricultural commercialization brings about sustainable food security and welfare and enhances vertical and horizontal market linkages (Timmer, 1997; Pingali, 1997; Birhanu and Moti, 2010). Commercialization of smallholder farmers has been viewed by the government as the major source of agricultural growth in Ethiopia. The government of Ethiopia implemented agricultural commercialization clusters with the primary goal of commercialization of smallholders' agriculture and agro-industrial development, offering a strategic entry point for private sector engagement (Pauw, 2017).

Commercialization of agriculture involves a transition from subsistence-oriented to increasingly market-oriented patterns of production and input use. It may be defined as the proportion of agricultural production that is marketed and can be measured along a continuum from zero (total subsistence-oriented production) to unity (100% of production is sold) (Timmer, 1997; Pingali, 1997). Smallholder commercialization occurs when a farmer participates in agricultural markets either as a seller or buyer. This can be achieved when a portion of the agricultural produce from the farmers is marketed and/or when part of the inputs are acquired from the agricultural markets (Pingali, 1997; Osmani and Hossain, 2015). Smallholder commercialization can occur in two ways; either by increasing productivity and marketed surplus of the food crops or by focusing on cash crops (Osmani and Hossain, 2015; Sharma and Wardhan, 2015).

Ethiopia is one of the top ten producers of total pulses in the world, the second largest producer of faba beans after China, the fifth largest producer of chickpeas and the second largest producer of pulses in the common market for eastern and southern African countries (COMESA region) following Sudan (USAID, 2010). In Ethiopia, pulses are the third largest export crop behind coffee and oil seed (Boere *et al.*, 2015).

According to CSA (2018) agricultural sample survey report in the main cropping season (Meher) of 2017/2018 about 8.32 million smallholder farmers cultivated 1.60 million hectares of land (12.61% of the total cultivated land) with pulse crops, from which about 29.80 million quintals of pulses (9.73% of the total harvested grain crop) was harvested. Faba beans, haricot beans, chickpea and field peas take the first four largest proportions which is about 9.21, 5.20, 4.99 and 3.68 million quintals respectively. Oromia, Amhara, SNNPR, and Tigray regions are the first four leading regions in producing pulses crops in the country. The total cultivated area under pulses in Amhara, Oromia, SNNPR, and Tigray regions is 0.68 (42.40%); 0.62(39.91%); 0.24(14.75%) and

0.037(2.3 %) million hectares of land, respectively. Considering the volume of production these four regions, Oromia, Amhara, SNNPR and Tigray regions take the largest percentage proportions which are 43.7; 39.47; 13.31 and 1.19, respectively. Amhara and Oromia regions alone produce 83.17% of pulse crops.

Most smallholder farmers in Ethiopia still cultivate using hoe or oxen power and rely heavily on family labor and it is dominated by subsistence, low input-low output and rain-fed farming system (Bezabih, 2010, Mitku, 2014). Market imperfections and high transaction costs have hindered smallholder farmers from exploiting the welfare outcomes of commercialization (Mitku, 2014). Therefore, it is imperative to measure and identify factors determining pulse commercialization in the output markets at the study area and draw policies and strategies to boost pulse output commercialization. There are no empirical studies conducted with regard to pulse commercialization in the study area. Hence, this study analyses pulse output commercialization levels and determinants of among smallholder pulse producers in areas of East Gojjam Zones, in Amhara National Regional State.

2. Data and Methods

2.1. Description of the study area

The study was conducted in three woredas namely Sinan, Debay Tilat Gin and Enarji Eawuga in East Gojjam zone of Amhara National Regional State of Ethiopia. The area lies at 10° 20' North latitude and 37° 43' East longitudes, and at an altitude range of 500-4154 m.a.s.l. The study zone is bordered in the South by the Oromia region, on the West by West Gojjam zone, in the north by South Gondar zone, and in the east by South Wollo zone. The bend of the Abay river defines the zone's northern, eastern and southern boundaries. The zone has 18 woredas and its zonal town is Debre Markos (DPPA, 2003). The annual rainfall of the area ranges from 900-1800mm and mean minimum and maximum temperature of 7.5°C and 25°C, respectively. The annual rainfall of the area ranges from 900-1800mm and mean minimum and maximum temperature of 7.5°C and 25°C, respectively (Dereje *et al.*, 2012). The study area is one of the major *teff* (staple food) and the second pulse crop producing areas in the region. Barely, wheat, oil seeds, sorghum, maize, wheat, oats, beans and peas are the major crops produced in large quantities (CSA, 2012).

2.2. Data source and sampling procedure

Both primary and secondary data are used. Primary data are collected through face-to-face interviews using structured and pre-tested questionnaire whereas secondary data are obtained from various sources such as reports of bureau of agriculture at different levels, NGOs, CSA, woreda administrative office and previous research findings. Multi-stage sampling techniques were employed to select smallholder pulse producers. In the first stage, three woredas, namely Enarg Enawuga, Sinan and Debay Tilat Gin were randomly selected from the 14 pulse crops producing woredas of East Gojjam zone. In the second stage, a total of nine pulse producing kebeles were selected by using simple random sampling method from each of the three selected woredas. In the third stage, 385 farm households were randomly selected based on the probability proportional to their total sizes/numbers.

To obtain a representative sample size for cross-sectional household survey, the study employed the sample size determination formula given by Kothari (2004):

$$N = \frac{Z^2 p q}{e^2} = \frac{(1.96)^2 (0.5)(0.5)}{(0.05)^2} = 385 \quad (1)$$

Where N is the sample size, Z is the inverse of the standard cumulative distribution that corresponds to the level of confidence, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population and q = 1-p. The value of Z is found from statistical table which contains the area under the normal curve of 95% confidence level.

2.3. Methods of data analysis

Descriptive statistics such as means, percentage and standard errors are used to analyze demographic and socio-economic characteristics of smallholder pulse producers.

2.4. Measurement of crop output commercialization

Household commercialization index (HCI) is used to analyze the level of pulse output commercialization. Here, the commercialization of pulse production was analyzed from the output side. The concept used in this study is also supported by other studies made on commercialization of agriculture (von Braun, 1994; Chukwukere *et al.*, 2012) that they define output commercialization of smallholder agriculture in terms of not only cash crop but also food crops sales. According to Strasberg *et al.* (1999) and von Braun and Kennedy (1994), commercialization index for crop production can be defined as:

$$HCI = \frac{\text{Grossvalue pulsesoldinyearj}}{\text{Grossvalue pulseproducednyearj}} * 100 \quad (2)$$

Where; HCI represents household commercialization index of pulses. The index measures the ratio of the gross value of pulse sales by the household *i* in year *j* to the gross value of pulse produced by the same household *i* in the same year *j* expressed as a percentage.

A value of zero for the HCI signifies total subsistence while a HCI value approaching 100 indicates higher degrees of commercialization. The measure is intended to measure commercialization in a scale-neutral manner, independently of the household's wealth (Rios *et al.*, 2008).

Tobit model is the most common censored regression model appropriate for analyzing dependent variables with upper or lower limits (Tobin, 1958, Liu *et al.*, 2013; Abu, 2015). For this study, the Tobit model was preferred because the dependent variable (output commercialization index) is bound between 0 and 1 and its values cluster at these points. Specifically, the output commercialization index is the dependent variable and is lower censored at zero and upper censored at 1. Thus, a two-limit Tobit model has been chosen as a more appropriate econometric model. The two-limit Tobit was originally presented by Rossett and Nelson (1975) and discussed in detail by Maddala (1992) and Long (1997). The two limit Tobit model can be specified as:

$$y_i^* = \beta x_i + \varepsilon_i \quad (3)$$

where y_i^* is a latent variable (unobserved for values smaller than 0 and greater than 1) representing subsistence or fully commercial index; x_i is a vector of independent variables, which includes factors affecting output sold; β is a vector of unknown parameters; and ε_i is a disturbance term assumed to be independently and normally distributed with zero mean and constant variance σ^2 ; and $i = 1, 2, \dots, n$ (n =the number of observations).

Given the observed dependent variable-commercialization index (y_i), the two limit Tobit model can be specified as:

$$y_i = \begin{cases} 0 & \text{if } y_i^* \leq 0 \\ y_i^* & \text{if } 0 < y_i^* < 1 \\ 1 & \text{if } y_i^* \geq 1 \end{cases} \quad (4)$$

McDonald and Moffit (1980) approach was also followed to decompose marginal effects in order to assess the effect of a change in an explanatory variables on the dependant variable. Therefore, the three types considered in the analysis of the Tobit model are shown below. These are:

a) The marginal effect on the latent variable (unconditional expected value)

$$\frac{\partial E(Y/X)}{\partial x_k} = \beta_k \Phi\left(\frac{x\beta}{\sigma}\right) \quad (5)$$

b) The marginal effect on the expected value of observations conditional on being uncensored

$$\frac{\partial E\left(\frac{Y/X, y > 0}{\partial x_k}\right)} = \beta_k + \beta_k \frac{\partial \lambda(c)}{\partial c} = \beta_k \{1 - \lambda(c)[c + \lambda(c)]\} < \beta_k \quad (6)$$

Where, $\lambda(c)$ is called the inverse mill's ratio. It captures the change in the dependent variable (conditioned on $y > 0$) when changing x .

c) The marginal effect on the probability that the observations are uncensored

$$\frac{\partial \Pr(y > 0/x)}{\partial x_k} = \phi\left(\frac{x\beta}{\sigma}\right) \frac{\beta_k}{\sigma} \quad (7)$$

Before running the Tobit model all the hypothesized explanatory variables were checked for the existence of multicollinearity problem. There are two measures that are often suggested to test the existence of multicollinearity. These are: Variance Inflation Factor (VIF) for association among the continuous explanatory variables and contingency coefficients for dummy variables. In this study, Variance Inflation Factor (VIF) and contingency coefficients were used to test multicollinearity problem for continuous and dummy variables respectively. Following Gujarat (1995), VIF is defined as:

$$VIF(X_i) = \frac{1}{1 - R^2} \quad (8)$$

Where: X_i is the i^{th} quantitative explanatory variable regressed on the other quantitative explanatory variables and R^2 is the coefficient of determination when the variable X_i regressed on the remaining explanatory variables.

If the value of VIF exceeds 10, it is used as an indicator for existence of strong multicollinearity among

continuous explanatory variables Gujarat (1995). Similarly, there may also be interaction among qualitative variables, which can lead to the problem of multicollinearity. To detect this problem, Contingency Coefficients were computed for each pair off qualitative variables. The Contingency Coefficients were computed as follows:

$$CC = \sqrt{\frac{X^2}{n + X^2}} \quad (9)$$

Where, CC=coefficient of contingency, X^2 =a chi-square random variable and n =total sample size. Contingency coefficient value ranges between zero and one and as a rule of thumb variable with contingency coefficient below 0.75 shows weak association and a value above it indicate strong relationship of variables Gujarat (1995).

3. Results and Discussion

3.1. Demographic and Socio-Economic Characteristics of Sample Households

The number of sample respondents were 385. The age of the sample respondents ranges from 28 to 71 years and the average age of these respondents were 50.1 years. The average family size per sample household was 5.8 which was larger than the national average household size of 4.6 persons per household (EDHS, 2012; CSA, 2014). In addition, the sampled households walked on average 50.19 minutes to arrive the nearest market center and 33.35 minutes to reach the main road (Table 1).

The livestock species found in the study area are cattle, goat, sheep, donkey, mule, horse and poultry. Livestock is kept both for generating income and traction power. To assess the livestock holding of each household, the Tropical Livestock unit (TLU) per household was calculated. As depicted from Table 1, the average livestock holding of the sample household heads was 6.5 TLU. Land is also one of the necessary factors of production for the households in the study area. The average landholding size in the sample study area was 1.04 hectares per household which was lower than the national average land holding size of 1.17 ha per household (CSA, 2014).

Regarding sex of the sample farm household heads, about 79.5% were male-headed and the remaining 20.5% were female-headed. The result indicated that about 35.6% of the respondents have got credit services for their own pulse production. Extension services usually play a major role in disseminating new and improved farming techniques. Table 2 showed that about 71% of the farmers had contact with the development agents. Moreover, 68.1% of the sampled households have accessed market information for pulse marketing from different sources. Training received on the use of improved seed, technology adoption, agronomic practices and pre and postharvest loses will enhance agricultural productivity and in turn increases market supply of the product. Thus, the result in the study area indicated that 69.9% of the respondents have got training access.

As displayed in Table 2, 67.3% of the sampled household heads were members of farmers' cooperatives where participation at cooperatives was believed to enhance the information exchange and experience sharing among farm households on the use of improved agricultural technologies and recommended agronomic practices. In addition, 87.8% of the sampled respondents were also participated in social engagements (*edir, equib*).

3.2 Measurement of Pulse Crops Commercialization

The proportion of households' output commercialization index was expressed through sale of grass pea, chickpea, faba bean and field pea at different levels which ranges from 0 to 1. As indicated in Table 3, the mean commercial index for the sampled household head was 0.345 which implied that on average a household sold 34.5% of his/her total pulse crop produce. This shows that the level of crop output commercialization in the study area was very low as compared to the national average which is about 52% (ATA, 2016). Comparison among pulse crops show that the households commercial indices of faba bean and field pea are larger than the commercial indices of grass pea and chick pea. This indicated that households majorly sold much of their faba bean and field pea output than that of grass pea and chick pea. The survey result showed that the farm households' crop output commercialization fall in semi-commercial level. As Table 3 indicates, about 36.9%, 47.3% and 15.8% of the sampled households were categorized under low, medium and high commercial level respectively.

3.3 Determinants of Pulse Outputs Commercialization

The estimates of the Tobit model have been presented in Table 5. The result of the existence of serious problem of multicollinearity among the hypothesized explanatory variables showed that the value of VIF for each of the continuous variables is found to be low (1.5) which is less than ten. Thus, there is no a multicollinearity problem among all the hypothesized continuous variables included in the model. The result of contingency coefficient (CC) is 0.24 which implies that there was no a serious problem of association among discrete explanatory variables as the contingency coefficients is less than 0.75.

Determinants of crop output commercialization: As indicated in Table 4, farm household's pulse output commercialization was positively influenced by improved seed used, cooperative membership, landholding size, market information access and pulse yield and it was also negatively influenced by family size and total livestock number.

Improved seed used: The result from Table 4 showed that improved seed used positively and significantly affected crop output commercialization at less than 1%. Thus improved seeds used yields higher production and were perceived to be of high quality crops results in high demand and possibly higher selling price for the crop. The results from marginal effect indicated that as household heads access to improved pulse seeds, the probability to sell their produce was increase by 17.4%. This study result resembles the findings of (Kumilachew, 2016).

Family size: It is measured in terms of the number of adult equivalent in a household. It influenced the level of household commercialization negatively and significantly at five percent probability level. The probable reason was that as the number of adult people increases the level of consumption of adults will increase to the extent that it will have noticeable negative impact on the available output with the consequences of limited produce available for sale due to increased consumption and diseconomies of scale (Adam and Dawit, 2015). The result from Table 4 indicated that the level of output sale decreases by 1.5% for each additional individual in the family members. This result was consistent with the hypothesized expectation and confirms the result of Benjamin *et al.* (2014) and Abdu *et al.* (2016) that households with large family sizes need to feed their family first and take the remaining small portion surplus to the market especially if the crop is consumable at home.

Cooperative membership: It influenced crop output commercialization positively at less than ten percent level of significance. The marginal effect result revealed that for households who were members of farmers' cooperatives, the likelihood to sell their output to the market increased by 7.1%. The result suggests that cooperative membership contributed to the practice of crop output market participation via its advantage of obtaining better information access to credit services. This finding is consistent with that of Rehima *et al.* (2013) and Stephen *et al.* (2017).

Landholding size: It has significantly influenced the level of pulse output commercialization. Large farms enjoy economies of scale and often produce surplus and easily become market oriented compared to small farms. This means that land plays a key role in promoting market oriented production in smallholder agriculture (Martey *et al.*, 2012). This will enable the farmer to produce more and increase the quantity to supply to the market. The marginal effect result indicated that for households who have large farm size the probability to sell their produce to the market increases by 7.6%.

Access to market information: It significantly and positively influenced crop output commercialization. Market information is very important in farming because farmers will get market prices and search for potential buyers thereby facilitating decisions on the quantity to sell. Results show that for households who have access to market information, the likelihood to sell their output to the market increases by 7.1%. Access to market information is an important factor in commercialization because it presents the farmers with all the options which are available for them to choose from so as to get higher returns. In addition, market information helps to increase utilization of yield enhancing farm inputs such as fertilizers and improved varieties which eventually increases commercialization levels (Ochieng *et al.*, 2015, Chauke *et al.*, 2016).

Quantity of pulse produced: The level of commercialization was significantly and positively influenced by it at less than 1 percent significance level. Thus, an increase in household gross production quantity will result in an increase in the household output commercialization level. An increase in household gross production quantity necessitates the producer to market the excess after taking away the portion for household consumption (Ochieng *et al.*, 2015). If farmers are specialized in the production of pulse crops, their emphasis to produce and sell output would be increased. Thus, the result indicates that as smallholder farmers produce more quantity of pulse, the likelihood to sell their output increased by 5.8%.

Total livestock number: This variable significantly and negatively affected the level of commercialization at five percent significance level. The marginal effect result shows that an increase in livestock owned by one TLU, the probability to sell pulse crops decreases by 0.5%. The possible explanation was that households who have large number of livestock, the larger portion of their earnings would come from the sale of livestock and their decision to produce crops for participation in output market would be low. The other possible reason could be that smallholder farmers who have large number of livestock might allocate large proportion of their land for grazing rather than growing crops. This study result was consistent with the findings of Alelign *et al.* (2016).

The ancillary statistic sigma is equivalent to the square root of the residual variance in OLS regression. Sigma is statistically significant means that the estimated coefficient (0.79) is statistically significantly different from 0. The validity of this test of sigma is a matter of debate among statisticians, and some programs will produce the estimate and standard error but not the test of statistical significance (McDonald, J. F. and Moffitt, R. A., 1980).

4. Conclusion and Recommendations

The results from the descriptive analysis revealed that only 34.5% of pulse produce was sold. A majority of 47.3% of farmers were categorized as medium level commercialized whereas 36.9% and 15.8% were low and high commercialized farmers respectively. Besides, the average commercial index of each specific crop in the study area was estimated. The result indicated that the average commercialization index of grass pea, chickpea, faba bean and field pea were 0.25, 0.28, 0.42 and 0.41 of the total production, respectively. This result may indicate

that faba bean and field pea in the study area could contribute to household commercialization.

The econometric result showed that farm household's crop output commercialization was positively influenced by improved seed used, cooperative membership, landholding size, market information access and pulse yield and was also negatively influenced by family size and total livestock number. From this study, the following policy implications might be forwarded

Access to improved inputs is a key step in bridging the yield gap between current and potential production. Government interventions for promotion of pulses production in the country include assistances for a strong support for critical inputs, like seed, nutrients and plant protection chemicals. The use of these improved seeds still remains very low and has not been widely practiced by smallholder farmers. Thus, efforts should be targeted at encouraging smallholder farmers to grow varieties that meet international quality standards which will require appropriate cultivation and post harvest handling practices to ensure the production and delivery of quality products. Hence, it is important to provide modern inputs at the right time and the required amount at reasonable price to increase production.

Households with high family size were also not able to sell more of their pulse products in the market since the consumption will take most of it. So policy makers may need to strengthen the family planning program which is being given in the area; so that the families will have planned family size and might be produce more surpluses for market.

The results of the study indicated that market information has a significant effect to the amount supplied. Hence, market information services have to be established or strengthened to provide farmers and traders consistently and timely. Therefore, the governments and NGOs should develop and facilitate market information systems in which it is symmetrically addressable to all stakeholders.

Membership to farmer cooperatives has a significant positive influence on the pulse commercialization of smallholder producers in the study area. A farmer who is member of farmer cooperative is more likely to adopt improved agricultural technologies and hence efficient in pulse production so as to supply the produce more than others who were not cooperative members. Thus it is important to strengthen the existing farmer cooperatives to reinforce farmer-to-farmer knowledge sharing through providing awareness creation, incentives and providing various facilities by the regional and local government.

Size of land allocated to pulse production positively and significantly affected the level of pulse commercialization. However, increasing the size of landholding was impossible since land is a limited resource. Interventions are needed to increase productivity of pulse per unit area of land through delivering appropriate and improved pulse production technology that increase smallholder farmers' commercialization. Hence, proper utilization of land resource requires intensifying the farm practices through provision of sustainable and timely supply of inputs, increasing the farmers' awareness creation on improving soil fertility and application of improved inputs which helps the farmer to produce and supply more pulse crops to the market.

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Table 1: Summary statistics of the sample households (continuous variables)

Variables	Min	Max	Mean	Std.Err
Age of household head (years)	28	71	50.07	0.56
Educational level (years of schooling)	0	8	1.21	0.10
Farming experience of household head (years)	8	49	29.2	0.54
Family size in adult equivalent	3	9	5.8	0.06
Distance to main market(min)	25	80	50.2	0.58
Distance to main road(min)	15	45	33.4	0.33
Distance to development agents (min)	10	45	30.1	0.35
Landholding size(ha)	0.50	1.75	1.16	0.02
Land allocated for pulse crops (ha)	0.06	0.63	0.33	0.01
Total number of livestock (TLU)	1	14	6.64	0.113

Source: Computed from survey data (2019)

Table 2: Summary statistics of sample households (categorical variables)

Variable	Description	No. of respondents(n=385)	Percent
Sex of household head	Male	307	79.7
	Female	78	20.3
Credit Access	Yes	137	35.6
Extension participation	Yes	273	70.9
Coops membership	Yes	259	67.3
Social participation	Yes	338	87.8
Training Access	Yes	269	69.9
Market information	Yes	262	68.1
Off-farm participation	Yes	70	18.2
Access to improved seed	Yes	273	70.9
Access to chemical fertilizer	Yes	261	67.8
Access to field chemical	Yes	238	61.9

Source: Computed from survey data (2019)

Table 3: Commercial indices of crops and commercialization status of households

Description	Min	Max	Mean	Std. Err.
Commercial index of grass pea	0.00	1.00	0.252	0.016
Commercial index of chickpea	0.00	1.00	0.288	0.016
Commercial index of faba bean	0.00	1.00	0.428	0.016
Commercial index of faba bean	0.00	1.00	0.413	0.015
Aggregated commercial index	0.00	0.81	0.345	0.013
		Number		Percent
Commercial status	low	42	36.9	
	Midium	182	47.3	
	High	61	15.8	

Note: Aggregated crops represent four crops (grass pea, chickpea, faba bean and field pea) Source Author’s computation from sample survey data (2019)

Table 4: Parameter estimates of two-limit Tobit model for commercialization index

Variables	Coef.	Std.Err.	Marginal effect
Sex of household head	0.049*	0.024	0.049
Age of household head	0.001	0.001	0.001
Education status	0.008	0.005	0.008
Family size	-0.015**	0.005	-0.015
Distance to market	-0.000	0.001	-0.001
Distance to road	-0.001	0.001	-0.001
Landholding size	0.076*	0.048	0.076
Access to improved seed	0.174***	0.036	0.174
Chemical fertilizer use	0.006	0.024	0.006
Training access	0.027	0.037	0.027
Field chemical use	0.034	0.018	0.034
Cooperative membership	0.071*	0.038	0.071
Access to market information	0.075**	0.041	0.075
Off-farm participation	-0.008	0.028	-0.008
Tropical livestock unit(TLU)	-0.005**	0.003	-0.005
Quantity of pulse yield	0.058***	0.006	0.049
Constatnt	1.89*		
Sigma	0.791		

LR $\chi^2(16) = 850.56$

Log likelihood =225.69

Prob > $\chi^2 = 0.000$

Pseudo $R^2 = 0.831$

Number of observation =385

Note: ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

Source: Model output based on survey data, 2019

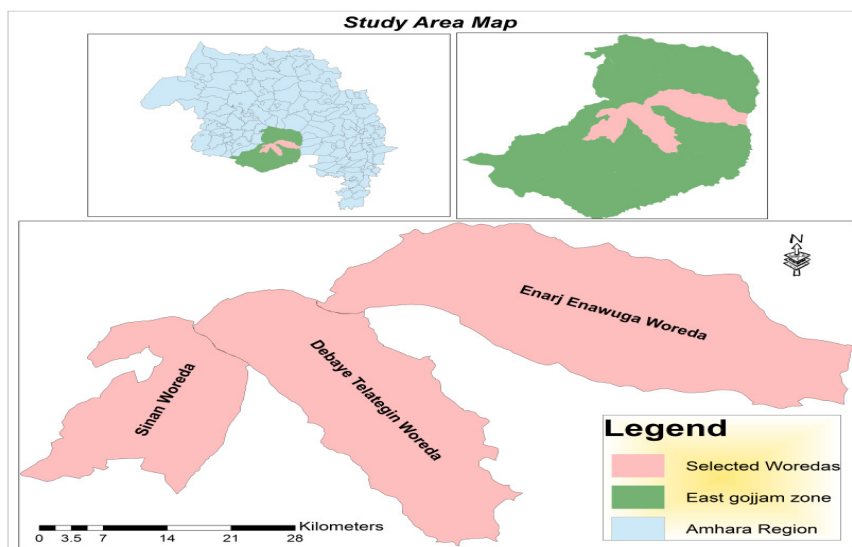


Figure 1. Map of the study are