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The Effect of Land Fragmentation on Cost of Production and Technical Efficiency of Wheat in North Shoa Zone of Yaya Gulale District of Oromia Region, Ethiopia

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Abstract

One of the obstacles for agricultural development is land fragmentation. Understanding of land fragmentation effect is viable for formulating strategies and policies. The study assessed the effect of land fragmentation on cost of production and technical efficiency of Wheat production in Yaya Gulale District, North Shoa Zone Oromia regional state of Ethiopia'. The study used survey data collected from 354 households in 2021. The data was analyzed using descriptive and econometric analysis. Besides, the study used stochastic frontier production frontier and ordinary least square (OLS) and Maximum likelihood estimation techniques. Regarding to measuring land fragmentation the study employed two indicators, namely; the number of plots of land and the Simpson Index. Accordingly, the study confirmed the existence of substantial land fragmentation. From the OLS regression result of the cost of production function, land fragmentation indicators are found to be having positive and statistically significant effect on the cost of wheat production per hectare of land. From the inefficiency model the two land fragmentation indexes are found to be significant—implying the positive association between land fragmentation and technical inefficiency of Wheat producers in the study area. Based on the above facts, the study identified that land fragmentation has an adverse effect on farmers production cost and their efficiency. Hence, considering proper land-use management policies is, therefore, recommended as long as agricultural productivity is concerned.

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Declarations

Availability of data and materials

The data of this study was collected using questionnaire from 354 farmer households are taken from the study. The dataset used in the empirical analyses is available upon request.

Competing interests

The authors declare that they have no any competing interest.

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JEL: Q3, Q12, Q15

1. Introduction

The proper use of agricultural development is influenced by several factors. These factors include climatic conditions, technology, farming practices, and policies—including those related to land tenure systems. One of the obstacles to agricultural development is land fragmentation (Gashaw, *et al*., 2017)—which is often considered as a barrier to long-term agricultural productivity. Land fragmentation, which is defined as a situation where a farming household possesses several non-contiguous land plots, often scattered over a wide area, is an incidence observed in many countries, especially in developing countries (Veljanosk, 2016). However, even though policymakers often point out the drawbacks of fragmentation there is no consensus that fragmentation is strictly a negative phenomenon.

Some authors such as Jabarin and Epplin (1994) argue that land fragmentation reduces productivity—since it is associated with the inefficient allocation of recourses (such as labour and capital)—causing increased costs of production, and lower productivity. It is also associated with production costs due to inefficient resource allocation (Gashaw, *et al*., 2017). Land fragmentation is said to harm agricultural productivity in different ways. Firstly, spatially separated farmland may hinder agricultural mechanization, resulting in lower production efficiency. The push for land consolidation and support for large-scale commercial farming lies with an inverse relationship between farm size and yield per unit of land (Paul & Gĩthĩnji, 2017). Secondly, if the plots are located far from the home, and far from each other, there is a waste of time for the workers spent on traveling in-between the plots and the home—increasing transport costs. Land fragmentation might increase the risk of disputes between neighbors. Lastly, it is noted that financial institutions are sometimes unwilling to take small, scattered land holdings as collateral, which prevents farmers from obtaining credit to make investments (Sundqvist, *et al*., 2006). For this case, most researchers suggest land consolidation as a solution to the adverse effects of land fragmentation.

Despite the negative impacts of land fragmentation, potential positive effects are also noted in many studies (Mengxuan, 2014). Land fragmentation can provide benefits to farmers (Veljanosk, 2016) and improves efficiency and productivity. Land fragmentation has the following advantages. The variety of soil and growing conditions reduces the risk of total crop failure by giving the farmer a variety of soil and growing conditions. It enables farmers to grow more types of crops or plant a certain type of crop in different plots under various conditions—it solves the risk of the market shock of a certain type of product (Mengxuan, 2014). It is accepted that spatial diversification of field locations can bring risk diversification benefits, having a cultivator's land distributed in many small fragments (Daniel, *et al*., 2015). Land fragmentation is the use of multiple eco-zones; different plots enable farmers to grow a wider mix of crops. It also helps farmers to avoid household labor bottlenecks (Sundqvist, *et al*., 2006).

Having discussed these mixed effects of land fragmentation; it is worthwhile empirically studying the effect of land fragmentation on agricultural productivity, producer's efficiency, and hence, cost of production. Even though many researchers have theoretically argued the twin impacts of land fragmentation, the empirical effect is region-dependent and showed mixed results. Some studies confirmed a positive impact of land fragmentation on agricultural productivity (Osei, *et al*., 2019; Selemon, 2013; Paul and Gĩthĩnji, 2017), while some others established a negative impact (Hua, *et al.*, 2018); Daniel, *et al.*, 2015); Hristov, *et al.*, 2012); Kawasaki, 2011; Faustin, 2016). Besides, there is a considerable lack of study about the effect of fragmentation on the cost of production. There are quite a few empirical researches conducted in the Ethiopia case. For instance, Knippenberg, *et al.* (2017) assessed the impact of Land fragmentation and food insecurity in Ethiopia and, their study found that land fragmentation reduces food insecurity. Gashaw, *et al*. (2017), studied the effects of land fragmentation on farmland productivity in the highland districts of Northwestern Ethiopia and found that land fragmentation had an adverse impact on land productivity. Selemon (2013) studied the effect of land fragmentation on farm productivity, efficiency, and crop diversity in Northern Ethiopia. His study found a positive and significant association between the number of plots and productivity, technical efficiency, and crop diversity. Paul and Gĩthĩnji, (2017) explored the relationship between yields, farm size, and land fragmentation in Ethiopia, and they found a positive association between yield and land fragmentation.

Today Ethiopian smallholder agriculture is characterized by extremely small farms, fragmented into multiple plots, with relatively large families that depend on labor-intensive methods of cultivation, and farm fragmentation has been a common feature of smallholder farmers in Ethiopia though has not widely been studied in the past. In Ethiopia, about 92.26% of rural households operate on holdings of a mean of 1.4 ha which constitutes 72% of the total crop area. The number of households operating on holdings smaller than or equal to 1 ha (mean 0.73 ha) constitutes 72.1% of the total while the national average holdings estimate is about 0.8 ha. At the regional level, the Oromia region has an average holding of 0.4 hectares (Gashaw, *et al*., 2017). This indicates that land fragmentation is a widespread phenomenon in the country that can hinder agricultural development In this case; Ethiopia has been subjected to extensive land grabs which have been largely supported by the government as part of its agricultural transformation strategy (Paul & Gĩthĩnji, 2017). The past national economic plans, namely the GTP I & II, in addition to the support for consolidation and small farmer commercialization the government, have embarked on a specifically pro-large-scale land acquisition program. Hence, understanding land fragmentation issues is viable for formulating suitable strategies and policies. The present study aimed to 'assess the effect of land fragmentation on cost of production and technical efficiency of Wheat production in Yaya Gulale District, North Shoa Zone Oromia regional state of Ethiopia'. The district is selected purposively based on its Wheat production capacity and population density since Land fragmentation is largely affected by population density (Niroula & Thapa, 2005). Regarding measuring land fragmentation the study employed two indicators, namely; the number of plots of land and the Simpson Index. Understanding the effect of land fragmentation on the cost of production and efficiency is therefore important to design policies concerning long-term agricultural development. The application of cluster farming and large-scale production tactics largely depends upon land consolidation. Accordingly, the major objective of the study is to 'assess the effect of land fragmentation on cost of production and technical efficiency of wheat in north Shoa Zone of Yaya Gulale District Of Oromia region, Ethiopia.

2. Research Methodology

The study examined the effect of land fragmentation on the cost of production and technical efficiency in the study area. For this purpose, the study employed descriptive statistics and different econometric techniques. This section describes the data type and data sources, Sampling techniques, method of data analysis and model specification, variable description, and hypothesis of the study.

2.1 Description of the Study Area

North Shewa zone, located between 9005’N and 10023’N latitude and 37057’E and 39028’E longitude, is one among the 18 zonal administrations of Oromia national regional state. North Shewa zone has an area of 8990 km2. The zone capital town is Fiche and it is located 112km far from Addis Ababa, the capital of Ethiopia. North Shewa zone has 13 rural districts with a total of 267 Kebeles and 26 towns with 30 Kebeles administration. The north shewa zone has a total population of 1,594,720 in 2017/18. Climatically, North Shewa zone is divided into three; Tropical (Kola), Sub-tropical (Weyina Dega), and Temperate (Dega). Which accounts for 20.7%, 42.6%, and 36.7% of the total area of the zone, respectively (BOFED, 2008). The average crude farm landholding size, of the North Shewa zone, was 0.637 hectares in 2017/18. In the North Shewa zone, Land cultivated and the crop produced in the zone is privately owned cultivation and there is no state land cultivation and crop production. According to the statistical abstract data of 2017/18, 489,902.93 hectares were cultivated land for crop production. The crops obtained from this cultivated land were 11,366,231.12 quintals. Teff and Wheat are the major crops grown in the zone (DAO, 2017).

Yaya Gulele district is part of the North Shewa Zone of Oromia state. It has one urban and 17 rural Kebeles. The environment is severely damaged through deforestation, the decline in soil fertility, wildlife depletion, and climate change. Agricultural practices in the study area are dominated by crop production together with the rearing of the animal. The main source of livelihood is agriculture which accounts for about 97% of the population, and the rest of 3% of the population who lives in town engage in partly trade and daily labor. Teff, wheat, barley, maize and sorghum are the main staple food crop. Among these Teff and wheat is mostly for sale (Ibid).

2.2 Sampling Design

In this research, the sampling unit is considered to be the head of the household, since the head of the household can give detailed information about the socio-economic and farm characteristics condition of wheat production, cost of production, and land fragmentation.

In the selection of rural household respondents, a multistage sampling technique is used. What makes the sampling technique a multistage is that, firstly, one of the 18 Zones—the North Shoa zone, was selected purposively. Then, from all the districts in the Zone, one district—Yaya Gulale District is selected based on its capacity for Wheat production and population density. In the third stage four *Kebeles* out of seventeen, namely *Nya & Sole*, *Rimeeti*, *Qarre Tokkee* and *Daleti*, from which the samples taken are selected. Finally, with the underlying assumption of the distribution of land fragmentation is equal throughout all Kebeles, and with the application of systematic random sampling, respondents are selected from each Kebeles based on the extent of wheat production. Then samples are selected based on the population content of the Kebele by using a simple random sampling technique. Four Kebeles constituent 3,078 household heads, which is the study's target population. From this total population, the study sample size is determined by using Yamane's (1967) sample determination formula. This formula has been chosen because of its simplicity, cost-effectiveness for large populations and the lower error committed bias (Ermiyas, *et al.*, 2019). Accordingly, the sample size is determined as follows;

$$n = \frac{N}{1 + N(e)^2}$$

Where, n is desired level of sample size

N is target population

e is level of precision (it is 0.05 in our case).

Following the above formula, $n = \frac{3{,}078}{1+3{,}078\ (0.05)^2} = 354$

2.3 Types and Sources of Data

The study used both primary and secondary sources of data. The study employed cross-sectional survey data collected by using a Questionnaire from randomly drawn households from the study area—Yaya Gulale District. The secondary data are obtained from kinds of literature related to this study, reports from the agricultural offices of the study, and other sources.

2.4 Method of Data Analysis

Descriptive statistics such as mean, median, and standard deviation, are used to present the data as part of the numerical methodology. The data were also summarized by using tabulations and graphical methods (charts) because both methods can be applied to the sample data sets. In addition to descriptive statistic, the number of plots of land (as an indicator of land fragmentation), have been employed. There are a number of land fragmentations in the kinds of literature. In this study, we used the number of plots and Simpson Index as land fragmentation indicators.

Simpson Index (SI): The Simpson index is defined as the sum of the squares of the plot sizes, divided by the square of the farm size. The standard formula of SI is defined as:

$$\mathrm{SI} = 1 - \frac{\sum_{i=1}^{n} a^2}{A^2}$$

Where ‘n’ is the number of parcels belonging to a holding, ‘a’ is the area of each plot ‘l’ and ‘A’ is the total holding size. An ‘SI’ value closer to zero indicates lower fragmentation.

2.5 Model Specification

The last two major objectives of the study were encountered using econometric techniques. The purpose of the study is to evaluate the effect of land fragmentation on the Cost of production of Wheat and the Technical efficiency of Wheat production—which requires two distinct model specifications. All models incorporated several independent variables such as farm characteristics, household characteristics, institutional characteristics, and land fragmentation indicators.

Cost of production

In agricultural production, plots can generally be used for more than just one crop, and Wheat is the main crop in the study area. However, the effect of land fragmentation is likely to affect all crops planted by a farmer—like the cost of production, productivity, and efficiency. Therefore, we decided to focus on the production costs, productivity, and efficiency of the main crop—Wheat—which is affected by the fragmentation of the whole farm. The first model is used for estimation of the cost of production of Wheat and to examine the impact of land fragmentation on the cost of production of Wheat. The cost of production equation is adopted following (Mengxuan, (2014); Tan, *et al*. (2008)) specifications. The cost of production equation is the function of land fragmentation indicators and other factors of farm characteristics that directly influence the production costs.

$$C= f(X,Y,Z,) \quad \textbf{(1)}$$

From the above equation; 'C' is the production cost per unit product, X is the farm-specific variables, 'Y' is the household characteristic variables and 'Z' is the institutional variables. However, it is noted that the land fragmentation index is incorporated under farm-specific variables. The total cost of production is determined by a combination of different factors. Before doing that, the total cost of production per hectare of land must be estimated. To this end, the following formula was performed.

Total cost of production of Wheat = Labour cost + Land cost + Seed cost + Fertilizer cost + Pesticide cost + Animal cost + herbicide cost

Most cost components, particularly labor cost, land cost, and animal costs are not easily observed—calling for estimation of their opportunity costs (shadow price). After the estimation of the total cost of production of given farmland, it needs to be converted into a hectare basis. Subsequently, we can put the functional form of cost of production and its possible determinants—including land fragmentation. As follows:

$$lnC_i = a_{0i} + \beta_{1i}\text{Gen} + \beta_{2i}\text{AgeHH} + \beta_{3i}\text{EdHH} + \beta_{4i}\text{FSz} + \beta_{5i}\text{LHz} + \beta_{6i}\text{DHP} + \beta_{7i}DHM + \beta_{8i}\text{FrqEx} + \beta_{9i}\text{FI} + e_i \quad \textbf{(2)}$$

Where, $ln\,C_i$ is the natural log of the total cost of production of Wheat production per hectare of land. It is noted that the degree of land fragmentation is incorporated as one of the farm characteristics. In this study, the number of Plots and Simpson index are considered to reflect the land fragmentation. The above model (equation 2) is estimated by using the ordinary least square (OLS) estimation technique.

Table 1: Explanatory variables and their expected sign

No	Variables	Symbol	Description	Expected sign
1	Gender of the Head	Gen	Male=1, Female=0	-
2	Age of HH head	AgeHH	Years	+/-
3	Education level of HH head	EdH	Years	-
4	Family size	FSz	Number of HH members	-
5	Land holding size	LH	Amount of land households have	-
6	Average distance from plots to homestead	DHP	Minutes	+
7	Distance to the nearest market center	DHM	Minutes	+
8	Extension service	FrqEx	frequency of extension service	-
9	Land fragmentation Indicator	FI	Number of Plot Simpson Index	+/-

Source: Survey result (2021)

Efficiency

Technical efficiency in crop production can be defined as a farmer's ability to maximize outputs given a set of inputs and technology. The degree of technical inefficiency reflects an individual farmer's failure to attain the highest possible output level given the set of inputs and technology used. The highest possible output, using the available inputs and technology, is represented by the production frontier. Technical efficiency explains the difference between potential and observed yield for a given level of technology and inputs (Minilik, 2019). A stochastic frontier production model proposed by Battese and Coelli (1995) is applied to cross-sectional data to determine the efficiency of the Wheat producers in the study area (Balogun & Akinyemi, 2017).

Among the possible algebraic forms, Cobb–Douglas and the translog functions have been the most widely used functional forms in most empirical production analysis studies. Some researchers argue that Cobb–Douglas functional form has advantages over the other functional forms in that it provides a comparison between the adequate fit of the data and computational feasibility. It is also convenient in interpreting the elasticity of production, and it is very parsimonious concerning degrees of freedom. In addition, due to its simple features, the Cobb–Douglas functional form has been commonly used in most empirical estimations of frontier models. This simplicity, however, is associated with some restrictive features in that it assumes constant elasticity, the constant return to scale for all firms/farms, and the elasticity of substitution is equal to one (Coelli, *et al*., 1998). Therefore, that is why Cobb–Douglas functional form was used in this study.

Stochastic production frontier is the most appropriate technique for efficiency studies which have a probability of being affected by factors beyond the control of the decision-making unit. This is because this technique accounts for measuring inefficiency as a result of these factors and technical errors occurring during measurement and observation. Wheat production in the study area is likely to be affected by natural hazards, unexpected weather conditions, and pest and disease occurrences that are beyond the control of the farmers. In addition, measurement and observational errors could also occur during data collection (Moges, 2019). The stochastic frontier production function model has the advantage in that it allows simultaneous estimation of individual technical efficiency of the respondent farmers as well as determinants of technical efficiency (Battese & Coelli, 1995).

The stochastic frontier approach (SFA) addresses some of the limitations of the deterministic frontier approach. In the new approach, the error term consists of two components, one is random and the other is a one-sided residual term representing inefficiency. Aigner, *et al*. (1977), Meeusen and Broeck (1977), and Amegnaglo, (2018) proposed that the production technology of a farm is represented by a stochastic frontier production function and the model has the following form;

$$Y = f\left(X_{ij}\beta\right) * \exp(e_i) \qquad i = 1, \dots\dots.., N$$
$$Y = f\left(X_{ij}\beta\right) * \exp(V_i - U_i) \qquad \textbf{(3)}$$

Where, Yi is the observed output of farmer i and $f\left(X_{ij}\beta\right)$; is a function such as a Cobb-Douglas production function of the vector and represents the maximum quantity that can be produced with Xi (vector of inputs) and technology described by the parameters β. The disturbance term e_i consists of two components; V_i and U_i. The term V_i, is the symmetric component and permits random variation of the production function across farms; while it also captures factors outside the control of the farmer. While A one-sided component (Ui > 0) reflects technical efficiency relative to the stochastic frontier, if $U_i = 0$, production lies on the stochastic frontier, and if $U_i > 0$, production lies below the frontier and is inefficient.

Equation (3) can be rewritten in Cobb-Douglass production function form. The original Cobb-Douglas function uses only two inputs, labor, and capital.

However, in this study, the function is adjusted to comprise all four factors of production and given as:

$$Y = AL^{\alpha}K^{\theta}S^{\gamma}X^{\beta}e \qquad \textbf{(4)}$$

The model, '*Y*' indicated the net farm income or land productivity of Wheat, 'K' is the capital used in production, 'L' is the labor used in production, 'S' is the size of the farmland (including land fragmentation index), 'X' represents other inputs including farmers' characteristics, 'A' is the technology of production, the disturbance term e consist of two components; V_i and U_i. The specification of the Cobb-Douglas stochastic production function which we chose for the econometric estimations has the form shown as;

$$\ln(Y_i) = \beta_0 + \alpha \ln(L_i) + \theta \ln(K_i) + \gamma \ln(S_i) + \sum_k^n \beta_k X_{ik} + V_i - U_i \quad \textbf{(5)}$$

Where 'Y_i' is the total quantity of wheat produced per hectare of land for i^{th} farmer, 'L_i' is the quantity of labor used by producer i, 'K_i' is the stock of capital used by producer i (proxied by the number of oxen-days), 'S_i' is the land size used by producer i, 'X_i' represents other explanatory variables, and β_0, the constant in the estimation, that can be interpreted as total factor productivity (Amegnaglo, (2016)). *ln*'s is natural logarithms; V_i is the symmetric component that considers random errors associated with random factor under the control of Wheat farmers; U_i is the asymmetric error component that represents the deviation from the frontier production (inefficiencies). Therefore the technical efficiency is to be estimated using the basic agricultural factors of production; like cultivated Land, Seed, Labour, Oxen (Ox), and Fertilizer. The technical efficiency of individual farmers is defined in terms of the ratio of observed output to the corresponding frontiers' output, conditional on the level of input used by the farmers. Hence the technical efficiency (TE) of the farmer is expressed as follows.

$$\text{TE} = \frac{f(X_{ij}\beta) * \exp(V_i - U_i)}{f(X_{ij}\beta) * \exp(V_i)} = \exp(-U_i) \qquad \textbf{(6)}$$

Where, 'TE' is the ratio of actual output relative to the potential output level. 'TE' takes a value between 0 and 1 with a smaller ratio reflecting inefficiency. The estimation of the parameters of the production function requires the imposition of an appropriate distribution concerning the inefficiency error term ui. The error term is assumed to follow one of three possible distributions (Bauer, 1990);

(i) Half-normal as U/N (0, δu^2)

(ii) Exponential as exp (μu, δu^2)

(iii) Truncated normal at zero N ~ (μu, u^2)

Using the assumption that the inefficiency effects are half normally distributed i.e. u_i~iidN (0, δu^2)**;** the technical inefficiency effect can be defined as;

$$u_i = Z_i\delta + \theta$$

Where Z_i is a (P×1) vector of explanatory variables associated with the technical inefficiency effect such as socioeconomic, demographic, farm management, and institutional characteristics and θ is the error term of the inefficiency (Amegnaglo, 2016). The function determining the technical inefficiency effect is defined in its general form as a linear function of different factors and given by the empirical model;

$$u_i = \delta_i + \delta_1 Gen + \delta_2 Avage + \delta_3 AvEdu + \delta_4 \mathrm{Fz} + \delta_5 Dep + \delta_6 Dp + \delta_7 Dm + \delta_8 \mathrm{FreqE} + \delta_9 Cr + \delta_{10} FI + e_i \quad \textbf{(7)}$$

Where $'u_i'$ denotes farm-specific inefficiency, 'δ' denotes a set of parameters to be estimated, and the variables that explain farmers' inefficiency equation with its expected signs are explained in Table 4 below. Aigner, *et al*. (1997) suggested the use of the likelihood function to allow for two variance parameters namely Sigma squared (σ_2) and gamma (γ) which have statistical applications. They are defined as follows:

$$\delta_T^2 = \delta_V^2 + \delta_U^2, \quad \gamma = \frac{\delta_U^2 2}{\delta_T^2} \quad \textbf{(8)}$$

The value of σ^2 measures the goodness of fit to the data. The γ value lies between zero to 1, where the value of zero indicates all deviation from the frontier is due to the noise effect and the value of 1 is indication that all deviation from the frontier is due to the inefficiency effect. Where σ^2 is the variance of output conditioned on inputs. This says that production uncertainty comes from two sources: pure random factors and technical inefficiency. Hence if γ, the proportion of uncertainty coming from technical inefficiency, is equal to zero, then it means there is no technical inefficiency. This can be used to test whether technical inefficiency is present in the firm (Mathias, 2010). Equations 5 and 7 are to be estimated by using the maximum likelihood estimation technique.

Table 2: Determinants of (in) efficiency

No	Variables	Symbol	Explanation	Expected Sign
1	Gender of the household head	Gen	(Male = 1, Female = 0)	+
2	Average Age of the farmer (Year)	AvAge	Years	+/-
3	Average Education level of HH head	AvEdu	Years spent in school)	+
4	Family size	Fz	Number	+
5	Dependency	Dep	The ratio of adult to non-adult family member	-
6	Average distance from plots to homestead	Dp	Minutes	-
7	Distance to the nearest market center	Dm	Minutes	-
8	Extension service contact	FreqEx	Frequency of extension visit	+
9	Credit	Cr	Yes=1, No= 0	-
10	Fragmentation Index	FI	Number of Plots Simpson Index	-/+

Source: Survey result (2021)

3. Results and Discussion

3.1 Descriptive Analysis

Households are important institutional units for most development processes including agricultural extension services delivery. Thus, discussing the demographic features and economic conditions of respondents would have a vital role in seeing the extent of variations in land fragmentation parameters and socioeconomic variables. This study was conducted on 354 household respondents, of which 336 are male household heads. As Table 3: Descriptive statistics of household and institutional variables below show, the mean age of the total sample respondents (354) is 45.5 years with minimum and maximum ages of 20 and 85 years, respectively. The mean educational level of sample respondents is 1.8 years, while the minimum and maximum years of schooling of household heads are 0 and 12, respectively. The mean family size of the respondent is found to be 5.31 with a standard deviation of 1.43, while the maximum and minimum family size of the respondents is 1 and 10, respectively. In addition, the table elaborates on the average

age and educational level of household members. Accordingly, the mean average age of household members is found to be 24.8, while the maximum and the minimum average age of household members are 12 and 72.5, respectively. The mean average educational levels of household members are found to be 3.76, with a standard deviation of 2.5. On the other hand, the maximum and the minimum average age of household members are 12 and 72.5, respectively.

Table 3: Descriptive statistics of household and institutional variables

Variables		**No. of obs.**	**Min**	**Max**	**Mean**	**Std. Dev**
Gender of	Male	336	-	-	-	-
household head	Female	18	-	-	-	-
Age of household head		354	20	85	45.3	12.34
Education level of household head		354	0	12	1.8	0.16
Family size		354	1	10	5.31	1.43
Average age of HH members		354	12	72.5	24.8	7.08
Average educational level of HH members		354	0	12	3.76	2.6
Distance to the nearest market center		354	2	120	42.5	31.36
Average distance from plots to home		354	0	8	4.9	2.92
Frequency of Extension service		354	0	3	1.81	0.44
Received credits	Yes = 66 No = 288	354	-	-	-	-
Amounts received credits (In ETB)		288	900	20,000	1,1401.6	3,268.6

Source; Authors, based on survey data (2021)

The mean distance to the nearest market center is 42.5 minutes, with the minimum and maximum values of 2 and 120, respectively. The mean value of the average distance from plots to the home of the respondents (measured in kilometers) is found to be 4.9 with a standard deviation of 2.92, while the maximum and minimum value of the average distance from plots to the home of the respondent is 0 and 8 minutes, respectively. Frequent extension contact (measured as the number of Extension services farmers received) enables farmers to use modern techniques and adopt improved agricultural inputs. The maximum and the minimum number of extension contact of the respondents are 0 and 3, respectively, with the mean value of 1.81. Among the 354 household respondents, 66 of them received credit from formal financial institutions in the 2019/20 year.

Table 4: Descriptive statistics of farm-related variables

Variables		No. of obs.	Min	Max	Mean	Std. dev
Land holding (hectare)		354	1	7	2.9	0.94
Total amount of Wheat production (KG)		354	400	8000	1513	889.2
Farm size allotted for wheat production (hectare)		354	0.5	5	1.61	0.66
	Seed (KG)	354	50	1000	292.8	168.8
	Fertilizer (KG)	354	50	1000	348.5	146.082
	Labour (Man-days)	354	17	169	59.38	29
	Oxen (Ox days)	354	8	131	45.43	22.48
	Chemicals used (In litter)	354	0.5	5.5	2.1	0.89
Fragmentation Index	Number of plots	354	1	12	3.69	1.33
	Simpson Index	354	$1E^{-}9$	0.838	0.64	0.1411

Source; Authors, based on survey data (2021)

Error! Reference source not found. in the above presets different farm-related features of the Wheat production of the study area. It shows the landholding (hectare) of respondents, farm size allotted for wheat production (hectare) in the 2020 harvesting year, and the amount of Seed, Fertilizer, Labour, Oxen (measured in oxen days), and Chemicals (the amount of herbicide & pesticide measured in a litter) used, and the level of land Fragmentation (Indexed by the number of plots and Simpson Index). The average, the minimum, and the maximum level of landholding of the respondents, as measured by hectare, are 2.9, 1, and 7 0.175, respectively. The minimum and the maximum of level wheat production in the 2020 harvesting year are 400 and 8000 Kilogram respectively. This production level has shown a big variability as explained by the standard deviation of 889.2, while the mean value of wheat production is 1513 Kilogram.

The average, the minimum, and the maximum amount of seed and Fertilizer used for wheat production in the 2020 harvesting year were 292.8, 50, and 1000 kilograms of Seed, and 348.5, 50, and 1000, kilograms of fertilizer, respectively. Similarly, respondents used a minimum of 17 labor and 8 oxen and a maximum of 167 labor and 131 oxen for wheat production. Regarding chemicals, respondents used a minimum of 0.5 and 5.5 litter of different chemicals (herbicide and pesticide), while the mean value and chemical usage were found to be 2.1 Littre. The minimum and the maximum number of plots of land of the respondents are 1 and 12, respectively, while the average number of plots of land of the respondents is 3.69.

3.2 The Current Land Fragmentation Situation in the Study Area

Land fragmentation is a phenomenon that exists when a household operates several owned or rented noncontiguous plots at the same time. Land fragmentation indicators like farm size, the total number of plots on the farm, average plot size, distribution of plot sizes, the spatial distribution of plots, and the shape of plots are commonly used in the literature (Balogun, & Akinyemi, (2017)). In this study, we used the number of plots and average plot size as land fragmentation indicators. A higher number of plots signify higher Land fragmentation and a lower plot number indicates lower Land fragmentation. As indicated in Table 5 below, the most frequent number of plots is 4, which occurs 121 times and covers about 34.18 percent of the surveyed households in the study area. The second most frequent number of plots is 3, which occurs 100 times and covers about 28.25 percent. Therefore, households who have 3 or 4 plots together account for more than 63 percent. Even though there is a standard benchmark for the severity of land fragmentation, studies link a higher number of plots with higher land fragmentation.

Table 5: Number of plots as a land Fragmentation Indicator

Number of plots	Freq.	Percent	Cum. Percentage
1	6	1.69	1.69
2	54	15.25	16.95
3	100	28.25	45.20
4	121	34.18	79.38
5	46	12.99	92.37
6	20	5.65	98.02
7	2	0.56	98.59
8	3	0.85	99.44
10	1	0.28	99.72
12	1	0.28	100.00
Total	354	100.00	

Source; Authors, based on survey data (2021)

Another land fragmentation proxy used in this study is Simpson Index. Accordingly, the maximum and the minimum value of the Simpson Index are 1E-9 (near zero) and 0.838, respectively. Whereas the average value of the Simpson Index is 0.63 with a standard deviation of 0.1411. About 8.19 percent of respondents, which occurred 29 times, have a fragmentation Index value of 0.44. The second most frequently appeared (13 times) index value is 0.60 which covers 3.67 percent of respondents. In general, the land fragmentation index value of the respondents is highly divergent and the result is presented in Appendix 4 (

Table 1). Besides we introduced agricultural extension experts and farmers who have a number of years of wheat cultivation experience in the study area. We raised different land fragmentation-related issues for the key informant interview. From KII discussions, we were able to note that, land fragmentation has resulted from high population growth, scarcity of land, marriage arrangement, and lack of job opportunities in other sectors. It has an even tendency to ever-expanding. The KII participants discussed their past experiences with land fragmentation issues. High population growth, accompanied by large family size, has a direct effect on land fragmentation. Land fragmentation, alongside the falling agricultural productivity, is becoming the main challenging issue in the study area.

3.3 The effect of land fragmentation on cost of production of wheat

The total cost of wheat production was computed by considering both the explicit and implicit cost components. Under explicit costs we included; seed cost, fertilizer cost, pesticide cost, and herbicide cost, for implicit costs we considered; the opportunity cost of land, labor (man-days cost), oxen (oxen-days cost). The total cost is then converted into a per-hectare basis so as to make a consistent comparison among wheat produces. Finally, the total cost of wheat production per hectare of land is regressed against the explanatory variables using the OLS technique, and the results are depicted in the table below. For the two different fragmentation indicators, the study regressed two separate models; the first model (Table 6) considers the number of land plots, while the second (Table 7) includes the Simpson index.

The effect of land fragmentation was analyzed by considering factors, including fragmentation indicators, influencing the average cost of wheat production. This was done based on the relationship established between the average cost of wheat production per hectare of land and the independent variables. Before running the model to estimate the equation of average cost of wheat production, the relationship between explanatory variables was checked by using the variance inflation factor (VIF) of collinearity and other diagnostic tests.

Table 6: Regression result for the cost of production of Wheat (number of plots)

Source	SS	df	MS	
Model	19.9097112	9	2.21219013	Number of obs = 354
Residual	18.5073849	344	0.053800537	F(9, 344) = 41.12
Total	38.417096	353	0.1088303	Prob > F = 0.0000
				R-squared = 0.5183
				Adj R-squared = 0.5056
				Root MSE = .23195

Total Cost	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
					Lower limit	Upper limit
Gender	0.0473085	0.0567304	0.83	0.405	-0.0642735	0.1588905
AgeHH	-0.0591858	0.0581617	-1.02	0.310	-0.173583	0.0552115
EdHH	-0.0528716	0.0180662	-2.93	0.004	-0.0884057	-0.0173376
FamilySize	-0.0540908	0.0473204	-1.14	0.254	-0.1471646	0.0389829
Landholding	-0.5770225	0.0336282	-17.16	0.000	-0.6431652	-0.5108797
DHM	0.1142502	0.0243025	4.70	0.000	0.06645	0.1620504
DHP	0.1431846	0.0168313	8.51	0.000	0.1100793	0.1762898
Frqex	0.137151	0.0471122	2.91	0.004	0.0444868	0.2298151
Number of plots	0.1135973	0.0387718	2.93	0.004	0.0373377	0.189857
Constant	9.883627	0.2356025	41.95	0.000	9.420224	10.34703

Source; Authors, based on survey data (2021)

Table 7: Regression result for the cost of production of Wheat (Simpson index)

Source	SS	d	MS	
Model	19.598416	9	2.17760178	Number of obs = 354
Residual	18.81868	344	0.054705465	F(9, 344) = 39.81
				Prob > F = 0.0000
				R-squared = 0.5101
Total	38.417096	353	0.1088303	Adj R-squared = 0.4973
				Root MSE = .23389

Total Cost	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]	
					Lower limit	Upper limit
Gender	0.0431199	0.0572742	0.75	0.452	-0.0695317	0.1557715
AgeHH	-0.0479128	0.0585938	-0.82	0.414	-0.16316	0.0673343
EdHH	-0.0515641	0.0183175	-2.82	0.005	-0.0875925	-0.0155357
FamilySize	-0.054165	0.0477851	-1.13	0.258	-0.1481528	0.0398228
Landholding	-0.5587158	0.0330536	-16.90	0.000	-0.6237284	-0.4937031
DHM	0.1230191	0.0243744	5.05	0.000	0.0750775	0.1709607
DHP	0.1420183	0.0169733	8.37	0.000	0.1086338	0.1754028
Frqex	0.1484542	0.0473129	3.14	0.002	0.0553953	0.2415132
SimpsonIndex	0.165963	0.1000449	1.66	0.098	-0.0308137	0.3627398
Constant	9.835522	0.239554	41.06	0.000	9.364347	10.3067

Source; Authors, based on survey data (2021)

The regression result of the OLS method as depicted in Table 6 and Table 7 above, shows education levels of household (edhh), landholding, distance from home to market (dhm), the average distance from home to farmland (dhp), frequency of extension services (frex), number of plots & Simpson Index (as a land fragmentation index) have a statistically significant effect on the cost of production of wheat. Whereas, the remaining variables namely Gender & Age of the household head and family size have no significant effect on the cost of production as conformed by the respective P-vales. Land fragmentation proxied by the number of plots of land and the Simpson Index is found to be having a positive and statistically significant effect on the cost of wheat production per hectare of land. Particularly, a one percent increase in the number of plots of land (the number of plots has already been converted into a natural logarithm) will automatically lead to a 0.11 percent increase in the average cost of production—and this is confirmed even at 1 percent significance level.

Similarly, the second regression output shows, that an increase in the Simpson Index (the value lies between 0 & 1, where a higher value is associated with higher fragmentation) leads to an increase in the average cost of production. Hence, both land fragmentation indicators have adverse effects on farmers' farm performance as indicated by the cost of wheat production. Theoretically, it has been argued that land fragmentation can be considered to increase the costs, because the spatially separated plots hinder the advantages of economies of scale and farm mechanization—small and scattered land plots hamper the use of machinery and other large scale agricultural practices. Thus, it will ultimately reduce efficiency and raises the cost of production. In addition to this, if the plots are located far from the home, and far from each other, there is a waste of time for the workers spent on traveling in-between the plots and the home—which results in increased transport costs. It is also noted that financial institutions are sometimes unwilling to take small, scattered land holdings as collateral preventing farmers from obtaining credit to make agricultural investments. This positive effect of Land Fragmentation on the cost of production is in parallel with Jabarin, *et al*. (2014) study in northern Jordan, and contrasts with the study of Mengxuan, (2014) in China.

Referring to the OLS regression results depicted in Table 6 and Table 7, the model was highly fitted to the data as shown by F-statistic, which was highly significant at less than a 1% probability level. The coefficient of multiple determinations for the model was also significant in explaining the relationship between explained and explanatory variables. Based on the result, it can be concluded that about 51% of the variation in the cost of wheat production among the farmers is jointly explained by the explanatory variables, in all cases. Finally, the model was checked for model diagnostic tests and was found to be free from heteroskedasticity, specification, and Multicollinearity problems (See Appendix 1).

3.4 The Effect of Land Fragmentation on Technical Efficiency of Wheat Producers

The production function parameters were specified and estimated using the maximum likelihood method to analyze the technical efficiency of sample households, and to observe the possible impact of land fragmentations in the study area. The result of the stochastic frontier model of wheat farmers in the study area is presented in

below. The maximum likelihood estimate of the Cobb-Douglas production function shows that the Lambda and Gamma values were 1.48 and 0.687 respectively significant at a 1% level. The values are significantly different from zero suggesting that the model is a good fit. Particularly, the estimated lambda (λ) implies that the discrepancy between the observed and the maximum attainable levels output is dominated by variability emanating from technical inefficiency. This test result entails the presence of significant technical inefficiency variation among plots. Besides, it suggests that the OLS estimate does not give efficient results, and better to use Maximum Likelihood estimation. Further, the estimates show that farm size, the number of oxen that participated (as an indicator of capital usage), the quantity of labor used, and the amount of seed, fertilizer, and chemical used (herbicide) are important inputs determining the output of wheat in the study area. All the upper mentioned factors have a positive and statistically significant relationship with technical efficiency.

All variables considered in the production function, had a significant effect in explaining the variation in wheat production among farmers. The coefficients oxen, seed, and fertilizer were significant at a 1% significance level; chemical and labor were significant at a 5% level of significance, whereas, farm size was significant at a 10% level of significance. The positive production elasticity with respect to farm size, labor, oxen, seed, fertilizer, and chemical implies, holding all other inputs constant that as these variables increase by 1 percent, the wheat output will increase by about 11, 52, 16, 44, 34 and 46 respectively. Summing the individual elasticity up yields a scale elasticity of 2.3. This indicates that farmers are facing increasing returns to scale and depicts that there is potential for wheat producers to increase their production. In other words, there is room to increase production at an increasing rate. The diagnostic statistics of the inefficiency component reveal that sigma squared (σ2) was statistically significant which indicates the goodness of fit, and the correctness of the distributional form assumed for the composite error term. The estimated value of gamma (γ) is 0.687 (see equation 9 in the methodology part) indicating that 68.7% of the total variation in wheat output is due to the technical efficiency variation of producers.

Table 8: Maximum Likelihood estimates of the Cobb Douglas stochastic production frontier

Stoc. Frontier normal/half-normal model			**Number of obs =354 Wald chi2(6)= 644.88**			
Log likelihood = -196.44363			**Prob > chi2 = 0**			
lnWheat	**Coef.**	**Std. Err.**	**z**	**P>|z|**	**[95% Conf. Interval]**	
					Lower limit	**Upper limit**
lnFarmsize	0.1134942	0.0581637	1.95	0.051	-0.0005046	0.227493
lnOxe	0.5279162	0.0757049	6.97	0.000	0.3795374	0.6762951
lnLabour	0.1687984	0.0825608	2.04	0.041	0.0069821	0.3306146
lnSeed	0.4468231	0.0592613	7.54	0.000	0.3306731	0.5629731
lnFertilizer	0.3479458	0.0497821	6.99	0.000	0.2503746	0.445517
lnChemical	0.1601724	0.0756115	2.12	0.034	0.0119767	0.3083681
_cons	0.4859565	0.3451705	1.41	0.159	-0.1905653	1.162478
/lnsig2v	-2.301197	0.1986488	-11.58	0.000	-2.690541	-1.911852
/lnsig2u	-1.514013	0.2749008	-5.51	0.000	-2.052809	-0.9752178
sigma_v	0.3164474	0.0314309			0.2604692	0.3844559
sigma_u	0.4690684	0.0644736			0.3582929	0.614093
sigma2	0.3201641	0.046676			0.2286807	0.4116475
lambda	1.482295	0.0911238			1.303696	1.660894
LR test of sigma_u=0: chibar2(01) = 6.63			Prob >= chibar2 = 0.005			

Source; Authors, based on survey data (2021)

The main aim of this study is to analyze the effect of land fragmentation on the technical efficiency (inefficiency) of wheat producers. To this end, the study uses two regression models to assess the impact of the two land fragmentation indexes. Accordingly, Table 8 Panel A shows the result from a combined estimation of stochastic production function and technical inefficiency effects of Wheat production. The generalized log-likelihood test shows that all variables are jointly significant. The estimates of coefficients of the explanatory variables of the stochastic frontier are found to have a similar effect in direction as before; however, labor input is found to be insignificant in the first model (Panel A). The further table 8 shows the effect of various explanatory variables on farmers' inefficiency of wheat production. Accordingly, only three variables incorporated in the inefficiency model, namely average household education level, frequency of extension visit, and the two land fragmentation indexes, are found to be significant in affecting inefficiency.

Table 9: The Maximum likelihood estimates of the stochastic production frontier and inefficiency effect Model

Frontier model	**Panel A (Number of plots)**			**Panel B (Simpson Index)**		
lnWheat	**Coef.**	**Std. Err.**	**P>|z|**	**Coef.**	**Std. Err.**	**P>|z|**
lnFarmsize	.1249409	.0612022	0.041	.1510758	.0599177	0.012
lnLabour	.1292763	.082487	0.117	.1455568	.0821604	0.076
lnOxe	.5242176	.0754593	0.000	.5179553	.0753574	0.000
lnSeed	.4817847	.0592431	0.000	.4922014	.058171	0.000
lnFertilizer	.3261772	.0487328	0.000	.3150718	.0480705	0.000
lnChemical	.1960581	.0794718	0.014	.2332463	.0795719	0.003
Cons	.494712	.3412864	0.147	.3853535	.3366295	0.252
Inefficiency						
Gender	.5309255	.3862396	0.169	.6997413	.5003832	0.162
AvAge	-.7652801	.689949	0.267	-.9565439	.7910723	0.227
AvEd	-.5533235	.2277371	0.015	-.5608874	.2598448	0.031
DHM	-1.061047	.3242815	0.001	-1.177231	.3576441	0.001
DHP	-.0828872	.175777	0.637	-.1670907	.2199981	0.448
FrqEx	-.3457559	.5055263	0.494	-.6865651	.5989917	0.252
Credits	.1883781	.3674889	0.608	.3002415	.453137	0.508
FamilySize	.0822172	.4629842	0.859	-.0907373	.5346342	0.865
Depedecy	-.0123115	.0113085	0.276	-.0170573	.0136135	0.210
Fragmentation	1.011363	.5954743	0.089	7.27364	3.302169	0.028
Cons	3.750854	2.654314	0.158	1.413697	3.072337	0.645
Sigma_v	.3328648	.0272996	.2834375	.3460126	.0242234	.3016489
lnsig2v_cons	-2.200038	.1640282	0.000	-2.12256	.1400143	0.000
Log-likelihood function		-180.98786			-177.69256	
Mean efficiency	.7145492					
Minimum efficiency	.2825953					
Maximum efficiency	.9283187					

Source; Authors, based on survey data (2021)

In panel B of Table 8, the effect of land fragmentation (Simpson Index) on the technical inefficiency of wheat producers is significant at the 10 percent level. It shows that there is a positive association between land fragmentation and technical inefficiency. Researchers (*eg*. Jabarin and Epplin, 1994) argue that land fragmentation is associated with the inefficient allocation of recourses (such as labor and capital). Land fragmentation is also associated with production costs due to inefficient resource allocation; underutilization of factor inputs (Gashaw, *et al*., 2017). The positive effect of the fragmentation index on the technical inefficiency of farmers confirms the results of Osei *et al*., (2019), Hristov *et al* (2012), Balogun & Akinyemi (2017), Dao (2013) who claimed that there is a negative relationship between land fragmentation and efficiency. The result is also inconsistent with the findings of Selemon (2013) and Tan *et al.* (2010), who found technical inefficiency is higher for farmers who cultivate few plots of land.

In addition to this from the inefficiency model, the average education level of household members and the frequency of extension service visits are found to be having a positive effect on the efficiency of wheat producers in the study area. This suggests extending educational access and supporting farmers via agricultural development assistants would help in improving Wheat producers' efficiency. Besides, Table 8 shows the minimum, maximum, and mean of the technical efficiency of Wheat farmers in the study area. Accordingly, the efficiency of Wheat producers in the study area ranges from 28.2 % to 92.8% with a mean value of 71.4%. This implies farmers in the farmer still have room to improve by adopting and practicing the best farming practices.

4. Conclusion and Recommendation

The rational use of agricultural land is influenced by land use limitations. One of the obstacles to agricultural development is land fragmentation—which is often considered a barrier to long-term agricultural productivity. Land fragmentation is the characteristic feature of most developing countries. Today Ethiopian smallholder agriculture is characterized by extremely small farms, fragmented into multiple plots, with relatively large families that depend on labor-intensive methods of cultivation, and farm fragmentation has been a common feature of smallholder farmers in Ethiopia though not widely studied in the past. However, understanding land fragmentation issues is viable for formulating strategies and policies. Although many researchers have theoretically argued the twin impacts of land fragmentation on agriculture productivity and producers' efficiency, the empirical effect is region-dependent. The present study 'assessed the effect of land fragmentation on the cost of production and technical efficiency of Wheat production in Yaya Gulale District, North Shoa Zone Oromia regional state of Ethiopia'. To this end, the study used survey data collected from 354 households. The data were analyzed using descriptive and econometric analysis. Besides, the study used stochastic frontier production frontier and ordinary least square (OLS), and Maximum likelihood estimation techniques. Regarding measuring land fragmentation the study employed two indicators, namely; the number of plots of land and the Simpson Index.

The result showed that households who have 3 or 4 plots together account for more than 63 percent. The Simpson Index has the maximum and the minimum value of 1E-9 (near zero) and 0.838, respectively. From the OLS regression result of the cost of the production function, Land fragmentation indicators are found to be having a positive and statistically significant effect on the cost of wheat production per hectare of land. Hence, both land fragmentation indicators harm farmers' farm performance as indicated by the cost of wheat production.

Regarding the inefficiency model the two land fragmentation indexes are found to be significant in affecting inefficiency. This shows that there is a positive association between land fragmentation and technical inefficiency of Wheat producers in the study area. Land fragmentation is associated with the inefficient allocation of recourses (such as labor and capital). Land fragmentation is also associated with production costs due to inefficient resource allocation and underutilization of factor inputs. In addition to this from the inefficiency model, the average education level of household members and the frequency of extension service visits are found to be having a positive effect on the efficiency of wheat producers in the study area. This suggests extending educational access and supporting farmers via agricultural development assistants would help in improving Wheat producers' efficiency. The concerned body needs to adopt strategies that curb land fragmentation; such as family planning and land ownership policies. Besides, considering land consolidation policies is, therefore, recommended as far as agricultural productivity is concerned.

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Appendix 1
Diagnostic tests of Model 1A

Heteroskedasticity test

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of latc

         chi2(1)      =     1.21
         Prob > chi2  =   0.2716
```

Model specification test

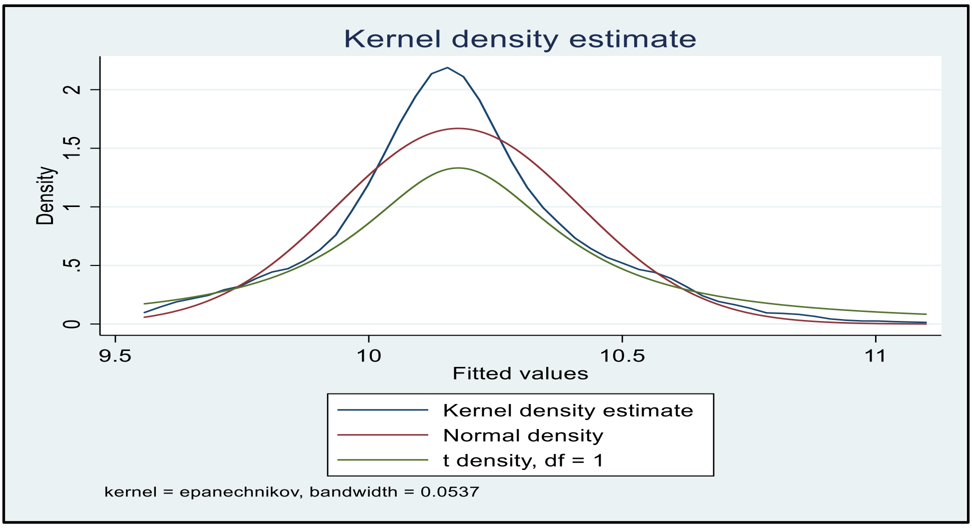
```
. estat ovtest

Ramsey RESET test using powers of the fitted values of latc
       Ho:  model has no omitted variables
                 F(3, 341) =      1.65
                  Prob > F =      0.1768
```

Multicollinearity test

. estat vif

Variable	VIF	1/VIF
AgeHH	1.65	0.607779
EdHH	1.58	0.631662
Landholding	1.52	0.657754
FamilySize	1.47	0.679223
DHP	1.47	0.681285
PlotNumber	1.34	0.743795
Frqex	1.18	0.847987
DHM	1.06	0.945019
Gender	1.02	0.978469
Mean VIF	1.37	

Figure 1: Normality test



Diagnostic tests of Model 1B

Heteroskedasticity test

```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of TotalCost

         chi2(1)      =     1.07
         Prob > chi2  =   0.2999
```

Model specification test

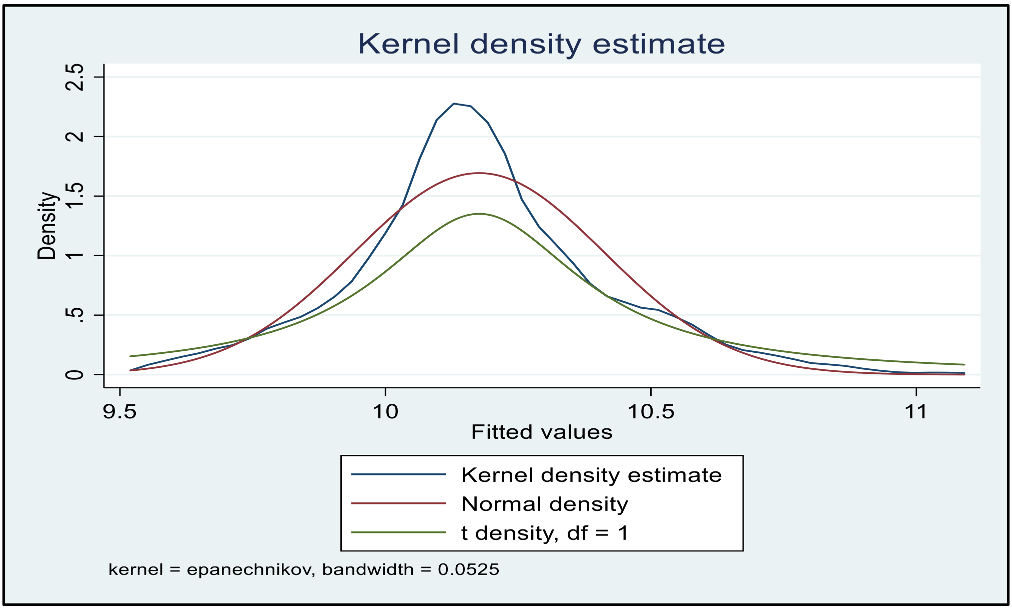
```
 using powers of the fitted values of TotalCost
 has no omitted variables
F(3, 341) =       1.79
 Prob > F =       0.1496
```

Multicollinearity test

```
. estat vif
```

Variable	VIF	1/VIF
AgeHH	1.64	0.608920
EdHH	1.60	0.624783
FamilySize	1.48	0.677279
DHP	1.47	0.681206
Landholding	1.44	0.692271
SimpsonIndex	1.29	0.776819
Frqex	1.17	0.854950
DHM	1.05	0.955256
Gender	1.02	0.976124
Mean VIF	1.35	

Figure 2: Normality test



Appendix 2

Figure 3: Kernel density estimation of error term, ui under half normal distribution (for model 2A)

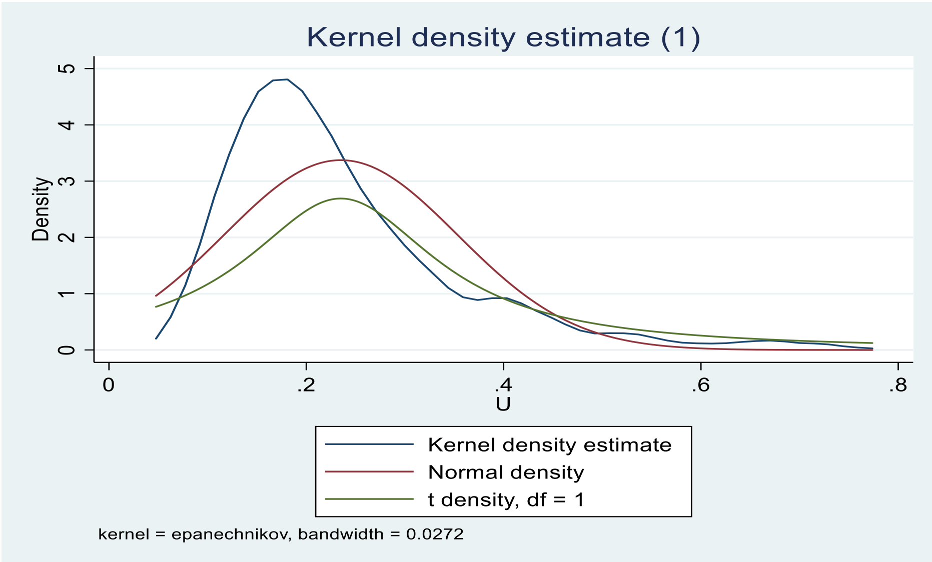
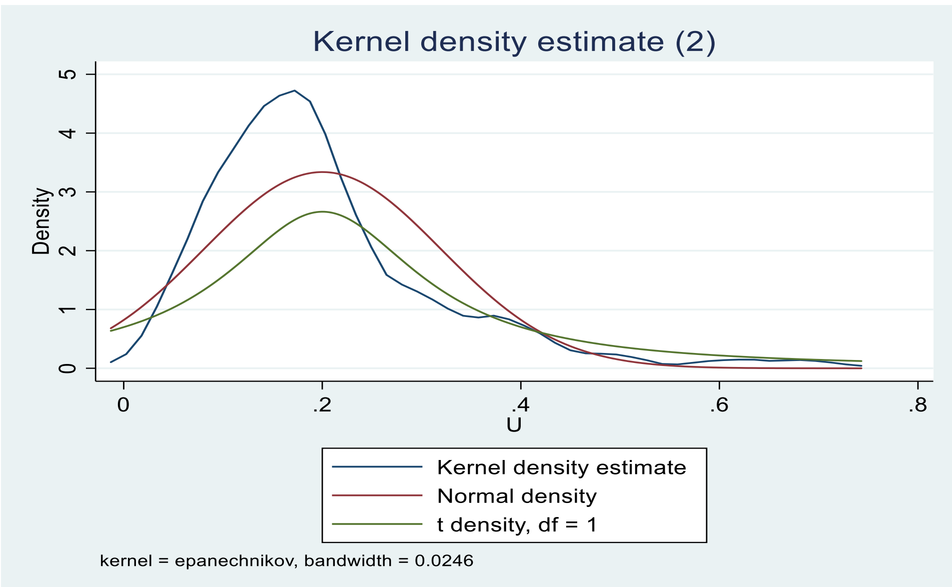


Figure 4: Kernel density estimation of error term, ui under half normal distribution (for model 2B)



Appendix 3

Table 1: Simpson Index

```
. tabulate SimpsonIndex, nolabel sort
```

SimpsonIndex	Freq.	Percent	Cum.
.4444444	29	8.19	8.19
.6094183	13	3.67	11.86
.6301939	10	2.82	14.69
.5714286	9	2.54	17.23
.5864198	9	2.54	19.77
.6423611	8	2.26	22.03
.7363281	8	2.26	24.29
.7426035	7	1.98	26.27
.7838401	7	1.98	28.25
0	6	1.69	29.94
.46875	5	1.41	31.36
.498615	5	1.41	32.77
.6111111	5	1.41	34.18
.6639232	5	1.41	35.59
.683391	5	1.41	37.01
.6900827	5	1.41	38.42
.7326389	5	1.41	39.83
.7456747	5	1.41	41.24
.79375	5	1.41	42.66
.4938272	4	1.13	43.79
.6427221	4	1.13	44.92
.6631944	4	1.13	46.05
.6712018	4	1.13	47.18
.7136	4	1.13	48.31
.7335601	4	1.13	49.44
.7395957	4	1.13	50.56
.7902696	4	1.13	51.69
.8134431	4	1.13	52.82
.8388889	4	1.13	53.95
.6275992	3	0.85	54.80
.6280992	3	0.85	55.65
.6315789	3	0.85	56.50
.6349207	3	0.85	57.34
.6527778	3	0.85	58.19
.655	3	0.85	59.04
.6577778	3	0.85	59.89
.7132964	3	0.85	60.73
.7187929	3	0.85	61.58
.7321429	3	0.85	62.43
.7408949	3	0.85	63.28
.2975207	2	0.56	63.84
.4591837	2	0.56	64.41
.4615385	2	0.56	64.97
.59375	2	0.56	65.54
.5983379	2	0.56	66.10
.6015625	2	0.56	66.67
.6077098	2	0.56	67.23
.644313	2	0.56	67.80
.6484375	2	0.56	68.36
.6688	2	0.56	68.93
.6768708	2	0.56	69.49
.6814494	2	0.56	70.06
.685	2	0.56	70.62
.6975309	2	0.56	71.19
.7050754	2	0.56	71.75
.7071006	2	0.56	72.32
.7168	2	0.56	72.88
.72	2	0.56	73.45
.7205786	2	0.56	74.01
.7245234	2	0.56	74.58
.7256944	2	0.56	75.14
.7311111	2	0.56	75.71
.7334594	2	0.56	76.27
.7377778	2	0.56	76.84

.7444444	2	0.56	77.40
.745867	2	0.56	77.97
.7627551	2	0.56	78.53
.767562	2	0.56	79.10
.7755102	2	0.56	79.66
.7759925	2	0.56	80.23
.7792969	2	0.56	80.79
.7888889	2	0.56	81.36
.18	1	0.28	81.64
.2268431	1	0.28	81.92
.375	1	0.28	82.20
.4489796	1	0.28	82.49
.48	1	0.28	82.77
.4827586	1	0.28	83.05
.4958678	1	0.28	83.33
.4977778	1	0.28	83.62
.5078125	1	0.28	83.90
.5605536	1	0.28	84.18
.5859375	1	0.28	84.46
.607438	1	0.28	84.75
.62	1	0.28	85.03
.6234568	1	0.28	85.31
.6297578	1	0.28	85.59
.6366782	1	0.28	85.88
.6427916	1	0.28	86.16
.6428571	1	0.28	86.44
.645	1	0.28	86.72
.6487603	1	0.28	87.01
.6487889	1	0.28	87.29
.6508875	1	0.28	87.57
.6537396	1	0.28	87.85
.6592	1	0.28	88.14
.665	1	0.28	88.42
.6655329	1	0.28	88.70
.6703398	1	0.28	88.98
.6759183	1	0.28	89.27
.6869835	1	0.28	89.55
.6893424	1	0.28	89.83
.6938776	1	0.28	90.11
.7021605	1	0.28	90.40
.704	1	0.28	90.68
.7069944	1	0.28	90.96
.7105624	1	0.28	91.24
.715	1	0.28	91.53
.7177778	1	0.28	91.81
.7229488	1	0.28	92.09
.7244898	1	0.28	92.37
.7249817	1	0.28	92.66
.725215	1	0.28	92.94
.7260774	1	0.28	93.22
.7261204	1	0.28	93.50
.7266667	1	0.28	93.79
.7346514	1	0.28	94.07
.7355555	1	0.28	94.35
.7419651	1	0.28	94.63
.746163	1	0.28	94.92
.7508218	1	0.28	95.20
.757565	1	0.28	95.48
.7626413	1	0.28	95.76
.771358	1	0.28	96.05
.7731569	1	0.28	96.33
.7786961	1	0.28	96.61
.7787755	1	0.28	96.89
.78125	1	0.28	97.18
.7825255	1	0.28	97.46
.7880886	1	0.28	97.74
.7885802	1	0.28	98.02
.7897153	1	0.28	98.31
.7918367	1	0.28	98.59
.8035371	1	0.28	98.87
.8210372	1	0.28	99.15
.8246914	1	0.28	99.44
.8367769	1	0.28	99.72
.8380592	1	0.28	100.00
Total	354	100.00	

Resilience to Drought and Climate Change and Its Determinants in the Pastoral Ethiopia

Mekonnen B. Wakeyo[1]

Abstract

Losses of livestock have been documented over long periods in the pastoral regions of Ethiopia. Nevertheless, resilience to drought and climate change in those regions is less studied than it deserves. Using survey data collected from the pastoralist regions, we followed factor analysis to estimate the resilience of the treated and untreated groups of households by household categories at the regional level. The factors influencing the estimated resilience of the households by region are also estimated using Poisson regression. In the estimated resilience by region, the components of income and access to food, access to public services, social safety net, asset, and finance & cash-in-hand played substantial role, among others. Consistent with expectations, in the treated groups, access to public services contributed much to the estimated resilience than the untreated groups. The estimated Poisson regression result indicated that the number of drought months, school-feeding, separate water sources for humans and livestock, access to livestock markets and credit, and improved livestock health influenced the estimated resilience. The study recommends the need to promote diversified income sources, livestock feed, school feeding, credit, and market access, improving food aid and water supply in the short run, and asset building, adaptation investments such as irrigation, public service (e.g. water points) in the mid to long run.

Keywords: Drought Resilience, Factor analysis, Poisson regression

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1. Introduction

Drought and climate change have been penalizing Ethiopian pastoralists who are living in the arid and semi-arid lowland areas. In the vast lowlands of Afar, SNNP, Somali regions and the Borena and West Hararge zones of Oromia, drought cause severe livestock losses (Birhanu et al. 2017; Belay et al. 2005), and the frequency and severity is exacerbated by climate shocks (Debela et al. 2015). The losses were as high as 80 percent of small ruminants and 40 percent of cattle during the 2015/16 drought (FAO, 2019), as they were in the past. According to Desta and Coppock (2002) who documented the losses, in the Borena zone alone the average cattle holding dropped from 92 to 58 heads per household from 1980 to 1997. The same study indicates that the droughts in 1983-1995 and 1991-1993 scored deaths of 37 & 42 percent of cattle, respectively, which amount up to 15 times higher than the net sales of households. Over 1980-1997, nearly 7,000 households targeted in the study area lost 700,000 cattle, equivalent to 45 million dollars. The 2021/22 and 2015/16 droughts are worst in life times and caused huge livestock losses in Borena, Somale and Afar regions. Devastating droughts are more common in those areas than in any other part of Ethiopia (FAO, 2019; Belay et al. 2005). Beyond drought and climate change, lack of insurance and remoteness intensified the problem. Even more, because of falling terms of trade during drought, the exploitative opportunity is created for livestock buyers, brokers, contrabandists, and re-sellers who are from domestic and neighboring countries. The distorted and distant markets and the drought uncertainty oblige pastoralists to sell their livestock for less attractive prices. These interrelated issues decrease the resilience of pastoralists (Birhanu et al. 2017; Gebru et al. 2004). Moreover, the population of the pastoral regions is increasing but there is no promising private investment to create employment as an alternative source of livelihood. Yet, stakeholder platforms on those complex issues are limited.

The existing efforts are inadequate to solve the chronic shortages of water (Flintan et al. 2011), irrigation, and road (Nicol et al. 2015; Headey et al. 2012). The recent documented policy seems to safeguard drought-prone areas (MoFED, 2003: 41), but the limited adaptation investments led to continued losses of livestock (Birhanu et al. 2017; Headey et al. 2012) due to severe drought occurring almost every 2-3 years. The government and NGOs just provide households with food-aid, even though the pastoral areas have enormous potential for food production (FAO, 2019). If resilience enhancing and adaptation investments are opted instead of food-aid, Ethiopia would benefit from several socio-economic development advantages. The benefits of food and nutritional security, Gross Domestic Product/GDP, agro-processing input, and foreign currency would be formidable (MoFED, 2003). However, the pastoralists struggle for recovery and thus the resilience study; literary the extent of recovery to their status before drought shocks happen, is meaningful for the drought-prone Ethiopia and other African countries. Documents show that thee pastoralists in Ethiopia account for 12 percent of the human and own 22 percent of the livestock population; occupy more than 60 percent of the land of the country (Debela et al. 2015), which could contribute to the development of the country if development and resilience interventions are in place.

The theoretical framework that explains household resilience is discussed in Alinovi et al. (2008), which is adopted in several studies (Mekuyie *et al*. 2018; Ambelu et al. 2017). In the framework, internal and external shocks that affect each component influence households' resilience. Households use their capacity within each component to overcome the consequences. Related to this framework, pastoral households build their resilience with access to public services and markets, stability, social capital, and asset. Based on this framework, Mekuyie et al. (2018) and Ambelu et al. (2017) estimated resilience at local than at regional levels, and mainly focused on the component of social safety nets as resilience factor of pastoral households, neglecting to evaluate several other components. Thus, this kind of study stimulates attention for investment in enhancing adaptation in pastoral areas, which has a win-win advantage, i.e. both to the pastoralists and to the country.

Studies in the developing countries on resilience deal with wide ranges of issues including food security, institution, and poverty (Gebeye, 2016; GWPEA, 2016; Mahoo et al. 2013); the concept of stability and the robustness of resilience (Urruty et al. 2016); resilience and its determinants (Keil et al. 2007); adaptive measures to the impact of droughts (Birhanu et a. 2017) and potential measures to enhance resilience (e.g. Headey et al. 2012; Getachew, 2004). Others studies dealt with the political economy of pastoralist livelihood (Headey et al. 2012), and sustainability vs. transformative interventions (Pfeiferet al. 2020; Gebeye, 2016). FAO (2019) and Flintan et al. (2011) critically see the change of pastoralists to an efficient and resilient economy, instead of rangeland fragmentation which has adverse effects and the need to stop the intervention to rescue pastoralism. World Bank (2010) conducted a study on resilience in conflict areas intending to estimate costs and suggest how to minimize its risks. Similarly, Gebresenbet and Kefale (2012) investigated local coping mechanisms. Likewise, Hill and Porter (2016), Birhanu et al. (2017), Tesso et al. (2012) and Pavanello, (2009) focused on drought and vulnerability rather than resilience. Other studies investigated adaptation and coping mechanisms (Berhanu & Beyene, 2015).

In Ethiopia, pastoral communities often face drought and climate change which affects both humans and livestock, and the study of resilience than vulnerability becomes more fitting (Alinovi et. al 2008). The vulnerability studies measure the probability of the household being food insecure, but resilience is a broader concept, which focuses on the capacity of recovery after shock to the previous status, and it stimulates policy options. In a few resilience studies, the analyses are localized, more qualitative (e.g. Birhanu et al. 2017), uses principal component analysis (PCA) based on local-level data (Ambelu et al. 2017; Alinovi et al. 2010), focusing on traditional safety-nets of resilience and neglecting variables such as access to finance. In traditional societies, neglecting communal relations, could lead to misleading conclusions. If individual households are targeted neglecting the wider regional and communal relationships, resilience oriented interventions could fail. In this regard, none of the previous studies estimate resilience at the regional level, which is more advantageous for macro and regional level policies.. Moreover, previous studies who estimate resilience in the pastoralist regions at a very local level did not try to look into the factors driving resilience (e.g. Mekuyie et al. 2018; Ambelu et al. 2017). Complementing an estimated resilience with identifying the driving factors it would have two major advantages. First, deriving factors widen policy options; and, second, the identification of the driving factors would help to check the robustness of the estimated resilience (e.g. Keil et al. 2007).

Following the discussed challenges and the gap in the previous resilience studies in pastoral areas, relevant questions include which household groups are more resilient than others, and which factors derive the resilience. . In this study, we attempt to answer these questions. The resilience influencing factors widen the policy options and simultaneously give evidence on the robustness of routine estimations.

The study is organized as follows. In sections 2 and 3, the objectives, approaches and study areas are discussed respectively. In section 4, results of estimation follow. Section 5 discusses and concludes, followed by policy recommendations.

2. Aim

The study attempts to answer the research questions such as which household clusters in which regions are more resilient than others; whether the factors of resilience are identical among regions and among intervention groups or not, and check whether the models adequately capture the factors that affect the estimated resilience. .

Following those questions the study, (1) aims to estimate the resilience of household categories, by intervention groups and regions; (2) identifies factors influencing resilience in the four pastoralist regions of Ethiopia by interventions; and, 3) finally, forwards relevant policy options.

3. Methodology

This study encompassed the estimation of resilience at national and regional levels by livelihood and intervention groups. When we say livelihood, the data allowed four household categories, i.e. all aggregated, pastoral, agro-pastoral, & non-pastoral-non-agro-pastoral/NPNA[2]) households. Following recent estimation of resilience (e.g. Mekuyie et al. 2018; Ambelu et al. 2017) and Alinovi et al. (2008), the estimation was carried out in two-stages, since resilience and its components are not directly observable. The two-stage estimation starts with selecting variables supposed to influence each component of resilience. Then, by using the selected variables for each component, a method of factor analysis is used to estimate each component of resilience by household category, intervention group and region. Following the estimation of each component by these three categories, resilience is estimated accordingly. Note that given the adequate cross-section data collected in 2017, the analysis adds new components such as asset and finance & cash-in-hand for the resilience estimations ~~compared~~ unlike the case of Alinovi et al (2008) and Mekuyie et al. (2018). The estimated resilience enables to find out the factors influencing the estimated resilience at least by intervention group and region. Econometric modeling of Poisson regression is used for this purpose, taking the average estimated resilience as a dependent variable. The approach of estimating resilience by region captures on the ground realities of socio-economic, cultural, environmental, and location[3]. It allows a comparison of the discrepancy or consistency between national and regional level estimations of resilience.

[2] The non-pastoral-non-agro-pastoral/NPNA households are neither pastoralist households who run livestock rearing only nor agro-pastoralist, who run both livestock rearing and crop growing.

[3] For example, the Afar pastoralists are beneficiaries from their access to the irrigation along the Awash Valley and from the few agro-processing factories because of their location.

3.1 Empirical Estimation

The equation to be used for the estimation of resilience is:

$$\boldsymbol{RI_{NP}} = \emptyset_{ifa}\boldsymbol{IFA_i} + \emptyset_{aps}\boldsymbol{APS_i} + \emptyset_{sn}\boldsymbol{SSN_i} + \emptyset_{s}\boldsymbol{S_i} + \emptyset_{ac}\boldsymbol{AC_i} + \emptyset_{a}\boldsymbol{ASSET_i} + \emptyset_{rm}\boldsymbol{FCIH_i} \qquad (\mathbf{1})$$

where $\sum \emptyset_j = 1.0$,

where **IFA** is Income and food access; **APS** is Access to public services; **SNN** social safety net; **S** is stability; **AC** is Adaptive capacity, **ASSET** is Asset, and **FCIH** is Finance and Cash in hand.

The estimation by region and intervention groups (treated vs. untreated[4]) follows the same route. The regional case is consistent with the estimation of Alinovi et al. (2010). Hence, resilience estimation for pastoralists, agro-pastoralist and NPNA in treated households of region i is:

$$\boldsymbol{RI_{tNP_i}} = \emptyset_{tifa}\boldsymbol{IFA_{i\_i}} + \emptyset_{taps}\boldsymbol{APS_{i\_i}} + \emptyset_{tsn}\boldsymbol{SNN_{i\_i}} + \emptyset_{ts}\boldsymbol{S_{i\_i}} + \emptyset_{tac}\boldsymbol{AC_{i\_i}} + \emptyset_{ta}\boldsymbol{ASS_{i\_i}} + \emptyset_{tfc}FCIH_{i\_i}. \qquad \mathbf{(2)}$$

[5]

A similar notation follows in the case of the untreated groups.

In all the estimations, the estimated resilience falls between zero and one, and higher values indicate higher resilience. In addition to the estimated resilience, the *value of the components* is also comparable in their contribution to resilience. The higher their value the higher is their contribution to the estimated resilience. Note that in the untreated group households, the resilience is expected to be showing a natural resilience assuming no synergy but in reality the synergy cannot be zero, whereas in treated groups, the resilience is '*natural resilience'* plus the portion that households get from the project, if any. However, this study has no objective to evaluate the project, but rather estimate the resilience of treated and untreated groups and compare the differences, for project variables that are relevant to resilience.

---

[4] This study is not an impact evaluation study. To differentiate the project participants and non-participants, we use the term treated and untreated groups respectively as per their intervention status.

[5] In Uganda, the food groups considered include cereals, tubers, vegetables, fruits, meat, egg, fish, pulses, milk, oil, sugar, miscellaneous (Swindale and Bilinsky, 2006).

In the estimation, variables are selected after equation (4). The selection of the variables encompasses the initial list of theoretically and empirically relevant variables (Yong and Pearce, 2013). In total, fifty seven variables are selected for all the components IFA, APS, SNN, S, AC, Asset and FCIH. Following the selection, factor analysis is launched.

The first factor is selected from the factor loadings of each component following Alinovi et al. (2010). The factor analysis of each of the seven components is estimated for the four categories of households in both intervention statuses, i.e. for all regions-in-one and for each of the four regions. Using the estimated seven components, for each intervention group four resilience tables (each of them in four household categories) and eight resilience tables were expected to be reported. But, dropping the one estimated for all-regions, two for each of the four pastoral regions are reported for the sake of saving space. Other than the tabulated four resilience estimates under each intervention group, for each of them, four correlation tables (in four household groups) and a table of *factor loadings* is also expected in the result report. However, again for the sake of saving space, only the four resilience tables under each intervention group are reported, and the rest is available on request. In all estimations, tests are run whether estimations and sampling are viable or not.

After the estimation, to identify the determinants of the estimated resilience an econometric model is estimated on the average estimated resilience for each intervention group by region, using k explanatory variables. Poisson regression is chosen for this purpose as the estimated average resilience is a kind of *categorical* dependent variable.

$$RI = \beta_o + \sum_{i=1}^{k} \boldsymbol{\beta_i X_i} + \varepsilon_i \qquad \textbf{(3)},$$

Where, RI the average estimated resilience by region and intervention status; β_o is constant term; $\boldsymbol{X_i}$ are **k** explanatory variables with β_i coefficients and ε_i is an error term with the Poisson distribution. The estimation is separately run for treated and untreated groups by region.

3.2 Data and study areas

The pastoral regions as a study area have attractive features (Table 1). In 2019, these regions accommodated nearly 13 million people and Afar and Somali are predominantly pastoralists with 81 and 83 percent of their population unlike Oromia and SNNP (FAO, 2019). In Oromia and SNNP, only 5 of 20 & 3 of 25 of their zones are pastoralists respectively. The pastoral zones are wide and sparsely populated. For example, on average 17.6 per square km dwell in Somali and 124.2 in West Hararge in the Oromia region.

Table 1: Geographical and demographic patterns of pastoral areas in Ethiopia in 2019

Region	Total number of zones in the region	Number /name of pastoralist zones in the region	Estimated pastoral area in ' 000 Km^2	Pastoral population Million	Population. density (pastoral zones average) /km^2	%age of Urban population
Afar	5	All five zones	72.05	1.60	25.10	19.0
SNNP	15	Bench Maji, Keffa South Omo	51.90	2.69	43.20	10.8
Somali	17	Almost all of nine zones	327.10	4.55	17.60	17.0
Oromia	20	Borena, Guji, Parts of West Hararghe, Bale, and East Shao zones	143.30	4.26	60.70	16.4
Total	**57**	**22**	**594.30**	**13.01**	**36.65**	**15.8**

Source: Author's compilation from secondary data sources (e.g. FAO, 2019)

To enhance development in these regions, decrease poverty and food insecurity in those regions, the Ministry of Federal Affairs/MoFA launched in 2004 a 15-year project in three phases (MoP, 2019). In 2014, the third phase and five-year project was launched in the four regions (MoP, 2019). The objectives of these 1-3 phases were to improve public services supply such as water supply, health, education, information, credit, and market access, but not directly supporting resilience.

The data used for this study is a cross-sectional data obtained from the Ministry of Agriculture. The Ministry of Federal Affairs conducted a baseline survey for the five-year development project in 2017 in collaboration with the Ministry of Agriculture Livestock Sector Department. The project was undertaken in 107-woredas of the pastoralist areas of Afar, SNNP, Somali, and Oromia since 2014. The sampling strategy is randomly sampling the woredas and then selecting households randomly from each woreda by stratified sampling. The survey includes 2756 sample households, of which 1836 are treated and 920 are untreated. In this study, the total sample is categorized by region, intervention status and household category (see Table-2).

Table 2: Sample size by household category, region, and Treated (T) & Untreated (UT) groups

Region Household	All Regions (Aggregate)		Afar		SNNPR		Somali		Oromia	
	T	**UT**	**T**	**UT**	**T**	**UT**	**T**	**UT**	**T**	**UT**
ALL Households	1836	920	523	251	263	143	527	263	523	263
Pastoral	747	380	397	167	3	35	211	131	136	47
Agro-pastoral	986	493	90	64	250	96	263	121	283	212
NPNA	103	47	36	20	10	12	53	11	4	4

Source: Author's computation from survey data. T: Treated UT: untreated

4. Results

4.1 Descriptive Analysis of the variables used in the resilience estimation

In this sub-section, some of the major variables selected for the factor analysis in each component are discussed

4.1.1 Income and food access/IFA: The households in pastoral areas generate their income from sales of livestock, livestock products and to some extent from crops, farm and non-farm employment, and other sources (petty trade, handicraft, etc.). The mean daily per capita income (DPCI) was only Birr 7.4 in 2017, was far below the poverty line of two dollars a day. This means these pastoral households live below the poverty line that the UN fixed in 2015. Surprisingly, only 133 sample households of the 2756 (4.8%) were earning higher than two dollars a day. Low DPCI could mean that during drought, households face food shortage unless the government, NGOs, and better-off households avail them of with food and water. By region, the median test shows that in Afar and Somali 67 and 54 percent of households respectively earn above the median DPCI of Birr 4.4, whereas in SNNP and Oromia, 59 & 69 percent respectively earn below the median DPCI. Diverse income sources show the probability of building resilience, but the average income source is 1.7 birr which shows no other income source mostly.

The daily per capita expenditure (DPCE) is composed of food and non-food expenditures per capita. The average DPCE with an average of 11.4 Birr is higher compared to the DPCI, which is 7.4 Birr. The median per capita consumption expenditure by region is 7.9 Birr in Afar and Somali, the majority of households fall above the median per capita consumption expenditure, unlike the cases of SNNP and Oromia. In 2016/17, all other regions were under drought except Afar, because Afar households recovered from the severe drought of 2015/16. The other variable, the average meal per day, is nearly 2.4 most probably because of the consumption smoothing factor. In SNNP, Somali and Oromia, the majority of the households reported twice a day, but in Afar 70 percent of them reported three times a day, for in Afar households seem to have recovered from the 2015/16 drought. The variable 'measure of food insecurity' indicates food security and starvation; captures how often the household is food insecure or the household depends on food-aid. The variable has explained the variation in IFA in both treated and untreated groups. *Food diversity* is the other variable used for IFA. The average food diversity is only 2.38. The treated households have slightly higher food diversity than the average of 2.4.

From the expenditure side, the non-food spending is not negligible. Among others, livestock health expenditure is a burden to the pastoral households. The preliminary data shows nearly 97 percent of the sample households on average spend Birr 235 in 2017, with a minimum of Birr 5 and a maximum of 4000. By region, Somali region has the highest average expenditures, amounting to 390.1 Birr, followed by Oromia (203.6 Birr), and Afar (125 Birr). On the other hand, treated and untreated households on average spend 200.1 and 193.6 Birr, with a minimum and a maximum of zero and 4000 Birr respectively.

4.1.2 Access to public Services/APS: The sample households were asked for their priority demands before the interventions. Households reported that before 2.5 years their priority demands were access to potable water, followed by access to the health facilities, schools, roads, and electricity. The same households are asked whether the top priority services are fulfilled in 2017 after the three-phase implemented project. To this question, only 26.7, 19.0 and 6.3 percent reported that schools, health facilities, and water are fulfilled respectively, indicating the limitations of stakeholders in solving the water and health facility shortages.

For this component, eight variables are selected. Aggregation is a challenge and there is a need to disaggregate by region. By region, the average physical distance to a ***health post*** in Somali, SNNP, Oromia, and Afar, is 19.9, 26.5, 46.8, and 48.9 minutes of walk respectively, indicating better advantage in Somali than in the other regions. Access to the services of water, electricity, and telephone is better in

Somali followed by Oromia and Afar, but least in SNNP. Security to accessible services is least in Somali, followed by Afar and SNNP but better in Oromia. Also, household mobility supported by infrastructure is better in Afar compared to other regions, followed by Somali and SNNP but least in Oromia. In addition ‘access to information’ related to upcoming drought is least in Somali, but better in other regions. Overall, households in Afar and Oromia are more advantageous in the selected services than those in SNNP & Somali.

Despite the interventions, the market challenges are still stringent. The survey data shows that pastoralists travel up to 8.87 hours to sell their livestock. For example, in Somali region, on average households travel up to 11 hours, ranging from 10 minutes to 8-days. In the Fik zone of the region, they travel from 1.4 to 8 days for this purpose. The regional average travel hour is the highest in Afar (12.6 hours), followed by Somali (11.3 hours) and Oromia (6.2 hours) and least for SNNP (2.6 hours). Traveling to distant markets causes weight loss of livestock which lowers the selling prices. It could also increase their susceptibility to disease and road insecurity, which again decreasing the households’ resilience.

4.1.3 Social Safety Nets/SSN: Households share food, water and other materials during drought; they exchange information and appeal together to authorities. The first variable of this component is per capita per day assistance. The average per capita food-aid per day of households is 2.8 Birr with a minimum of 0.03 and a maximum of 50 Birr. The regional difference in SSN is high. In Afar households receive the highest average food-aid of 4.6Birr followed by Somali (2.6Birr) and 1.15 Birr in Oromia. This indicates that food aid contributes to the resilience of Afar and Somali. Also, households were asked to rate the timeliness of the three sources of food aid with little difference in the rate. The rating by region of the three sources, i.e. Government, NGO, and community chief, is close to each other but the government rate is relatively lower compared to that of NGO sources followed by that of community chief’s. Among the regions, SNNP rated all the three sources satisfactory; followed by Oromia, and Afar rated least compared to the other regions. NGOs are rated top in all regions probability because of the less bureaucratic procedure compared to the government’s routine process to distribute aid. In the case of the community chief, resource shortage is a major challenge though timely distribution is possible. The frequency of aid is another selected variable. The average aid frequency is just 0.3. By region, the majority of households in Afar reported an aid frequency of one, whereas other regions reported less than this. Another variable is employment to work for better-off households. About 409 households (15%) were employed by better-off households. It is least in SNNP compared to that of other regions. Nearly 45 percent of the households share food, water, and material during drought. Sharing food and material is highest in Oromia, followed by Afar and SNNP, but least in Somali contrary with the expectation, for Somali community are known for their sharing culture.

4.1.4 Stability/S: Some of the variables of this component include **c**hanges in income sources, change of living place, and loss of crop and livestock. Other than these variables, the preliminary analysis shows that both pastoralist and agro-pastoralist households tend to move to NPNA (2.5 and 1.1 percent, respectively), whereas only five percent of NPNA move to pastoralist and five percent to agro-pastoralist. The pastoralists and agro-pastoralists also shift to each other, i.e. 2.3 from pastoral to agro-pastoral and 1.7 percent pastoral to agro-pastoral. This means that even though in the short term the move is very low, in longer years, the dynamics of shifting from one to another livelihood are higher. For example, 4.1% of households shift to another livelihood in 2.5 years period.

***4.1.5 Adaptive Capacity/AC*:** One of the variables is about recent drought years. To the question of 'when is the most recent drought year', households in most regions quoted the drought frequencies of 2014/15 -2016/17 (Table 3). Related to the drought years, households were asked how long the drought affected them. Nearly 87.1 percent of them reported 3-12 months, 2.5 percent of them reported less than a year, and nearly 10 percent reported more than a year. The hard drought-period is about a year or less and this shows that it is relatively easy to manage, but limited attention seems to be paid on transformative resilience.

Table 3: Sample households who faced drought during 2002/03-2016/17(by region)

Year	Afar	SNNP	Somali	Oromia	Total
2009/10	2	1	0	7	10
2010/11	2	3	0	2	7
2011/12	7	1	0	5	13
2012/13	6	4	0	14	24
2013/14	59	8	0	20	87
2014/15	365	11	23	198	597
2015/16	315	107	442	165	1029
2016/17	14	261	324	365	964
Total	770	396	789	776	2731

Source: Author's computation

Despite the frequent occurrences of catastrophic drought, pastoral households are living in their places than leaving it. The average number of years living in a sample area is highest for Oromia (31.7 years) and lowest for SNNP (22.3 years). The lower SNNP drought occurrence might be because of more mobility in SNNP pastoral zones. In the treatment group 93.5 percent and in the untreated 94.9 percent mentioned the 2014-2017 period as their recent drought years.

Households have several adaptive capacities and experience of coping with drought and climate change. In almost all regions, the income sources fall between one and four categories. Households were asked if they frequently attend community development associations and unions meetings that help households' access information and learn the options for coping mechanisms. In SNNP and Oromia, many households attend more meetings than in other regions. Studies also show the primary sources of water, assistance sources, and livestock diversity build resilience.

For pastoral households, the average holding of cattle, sheep, goat and camel are 6.4, 16.2, 26.5 & 4.7 respectively, whereas for agro-pastorals the respective figures are 5.6, 11.9, 15.1 & 4.2, which is lower than the former, as expected. The difference between treated and untreated households in livestock diversity is negligible. Following this basic feature, livestock diversification is one of the adaptation strategies of households. The computed average livestock diversification[6] of all households is 2.8. The percentage of those who diversify more than two types is 83.3, ranging from 67.3 in SNNP to 91.7 in Somali. In Oromia and Somali, households diversify more than in other regions.

4.1.6 Asset/ASS: Carter and Barrett (2006) defined asset as conventional, privately held productive and financial wealth, plus social, location and market access, possibly leading households to economic advantage. Also, an asset is a property that helps households to generate income. The major asset of the households is livestock. Also, households sell their durables (e.g. equipment, ornaments) as income sources during drought. The average livestock asset of all households is 6.32 Total Livestock Unit (TLU), with a minimum of zero and a maximum 130.3. By region, Afar has the maximum livestock asset in TLU of 8.7, followed by Somali (7.5), SNNP (6.3), and Oromia have the least livestock asset in TLU (5.1). Land ownership is also an essential asset to generate crop and non-crop income, grazing land (to hold more livestock), fallow, and shifting cultivations, which build up resilience. In SNNP and

[6]Variable that measures livestock diversity is sum of all dummies if household owns a livestock type or not.

Oromia, the average land holding is equal and more of the landholders are agro-pastoralists. This means that grazing land is more important than cropping land for Somali and Afar.

In the pastoral areas, the data shows only 3.6 percent of households use irrigation and 82 percent of them are agro-pastoralists in Afar. Other than irrigation, households were asked if they have solar or wind electric sources. About 552 of the 2756 households (20%) have sources of electric power and in the Somali region (42%), followed by Oromia (14.5%) and the least in SNNP (11.6%). The data shows that 16.3 percent of households have several animal breeding technologies (insemination, pregnancy diagnosis, etc.), and 89% have only one breading technology. Among those who reported that they own those technologies, Afar and SNNP have 81% of them; whereas Oromia has the least (7.7%). The last variable in the asset component is the proportion of livestock that survived the drought. In Somali and SNNP, 64 and 40 percent of their livestock survived, whereas in Oromia and Afar 33 & 37 percent respectively.

4.1.7 Finance and Cash-in-Hand/FCIH: During a drought year, cash holders can purchase items such as livestock feed, pay for transport, and so on from surplus areas. The need for cash-in-hand is immediate and it has a separate role from non-financial assets. Households may have to change their asset to secure money when they have no cash, but buyers could pay low prices for the livestock. Among others, several loan questions are asked and 2623 households (95%) do not borrow for any purpose except a few in Somali and Oromia. To the question of whether there is a difficulty of repaying loans, 133 households (16.5%) answered the question. Of those 133 households, 111 of them (83.5%) answered that they have no difficulty of repaying their loan, which can be considered as the practicality of availing credit. The other variables in this component are direct forward and need no further elaboration.

4.2 Estimation of resilience components using the selected variables

4.2.1 Estimated variables under each component

A total of 20 estimations for treated and 20 for the untreated groups are estimated and the summarized in Table 4.

The resilience estimated for treated groups by region ranges from 0.323 in agro-pastoralists of the SNNP region to 0.90 in the NPNA households in Afar region. In the untreated group, they range 0.32 from agro-pastoralists in SNNP to 0.55 of pastoralists in SNNP. In the estimations, 35 of 57 of the selected variables have higher than 0.50 contributions to the variance in the factor analysis.

Table 4: Estimated average resilience of treated and untreated household clusters (by region)

Household	All-Regions		Afar		SNNPR		Somali		Oromia	
Category	T	UT	T	UT	T	UT	T	UT	T	UT
All households	0.12	0.46	0.72	0.41	0.41	0.33	0.38	0.35*	0.46	0.38
Pastoralist	0.56	0.54	0.49	0.40	0.36	0.55	0.39*	0.49	0.45	0.49
Agro-pastoral	0.37	0.47	0.46	0.48	0.32	0.32	0.43	0.51	0.44	0.49
NPNA	0.32	0.48*	0.90*	0.43	0.45	0.42	0.46*	0.37	0.48	0.33

Note: In the LR test, all are significant at least at 5%, five at 10%, one is not even at 10%. T-treated; UT-untreated

Table 4 shows the variation of the estimated resilience across regions. But the resilience estimated for the aggregated estimations hides those variations. For example, in the treated groups, (1) The average of the regional estimations of the household categories for pastoralists and agro-pastoralist is higher than that of NPNA in aggregated estimates, which is not supported by any of the estimations for other region . (2)The estimated resilience of the NPNA is lower than that of both pastoral and agro-pastoral in the treated groups and least of all in the untreated groups in the aggregated estimates, which is not true for regional NPNA in the treated groups of the disaggregated estimates by region. In the treated groups, the estimated resilience of the NPNA is the highest of all household categories in all regions. (3) The variance of the estimated resilience of aggregated households is higher than the average of all regions in both treated and untreated groups, and this exaggerates the estimated resilience. These points show estimation by household categories and by regions are viable rather than the aggregated estimation.

In the treated groups, the respective estimated resilience of NPNA for each region is higher than the other household clusters. In the outcome, the components IFA, S and FCIH consistently contributed to NPNA in all regions. However, the question deserving attention is why the NPNA in the treated groups becomes the highest of all groups and why NPNA in Afar is highest. First, it is because the NPNA households are less directly dependent on extreme weather such as drought compared to other household groups. They engage in handicraft, petty trade, forest use (e.g. charcoal), milk and livestock off-road sellers, salt traders, and so on.

These scenarios are clear in Afar NPNAs who make money along the busiest road of Addis to Djibouti throughout the year. In Afar, when the pastoral and agro-pastoral are hit by drought, the NPNA can easily move to non-harmed areas. Hence, the better-estimated resilience for them is not surprising. Similar to NPNA in Afar, in Oromia and Somali, less busy asphalt road crosses the highway from Addis to Moyale in Borena and to Jigjiga in Somali serve similar options for sellers off-road. In the treaded groups of NPNA in Afar, the components IFA, S, AC, S and FCIH add to the estimated resilience, whereas in other regions, the components APS, SSN & Asset contribute more than adaptive capacity (AC).

In the treated households, the interventions in APS, Income Generating Activities (IGAs), and credit schemes enhance the resilience of the NPNA households compared to the natural resilience in untreated groups. Similar to the case of Afar, in the treated groups of Oromia, the NPNA are the most resilient clusters. The components enhancing the estimated resilience for the NPNA include IFA, APS, AC, Stability and FCIH, which are almost the same except FCIH in the case of Afar. The 15 years interventions of the project are predominantly development-oriented than resilience enhancing, except the water schemes and health posts, and APS has largely contributed to the estimated resilience, whereas the project evaluation reports of MoP (2019) mentioned that the contribution of the APS is not significant.

In the treated households, the pastoralists have higher estimated resilience than agro-pastoralists for Afar, SNNP, and Oromia, but slightly lower for the Somali region. The components IFA, SSN, S have uniformly contributed to the estimated resilience of pastoralists in all regions. In Afar, even though Afar pastoralists have been pushed off the Awash valley for the purpose irrigation, where they have been grazing their livestock, they still use the marginal areas of Awash valley for livestock grazing. Also, the Afar pastoralists diversify their income by selling salt and other commodities off-road trading similar to the NPNA households and have chances of off-farm employment in Middle and Lower-Awash irrigated fruit & vegetable farms. In the case of SNNP, the largest proportion of households are agro-pastoralists and the drought is relatively mild, but because of their subsistence agriculture, the components IFA, AC and FCIH have little contribution to the estimated resilience compared to their contribution to pastoralists in other regions. In the agro-pastoral of the treated groups, five components of IFA, APS, SSN, S, & Asset contributed to the estimated resilience. However, it is only in the Somali region that the estimated resilience of treated agro-pastoralists exceeds that of pastorals. In the region, APS is easier to provide for settled agro-pastoral than pastoralist households that are mobile. Pastoral Somalis live in the second vast region, but the poor rural road seems to bind the expansion of APS difficult for the pastoralist households. These pastoral households face drought and lose their livestock frequently compared to the other regions and these days they tend to settle to agro-pastoral livelihood, unlike in Oromia pastoralists, whose culture is tied to the pastoral system. Thus, the provision of the APS in the Somali region favors the agro-pastoralists of the treated group and this is could be one of the reasons for the higher estimated resilience compared to the pastoralists.

The estimated resilience for *untreated* households is expected to reflect their natural resilience. In all the three household clusters, the seven components (except AC) positively contributed to the estimated resilience (the table is not depicted here for the sake of space but available on request). For example, either due to synergy or non-project services, APS positively contributed to the estimated resilience to all regions except in Oromia. The estimated resilience in Table 4 indicates that in SNNP pastoralists and Somali and Oromia agro-pastoralist and pastoralists has almost equal estimated resilience. For the untreated pastoralists in SNNP, all components contributed to the higher estimated resilience. The SNNP pastoralists have a low risk of drought compared to the pastoralists in other regions such as Afar, Somali, and Oromia. For example, in the famous 2015/16 drought, the proportion of households in SNNP who were affected by the drought is the least of all regions (29.1%), compared to 87.9 percent in Afar, 58.9 percent in Somali, and 46.2 percent in Oromia. The preliminary data analysis shows in those years, not only crop failure but also starvation of livestock is the highest in the three regions compared to SNNP. However, under the extremely subsistence agriculture of SNNP agro-pastoralists, they could earn lower-income, unlike mobile and herder-households in the same region. Also, because of the low infrastructure in other pastoral regions (water, electricity, road, etc.), the untreated group NPNA in all regions are less resilient than that of Afar. In Afar, the estimated resilience of the three clusters in the untreated group is lower compared to that of NPNA mainly because of the better off-road sales trade income compared to the NPNA in other regions.

Another interesting finding is that in Oromia, **Assets** have contributed to the estimated resilience better than IFA, but in Somali both IFA and Asset contributed in the untreated groups. In Oromia, rather than IFA, the SSN was found to build up the estimated resilience, whereas in the Somali region, the IFA and FCIH contributed much to the estimated resilience. This is not surprising because in the Somali region FCIH contributed to the estimated resilience due to remittance, gift, and borrowing from clans, relatives, and friends are cultural. The descriptive analysis of the data shows that domestic remittance is highest in Somali and lowest in Afar.

In Oromia, most of the households are agro-pastoralist rather than pastoralist. The agro-pastoralists are slightly less resilient as they often face crop loss, unlike the pastoralists who are mobile, for mobility is one of the adaptation mechanisms. For example, in response to the question 'how often do you lose crops', the least frequent response of' never', and the most frequent response of 'always' and 'many times' are in Oromia agro-pastoralists. Also, APS & Asset (e.g. irrigated land) in agro-pastorals add relatively better to the resilience of household category in Somali. In Somali and Oromia treated and untreated groups, the pastoralist cluster had a unique experience of adaptation. In Somali, the contribution of IFA is positive and high, whereas in the case of Oromia this component contributes, though it is little compared to that of Somali. The Somali pastoralists trade in their border with Somalia in the East (illegal trade is often reported), where they have an advantage in generating income unlike the case of Oromia who are generating income from the less attractive border or domestic markets. Thus, the computed average per capita income of the sample pastoralists in Somali exceeds that of Oromia. In addition to income, the FCIH component contributes little to Oromia and more to Somali due to better income, saving, and sharing among households in Somali region. Contrarily, in Somali, the contribution of AC is low, but better in Oromia, contributing to the difference in the estimated resilience.

Finally, the tests of the factor analysis estimations are worth discussing. The Likelihood Ratio Test (Yong and Pearce, 2013) in all the estimations have been carefully checked and independence is rejected in favor of the saturated at least at 5 percent, and in five cases at 10 percent, except the insignificance in the treated SNNP pastoralists (see Table 4). This indicates that the estimations of the component variables, components of resilience and resilience estimations are robust. For the sake of space, the tests of the estimations before resilience are not depicted here, but available on request. The KMO tests for all of them reject the null that the sample selection is biased.

4.2.2 Factors of the estimated regional resilience

The estimation of factors of resilience at the regional level has two advantages. First, it could identify policy variables, as usual; and second, it tells about the viability of the routinely computed resilience. Eying these advantages, two equations are run by region using Poisson regression. The two estimates by region, which are categorized by treatment & untreated groups, are depicted in Table 5 and

Table 6 respectively. In those estimations on the average resilience, the variables used in the resilience estimations are not included as the explanatory variables. In the estimated model for the treated group (Table 5), the variables that consistently and strongly explained the estimated resilience include the number of months of drought, separated water source for humans and livestock, private grazing land, percentage of dairy food, and dissatisfaction with the number of livestock buyers. The rising drought months decreased the resilience of households in Afar, Somali and Oromia, but increases in SNNP though that of SNNP is weakly significant. Given that SNNP is relatively less drought-prone (See Section 4.2.1), the unexpected sign is not surprising. Increasing dependency on dairy food could decrease resilience in Afar and SNNP during droughts when milk supply falls. Also, the variable dissatisfaction with the number of buyers and traders of livestock carries a negative sign for Afar and SNNP, but positive for the case of Somali though weekly significant.

Dissatisfaction in the livestock market decreases resilience consistent with our expectation. On the other hand, some of the significant variables in the treated groups such as family planning, school feeding, and percentage of grain food have mixed signs of coefficients. The negative sign of school feeding for the case of Somali is strongly significant, possibly because of the negative and significant correlation of -0.05 which means less resilient household categories do not receive school feeding unlike more resilient such as the NPNA households. School feeding in Afar has a positive correlation of 0.3 and it carries a positive sign as expected. Membership to PSNP carries a negative and significant sign in the case of Afar and SNNP, indicating that it decreases resilience. Possibly, a labor shortage might affect engaging in PSNP for a resilient household. Moreover, improved livestock health has explained the resilience in the case of SNNP & Oromia, but negative in SNNP which is unexpected, possibly because relatively low (only 9%) of the households in SNNP have improved livestock health.

Table 5: Poisson Regressions on Estimated resilience for Treated groups [by region]

Variable	Afar	SNNP	Somali	Oromia
Dependent Variable: (**Estimated resilience)**	**Robust Coefficients†**	**Robust Coefficients**	**Robust Coefficients**	**Robust Coefficients**
Age	-0.001**	-0.001**	0.0002	-0.00002
	(0.001)	0.0003	(0.0002)	(0.00002)
Marital Status	-0.080**		-0.009	0.0001
	(0.037)		(0.010)	(0.001)
Family planning	-0.038	-0.018**	0.017*	-0.003***
	(0.050)	0.009	(0.010)	(0.001)
School Feeding	0.032*		-0.021***	-0.00001
	(0.018)		(0.005)	(0.001)
Credit Increased	-0.026	-0.015*	0.016	-0.001
	(0.051)	0.008	(0.010)	(0.001)
# of drought months	-0.010***	0.003*	-0.002**	-0.0001***
	(0.003)	(0.002)	(0.001)	(0.00002)
Separate water source	0.036**		-0.002	0.0021***
for humans & animals	(0.017)		(0.005)	(0.001)
Improved herd health	-0.061	-0.023**	0.001	0.003 ***
	(0.042)	0.011	(0.013)	(0.001)
Access to drug store	-0.004		0.003	-0.004***
	(0.028)		(0.008)	(0.001)
Member of PSNP	-0.067***	-0.029***	-0.002	-0.0004
	(0.024)	0.011	(0.008)	(0.001)
Private grazing land	0.186*		0.004	-0.002**
	(0.112)		(0.007)	(0.001)
Rented out land	-0.096***			
	(0.029)			
% food from dairy	-0.006***	-0.001**	0.0002	0.00002
	(0.001)	0.001	(0.0003)	(0.00004)
% food from grain	-0.004***	-0.001**	-0.001	0.002***
	(0.001)	0.0004	(0.0002)	(0.00004)
Satisfy in market health	0.001		0.004	0.001*
	(0.018)		(0.007)	(0.001
# of livestock buyers	-0.063*	-0.026**	0.007*	-0.001
	(0.026)	0.013	(0.006)	(0.001
Constant term	-0.081	-1.029***	-0.811***	-0.830***
	(0.097)	0.041	(0.025)	(0.004
Wald chi2()	chi2(19)	chi2(10)	chi2(19)	chi2(19)
	=68.4***	=16.04*	=102.6***	=202.9***
	P-value:0.000	P-value:0.09	P-value:0.000	P-value:0.000
Sample size	523	263	527	

†Note: In the brackets are standard errors. ***p < 0.01, **p < 0.05 and *p < 0.1. Note also that only significant variables are reported.

In the model estimated for the untreated groups (Table 6), the number of months of drought has a positive sign for Afar and SNNP, but negative (and consistent) in Oromia as expected. The descriptive data witness that in the untreated groups of Afar and SNNP, the variations of the number of months of drought are only two and four, respectively, unlike 29 in Oromia, and this could change the sign of the coefficient in case of Afar and SNNP. Water source separated for humans and livestock, family planning, satisfaction in market location, increased credit over two years, improved livestock health, dissatisfaction of the number of buyers of livestock carry the expected signs. School-feeding has positive sign in the case of Afar, consistent with that of treated household as expected, but negative in the case of SNNP, because of the possible distributional problem in the region. Overall, in both regressions at least some variables explained the estimated resilience.

Table 6: Poisson Regressions on Estimated Resilience for untreated groups (by region)

Variable	**Afar**	**SNNP**	**Somali**	**Oromia**
Dependent Variable: (Estimated resilience)	**Robust Coefficients †**	**Robust Coefficients**	**Robust Coefficients**	**Robust Coefficients**
Age	0.001*	0.001	-0.0001	
	0.0004)	0.009	0.0002	
Gender	0.005	-0.049	0.012*	
	0.012	0.048	0.008	
Marital Status	0.002	-0.045	0.017	-0.006*
	0.017	0.041	0.017	0.004
Family planning	0.046**	-0.038	0.014*	
	0.020	0.029	0.009	
School Feeding	0.020*	-	0.002	-0.006
	0.011	0.113***	0.009	0.006
		0.030		
Credit increased	0.073***	-0.051	0.005	
	0.021	0.039	0.014	
# of drought months	0.006***	0.006*	-0.0004	-0.005*
	0.002	0.004	0.0004	0.003
Separate water for	0.016	0.070*	0.008	0.007*
humans & animals	0.013	0.042	0.009	0.004
Improved livestock	-0.050	-0.094**	0.021*	0.007**
health	0.036	0.052	0.013	0.003
Access to drug store	0.021	0.001	0.021***	
	0.028	0.036	0.007	

Member of PSNP	0.020*		0.007	0.005
	0.010		0.013	0.005
Private grazing land		-0.095	0.018**	
		0.027	0.001	
% food from dairy	0.00002	0.008***	0.0003	
	0.001	0.001	0.0004	
%.food from grain	-0.0004	0.003***	0.0003	
	0.0004	0.001	0.0004	
Satisfy in market	0.019*	0.072***	-0.013*	0.010**
Location	0.010	0.028	0.001	0.005
Satisfy in market health	0.004	0.004	0.002	0.006*
	0.012	0.037	0.010	0.003
# of livestock buyers	0.021*	-0.060**	-0.005	-0.002
	0.013	0.032	0.007	0.007
Constant term	0.963***	-1.357***	-0.770***	-0.715***
	0.045	0.113	0.038	0.004
Wald chi2(.)	$chi^2(19)=69.6$***	$chi^2(18)=439.7$***	$chi^2(19)=45.4$***	$chi^2(8)=13.3$*
	P=0.000	p=0.000	Pp=0.000	P= 0.008
Sample size	251	143	263	263

†In the brackets are standard errors. ***p < 0.01, **p < 0.05 and *p < 0.1. Note also that only significant variables are reported.

Finally, it is essential to discuss the tests. The estimated regression by region is significant at one percent in most of the regions, indicating the fair robustness of the estimations, though weekly significance in treated household groups of SNNP and untreated household groups of Oromia. The coefficient, standard error and level of significances are decreasing in Poisson regression than in other multiple regressions, indicating the advantage of the former over the latter estimation.

4.5 Discussions

This study mainly investigates household resilience in pastoral areas in Ethiopia that are often hit by drought. The findings in both the descriptive statistics and the estimated resilience are relevant. In the estimated resilience, among the components, the Income and Food Access (IFA) component adds to resilience in almost all the estimations consistently, showing the formidable role of the IFA. In the descriptive, the average daily per capita income of households is extremely low, falling below the poverty line. Only 4.8 percent of the households earn higher than a dollar a day. This finding is consistent with Tsegaye et al. (2013) for the Afar region.

The low income means that the pastoral households overcome their food shortage due to the food assistances either from the government, NGOs, or social safety-nets. Consistent with the economic theory (Dercon and Christensen, 2011; Friedman, 1956), the data indicate the average daily per capita expenditure is higher than the discussed average DPCI. Households receive food aid or otherwise dis-save to smooth out consumption. Similarly, the variable *measure of food insecurity* explained the role of IFA in many of the estimations. Relative to these variables, food diversity had a lower role. Conceptually, the more food diversity the more the household is healthy to resist starvation.

Almost all the other components (except AC) SSN, APS, S, Asset & FCIH added to the estimated resilience by capturing regional variations in both treated and untreated groups. The contribution of adaptive capacity is low relative to the challenge of drought and climate change. Ethiopia is a drought-prone country with frequent occurrences of drought (Mera, 2018; Wakeyo and Gardebroek, 2017) which might decrease the resilience of households. Several studies found that the more income sources are diverse the better the households cope with the negative effect of drought (Headey et al. 2012; Alinovi et al. 2010), but income source diversity as an adaptive capacity to drought has low contribution to the component except for the case of Afar. In Afar, because of their relatively diverse income sources, the estimated resilience of NPNA is higher than that of other household categories in other regions, consistent with previous findings (Mekuyie et al. 2018; Ambelu et al. (2017). The other variable of adaptive capacity is livestock diversity. This variable relatively contributes better than other variables of the AC component. Livestock in the pastoral area are generally diverse (FAO, 2019; CSA, 2017). Studies indicate that the average livestock holding per household is higher than that of households in the highlands (FAO, 2019). In the pastoral lands, households can diversify and hold easily breading and recovering species to decrease the loss of livestock during severe droughts (Boku, 2006). The finding shows in many of the regions (e.g. the livestock diversity) contributed to the improved adaptive capacity and hence resilience of mainly the pastoral household category. In the estimated resilience for the other than pastoralist households, in Somali region the contribution of AC is low, but better in Oromia consistent with Belay et al. (2005).

In the untreated groups, almost all components have positive contributions but lower coefficients than the case of the treated groups. Surprisingly, the main intervention variable APS adds to the estimated resilience of the untreated group more often than the treated groups, contrary to the report of MoP (2019). This could be because if a health post, school, or water point is built in treated areas, for example, the synergy from the services could be positive. Moreover, the untreated groups might be better-off compared to the treated which could be why they are not inviting intervention. With the support of APS such as infrastructure, water points, health centers, technology, and schooling, the *estimated resilience* of the agro-pastoralist areas must have improved. This means that the asset ownership such as livestock and irrigation can be matched with the infrastructure; marketing, improved technologies such as animal breading, fertilizer, and improved seed could increase the resilience of agro-pastoralists. Irrigated land in both the highland and the pastoralist areas is not more than five percent (Wakeyo et al. 2017; Headey et al. 2012). Moreover, because of the extensive landmass in the pastoral regions, availing access to public services (APS) especially to pastoralist households is difficult. As per the finding, APS tends to be biased in agro-pastoral than in pastoralist households, mainly in the Somali & Oromia. The APS project seems to favor agro-pastoral than pastoral for the former are organized in relatively smaller locations, and consequently, other adaptive measures can have a lower effect in the latter. The contribution of SSN to the estimated resilience in both treated and untreated groups show their importance to the pastoralists than to the agro-pastoralists.

Conceptually, the stability variables capture natural and man-made shocks. Drought, flooding, conflict, and war fall under those categories (Alinovi et al. 2008). In this study, this component is captured by social instability variables such as education and health instabilities. Households with education, income, experience, socio-economic, and environmental knowhow can overcome instability, and build up their resilience. War, conflict, and socio-economic disorders during drought and climate change are sources of instability in pastoral areas, and they decrease households' resilience. It could be challenging to exactly capture conflict areas in a survey because samples are often taken from safe survey sites. Also, possibly because of resilience and adaptation purpose or the loss of property over a long-period, households shift from one to the other livelihood. The shift could be due to drought, climatic shock, and overall instability.

The other component that explained resilience is asset. Asset contributes to household resilience by providing chances of withstanding shocks by selling or dis-saving. For pastoralists grazing land is more important compared to cropping land consistent with Shrum et al. (2018) as in Somali and Afar, or may harvest grass from their grazing lands for feeding their livestock for long period or for sale, or they may also grow special grasses such as elephant grass (Birhanu and Beyene, 2015). The farm asset irrigation provides a resilience advantage, but the share of irrigated-land is generally low. e. In the pastoralist regions, only 3.6 percent of households use irrigation and 82 percent of these irrigator households are agro-pastoralists in Afar region. MoP (2019) reported 37 and 40 small-scale irrigation projects are in Afar and Somali respectively. This shows the investment in irrigation is limited in Oromia and SNNP though irrigable land is substantial to curb starvation and livestock loss (Catley et al. 2014; Headey et al. 2012). Measures to decrease asset losses such as growing grass by irrigation are missing in Afar, SNNP, and Oromia. In the treated group of the Somali Region, the regional government pays attention to the agro-pastoralist by encouraging pump irrigation along the rivers such as Wabe Shabelle, Erer, etc. (e.g. Desalegn and Merrey, 2010) unlike in other regions.

In the component FCIH, the finding shows that households have no difficulty repaying their loan; remittance is highest in Somali region compared to all other regions, and this plays significant role to build up households' resilience in the region, consistent with Devereux and Næraa (1996) where the role of credit during drought in Namibia is substantial. However, some regions (e.g. SNNP) and household categories (mainly pastoral) lack access to credit to postpone selling their livestock at the cheapest prices- when drought looms.

The finding also shows that the estimated resilience for the three household categories ranges from 0.32 to 0.90, the lowest in agro-pastoralist of SNNP and the highest in Afar NPNA.

This is viable to reflect the situation on the ground in that agro-pastoralists in SNNP (both treated and untreated groups) are in remote and extremely subsistence communities, lacking adequate access to agricultural technologies, finance, low income, limited income sources, and less mobility (unlike mobile and herders in the region) (Birhanu and Beyene, 2015; Tesso et al. 2012) Those challenges could limit their resilience. Only the pastoral household catagories in the untreated group SNNP have better estimated-resilience, due to income and access to food (IFA), adaptive capacity (AC), and stability(S). The highest estimated resilience in Afar NPNA is because of the components IFA, diverse income sources, stability, and better cash-in-hand. Overall, the NPNA households in the treated group have better estimated-resilience compared to the other household categories and the untreated group NPNA.

Related to the determinants of the estimated resilience, overall in both regressions at least some variables explained the estimated average resilience, indicating the soundness of the estimated resilience. The finding on the number of drought months, school -feeding, water sources for human vs. livestock, and livestock markets are indicator variables stimulating policy.

Finally, previous studies investigate resilience at a local level (Ambelu et al. 2017; Mekuyie et al. 2018) and a slightly wider scale (Alinovi, et al. 2008). In Ethiopia, regional-level studies are rare. Lack of regional level data and fear of aggregation might have constrained such kind of studies. In this study, however, the estimated resilience by region is robust and it suggested insights than the fear of aggregation.

5 Conclusion and policy recommendations

5.1 Conclusion

In this study, household resilience is estimated using the data collected from pastoralist areas in 2017 in a two-step approach. The findings suggest that aggregated regional data hides the estimates of resilience and its variation by region. Beyond this finding, mainly the components IFA, APS, SSN, S, Asset and FCIH contributed a substantial role in the estimated resilience of both the treated and untreated groups. Besides, at least some of the factors identified to influence the estimated resilience soundly provide policy options and indicate that the estimated resilience by region and interventions status is robust, even under the aggregated estimation. Importantly, the role of IFA in both treated and untreated group is essential because in almost all the resilience tables, IFA has significantly explained the variations in the estimated resilience. Furthermore, under low investments in water points and irrigation (a variable included in the ASSET component of the estimated resilience), there is a high probability of livestock asset loss during drought. As per the finding, only 17.4 percent of the sample households have separate drinking water from livestock and only 3.6 percent of the sample households use irrigation.

Surprisingly in both treated and untreated groups, the contribution of APS to the estimated resilience is not simple. The APS are indicators of road, ease of mobility, health posts, education, security, and information and their role is not negligible, but there seems to be distribution bias of the APS in favor of the agro-pastoral than pastoralist households because of the limited infrastructure in the latter. The social safety-net/SSN component (food aid and role of government, NGOs, and community leaders, timeliness, and so on) increases resilience especially in pastoral than agro-pastoral areas. However, with the existing food-aid approach to the pastoral areas, the low level of resilience continues, and their asset loss during drought in the pastoral areas too. Rather than food aid alone, with a better amount of credit, households create assets such as transport vehicles, which would support the transport in the vast area during bad and good years. The finding also shows famine is less likely in humans, but it is not addressed in livestock mainly because the distribution of water aid is not reliable and efficient.

5.2 Policy Recommendation

Pastoralists in Ethiopia dwell in remote and low infrastructure environments where poverty is prevalent and livestock asset losses are tremendous. The findings of this study stimulate several policy measures in the short- and long-run. In the short run, burning issues needs to be fixed whereas in the long-run adaptation investments are advisable. Thus, in the short run, (1) the contribution of IFA is formidable and the need to promote diversified income sources such as encouraging on-farm and off-farm employments. (2) The pastoral and agro-pastoral households can use *technologies* (e.g. crop production, breading, etc.) to transform their livelihood. Otherwise, they continue in subsistent livestock rearing and lose their assets due to drought and climate change. For example, promoting breading technologies help diversify livestock, which decreases the probability of losing all livestock. (3) The SSN plays an essential role and changing suddenly the traditional social safety-net system could end up in challenges. Often the agro-pastoral rather than pastoralists are favored in those services for the former are settled in a specific location. Agro-technology, education, and health systems play a pivotal role to transform the pastoral community gradually. (4) Cash-in-hand has a positive contribution to resilience. Improving credit increases resilience and motivates to use potential resources. (5) Increasing efficiency in the distribution of food aid decreases starvation and loss of livestock. However, as far as the food-aid approach is in place instead of adaptation investments, the loss of livestock could continue. (6) School feeding and separating water for animals and humans improves resilience. The former enables children to get minimum acceptable diet and creates demand for commodities (Lundqvist et.al 2021). (7) The need for providing information related to early warning system drought, market, finance, and the weather improves the resilience of households.

In the long run, adaptation investments are critically important to sustainably solve the resilience challenges of pastoralists, and to direct their resource potential to their development. Thus, (1) existing investments focus on small water points, health, and education rather than on adaptation measures, though those interventions add to the estimated resilience in both treated and untreated groups. However, adaptation investments equivalently need to be encouraged in the medium to long run. The private sector needs to be encouraged to invest and avoid the public failure to fulfill the top priority investments such as irrigation, infrastructure (e.g. water points, road, telephone, etc.). Those measures can contribute to income generation and increase resource reliability to establish agro-processing which creates employment. Due to lack of road, traveling up to eight days to the market center by pastoralists requires the attention of stakeholders. (2) Ethiopia can develop the vast pastoral lands to increase the volume of its livestock feed, similar to the advanced countries, if supported by a feed strategy.

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Appendix Table 1

Variables	Mean	Std. dev.	Min	Max	E > 0.5 (T, C)*	Treated (Mean)	Untreated (Mean)
Income and Food Access (IFA)							
Daily per capita income (in Birr)	7.43	11.34	0	137	(19,18)	7.53	7.21
Daily per-capita consumption expenditure(birr)	11.39	12.89	0	214	(17,14)	11.50	11.10
Measure of food insecurity	3.38	1.74	0	9	(10,13)	3.31	3.51
Income sources diversity (CaV)	1.72	0.86	0	5	(6,9)	1.75	1.65
Average number of meals per day per household	2.38	0.54	1	0	(4,13)	2.40	2.34
Food diversity (project definition)	2.25	0.99	1	8	(5,9)	2.26	2.24
Is there a member favored in meal? yes/no	1.55	0.50	1	2	(3,6)	0.46	0.42
Access to Public Services (APS)							
Minutes of walk to health post? (minute)	36.78	39.78	1	400	(9,13)	37.00	36.30
Use of health post (compiled from 10 variables)	1.58	2.06	0.01	9	(19,18)	1.68	1.34
Level of satisfaction[1] with school education	0.72	0.35	0	1	(6,12)	0.73	0.69
Security on the way to school & health-posts	0.13	0.46	0	3.8	(15,15)	0.11	0.16
Access to water, tele, electricity (CaV)	2.53	1.51	0	6	(4,8)	2.61	2.36
Mobility ease (access health/school infra), CaV	0.97	0.76	0	2	(19,19)	0.91	1.08
Any info on whether drought is coming? yes/no	0.20	0.40	0	1	(2,4)	0.22	0.16
Access to nutritional information? yes/no	0.13	0.34	0	1	(17,16)	0.15	0.10
Social Safety-net (SSN)							
Per capita per day assistance (in Birr)	1.87	3.59	0	50	(12,13)	1.90	1.79
Rate of response time of NGO to food aid	3.52	1.23	1	5	(16,19)	3.48	3.58
Rate of response of community leaders to food aid	3.50	1.14	1	5	(18,18)	3.48	3.54

[1] Level of satisfaction is computed for 12 variables including location, staff number per student, etc. Then satisfied, satisfied, fair, unsatisfied, and not satisfied at all are leveled.

Rate of response time of government to food aid	3.17	1.17	1	5	(18,20)	3.17	3.14
Annual frequency of food and water aid (CaV)	0.34	0.47	0	1	(13,12)	0.33	0.35
Traditional Info on drought? yes/no	0.20	0.40	0	1	(2,5)	0.22	0.15
Income from local employment	0.15	0.36	0	1	(1,3)	0.16	0.12
Stability (S)							
Number of years of schooling of household	15.26	7.65	1	21	(17,17)	15.10	15.60
Sum of changes in income source	0.83	2.42	0	12	(4,7)	5.82	5.83
Did the household face crop/livestock loss? yes/no	0.92	0.26	0	1	(4,9)	0.93	0.90
Years of schooling of head	2.09	3.33	0	17	(19,19)	2.10	2.06
Experience of household head (in years)	28.34	15.57	0.5	90	(17,15)	27.7	29.50
Number of years of living in this place?	38.59	11.63	17	90	(17,13)	37.9	39.80
Professional skill dummy (yes/no)	0.06	0.24	0	1	(3,10)	0.05	0.06
Adaptive Capacity(AC)							
Diversity of income sources	1.87	0.98	0	5	(7,10)	1.91	1.76
Less meal per day of household for coping	0.32	0.47	0	1	(10,9)	0.32	0.31
Do you use traditional finance source? yes/no	0.07	0.26	0	1	(10,11)	0.07	0.06
Number of meetings attended last year?	4.33	6.77	0	56	(5,7)	4.58	3.82
Are you member of any group or union? yes/no	0.12	0.33	0	1	(8,13)	0.13	0.10
Water for animal & humans same? (yes/no)	0.19	0.39	0	1	(5,7)	0.19	0.16
Number of assistance sources? (CaV)	0.70	0.52	0	2	(7,9)	0.69	0.72
Coping mechanisms (sold livestock, borrow, etc.)	2.79	2.09	0	10	(7,12)	2.80	2.76
Asset/ASSET							
Did you sell durables to raise cash? yes/no	1.99	0.09	1	2	(2,3)	1.99	1.99
Livestock asset in TLU	6.32	7.57	0	130	(20,20)	6.37	6.20
Livestock diversity (livestock types owned)	4.52	2.54	0	12	(18,20)	4.53	4.48
Crop land owned (in hectare)	1.07	1.41	0	10	(13,18)	1.10	1.00

# of months of using grazing area by household	3.04	3.86	0	12	(5,9)	3.05	2.99
Any of your crops irrigated? yes/no	0.61	0.56	0	2	(12,15)	0.62	0.58
Land used for livestock (in hectare)	0.17	0.84	0	15	(3,2)	0.17	0.15
Do you have access to solar/wind electric? yes/no	0.20	0.40	0	1	(2,11)	0.21	0.17
Source of breeding technology?	0.19	0.46	0	5	(4,4)	0.19	0.17
Percentage of livestock died due to drought?	35.07	31.54	0	100	(2,6)	35.00	35.20
Finance and Cash-in-hand (FCIH)							
Did you move animal to neighbours? yes/no	0.12	0.33	0	1	(7,12)	0.14	0.08
Did you save outside the saving group? yes/no	0.08	0.27	0	1	(5,14)	0.08	0.06
Is your saving chance same as 5yrs ago? yes/no	0.53	0.49	0	1	(18,18)	0.46	0.67
Is your saving chance excels 2.5yr ago? yes/no	0.36	0.48	0	1	(17,17)	0.44	0.20
Expense on animal health (in Birr)	197.0	351.0	0	4000	(4,4)	200.0	192.00
Did you borrow more in 2.5yrs than before? yes/no	0.05	0.22	0	1	(3,4)	0.05	0.04
Are you saving more than 2.5yrs ago? yes/no	0.13	0.34	0	1	(18,13)	0.18	0.04
Is the health service affordable for you? yes/no	1.24	1.40	0	5	(2,4)	1.31	1.10
Percent of income of Income Generating Activity	12.70	27.40	0	100	(3,10)	13.40	11.20
Is your saving rose with public services? yes/no	0.09	0.29	0	1	(18,14)	0.13	0.01

Determinants of Rural Household Saving: Evidence from the South-West Shoa Zone of Oromia, Ethiopia

Bekele Alemayehu[1] and Obsa Urgessa[2]

Abstract

Saving as a percent of GDP is very low relative to investment needs in Ethiopia. To fully mobilize rural household saving, identifying the constraining factors responsible for its underperformance is a priority issue. The main objective of this study, therefore, was to identify and estimate the main determinants of household saving behavior in rural Ethiopia. To achieve this objective, we collected primary data from 389 households using structured questionnaire. To analyze these data, we relied on Tobit model. Our findings suggest that household disposable income, education of household head, number of income earner in the family and livestock ownership influence household saving positively and significantly. Similarly; family size, participation in off-farm activities and distance from woreda center influence household saving negatively and significantly in the study area. To encourage more saving in the study area, measures that reduce fertility rate,
income inequality and encourage women resource empowerment and provision of rural infrastructure are necessary.

Keywords: Rural, Household, Saving, Tobit, Income.

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1. Background of the Study

Empirical studies extensively shows that there is strong relationship between saving and economic growth (Attanasio et al., 2000; Banerjee & Esther, 2005). The ability of a country to raise productivity depends on its capability to mobilize saving (Lin, 1992). For households and individuals, saving provides caution against uncertain events in the future and for nation, it is the sources of funds for investment. Saving has been considered as a source of funds for capital accumulation. Therefore, by influencing investment, saving determines the direction of economic growth at least in the short run (Solow, 1956). For example, Touny (2008) suggest that low saving level is the main reason for low level of economic growth scored by developing countries. Domestic saving not only helps to support capital formation, but also reduce dependency on unreliable foreign source of finance. Developing countries are highly dependent on foreign aid and grants. This in turn tends to increase their level of indebtedness. IMF report in 2018 shows that Ethiopia's outstanding public debt is around 56 % of GDP in 2017/18 fiscal year.

Even though saving level is thought to be the main driving factor of economic growth; in Africa, it accounts the smallest percentage of GDP. Specially, in sub-Saharan Africa it is less than any part of the world. The average saving rate in this region is less than 15 percent of their national income (Loayzaet al, 2000). While it showed some significant improvement in East Asian countries, historically it remained stagnant in Caribbean and sub-Saharan Africa. Many factors like financial illiteracy, lack of information, financial advice and retirement plan have contributed to low level of saving in these regions (Lusardi, 2008). The saving rate in Ethiopia is less than the investment requirement and little is empirically known for its patterns in rural areas. According to the National Bank of Ethiopia (NBE) report in 2016/17, the ratio of domestic saving to domestic gross product was 18.4 percent while the share of gross domestic investment to GDP was 39 %. Even though majority of rural household saves their income either in cash or in kind, per capita level of saving is very low in rural Ethiopia.

Empirical studies conducted so far in developing countries in general and in Ethiopia in particular mainly focused on macroeconomic determinants of domestic saving. However, "these macroeconomic studies cannot deal with "real-world" features that reflect the diversity of saving behavior (Abdelkhaleket al, 2010). Thus, little is empirically known about factors determining household's saving at micro level in rural Ethiopia. Thus, this study attempts to reveal the main factors explaining the patterns of saving in rural Ethiopia. Specifically, the study attempts to address the following research questions:

- What are the determinants of household saving behavior in rural Ethiopia?
- Which type of saving motive is dominant among rural households?
- Which form of saving do rural household dominantly practice in rural Ethiopia?

2. Objective of the Study

The general objective of this study is to investigate the determinants of rural household saving behavior in rural Ethiopia. The specific objectives of this study include:

- To identify and estimate the determinants of household saving behavior in rural Ethiopia
- To identify the most prevalent type of household's saving motive among rural households.
- To identify the dominant form of saving practice by rural household.

3. Methodology of the Study

3.1 Types, data source and sampling technique

The main type of data used for this study is primary data. It was collected from individual sample household through semi- structured questionnaires. Secondary data were collected from both published and unpublished sources. Multi-stage sampling techniques is employed to reach at the final sampling unit. In the first stage, 6 woreda were randomly selected out of 11 woreda. In the second stage, 106 sample peasant associations/kebeles1 from the sample woreda were randomly selected. In the third stage, sample household were selected from each sample kebele. The total sample was allocated to each sample kebele in proportion to their population size.

Individual sample households formed the sampling unit/ element of this study. Hence, 398 sample household were selected based on the simplified formula developed by Yamane (1967) at 95 percent confidence level, 0.5 percent of degree of variability and 5 % percent of level of precision for this study. The formula is:

$$n = \frac{N}{1 + N(e^2)} = \frac{95{,}167}{1 + 95{,}167(0.05)^2} = \cong 398$$

3.2 Methods of data analysis

To achieve the overall objective of this study, descriptive and econometric method of analysis are employed. Descriptive statistics like percentage, frequency distribution, standard deviation and graphs were used where necessary. To estimate the determinants of household saving behavior, a censored Tobit model was employed. A censored Tobit model is used to map all negative values of saving to zero. The rationale behind selecting this model is that saving in the sample household contains negative, zero and positive values. Hence, saving below zero is censored at zero. When observations are either censored or truncated, Tobit model is used to obtain consistent estimates (Amemiya, 1985; Madala, 2005). If there is some sort of censoring/truncation, OLS estimators is inconsistent. Thus, the Tobit model is specified as:

$$Y_i^* = X_i\beta + u_i.. \quad \textbf{(1)}$$

$$Y_i^* = Y_i \ if \ Y_i > 0 \quad \textbf{(2)}$$

$$= 0 \ if Y_i \leq 0$$

Where Yi : is the observed amount of saving, Y_i^*- is the latent variable that is not observed, β - is the vector of unknown parameters, X_i is the vector of explanatory variables ((income of the household, household head's education, gender of household head, family size, dependency ratio, access to credit, land size holding, possession of irrigable land, participation in off-farm activities, number of income earner in family, livestock ownership, location from woreda center, age of household head and square of household head's age). Four marginal effects were estimated using STATA. Estimation of the marginal effects were conducted by maximum likelihood method.

4. Result and Discussion

4.1 Descriptive Analysis

4.1.1 Demographic Characteristics of the Respondents

The average age of household heads in the sample respondent is 46 years with 10 years standard deviation. The implication is that, on average, the respondents are in the productive age category. The mean value of family size in the sample respondent is around 7 members. The largeness of family size can influence the amount of saving decision of household negatively as large family size may be associated with large dependency ratio. Education is another variable that have viable theoretical effect on household saving. The average year of education for sample household head is found to 5 years. From the sample data, around 20% of the respondent/household heads did not attend any formal education, whereas 26% and 38% of them attended first and second cycle respectively. Only 16% of them attended secondary education and above. As far as gender is concerned, 10% of the respondents are female headed while 90% of them are male headed. Another demographic factor that has negative theoretical impact on household saving is the dependency ratio. The mean value of dependency ratio in the sample household is around 0.64. This value indicates the presence of high dependency ratio in the sample population. High dependency ratio implies that larger fraction of family members consumes and absorb what has been produced by productive fraction of family members and hence, it leads to a reduction in income left after consumption.

Table 1: Household's Demographic characteristics

Variable	**Obs**	**Mean**	**Std. Dev.**
Age of household head	389	46.46	9.93
Household head education level	389	4.8	3.50
Family size	389	7.03	2.49
Dependency Ratio	389	.64	.53
Household heads' gender	**Freq.**		**Percent**
Female	40		10.28
Male	349		89.72
Total |	389		100.00

Source: Survey data, 2020

4.1.2 Socio-Economic Characteristics of the Respondents

Theoretically and empirically, income is the prime determinant of household saving. Income in this paper is measured as the sum of money received from agricultural production, sale of livestock and livestock products, wage and self-employment, remittance and sale of assets. In the study area, income from crop production takes the lion share followed by sale of livestock and livestock products. The average annual income per sample household is estimated to be 34,743.94 birr with standard deviation of 31,923.82. The distribution of income in the study area is shown by decile on Table 2. All the sample household were divided in to ten equal deciles. The fifth column shows the cumulative percentage of income earned by the cumulative fractions of sample household (shown by 3rd column).

Table 2: Cumulative Income distribution by deciles

Group	Percentage of population (%)	Cumulative percentage of population (%)	Income share (%)	Cumulative income share (%)
D1	10	10	0.012582	0.012582
D2	10	20	0.023483	0.036065
D3	10	30	0.035251	0.071316
D4	10	40	0.047171	0.118487
D5	10	50	0.059435	0.177921
D6	10	60	0.077582	0.255503
D7	10	70	0.109675	0.365178
D8	10	80	0.141498	0.506676
D9	10	90	0.179649	0.686325
D10	10	100	0.313675	1.000000

Source: Own survey, 2020

From Table 2, the poorest 10% of the sample population earns 1.3% of the total income while the bottom 20% of population receives only 3.6% of total income. In addition, the bottom 50% of the total population receives only 17.8% of total income while the top 10% and 20% of the total population receives 68.6% and 50.7% of total income. Therefore, the result shows the presence of moderate-income inequality in the study area.

4.1.3 Characteristics of household saving in the study area

Theoretically, saving is defined as the amount of income left after consumption expenditures are deducted from disposable income. In this study too, saving is measured as the amount of money deposited in cash and physical assets after consumption expenditure is deducted. In the study area; households are practicing saving through bank deposits, cash holding at home, lending to others and purchase of livestock. From the sample data, 74.04 percent of household are net savers while the remaining are either a borrower or none of the two during a survey year. The per capita saving is estimated to be 13,979.92 ETB while the average saving rate is found to be 0.44.

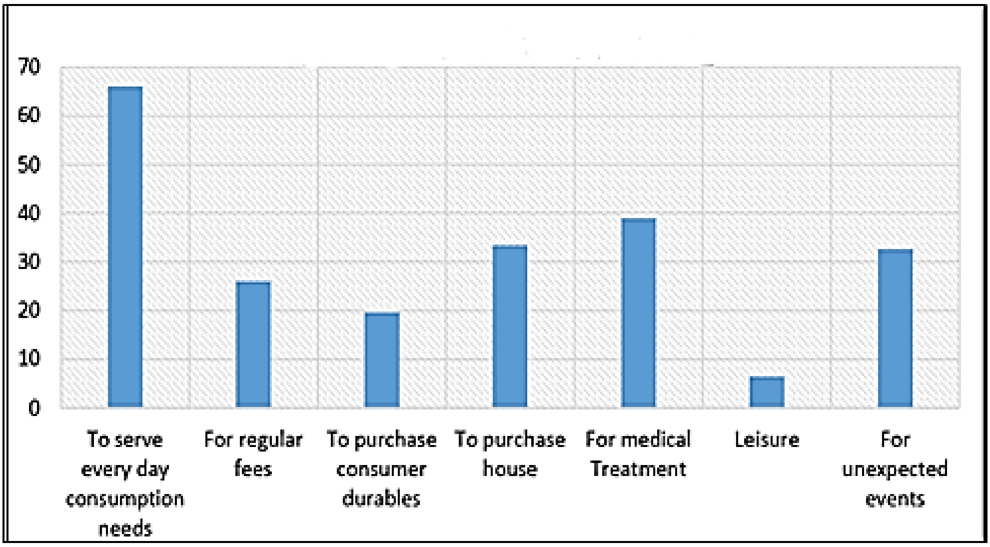
Table 3: Average values of continuous variables for savers & non-savers

S.no	Variables	Average values for savers	Average values for non-savers
1	Disposable income	74.04	25.97
2	Age of household head	46.68	45.81
3	Education of household head	5.23	3.47
4	Land size owned	2.65	1.6
5	Family size	6.8	7.1
6	Dependency ratio	0.64	0.67
7	Distance from woreda Center	7.76	8.39

Source: Own survey, 2020.

From Table 3, it is easy to observe that the average value of income, age, education and land size for net savers is greater than that of non-savers. The mean age for net savers is 46.68 years while for non-savers is 45.81 years. Similarly, net savers possess better education and land size than those of non-savers and hence, on average, they do have better saving practices. The mean values of family size and dependency ratio for non-savers is greater than the mean values of net savers.

Figure 1: Motive of saving



Source: Own survey, 2020

From Figure 1, the dominant motive of saving is to smooth the consumption needs of household. This is so because, in the study area, production is carried once a year. Hence, to smooth consumption throughout the year, they put aside some fraction of their income/output. The next main motive is for medical treatment during sudden illness. The percent of household that rank 1st saving to finance consumption need of household comprises 66.7 percent while 39.02% of sample household saves for medical treatment. The third main motive of saving in the study area is to finance unexpected events. Around 32.65% of household saves for this purpose. Saving for leisure is found to be the least motive of saving among the sample household.

4.1.4 *Forms of saving in the study area*

Empirical evidence shows that rural household practices saving both in cash and non-cash forms (Issahaku H, 2011; Nayak S, 2013; Egwu P &Nwibo S, 2014). Examinations of sample data describes that sample household are practicing saving in cash, bank deposit, contributions to Equb and Idir, loan to relatives and non-financial forms.

Table 4: Forms of saving across households in the study area

S. No	Form of saving	Freq.	% share
1	Formal saving (Deposit at a bank and microfinance).	171	43.96
2	Informal saving (equb & idir, lending to others, cash holding at home)	170	43.70
3	Non-financial savings (livestock & crop)	100	25.77

Source: Own survey, 2020.

From Figure 2, we observe that 44% of sample household are saving their income in formal financial institutions. Similarly, 43.7 % are saving in the informal way (through Ekub & Idir) while 25.8 % of them are saving in non-financial forms (like livestock and other assets).

4.2 Regression Result Analysis

Based on economic theory and empirical researches, 14 explanatory variables have been identified in this study. The description of these variables is provided below:

Descriptions of variables:

Disposable income: The natural logarithm of household's annual total disposable income

Age: Age of household head measured in years.

Squared age: The Square of the age of household head to describe the marginal return of age.

Education: Education level of household head measured in years

Gender: Sex of household head (entered as dummy=1 for male & =0 for women)

Family size: Adult equivalent family size measured using the OCED adult equivalent size

Dependency ratio: Ratio of family members below age 14 and above age 60 to age from 15-60

Access to credit: Households' access to credit (entered as dummy=1 if taken credit & 0 otherwise)

Land size: Household land size owned in hectare

Income from large land size owned: It is an interaction variable showing more income generated due large land size owned.

Off-farm activity: It is a dummy variable assigned 1 if household is participating in off-farm activity and 0 otherwise.

Number of income earner: Number of family members earning income

From the regression result, most of the included explanatory variables significantly influence household saving in the study area. For example, household disposable income influence positively and significantly household saving for the sample household. On average, extra unit of disposable income increase household saving by 0.49 ETB for the average household. This result aligns with the microeconomic theory of household income allocation decision. Education of household head is also found to influence saving positively and significantly in the sample household. On average, additional year of education increase the level of household saving by 497.5 ETB for the average household. The implication of this result is that the influence of additional education on household saving is magnificent in the study area. Off-farm activity participation and distance from the district center is also found to influence household saving negatively and significantly. Participation in off-farm activity is also found to influence saving negatively. This might be due the fact that those household participated in the off-farm activity were poor household whose income and hence, saving is low. Distance from the district center acted to reduce household saving since distant household would have low business opportunities than households closer to the district center.

Table 5: Regression results and marginal effect

Variable	Marginal effects on;	
	Tobit result $E(y^*\|x)$)	**Total saving $[E(y\|x)]$**
Disposable income	5448154* (.04829)	.4892316* (.04411)
Age of household head.	119.3786 (390.6)	107.1993 (350.22)
Square of household head's age	-1.44731 (4.29376)	-1.299651 (3.8483)
Educational level of HHH	553.875* (138.4)	497.367* (123.56)
Gender of household head	-2779.317 (1880.7)	-2554.551 (1764.3)
Family size	-510.036** (224.21)	-458.0005** (99.78)
Dependency ratio	-241.7489 (812.72)	-217.0849 (729.2)
Access to credit	-1432.786 (948.37)	-1282.523 (843.54)
Land size owned	837.6693 (725.77)	752.2076 (644.52)
Income due to large land size	-.0002062 (.0135)	-.0001852 (.01212)
Off farm activity	-2517.138** (1094.3)	-2226.039** (946.36)
Number of income earners	4515.452* (1661.7)	4054.772* (1477.9)
Distance from nearby town	-159.4982** (76.23)	-143.2257** (67.932)
Livestock owned by the HH	2189.394*** (1159.8)	1938.622*** (1002.4)

Note: * shows significant at 1%   *** shows significance at 10%
** shows significant at 5%   Values in bracket are standard errors
Log pseudolikelihood = -2935.381 Number of obs = 374   F (14, 360) = 59.50
Σ= 8086.713   Prob > F = 0.0000 $R2$ = 0.8381

Source: Own computation, 2020

Family size and dependency ratio are also found to influence household saving negatively. Family size decreases household saving significantly at 5% level of significance. Extra family member reduce household saving by 458 ETB for the average household. Household ownership of livestock also found to affect positively and significantly for the sample household. Each additional livestock owned increased household saving by 1,939 ETB for the average household. In general, disposable income, education and livestock ownership are found to influence household saving positively and significantly. Family size, location and off-farm participation are found to influence rural household saving negatively and significantly for the average household.

5. Conclusion and Recommendation

Saving plays an important role in the development process of every country as a source of investment funds. However, in Ethiopia, its share in national GDP is very low relative to investment requirement. In the study area too, majority of household income goes to family consumption. This trend hinders the future consumption of household and the growth trend of national economy. Therefore, to encourage and promote saving in the study area in particular and country in general, the following policy intervention were recommended based on the findings of this paper:

Reducing income inequality through intervention strategies like livelihood diversification, adoption of improved inputs, provision of rural infrastructure to link rural products to urban markets and provision of rural financing

Family size also acts to reduce household saving in the study area. Large family size and dependency ratio is due to high fertility rate in the study area. Hence to reduce fertility rate in the sample household, awareness creation strategies should be persuaded by government bodies and family planning strategies should also be practiced by the population in the study area. Saving among male-headed households is less than those of female-headed household.

Saving among male headed household is less than those of female headed household. However, in rural household, females are discriminated in the possession and administration of economic resources. Hence, to encourage saving more among female headed household, Empowering and training, women in economic decision-making also needs special emphasis.

Majority of Participant in off-farm activities are poor households. To encourage saving among this group of households, there should be fair payment for them.

Distance they travelled to reach the nearest town is also another variable that acts to reduce saving in the study area. This might be due to the fact that household living far away from woreda center has low access to information than households near woreda center. Therefore, to encourage saving in remote areas, the provision of rural infrastructure and financing should get special attention.

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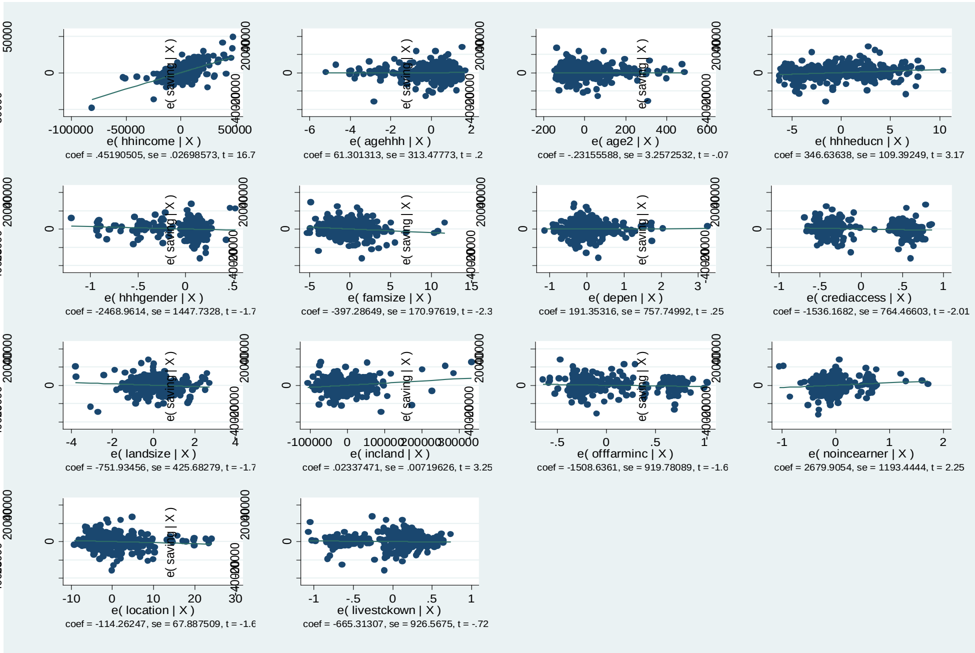
Appendix:

Appendix A: Normality test



Appendix B: Multicollinearity test (vif)

Variable	VIF	1/VIF
agehhh	72.00	0.013889
age2	70.40	0.014204
incland	9.21	0.108600
hhincome	4.65	0.215020
landsize	4.20	0.237885
noincearner	1.79	0.559893
hhhgender	1.46	0.686146
famsize	1.34	0.745373
offfarminc	1.27	0.786308
livestckown	1.24	0.803861
depen	1.19	0.842135
hhheducn	1.10	0.911801
location	1.07	0.934197
crediaccess	1.06	0.943686
Mean VIF	12.28	