ADDIS ABABA UNIVERSITY SCHOOL OF GRADUATE STUDIES

The Determinants of Agricultural Productivity and Rural Household income in Ethiopia

By

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DECLARATION

I, the undersigned, declare that this thesis is my original work, has not been presented for degrees in any other University and all sources of materials used for the thesis have been duly acknowledged.

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Abstract

The Determinants of Agricultural Productivity and Rural Household Income in Ethiopia

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Addis Ababa University, 2015

This paper aims at investigating the determinants of agricultural productivity and rural household income in Ethiopia. Three econometric modes namly: Pooled ordinary least square (POLS), fixed effects (FE) and random effects (RE) model were used to examine the relationship between productivity and income; using Ethiopian socio-economic survey of 2011/12 and 2013/14 data, collected by CSA of Ethiopia in collaboration with the world bank.

Results showed that, Land-labor ratio, use of pesticide, manure and household size are found to be the most significant variables that affect agricultural labor and land productivity. However, drought has statistically significant and has negative effect on both labor and land productivity by the same magnitude. Labor productivity, non-farm income and land productivity are found to be the most determinants of household income. However, number of dependency ratio is significantly and negatively affects the rural household income. Sex of the household head is the main socio-economic factor for the variation of income among the rural households. The study also concludes that, Labor productivity is the most potent for factor of production and rural household income enhancement. The policy implication of the study is that, increasing land-labor ratio is important for agricultural productivity enhancement and promotion of both farm labor and non-farm income are best focusing to speed up for the enhancement of rural household income.

Key words: Labor productivity, Land productivity; Rural Household income, Rural Household Panel Data, Fixed effect model.

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Tessema Urgessa

Addis Ababa, june, 2015.

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LIST OF ACRONYMS

ADLI: Agricultural Development Led Industrialization

AgSS: Annual Agriculture Sample Survey

CSA: Central Statistical Agency

EA: Enumeration Area

EAP: Economically Active Person

ERSS: Ethiopian Rural Socio-economic Survey

EPRDF: Ethiopian People's Revolutionary Democratic Front

FA: Farmer Association

FEM: Fixed Effect Model

FGLS: Feasible Generalized Least Square

IV: Instrumental Variables

IFAD: International Fund for Agricultural Development

IFPRI: International Food Policy Research Institution

ISLM: International Standard Living Measurements

LSDV: Least Square Dummy Variable

MLE: Maximum Likelihood Estimation

NBE: National Bank of Ethiopia

NGO: Non Governmental Organization

OECD: Organization for Economic Co-operation and Development

OLS: Ordinary Least Square

PFP: Partial Factor productivity

PIF: Policy Implementation Framework

PP_2: Producer price

PSU: Primary Sampling Unit

SLF: Sustainable Livelihoods framework

SSA: Sub-Saharan Africa

2SLS: Two Stage Least Square

TFP: Total Factor Productivity

TLU: Tropical Livestock Units

WB: The World Bank

CHAPTER-I

1. INTRODUCTION

1.1. Background of the study

Ethiopia is one of the Sub-Saharan African countries which liberalize its economy to maintain in all sectors a sustained economic growth and reduce poverty. Over the last ten years the sustainable economic growth brought with it positive trends in reducing poverty in urban and rural areas: While 38.7% of Ethiopian lived in absolute poverty in 2004/05. However, five years later this was declining to 29.6% in 2010/11. Moreover, poverty head count is still more prevalent in rural 30.4 percent than urban areas 25.7percent in Ethiopia (CSA, 2010/11).

In Ethiopia, about 83.9 % of total population is lives in rural area and agriculture is main source of their livelihood. Since 2010, Agriculture become the second most dominant next to service sector of the country’s economy, by providing employment for 80 % of the total labors force and contributes 42.7 % to Gross Domestic Product and 70 percent of foreign exchange earnings (NBE, 2013; CSA, 2013).

Due to it’s importance, the government of Ethiopia gives high priority to the agriculture sector by setting a strategy of agricultural development led industrialization (ADLI). The main goal of the agricultural policy is not only achieving the sustainable increase in agricultural production and productivity of small holder farmers but also accelerate agricultural commercialization and agro industrial development in the country (PIF, 2010-2020). Agricultural productivity can be increased by using two ways. The first method is through improvement in technology given some level of input and the other option of improving productivity is to enhance the output per household labor ratio of rural household farmers, given fixed level of inputs and technology. This study was mainly concerned about the second option of increasing productivity i.e. output per labor input and output per cultivated area of land.

It is clear that, agricultural development needs timely and adequate supplies of essential farm inputs. However, the investment capacity of majority of Ethiopian farmers is low, the poor farm household cannot afford to meet increased demand for the purchase of improved seeds, recommended quantity of fertilizer, buying or hiring of farm machinery etc; so lack of finance is one of the main reasons for low productivity in our agriculture. A number of studies show that farmers' yields of various crops were higher for borrowers than non borrowers (Kebede, 1995; Assefa (1989); Tefera, 2004)**.** All these studies have recommend that credit is one of the important inputs to meet the cash demands of the farmers and play the role of a bridge leading or shifting from subsistence to cash economy and eventually to marketable output. Similarly, other studies have found negative effects of lack of access to credit on agricultural production or profitability in developing countries (Freeman, Ehui, and Jabbar (1998) in Ethiopia and Kenya; Foltz (2004) in Tunisia; and Guirkinger and Boucher (2008) in Peru.

However, output per unit of land or crop yield is commonly used by agricultural scientists to evaluate the success of new production practices. Land productivity is also used by national policy makers to evaluate agricultural production intended to meet national food security needs. Output per agricultural worker, on the other hand, may be a more important indicator of rural household standards of living and their welfare (Block, 1995). Therefore, enhancement of agricultural productivity is thus an important condition for alleviating rural poverty, and due to it increases household income and stimulating the growth of non-farm activities among rural households.

It is widely argued that, achieving agricultural productivity growth will not be possible without developing and disseminating improved agricultural technologies that can increase productivity to smallholder agriculture farm (Asfaw, Shiferaw, Simtowe, & Lipper, 2012). Like in many other Sub-Saharan African countries, agriculture is the most important sector for economic growth and for the enhancement of household income in Ethiopia. However, lack of adequate farm management practices and low level of inputs applied, the highly rain fed dependent agriculture system are major challenges to sustain the agricultural production in Ethiopia (Grepperud, 1996; Pender & Gebremedhin, 2007; Kassie, Zikhali, Manjur, & Edward, 2009).

Despite the fact that, the agriculture sector is mostly susceptible in seasonal rain fall, the rural households are generating their family income from difference sources to averse the risk associated in agricultural farm sector. As a result the main source of income in most rural household of Ethiopia is derived from farm and non-farm activities. Agriculture is the primary source of rural income as 80% percent of the rural labor force is engaged in this sector (CSA, 2013). Non-farm income of the rural household referred to an income that the rural households generate from none of crop or livestock production during a one year of agriculture production period. Non-agricultural activities are not getting prevalence in rural Ethiopia because households are rarely practicing dominated by a subsistence agriculture sector. As a result of this, the income from nonfarm activity is also very low.

This subsistence agriculture and low level of rural household income is socially and economically could make unstable the rural society. Therefore, it is significantly important to identify the factors that affect agricultural productivity and find the methods of the rural household income improvements.

1.2. Statements of the problem

Important resources are being utilized by the Ethiopian government to improve the agricultural productivity and rural household income to alter the state of agriculture in the country. Material resource and human capitals are allocated towards this end. Extension workers, packages or programs, and agricultural inputs are some of the resources that are made available to farmers to change their style of farming and augment productivity (CSA**,** 2013)**.** Despite of all these efforts of the government, the agricultural productivity and farm household income is still very low in Ethiopia. The major reason behind is mainly the backwardness of the agricultural sector. Using farm technology is enormous for rural households of Ethiopia as land productivity, traditional tools, draft animals and family labor are still the most important factors of production (Beyene, 2004).

Actually here the important question to raise for agricultural policy makers will be, whether the agricultural sector can be made more productive, by achieving more output with the current input level, or achieving the current output with less input usage than is currently observed in Ethiopia. An important step in answering this question is to identify the determinants of productivity enhancement and its components. Significant share (about 98 percent) of Ethiopia's agricultural output comes from small-scale farm households, but subsistence farmers are still operating under traditional practices. This has limited total production that would have been produced in the country if the productivity of the small scale farmers were enhanced either by improving their production capacity or by using modern technologies or a combination of both.

Even though a positive incremental trends of rural households agricultural production in the last decades in the country, seasonality of farming activity results in unemployment and underemployment for a significant proportion of the rural labor force during most part of the production year. Actually the 2013 national labor force survey indicates that level of unemployment in rural area is only 2% but this figure doesn't include the underemployment rate, CSA, (2013). But practically the rural farm activity in Ethiopia is not worked the full year rather the crop season. This compiled with other economic and natural factors aggravates the problem of the rural household income in the country.

Rural households are usually engaged in both agriculture and non agricultural activities to averse the risk associated with their family income. Some households might depend exclusively on crop farming for their livelihoods and some households might employ in wage in the subsistence agricultural sector or other sectors else were.

In Ethiopian rural household until recent years, the income from non-agricultural sector has not been well known in magnitude. Few empirical studies have indicated that the contribution of non agricultural sector to total household income with sharing range 18.7% to 59.5% in rural areas (Delil, 2001; Tassew, 2000). Most of these studies focus on identifying determinants of occupational diversification, household participation in off farm wage employment and off farm self-employment or both. Few of them are try to show the factors that determine the choice of household between off farm self and wage employment e.g. Tassew (2000) and the role of nonfarm activities on poverty alleviation, farm output growth, and the effect of specific source of income on rural income diversification.

In developing countries, like Ethiopia, where income from farm activities varies considerably, farm households usually participate in non agricultural activities to supplement their agricultural income (Beyene, 2008). Hence, income from non agricultural activity is also expected to enhance household's production and productivity in farming activity. However, it is not known to what extent households with non agricultural income are better off than those without non agricultural activity income and whether there exists variability in the level of technical efficiency among the two groups of households in Ethiopia. Rural Farm household income is also often determined by a range of socio-economic and demographic factors. Knowledge of such factors has to be assembled carefully to determine their levels of influence on the change of household income.

However, many rural households' incomes are simultaneously the combination of their livelihood-agriculture with either wage employment, off farm business or both. Consequently, the majorities of the rural households of Ethiopia are combining their livelihood agriculture outputs through their family labor and land productivity enhancing with the non agriculture income, pare rally at the same time to enhancing their total family income.

Most of previous studies are failed to consider which agricultural productivity (land or labor) is the most determinants of the agricultural farm productivity and rural household income at national level. Some of them are focused on district or zonal administrative level and few of them are on regional level. Off these, all are focused on the total factor productivity which is not appropriate enough to measure the wealth and living standards of the household; others are focusing on the income diversification. Therefore, this study tries to fill this gap and considering the partial factor productivity measurement to indentify through which agricultural productivity indicators, the rural household agricultural productivity and rural household income adversely changes in Ethiopia.

1.3. Objective of the study

The main objective of this study was to examine the determinants of Agricultural productivity and rural household income in Ethiopia and its change over time on the entire household's total income. More specifically the study was:

- To determine the agricultural farm productivity/output per unit of labor input and output per unit of cultivated area of land
- To examine socioeconomic factors which can best predictor for the variation in agricultural productivity and income among rural households
- To examine the most potent productivity to enhance the rural household income
- To recommend possible policy implication based on the research findings.

1.4. Research Question

This study tried to answer the following four basic questions derived from its objectives.

- What factors determine the agricultural productivity of the rural households?
- Which factors of production are the most potent for the change of productivity and Household income?
- At what level changes the agricultural productivity & household incomes of small farm household in Ethiopia?
- Are there socioeconomic factors that explain the variation in income among the rural households? If yes, what are they?

1.5. Significance of the study

The reason behind the low level of rural household income and agricultural productivity as well as unable to attractive investment opportunity is considered to be inadequate economic development in most of developing countries. But several attempts are made in Ethiopia through, capital inflow like improved farm tools as well as the supply of financial means through group lending methodology by financial institutions to enhance the rural agricultural productivity and their household income. The significant agricultural sector productivity growth of the world is mainly comes from the technological improvements. This has been proved in most Asian countries but countries like Ethiopia, where the agriculture is the main livelihood for rural area, technology is enormous to enhancing agricultural productivity. As the main income source of the rural household is highly susceptible on this sector, the overall rural household income will be depends on the success or the failures of agricultural productivity. Therefore identifying the determinants of agricultural productivity and rural household income is very important.

All development partners like development agents, technical assistants, (NGO's) and other stockholders those who are involved in the agricultural productivity development must be aware and understand the factors affecting the agricultural productivity to enhance the rural household income. It is also important for policy makers to know the critical factors that could accelerate the agricultural productivity and rural household income in the country's rural area. Also it make easier to facilitate the necessary resources allocation for the rural household income research work, extension service and other rural household income development programs.

Therefore, the finding of this paper was significantly important to identify what factors are affecting the agricultural productivity and what determines the sampled rural household income in Ethiopia.

1.5.1. Justification and Expected Contribution of the Study

Knowing and understanding the key variables, which affect the agricultural productivity of small holder farmers, is of great importance for designing economic policies and their ultimate implementation in Ethiopia. Explanations of productivity and household income differences among the farmers may include variability of nonfarm income, lack of effective labor input and loss of production efficiency, level of household head education, age and household size. Identifying the reasons for the determinants of agricultural productivity and rural household income is not only important from the point of income perspective, but perhaps, it may useful to evaluate the effectiveness of the existing policies.

There have been changes in agricultural policies in Ethiopia since 1991 EPRDF takes the ruling power. ADLI Policies were mainly put in place to improve productivity of smallholder farmers and therefore improve their livelihoods. The results of the policies were shows a positive changes as poverty declines to 29.6%. But the rural poverty is still higher (30.4%) than the urban living population. Government rural policy intention is sustainable poverty reduction through improving agricultural productivity. But it is very important to evaluate the causes of success or improvements of policy interventions to support households who earn lower income among the rural households. Empirical studies in these areas are rare and they have not been sufficiently recognized and articulated by researchers. Despite this fact, there is a need to conduct a study exploring these issues.

1.6. Scope and Limitations of the study

As this study was undertaken at national level, there is no limitation in scope. However, it is restricted with partial factor of productivity measurements for the identification of factors that influencing and assessing the level of agricultural productivity and household income in Ethiopia. In addition to the budget and time constraints, this study was also limited to only the secondary source of data.

1.7. Organization of the Thesis

This study paper is organized into five chapters. Chapter one constituted the introduction, which focuses mainly on the background, statement of the problem, objectives, significance of the study, the scope and its limitation. Chapter two is deals with the review of the theoretical and empirical literature pertinent to the concern of the study. Chapter three describes the research methodology that includes a brief description of how & who collected the secondary data, procedures, analytical model and techniques of estimation method. Chapter four deal with reports on results of the study along with discussion. Finally, summary of the major findings, conclusion and recommendation are presented in Chapter five.

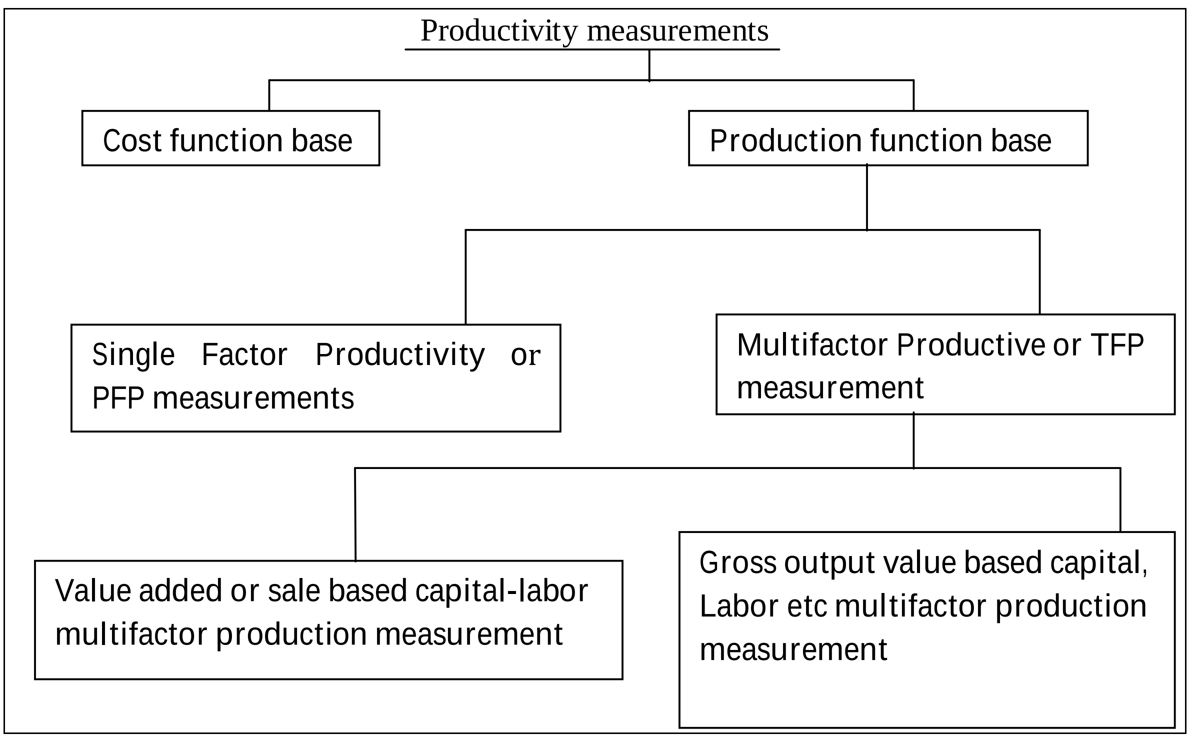
CHAPTER-II

2. REVIEW OF LITERATURE

2.1. The concepts and Theories of Agricultural Productivity Measurements

Agricultural productivity is refers as the output produced by a given level of input(s) in the agricultural sector of a given economy (Fulginiti and Perrin 1998). More specifically, it can be defined as "the ratio of the value of total farm outputs to the value of total inputs used in farm production" (Olayide and Heady 1982). However, agricultural productivity can be measured by partial productivity or total factor productivity measures depending on the number of inputs under consideration

Figure 1: Productivity measurement methods



Source: OECD Manual, 2001

Total factor productivity is also defined as the ratio of an index of agricultural outputs to an index of agricultural inputs. The agricultural output index is a value-weighted sum of the whole components of agricultural production, whereas, the agricultural input index is the value-weighted sum of the whole conventional agricultural inputs such as fertilizer, land, labor, machineries and livestock.

However, it is difficult to aggregate variety of outputs and inputs into a single index to measure productivity (Ruttan 2002). This approach is also overstates or understates productivity of inputs when input ratios change without a change in technology (Gebreeyesus 2006). Markets are also not well-functioning in the case of aggregating output and input. For example, if the market of land and labor are not well functioning, rental values and wage rates for hired labor cannot be measured with accuracy and hence TFP measure becomes intractable. This idea is supported by Kelly et al, (1995) and finds that TFP calculations in many areas of Africa is constrained by missing input prices (from missing markets), especially for land and manure and to a lesser extent for labor. As a result of these limitations, this study is considering the partial measure of agricultural productivity to address its objectives.

Partial measures of agricultural productivity are the amount of output per unit of a particular input (Diewert and Nakamura, 2005). It is commonly used partial measures yield (output per unit of land), labor productivity (output per economically active person (EAP) or per agricultural person-hour). Yield is commonly used to evaluate the progress of new production practice or technology (Wiebe et al, 2003; Zepeda, 2001). And Labor productivity is mainly used for measuring as comparing the productivity of agricultural sectors within or across the rural households. It also used to measure the rural living standard or welfare indicator as it reflects the capacity to making income through sale of agricultural production. Partial measurement of productivity is a key element towards assessing standards of living. A simple example is per capita income, probably the most common measure of living standards: income per person in an economy varies directly with one measure of labor productivity, value added per hour worked. In this sense, measuring labor productivity helps to better understand the development of living standards (OECD, 2001).

Partial measures of productivity index also have a limitation that, it may not account for all the inputs used in production process. However, carefully constructed partial measures are applied to measures output that attributable for variations in measured factors (Alston, Anderson, and Pardey 1994). This study is considered both land and labor productivity measurements to evaluate the progress of farm production practice and the change of income per household in rural household.

The stochastic front production function can be specified through the use of the Cobb-Douglass or translog production functions (Biggs 2007; Zhang and Fan 2001) used for the measurements. The Cobb-Douglass production function is a simple tool which can handle multiple inputs in its generalized form. However, use of Cobb-Douglass production function also its own limitations due to its restriction on the elasticity of substitution (Kim 1992).

Therefore alternatively, translog functions are more sufficiently flexible to use. Since it allow us for the estimation of various partial elasticities of substitution for any number of inputs, (Zhang and Fan 2001). Because it doesn't imposes a restrictions on elasticities of substitution and returns to scale and also the Cobb-Douglass production function has both linear and quadratic terms which enable for using more than two factor inputs (Kim 1992). But, the variables in such a specification are highly correlated and hence the choice among Cobb-Douglass and translog has to be based on the overall goodness of fit and other diagnostic results such as multicollinearity and Heteroskedasticity.

2.2. The concepts and Theories of Rural Household Income Measurements

The conceptual framework for the rural household income measurement is drawn from the Sustainable livelihoods framework (SLF). In the SLF framework, assets, all activities, and their access, are altogether are required for a means of living by an individual or a household to construct a livelihood (Chambers and Conway, 1991). The framework shows how, in different contexts, sustainable livelihoods are achieved through access to a range of livelihood assets which are combined in the pursuit of different livelihood strategies to achieve certain livelihood outcomes such as increased incomes (Alinovi *et al.*, 2010). Households can access a range of assets or resources (physical, natural, economic, human and social capital) which they can use to engage in farm or non-farm activities or both (Scoones, 1998). The decision of rural households to participate in non-farm activities is influenced by individual or household specific factors, as well as other social, economic and environmental factors (Barrett et al. 2001; Barrett, Reardon and Webb 2001; Escobal 2001;Lay et al. 2008; Idowu et al. 2011; etc). Various social relations, institutions, organizations, policies, as well as trends, shocks and seasonality modify access to and ability to convert livelihood assets into livelihood outcomes (Vedeld *et al.*, 2012). As regards seasonality; in the dry season, especially in semi-arid regions some rural households obtain remittances from seasonal migrants, incomes from local nonfarm activities and, cash from the sale of crop and livestock products (Reardon 1997; Ellis 1998). While some farm households can also allocate part of their labor during the rainy season where nonfarm labor pays better than farming and where farm households can count on food markets to buy food (Reardon 1997). However, the rural household income could be measured using Ordinary least square (OLS), feasible generalized least square (FGLS) and two stage least square (2SLS) measurement technique.

2.3. Measurements of theoretical model for analyzing agricultural Productivity and Rural household income

2.3.1. Theoretical model for analyzing agricultural productivity and its Measurements

Agricultural productivity is a crucial factor in production performance of agricultural output in one nation. Increasing national agricultural productivity could raise the living standards and wealth of rural households, because more real income improves people's ability to purchase goods and services, enjoy leisure, improve housing and education and contribute to social and environmental programs. By considering of its importance, measuring agriculture productivity will clearly shows the level of incomes of the rural household those who are engaged in agricultural activity. Agricultural productivity most commonly estimated using parametric and the non-parametric approach. In the parametric approach, the coefficients of the production function are estimated statistically using econometric approach whereas, in the non-parametric approach by using the mathematical programming approach. It is the parametric approach commonly used in the estimation of production functions while the non-parametric approach used in efficiency analysis (Coelli et al., 1998).

This study is considering the parametric approach to estimate the agricultural productivity function. Because the econometric approach has the advantage of being statistical, hence permitting hypothesis testing and calculation of confidence intervals to test the reliability of the model estimated. This approach explicitly measures the marginal contribution of each category of inputs to aggregate agricultural output. If a flexible functional form is chosen, a further advantage is that fewer restrictive assumptions about technology are imposed; the flexible functional form provides a second order approximation to a general function (Antle and Capalbo, 1988). The major limitation of the econometric approach is that it requires more data than the other approaches.

As Singh and Dhillion, (2000) stated that agricultural productivity is frequently associated with the attitude towards work, thrift, industriousness and aspirations for a high standard of living, etc. Hussain, (1976), also developed a technique of how to measure agricultural productivity of farm households. He converted all the agricultural production into its monetary values of a regional unit in production.

For the analysis of agricultural productivity, the Cobb-Douglas production function found to be theoretically and empirically more apparently reasonable, since it is easy to estimate and mathematically manipulate and possible to test the significance of the estimated elasticities using standard test statistics such as t–ratios and f-ratios. However, according to Coelli et al. (1998) it has also many restrictive properties imposed on the production structure like fixed returns to scale and elasticity of substitution always equal to unity.

Therefore, by following Nigussie and Mulat (2003), the Cobb-Douglas production function can be specified as:

$$\boldsymbol{Y = F(X, E)}$$

Where: Y= Yield response

X= a vector of technological inputs like fertilizer, pecticide and others

E= vectors of physical inputs such as sex, age, level of household head education, farm size, household size, and others.

Therefore, the Cobb-Douglas production function can be expressed as:

$$\mathbf{Y_i = \pi(X_{ij}^{\beta j} E_{ij}^{\delta j}) e^{\alpha + \varepsilon i}}$$

Where: $\mathbf{Y_i}$ = yield response of the ith Area of land

$\mathbf{X_{ij}}$ = the use of the ith Area of the jth technological input

$\mathbf{E_{ij}}$ = the use of the ith Area of the jth physical input

For all the above production functions, Y is the output produced and X's are the inputs used in the production process.

2.3.2. Theoretical model for analyzing rural household income and its measurements

Theoretical analysis of household income revealed that rural income is mainly derived from farm and non-farm sources. Farm and non-farm variables played a vital role in rural household economy. All variables had their own effects, either increasing or decreasing effect. In this part the study tries to investigate the determinants of income to explore the basic sources of welfare of rural households. It also examined what characteristics of rural households were associated with their real income. It used econometric models and the ordinary least square (OLS) regression estimation technique to establish relationships between income and various household characteristics. It considered both economic and non-economic characteristics of rural households to identify determinants of household income.

The economic characteristics include land size owned by individual households, and income shares from agriculture, wage-salary, business-commerce, gift-remittance-assistance and income from other sources. The non-economic characteristics include household size, household type, household head's age, Sex and educational status. One important dummy variable will be used to capture the effects of credit constraint on the specific household income. These variables included whether the household has credit constraints or not. This implies that a borrower household who needs a desire for more credit and non borrowers who responded that they couldn't obtain credit will assumed as credit constraint.

The study constructed regression models as defined and used by Dercon (2006), and Isik-Dikmelik (2006). The model for estimation is as follows:

$$\boldsymbol{log(y_{h,t})} = \mu_{\boldsymbol{h}} + \Psi \boldsymbol{X_{h,t}} + \boldsymbol{\varepsilon_{ht}};$$

Where, $\boldsymbol{log(y_{h,t})}$ = the dependent variable, is the income (logarithm) of the rural households;

$\mu_{\boldsymbol{h}}$ = is the intercept of the regression line;

$\Psi \boldsymbol{X_{h,t}}$ = is the explanatory variables which influence Household income, Productivity & non-farm income etc.

$\boldsymbol{\varepsilon_{ht}}$ = is the error terms.

μ and **Ψ** = are called the parameters, also known as regression coefficients

This model could be extended by separating household economic and non-economic characteristics (endowments).

2.4. Empirical literatures

2.4.1. Agricultural productivity and rural household income in developing Countries

There exists quite vast literature on the trends of agricultural productivity, factors affecting agricultural productivity and ways to improve agricultural productivity in both developed and developing countries. Agricultural productivity of a given farm household is determined on many factors in the literature. Ellis (1993) argued that small farms in terms of land size are more productive than large farms and his recommendation that agricultural development strategy based on the promotion of small rather than large farms can serve both growth and income distribution objectives. Empirical studies have also arrived on the same conclusion (Berry and cline, 1979; Bhalla, 1979). But still there are also counter arguments which says large farms perform better than the small one.

Literature reviewed showed that agricultural productivity increases more in developed countries compared to less developing countries. This is due to high investment in research and development, labor, land and capital and improvement in the use of inputs such as fertilizer, machinery increases and others. It must be notice that Agricultural productivity depends primarily on technological change, improved input use efficiency and conservation of natural resources. These in turn, depend crucially upon investments in agricultural research, extension and human capital.

Agricultural growth may reduce poverty through direct effects on farm productivity, incomes, and employment. It may also generate indirect impacts on the welfare of rural households through the growth linkage with the non-farm sector as well as through its impacts on food prices (Adeoti and Sinh, 2009; Bezemer and Headey, 2008; Byerlee *et al.*, 2005; Popli, 2010;). There have been arguments that the poor typically spend a high share of their income on staple food; therefore, they benefit from a decline in the price of staple food induced by agricultural productivity improvement.

In Asia, Chang *et al* (2001) determined how to promote agricultural productivity growth to achieve sustainable food security. The study looked at the role of investment, both in physical and human capital, in maintaining and increasing agricultural productivity. By using TFP and partial factor productivity functions they found that, the only way to promote agricultural productivity was through improving labor productivity. Due to the improvement in labor productivity, the agricultural output growth for these countries has remains positive from the period of 1961 to 1994.

According to Haji, (2008), increased productivity in agriculture has a number of advantages. Firstly, it increases the flow of resources from one sector to the other, thereby enhancing economic growth. Secondly, a higher level of agricultural productivity results in lower food prices that increase consumers' welfare. Thirdly, productivity growth improves the competitive position of a country's agricultural sector.

Zepeda (2001) by using number of models of production growth (index numbers or growth accounting techniques, econometric estimation of production relationships and nonparametric approaches) to measure the change in output, to identity the relative contribution of different inputs to output growth and to identify the Solow residual or output growth not due to increases in inputs. He founds that a relatively weak relationship between physical capital and growth, as compared to investment in technology and human capital.

Fulginiti *et al* (1998) using the data of eighteen developing countries over the period 1961–1985 to examined the changes in agricultural productivity. The study used a non parametric, output based malmquist index and a parametric variable coefficient Cobb-Douglas production function to examine, whether declining agricultural productivity in less developed countries was due to use of low inputs. Econometric analysis indicated that most output growth was imputed to commercial inputs like machinery and fertilizers.

Another study made by Byerlee, Diao and Jackson (2005), Winters, McCulloch and McKay (2004), and Bezemer and Headey (2008) argued that interaction of productivity growth, farm income, employment, and food prices could lead to a pro-poor outcome depending on two key conditions. Firstly, agricultural productivity per unit of labor must increase to raise farm income, but agricultural productivity per unit of land must increase at a faster rate than that of labor in order to raise employment and rural wages. Secondly, increased total factor productivity (TFP) in agriculture must result in a decrease in real food prices, but the TFP must increase faster than food prices decrease for farm profitability to rise and for poor consumers to benefit from lower food prices.

Agriculture and Natural Resources Team and Thomson (2004) indicated four transmission mechanisms when there is an increase in agricultural productivity to progress the poverty reduction in rural households. These four transmission mechanisms are the direct impact of improved agricultural performance on rural incomes; an impact of cheaper food for both urban and rural poor; an agriculture's contribution to growth and the economic opportunity in the non-farm sector; and agriculture's fundamental role in stimulating and sustaining economic transition as shift from being primarily agricultural towards a broader base of manufacturing sector and services.

Tripathi *et al* (2008), they study Indian agricultural productivity growth by using Cobb-Douglas production function, argued that an improvement in not only labor but also capital and land productivity can improve agricultural productivity. Their results indicated that output elasticity of land was 1.98, labor 1.06 and capital 0.15 and when added up they gave a sum greater than one. This meant that labor and land inputs had positive and significant influence on agricultural productivity growth.

Rao and Chotigeat (1981) studied the relationship between size of land holdings and agricultural productivity. They used the GLS regression technique to estimate a translog function to formalize the relation between output and inputs. Their study was conducted using farm level data from several states in South India over the period 1962 to 1970. The study finds that there was no systematic relationship between the measures of productivity and land size. They also indicated that capital had a positive effect, land and labor, a negative effect on the elasticity of gross value of output per unit of land. However, large capital infusion canceled out the negative effects of land, and led to a positive relation between land-size and productivity.

Another study made by Venkatensan and Kampen, (1998) stated that, the growth in agricultural production in Sub Saharan Africa in the past was achieved by expanding the amount of land cultivated, but today there is litter scope for increasing the area under cultivation. Further increase in agricultural production in the area could be achieved only by increasing the productivity of land and labor.

Wiebe et al (2001) in their study on "Agricultural policy, Investment and Productivity in sub-Sahara Africa (SSA)", argued that an expected increase in output from improved infrastructure and price policies were difficult to quantify, but such improvements were probably prerequisites to make possible the increases in productivity from the use of conventional inputs and research. The study concluded that education of rural labor force and agricultural research is needed to improve the future prospects for productivity growth in SSA.

Owuor, (2000), study partial factor productivity measurement by using cob-Douglas production function method; founds that the determinants of family labor productivity are consistent with those of land productivity in Kenya. Agricultural land and family labor productivities are positively correlated and significant (0.64, 0.01) respectively.

Most of the literature suggests that rural household income is increases trough agricultural farm land and agricultural labor productivity. This could be due to the fact that, agricultural productivity has a positive impact on real rural household incomes. This idea is consistent with Blunck, (2006) argued that a high standard of living can be sustained by improvements in agricultural productivity, either through achieving higher productivity in existing farms or through successful entry into higher productivity farms.

Sen and Palmer-Jones, (2006), during their evaluation of the link between poverty and geographical location of rural Indian households by using ordinary least square (OLS) and maximum likelihood (ML) estimation technique, finds that the rural households are being poor or rich was strongly associated to where they lived and the low level of income as well as poverty were highly correlated with agricultural productivity performance.

Aikaeli, (2010), study the determinants of rural income in Tanzania by using feasible generalized least square (FGLS) estimation technique, finds that as the size of family labor force, cultivated land size for farm income and educational level of the household head increases, the per capital income of the rural household is significantly increased.

Akram, Naz and Ali, (2011) in Pakistan by using cross-sectional data to analyze an empirical analysis of rural household income finds that, the increase of land holding size, the level of household head education, the households rental income and non-farm occupation are significantly increases the rural household incomes. The study used semi log multiple regression model to analysis the cross-sectional data.

Another literature shows that the standard of living or household wealth in most nations is determined by productivity with which a nation's human capital and natural resources are deployed and the output of the economy per unit of labor and/or capital employed (Porter, 2001; Blunck, 2006).

2.4.2. Agricultural productivity and rural household income in Ethiopia

It is important to identify factors that influence on agricultural productivity in Ethiopian agriculture because these factors would automatically have indirect impacts on the poverty incidence if the force of agricultural productivity to the household income is significant. The determinants of agricultural productivity in particular country are different and distinctive from others. This section would refer to some studies in indicating of determinants of agricultural productivity rural household income in Ethiopia.

By using a cross-sectional data, a study conducted in walaita and Gemugofa zones of South nation, nationalities and people of Ethiopia for assessing productivity and technical efficiency of smallholder farmers, shows that, there was significant level of productivity improvement among maize producing farmers (Geta *et al*., 2013). They were used a two stage estimation technique, translog production function to determine the levels of productivity and Tobit regression model to identify factors influencing technical efficiency. The model result depicted that productivity of maize was significantly influenced by the use of labor, fertilizer, and oxen power.

Another literature studies by Berg and Kumbi (2006) were suggested that agriculture was the main source of rural income inequality in Oromia national states of Ethiopia. Their results showed that 90 percent of total inequality was due to farm source of income. On the other hand, nonfarm income was found to be inequality decreasing source of rural income.

As Adugna (2002) identifying the determinants of household income in rural households of Ethiopia indicates that, the household demographic characteristics like family size, educational status of the household head and sex of the household head is determining the income of the household to enhancing or to lowering.

The study conducted by Bogale, Hagedorn and Korf (2005), in the assassination of the determinants of poverty in rural Ethiopia shows that cultivated land per adult in the household, the living geographical locations of the rural household, educational status of the household head and owning of oxen are significantly important determinants for holding the household resource endowments or households are deprived from basic livelihood assets.

Another study made by Endale, (2011) by using the panel data of cereal crops and translog estimation technique followed by FGLS for the fixed effect estimation, founds that the land size and family labors are significant for agricultural productivity in the study area of four regional state of Ethiopia.

The study made by Gebru and Holden (2013), for the aim of investigating productivity difference among land certificate owner and non owner in Tigray Regional state of Ethiopia by using DEA based on malmquist productivity index, founds that on aggregate farmers those who are not owned the land certificate are less productive than those who are already owned the land certificate. The study also found no evidence to suggest that, the agricultural productivity difference between the two groups is due to difference in technical efficiency.

2.4.3. Factors affecting agricultural productivity

In African agriculture, the literatures are stated a few of factors affecting agricultural productivity such as Fufa and Hassan (2003), Alene and Hassan (2003), Tijani (2006), and Mushunje *et al*. (2005). From this literature, the factors that influence the production function include: fertilizer, labor inputs, cultivated land area or farm size, seeds, animal and tractor power etc.

2.4.3.1 Chemical Fertilizer

A soil which has a high production potential and which at the same time is fertile can naturally produce high yields. Binam *et al*. (2004) found that farmers who are located in more fertile regions perform significantly better than those located in less fertile regions. Therefore, reinforce the argument that improvement in soil fertility is a crucial element in increasing productivity. Tchale and Sauer (2007) results also show that high levels of technical efficiency are obtained when farmers use integrated soil fertility options compared to the use of inorganic fertilizer only. Therefore, fertilizer appears to be the most important factor of production

2.4.3.2. Labor

Most of African agriculture is traditional and characterized by labor intensive production and excess demand for labor often occurs during periods of land preparation, weeding and harvesting. Agricultural labor consists of two categories, namely hired labor and family labor. According to Mensah (1986), as stated by Antwi (1997), the causes of labor shortages in less developed countries is largely due to the migration of labor from rural to urban areas. According to Antwi (1997), labor is normally measured in man-days, man hours or in value terms. Labor availability is another often-mentioned variable affecting farmers' decisions concerning the adoption of new agricultural products or inputs. Most empirical studies are found that the estimated coefficient for labor was positive and statistically significant, which implies that labor increases the level of production and productivity. This means that the larger the family size with effective members, the more labor is available for farming operations, thus increasing the production of farmers. On contrast, over utilization of labor input is negatively affects farm production, Tijani (2006) and Tchale and Sauer (2007).

2.4.3.3. Land area or farm size

Land in agricultural production is quite heterogeneous in terms of soil size, soil type, associated soil characteristics and other productivity-related factors within developing countries. Failing to account for these differences would lead to a biased measure of the land input as well as productivity levels (Nehring *et al.*, 2003). The majority of studies of agricultural productivity in developing countries support the view that there is an inverse relation-ship between productivity and farm size. This may be a result of market imperfections, such as missing rural labor markets. The recent literature suggests that land has a major influence on production since its estimated coefficient is positive in most studies; for instance, Mushunje *et al*. (2003) study on relative technical efficiency of cotton farmers in Manicaland Province of Zimbabwe, find positive coefficients in land significant at all levels. Fufa and Hassan (2003) also find that the estimated coefficient of land is positive and significant. This shows that the positive influence of land on agricultural production. Most literatures are shows a positive relationship with output. However, producing farm outputs in uneconomic region or zone found to negative correlation with output, Chirwa's (2003).

In the above literature we reviewed both the theoretical and empirical literature on agricultural productivity and rural household income. The theoretical literature suggests that, the agricultural labor productivity is crucial for household income enhancement and the rural farm-household income is revealed mainly derived from farm and non-farm sources.

In the empirical literature, agricultural productivity determinants are generally estimated using the Cobb-Douglas production function models and argued that, both labor and land productivity can improves agricultural productivity. Regarding household income analysis, literature shows that, rural household income is increases through agricultural labor and land productivity duo to its positive effect on household income.

A review of studies in Ethiopia also addressing issues related to improved agricultural productivity and household income suggest that, the size of farm land and labor productivity are significant for agricultural productivity and positively affects the household income.

By considering the above literature reviewed, this study result contributes for the future literature in Ethiopia on the following points:

- It could contributes the factors that determines of farm productivity in rural households of Ethiopia
- It could contributes the effect of productivity on rural household income in Ethiopia
- It could contributes the factors that determines the rural household income in Ethiopia

CAPTER-III

3. DATA AND METHODS

3.1. Source of data and the type of data used

The data for this research paper is comes from the two round of panel survey of Ethiopian Rural Socioeconomic survey (ERSS), conducted by Central Statistical Agency (CSA) with the collaboration of the World Bank Living Standard Measurement Study (ISLM) team. The survey was conducted in 2011/12 for the first time in Ethiopia in full sample coverage at National level and second round was conducted after two years later in 2013/14. This primary data contains two part namely agriculture and households different socioeconomic characteristics. The agriculture part contains cultivated land area the types of input used, crop production in quintal and Livestock production of the farm households. The Household socio-economic characteristic contains household borrowing, lending, from where they borrow and to whom they lend, food consumption items, the income from different source including remittance and source of their income, educational status of the household members and household demographic characteristics etc. This socioeconomic survey also asked the number of household asset, the loan amount of money in cash or in kind that the household received, time of repayment, if the household repay on time or not and the amount will be paid back and the reasons for those who don't get loan etc.

3.2. Sampling frame

CSA has the standard procedure for data collection and it uses the sampling frame, the list containing Enumerations Area (EA) of rural Ethiopia and its respective agricultural households obtained from the 2007 (1999 E.C) Population and Housing Census Frame was used as the sampling frame in order to select EAs Primary Sampling Units (PSU). EA's are the area within a kebele administrative, and contain about 100 to 150 households. Consequently, all sample EAs were selected from this frame based on the design proposed for the survey. Second stage sampling unit's is the households were selected from the list of households that were prepared for each EA at the beginning of survey period.

3.3. Sample Design

The CSA sampling design is a two-stage probability sample design. The first stage of sampling design entailed selecting primary sampling units, which are a sample of the CSA enumeration areas (EAs). For the rural sample, 290 EAs were selected from the Annual Agricultural Sample Survey, (AgSS) EAs. However, only 278 EA's were fully covered[1]. The AgSS EAs were selected based on probability proportional to size of the total EAs in the region.

The second stage of sampling was the selection of households to be interviewed in each EA. For rural EAs, a total of 12 households are sampled in each EA. Of these 12 households, 10 households were randomly selected from the sample of 30 AgSS households. The AgSS households are households which are involved in farming or livestock activities during each survey period. Another 2 households were randomly selected from those who are not involved in agriculture or livestock activities during the first round of survey period in the rural EA. Based on the above procedure the total of 2,780 households are from agriculture holder and 556 households are from non agriculture holder were selected at national level. However, we should have to drop the

[1] Interested readers can see the sampled EA's table with its selected household on appendix- X

non agriculture holder households, since they are not part of our objectives. There for based on the agriculture holder households i.e. 2,780 households were selected and 2,646 households were fully covered in round one. In the second round by considering the round one covered of 2,646 households, we only founds 2,236 households in their respective EA's and Farmer Association (FA's) during the second survey period. About 410 households were could not be traced correctly. Finally based on this evidence, a balanced panel of 2,236 households, almost the fully coverage of the second round over two rounds was created.

3.4. Methods of Data Analysis

Quantitative methods were used to analysis the data. Mean tabulation and frequency distribution was used to analyze in detail. On top of that F-test and Chi-square statistics is implemented to measure the mean and percentage difference between productivity and income of the rural households. The log-linear of Cobb_Dauglas production function of the within-group or LSDV, the random effect (RE) and the fixed effect (FE) model was used for the determinants of agricultural productivity and the IVreg2 (2SLS), the random effect (RE) as well as the fixed effect (FE) model was employed for the estimation of the determinants of rural household income.

3.5. Empirical productivity Model specification

Most of the studies using the Cobb_Douglaus production function approach stated that the functional form of the Cobb-Douglas production model is assume homogeneity, unitary elasticity of substitution between input and output. And also it is among the best well known production function utilized in applied production and productivity analysis (Enaami et al, 2011). By considering all this the model we employee will be specified starts with output supply equation which is taken out from the theoretical farm household model described under the theoretical model measurements in chapter two. The output supply equation includes inputs, farm characteristics and household characteristics.

Agricultural labor productivity levels are determined by many causes, including in any production function of the agricultural sector except the labor force since it is already the labor productivity denominator. These agricultural productive factors have been included in all estimations of agricultural productivity (Hayami and Ruttan, 1985; Kawagoe et al., 1985). However, the current analysis consider all the factors of production such as cultivated area of land, chemical fertilizer, number of oxen as proxy for capital input, etc are considered.

$$\mathbf{y_{it} = \alpha(L_{it}^{\beta_1} K_{it}^{\beta_2}) e^{\mu_{it}}} \quad \text{--} \ \mathbf{(1)}$$

Where: $\mathbf{Y_{it}}$ = is the value of the $\mathbf{i^{th}}$ household's all farm output in Ethiopian birr during Period t

$\mathbf{L_{it}}$ = is the i^{th} labor inputs used during period t

$\mathbf{K_{it}}$ = is the i^{th} capital inputs at a time t

$\boldsymbol{\mu_{it}}$ = the disturbance or an error term

$\boldsymbol{\beta_1}$ **and** $\boldsymbol{\beta_2}$ = output elasticity of labor and capital

If we transform equation (1) in its log-transformation form, it will give us:

$$\mathbf{lnYit = \beta_i + \beta_1 lnL_{it} + \beta_2 lnK_{it} + \mu_{it}} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (2)$$

Therefore, in the case of our several dependant variables the ln-linear model would be:

$$\ln Y_{it} = \beta_{0i} + \beta_1 \ln AI_{it} + \beta_2 \ln A_{it} + \beta_3 \ln RAV_{it} + \beta_4 \ln FET_{it} + \beta_5 \ln OX_{it} + \beta_6 AG_{it} + \beta_7 EDU_{it} + \beta_8 HHS_{it} + \gamma_1 SEX_{it} + \gamma_2 PES_{it} + \gamma_3 DRT_{it} + \gamma_4 CRD_{it} + \gamma_5 EXTN_{it} + \gamma_6 IRRN_{it} + \gamma_7 MANURE_{it} + \varepsilon_{it} \quad \text{------} \quad (3)$$

Where,

$\ln Y_{it}$ = the log of total farm output produced by i^{th} household during period t

$\ln Al_{it}$ = the log of i^{th} household agricultural labor inputs during period t

$\ln A_{it}$ = the log of cultivated land area of the i^{th} household during period t

$\ln RAV_{it}$ = the log of real asset value of the i^{th} household during period t

FET_{it} = the amount of chemical fertilizer used by i^{th} household during period t

OX_{it} = the number of oxen used for plough by i^{th} household during period t

AG_{it} = The Age of the household head during period t

EDU_{it} = Educational level of the i^{th} household head during the period t

HHS_{it} = family size of the i^{th} household during period t

SEX_{it} = Sex of the i^{th} household head during period t

PES_{it} = if the i^{th} household were used pesticide or not during period t

DRT_{it} = if drought was happened to the i^{th} household farms during the pried t

CRD_{it} = if the i^{th} household was got credit during period t

$EXTN_{it}$ = if the household used extension service during the period t

$IRRN_{it}$ = if the household used irrigation during the period t

$MANURE_{it}$ = if the household used animal manure during the period t

But our interest is to come up with the labor and Land productivity equation and hence, let us first divide both sides of equation (3) by agricultural farm labor force (AL), to determine the labor productivity equation. According to Ramirez (2006), we will have aggregated output per unit of labor as a measure of labor productivity and taking log of both sides of the equation it will gives us;

$$\ln\left(\frac{Y}{AL}\right)_{it} = \beta_{0i} + \beta_1 \ln\left(\frac{AL}{AL}\right)_{it} + \beta_2 \ln\left(\frac{A}{AL}\right)_{it} + \beta_3 \ln\left(\frac{RAV}{AL}\right)_{it} + \beta_4\left(\frac{FET}{AL}\right)_{it} + \beta_5\left(\frac{OX}{AL}\right)_{it} + \beta_6 AG_{it} + \beta_7 EDU_{it} + \beta_8 HHS_{it} + \gamma_1 SEX_{it} + \gamma_2 PES_{it} + \gamma_3 DRT_{it} + \gamma_4 CRD_{it} + \gamma_5 EXTN_{it} + \gamma_6 IRRN_{it} + \gamma_7 MANURE_{it} + \varepsilon_{it} \text{ ---------- } (4)$$

Where $\ln\left(\frac{Y}{AL}\right)$ = is a measure of partial labor productivity. It is worth to mention that our productivity measurement is partial. For the sake of simplicity if we let set equation (4) in the following form:

$\ln\left(\frac{AL}{AL}\right)$ which is the same as to $\ln L = X_1$ **$\ln\left(\frac{A}{AL}\right) = X_2$**

$\ln\left(\frac{RAV}{AL}\right)_{it} = X_3$ **$\left(\frac{FET}{AL}\right) = X_4$** **$\left(\frac{OX}{AL}\right) = X_5$**

$AG = X_6$ **$EDU = X_7$** **$HHS = X_8$**

Then, we can rewrite equation (4) in a compact or reduced form in the following method**:**

$$\ln\left(\frac{Y}{AL}\right)_{it} = \beta_{0i} + \beta_i \sum_{j=1}^{n} X_{it} + \gamma_i \sum_{k=1}^{n} D_{it} + e_{it} \text{ ---------- } (5)$$

Where, j = 1, 2, ---, 8 and

K = 1, 2, ---, 7

In similar fashion we compute the Land productivity equation based on equation (3) above by dividing the right and the left hand sides by cultivated area of land (A). Then, we will have aggregated output per cultivated area of land as a measure of land productivity will gives us;

$$\ln\left(\frac{Y}{A}\right)_{it} = \beta_{0i} + \beta_1 \ln\left(\frac{AL}{A}\right)_{it} + \beta_2 \ln\left(\frac{A}{A}\right)_{it} + \beta_3 \ln\left(\frac{RAV}{A}\right)_{it} + \beta_4\left(\frac{FET}{A}\right)_{it} + \beta_5\left(\frac{OX}{A}\right)_{it} + \beta_6 AG_{it} + \beta_7 EDU_{it} + \gamma_1 SEX_{it} + \gamma_2 PES_{it} + \gamma_3 DRT_{it} + \gamma_4 CRD_{it} + \gamma_5 EXTN_{it} + \gamma_6 IRRN_{it} + \gamma_7 MANURE_{it} + \varepsilon_{it} \quad \text{....}(6)$$

Therefore, the reduced form of equation (6) will gives us the following equation (7):

$$\ln\left(\frac{Y}{A}\right)_{it} = \boldsymbol{\beta_{0i}} + \boldsymbol{\beta_i} \sum_{j=1}^{n} \boldsymbol{X_{it}} + \gamma_i \sum_{k=1}^{n} \mathbf{D_{it}} + \mathbf{e_{it}} \text{------------------------------------}(7)$$

Where, $\ln(\frac{Y}{A})$= is a measure of partial land productivity and, j =1, 2, ------------------, 8

i= 1, 2, -------------------, 7

During the pooled OLS model is employed a random variable $\boldsymbol{\varepsilon_{it}}$ are assumed to be **iidN(0,** $\boldsymbol{\delta_{\varepsilon}^{2}}$ **)**.

3.6. Estimation Technique

We use equation (8) and (9) to estimate the labor and land partial factor productivity measurement specified under equation (5) and (7) respectively. For the model estimation, we were employ panel data estimation technique. Following Baltagi (2001), Gujarati and Porter (2009), and Greene (2003) panel data regression model presented below.

$$\boldsymbol{Y_{it}} = \boldsymbol{\alpha_{it}} + \boldsymbol{\beta X_{it}} + \boldsymbol{U_{it}}, \quad i = 1......, N \;\&\; t = 1, \ldots\ldots\ldots\ldots, T \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Where,

$\boldsymbol{Y_{it}}$ = is the dependant variable

$\boldsymbol{X_{it}}$ = is the independent variable

$\boldsymbol{\alpha_{it}}$ = is the unobserved individual heterogeneity or the individual fixed effect

$\boldsymbol{\beta}$ = is the parameter to be estimated

$\boldsymbol{U_{it}}$ = is the residual

There will be two panel data regression models that we were used in this study i.e. the within-group estimation Method and the Fixed Effect model.

The Pooled OLS Method (equation 8)*:* In pooled regression the model has common constant and hence it neglects cross- section and time series nature and estimate the grand regression. Whereas, the within-group estimation model which is equivalent to the Fixed Effects least squares dummy variables (LSDV) model (equation 9), all cross-section units have their own fixed intercept. In the Fixed Effect regression model (FEM) each unit has its own intercept (the Subscript i in the intercept shows that the units may have different intercepts). There will be heterogeneity among the unit due to individual intercepts. There is also in fixed effect model even if they might be different among cross section units, the unit intercepts are time-invariant meaning that they do not vary over time.

Dummy variable technique is the way to create different intercept among the cross section unit as shown in equation (9) below.

$$\boldsymbol{Y_{it} = \alpha_1 + \alpha_2 D_{2i} + \alpha_3 D_{3i} + \ldots D_{Ni} + \beta_2 X_{it} + \ldots \beta_N X_{it} + U_{it}} \quad \text{----------------- } \mathbf{(9)}$$

i= 1……………., N and t = 1….............................. T

Here $\boldsymbol{\alpha_1}$ is the intercept value of the first cross sectional unit and the other $\boldsymbol{\alpha}$ coefficient tells us by how much the intercept value of the other cross section units differ from the intercept value of the first cross- section unit. For instance $\boldsymbol{\alpha_2}$ shows that by how much the intercept value of the second cross section unit differs from $\boldsymbol{\alpha_1}$. Therefore, the sum of $\boldsymbol{\alpha_1}$ and $\boldsymbol{\alpha_2}$ gives as the actual value of the second cross section unit.

In order to test the pooled OLS model is fitted or not, we will be employee the standard F-test by using equation 11. The F-test will be used to check fixed effect against Pooled OLS Method (Common constant). The null hypothesis (equation 10) is that all the intercepts are the same and the Pooled OLS Method is applicable.

$$H_0: \alpha_1 = \alpha_2 = \text{----------------------} = \alpha_N \quad \text{--------------------------------------} \; \textbf{(10)}$$

$$F = \frac{(R^2_{UR} - R^2_R)/J}{(1 - R^2_{UR})/(n-k)} \quad \text{--} \; \textbf{(11)}$$

Where, $\mathbf{R^2_{UR}}$ = Unrestricted R squared

$\mathbf{R^2_R}$ = Restricted R squared

J = Number of restrictions

n = Total number of observations

k = number of parameters in the unrestricted regression

In Pooled OLS estimation Method, since the model has common intercept for all unit it is a restricted model. If the value of F is statistically significant, we will reject the null hypothesis that all the intercepts are the same. If the F value is not statistically significant we know that all the intercepts are the same. If these conditions are satisfied, the Pooled OLS Method (Common constant) will be appropriate model for our estimation. The model or equation (11) is a one way fixed effects model, since we allow different intercept for all units. If we include time dummies in one way fixed effect model it will be two way fixed effects as long as we allow the unit and time effect. However, in this study we only use one way fixed effects model.

The Houseman test was help us to choose the best fitted model among the random effect and the fixed effects, since the problem with both random effect and fixed effect make us to assume the Hausman test to select the best efficient model. Therefore, by assuming the houseman test we were made analysis based on the fitted model i.e. the fixed effect model in order to meet our objective.

3.7. Dependant variable

The dependent variable of y_{it} is the logarithm form of the value of the i-th rural household total farm output (in Ethio birr). We were convert the out puts by using the survey price data of CSA annual farm get price or producer price (PP_2) for all farm outputs.

3.7.1. Explanatory variables of the study

Review of literatures on the determinants of agricultural productivity of the rural household conventional inputs that are all used for farm production, are also used as inputs for productivity measurements. Beside the conventional inputs, the demographic and socioeconomic factors are used to establish working hypotheses for this study. In other words, among a number of factors, which have been related to productivity, in this study, the following conventional inputs and demographic, socio-economic factors were hypothesized to explain the dependent variable.

1. **Agricultural labor input (AL):** This refers to the total number of family members of the household who have directly involved on the farm activity measured in man equivalent and the total hired labor during the production process. The number of all family members those who were involved in farm activity was included as family labor. The more the labor force utilized for the farm production process the more farm land preparation will be made. Therefore, agricultural labor was hypothesized to have a positive impact on agricultural productivity.

2. Cultivated area of land (A): It is a continuous variable which is the total cultivated area of land (it is the sum of owned cultivated land, rented-in land and land secured through sharecropping arrangements during the survey period) by the household. Larger firms might benefit from economies of scale, but larger farms can also practice less intensive forms of agriculture, which will result in a lower productivity per hectare, but not necessarily per worker. The larger the cultivated land size the more households may produce farm output which required additional labor and capital demands. The main hypothesis was that the households who cultivates larger size of land can utilize more labor and will be more productive than household those who cultivate small size of land.

3. Real Asset value (RAV): we were evaluating in Ethiopian birr the total household assets, to determine their level of productivity variation among farmers. Households those who have better asset value may have a more agricultural productivity than those who have less assets. Therefore, real asset value was assumed to have a positive relationship with productivity.

4. Chemical fertilizer (FER): It is a continuous variable that the total amount of chemical fertilizer used by sampled households to produce farm output. The agricultural productivity of the household those who are the user of chemical fertilizer and do not user varies due to may be chemical fertilizer input. Therefore, Chemical fertilizer was expected to hypothesize that it is positively related with farm productivity.

5. Number of oxen (OX): is the number of oxen that the household was used to produce the farm output during the survey period. There may be a productivity differences between households those who has an ox and not have. As a result, there will be a positive relationship between productivity and number of oxen (Beyene, 2000).

6. Age of the rural farm household head (AG): It is a continuous variable, defined as the farm household heads age is the number of years from the date of birth to the day of the survey interview date in full year. Those household heads having a higher age due to a good farm experience will have much better association with more productive, and it will hypothesized that household heads with certain age rage may have more productive.

7. Educational level of the household head (EDU): The number of years or the highest grade completed by the household head during the survey period. Household heads who attend more level of education are expected to have more exposure to the external environment and accumulate knowledge of farm practicing. They have a better ability to identify the problem of their farm income as well as analyze its costs and benefits. Therefore, it will expect that those farmers who are advanced in school level have better opportunity for agricultural productivity, (Lelissa, 1998 and Beyene, 2000).

8. Number of the household size (HHS): It is a continuous variable, defined as the total number of members living together during the survey period. Those households having a large number of family sizes may have large number of family labor and it will affect positively the household's farm productivity.

9. Sex of the household head (SEX): this is a dummy variable that assumes a value of "1" if the head of the household is male and "0" otherwise. These are related to women's lack of control over economic resources and the nature of their economic activity". With this background including the existing gender differences; male headed households have mobility, participate in different meetings and have more exposure to information about better farm inputs and practice; therefore it was hypothesized that male headed households have more productive to produce farm output.

10. Pesticide (PES): It takes a dummy variable we-there the households were used pesticide or not to produce output during the two survey period. The labor productivity of the household those who are the user of pesticide and do not user varies due to may be the use of pesticide input. Therefore, pesticide was expected to hypothesize that it is positively related with farm productivity.

11. Drought (DRT): it takes dummy variable if there was the households face a drought during the last 12 months prior to the survey period is ‘’1’’ and ‘’0’’ otherwise.

12. Credit access (CRD): It is measured in terms of whether at least one member of the household has received a credit or not during the last 12 month prior to the survey period. Farmers who have access to credit may overcome their financial constraints and therefore buy inputs. Farmers without cash and no access to credit will find it very difficult to attain and adopt new technologies (Wolday, 1999; Mulugeta, 2000). It is expected that receiving credit was increase the probability of farm productivity.

13. Extension service (EXTN): It is a dummy variable which measured whether the household used the extension program or not during both survey period. Households those who were used extension service during their farm production process would expect to increase the probability of farm productivity.

14. Irrigation used (IRRN): It is also a dummy variable which measured whether the household used the irrigation system or not during both survey period. Households those who were used irrigation for crop production process during the survey period would expect to increase the probability of farm productivity.

15. Manure used (MANURE): It is also a dummy variable which measured whether the household were used the animal dung or manure or not during both survey period. Households those who were used animal dung or manure for crop production process during the survey period would expect to increase the probability of farm productivity.

Table 1: Variable description and the variables used for regression of determinants of agricultural productivity

Variables	Descriptions	Measurement units
lnY_{it}	The natural log of the value of total output produced by the household	Ethiopian Birr
lnAL	The number of family members and hired labor those who are participated on farm production process	Number
lnA	The natural log of the total cropped area of land by each households	Hectare
lnREV	The natural log of the monetary value of the assets that the household have	Ethiopian Birr
FER	The amount of chemical fertilizer applied for each cropped area to produce output	Kilogram
OX	Number of ploughed oxen owned by the households	Number
AG	Age of the household head	Number
EDU	The highest level of grade completed of the household head in year	Grade completed
HHS	The number of household living in the same dowelling, cooking and eating together for at least 6 months and above just prior to the survey period	Number
SEX	Sex of the household head	Dummy “1” if male and “0” otherwise

PES	Whether the households were used pesticide or not to produce farm output	Dummy "1" if used "0" otherwise
DRT	During the production year if the crop was affected by drought during the survey period	Dummy "1" if yes "0" otherwise
CRD	At least if one member of the household was received credit	Dummy "1" if yes "0" otherwise
EXTN	If the household were used the extension service or program	Dummy "1" if yes "0" otherwise
IRRN	If the household were used irrigation system	Dummy "1" if yes "0" otherwise
MANURR	If the household were used Manure or not	Dummy "1" if yes "0" otherwise
T	the survey year which is a proxy for Hicks-neutral technical progress	
B and γ	Parameters to be estimated	
α_{it}	The individual fixed effect	
ε_{it}	the error term	

3.8. Empirical model specification for rural household income

Repeated surveys of the same sample of households by CSA have enabled to setup a panel data for regression analysis. It is clear that panel data have a lot of advantages compared to the cross sectional data. A more significant reason of using panel data is it may control for unobserved characteristics (heterogeneity) which is an important issue in econometrics (Haughton and Khandker 2008). Likewise, the use of panel data set for this study will expected to help drop out the effects of unobserved factors. Therefore, we try to explain the econometrics method used to measure the link between agricultural productivity change and rural household income. Income per capita per household is used as an indicator of household welfare and the living standard of the rural households. By following Simler *et al.* (2004) and Demeke *et al.* (2003), we try to estimate the determinants of the rural household per capita income. The framework is the unobserved effects model which is adapted from Wooldridge (2009) and Greene (2003).

$$\ln(I_{it}) = \beta_i + \gamma prod_{it} + \beta X_{it} + \varepsilon_{it}, \quad i = 1, ----, N, \quad t = 1, -----, T ------------ (12)$$

Where $\ln(I_{it})$ = is the natural logarithm of the rural household income per capita of the i-th household

β_i = is an individual-specific or unobserved effects which is fixed over time.

βX_{it} = are vectors of explanatory variables which serve as control.

$\gamma prod_{it}$ = represents the agricultural productivity of farm households.

ε_{it} = the error terms which are assumed to be uncorrelated with the exogenous Variables X_{it} with mean zero and variance δ^2_ε

There are also dummy variables in our regression model. According to Verbeek, (2004) equation (11) will be specified with dummy variable as follows:

$$I_{it} = \sum_{j=1}^{N} \alpha_j d_{ij} + \gamma prod_{it} + x'_{it}\beta + \varepsilon_{it} \text{ -------------------------------- (13)}$$

Where d_{ij} = is a dummy variables which takes 1or 0 for j = (1, ------, N)

Since the agricultural productivity variables are causing the endogenous problem, the agricultural labor productivity and land productivity were characterized by endogenity problems. Therefore, to overcome these endogenity problems, we use z_{it} as instrumental variables (IV's) for the productivity variables.

The productivity of X_{it} was instrumented by:

$$prod_{it} = \pi_1 z_{it} + \pi_2 x_{it} + v_{it} \text{ --- (14)}$$

Where,

The agricultural productivity and instrumental variables (IV's) z_{it} are correlated, i.e **Cov** $(z_{it}, prod_{it}) \neq 0$ but the idiosyncratic error term is uncorrelated with the instrumental variables (IV's), thus **cov** $(z_{it}, \varepsilon_{it}) = 0$

3.8.1. Estimation technique

The estimation technique of the determinants of the rural household income were used the IVreg2 or two stages least square (2SLS), fixed effect (FE) and the random effect (RE) estimator based on equation (13) and (14) above. This equation also enables us to investigate the change in income per-capita per-household by applying the fixed effect estimation.

3.8.2. The variables to be estimated for the determinants of the rural household Income which is not described under the productivity measurements

1. Land Productivity (LP): is the ratio of total household farm output per unit of area in hectare. It is also expected to positively relate with per-capita income of the rural households.

2. Agricultural Labor productivity (ALP): is the ratio of total household farm output per unit of labor (family and hired labor) input. Labor is assumed to man-day adult equivalent. It is also expected to positively relate with per-capita income of the rural households.

3. Non-farm income (NFI): it is an income that the household generate out of agricultural farm production during the agricultural production of one year period. It includes family business, remittance and other any incomes. There is expected to a positive relationship with the household those who have non-farm income and negative for don't have.

4. Dependency ratio: the ratio of the number of households those who are economically inactive to generate income for the households such as children less than age of 10 and the elders in the households are negatively related with household's per-capita income.

5. Tropical Live-stock units (TLUs): The number of livestock's that the households have could be valued in terms of Tropical Livestock Unit (TLU). This could be expected positively related with the household per-capita-income.

Table-2: Variable description for the rural income determinants

Variables	Descriptions	Expected sign
$\ln I_{it}$	Income is assumed to be the sum of farm and non-farm income within a year, and it takes the natural log of per-capita income of per-household	
lnLP	The natural log of total output per unit of land area in hectare	+ve
lnAL	Agricultural labor productivity is the natural log of total output per unit of labor input	+ve
NFI	It takes dummy if the household got an income from non-farm activity or not	"1" got "0" otherwise
Sex	The sex of household head	+ve for male & -ve for female
Age	Age of the household head in a year	+ve
Years of schooling	Educational level of the household head	+ve
Household size	The number of household members living in the same dowelling, cooking and eating together	-ve
Dependency ratio	The ration of the number of households those who are not economically active to generate or to participating on the income earning activity with the total household size	-ve

Access to credit	If the households has got or get borrowed for any income generating activity or for running Owen business	+ve
TLU	Livestock ownership in tropical livestock units	+ve

CHAPTER-IV

4. RESULTS AND DISCUSSION

4.1. Descriptive of agricultural Labor productivity

The summary of the data on a variables used in the agricultural labor productivity is given in Table 3 below[2] shows that, the rural farm household's value of output per unit of farm labor input was used as a dependent variable in the productivity model. As a result the mean value of labor productivity is 7.26 birr per day with its standard deviation of 1.42. The mean value of Household's Real Asset value per unit of labor in real terms is 5.44 birr with its standard deviation of 1.32. The mean value of farm household those who are uses fertilizer input is about 35 percent out of the total sampled for the survey with its standard deviation of 0.47. The mean of the household that uses the pesticides input and get Credit accesses are 17% and 28% of the total sampled household with their standard deviation of 0.38 and 0.45 respectively. However, the mean value of land per unit of labor is only 0.10 hectare and its standard deviation is 0.17. This implies that there is a sign of cultivated land scarcity to land-labor ratio. The mean value of Extension service user Irrigation and manure are 0.35, 0.14 and 0.56 with their standard deviation of 0.48, 0.34 and 0.49 respectively.

[2] Interested readers can see appendix I for detail summary statistics of panel data for labor productivity

Table 3: Descriptive statistics of labor productivity over the two survey period

Variable	Obs	Mean	Std. Dev.	Min	Max
Log Labor productivity(output/labor in birr)	4395	7.27	1.42	-0.86	12.30
Log of Area per unit of labor (in hectare)	4400	0.10	0.17	0.01	4.18
Log of Real asset value per unit of labor (in birr)	4358	5.44	1.32	0.16	11.71
Number of oxen per unit of labor	4400	0.09	0.19	0	4
Age of the household head in year	4472	45.51	15.00	17	99
Educational level of the household head	4472	0.39	0.63	0	3
Household's member size	4472	5.57	2.26	1	16
Sex of the household head (male =1)	4472	0.81	0.39	0	1
Use of fertilizes (yes =1)	4472	0.34	0.47	0	1
Use of pesticides (yes =1)	4472	0.17	0.38	0	1
Drought situation (yes =1)	4472	0.12	0.31	0	1
Credit accesses (yes =1)	4472	0.28	0.45	0	1
Extension service (yes =1)	4472	0.35	0.48	0	1
Irrigation used (yes =)	4472	0.14	0.34	0	1
Manure used (yes =1)	4472	0.56	0.49	0	1

Source: Own Calculation based on ERSS data

4.2. Descriptive of Land productivity

The summary of the data on a variables used in the land productivity is given in table 4 [3] below shows that, the rural farm household's value of output per unit of cultivated area of land was used as a dependent variable in the land productivity model. The mean value of land productivity is 10.12 with its standard deviation of 1.30 and it shows a little higher than labor productivity during the analysis period (2012 -2014). The mean value of labor per unit of area is 2.84 with its standard deviation of 1.07. This implies that, per household

[3] See appendix I for detail summary statistics of panel data of land productivity

there are about 2.8 of farm labors are participated in one hectares of land for crop production process to enhance land productivity. The mean value of farm household those who are uses fertilizer input is about 35 percent out of the total sampled for the survey with its standard deviation of 0.47. The mean value of Household's Real Asset value per unit of cultivated area of land in real term is 8.28 birr per hectare was used with its standard deviation of 1.46. The number of owned oxen used for ploughed, Use of pesticides, Credit accesses, use of extension service and irrigation are 2.47, 0.17, 0.28, 0.35 and 0.14 with their standard deviation of 56.09, 0.38, 0.45,0.48 and 0.34 respectively.

Table 4: **Descriptive statistics of land productivity over the two survey period**

Variable	Obs	Mean	Std. Dev.	Min	Max
Log of land productivity (output/land in hectare)	4466	10.12	1.30	2.64	14.85
Log of labor per unit of land in hectare	4400	2.84	1.07	-1.43	9.60
Log of real asset value per unit of land in hectare	4420	8.29	1.46	3.16	17.32
Number of oxen per unit of land in hectare	4472	2.47	56.09	0	27.70
Age of the household head in year	4472	45.52	15.00	17	99
Educational level of the household head	4472	0.39	0.63	0	3
Household's member size	4472	5.57	2.26	1	16
Sex of the household head	4472	0.81	0.39	0	1
Use of fertilizers (yes =1)	4472	0.34	0.47	0	1
Use of Pesticides (yes =1)	4472	0.17	0.38	0	1
Drought situation (yes =1)	4472	0.11	0.31	0	1
Credit access (yes =1)	4472	0.28	0.45	0	1
Extension used (yes =1)	4472	0.35	0.48	0	1
Irrigation used (yes =1)	4472	0.14	0.34	0	1
Manure used (yes =1)	4472	0.56	0.49	0	1

Source: Own Calculation based on ERSS data

4.3. Descriptive of Rural Household Income

The mean value of dependant variable, which is the value of the rural household per capita income, i.e. the total income earned from household's farm income and non farm income including remittance is 9.75 birr per day with its standard deviation of 1.52 as shown in table 5[4] below. Similarly the mean value of the independent variables, labor productivity and land productivity are also 7.27 and 10.11 with their standard deviation of 1.42 and 1.30 respectively. However, the mean values of the number of households those who get an income from non-farm activity and the number of household those who are get credit access are very small in magnitude. This implies that, only few rural household have earns non-farm income and have got a few credit accesses.

Table 5: **Descriptive statistics of rural household income over the two survey period**

Variable	Obs	Mean	Std. Dev.	Min	Max
Rural Household Income per day	4467	9.75	1.52	0.29	15.26
Labor productivity	4395	7.27	1.42	-0.86	12.30
Land productivity	4466	10.11	1.30	2.64	14.85
livestock owner in tropical livestock unit(TLU)	4379	3.26	0.20	0	32
Number of dependency ratio	4472	0.49	0.22	0	2.5
Age of the household head in year	4472	45.51	15.00	17	99
Educational level of the household head	4472	0.39	0.63	0	3
Household's member size	4472	5.57	2.26	1	16
Sex of the household head (male =1)	4472	0.81	0.39	0	1
Non-farm income (yes =1)	4472	0.25	0.43	0	1
Credit access (yes =1)	4472	0.28	0.45	0	1

Source: Own Calculation based on ERSS data

[4] See the summary statistics tables for panel data of household income in appendix I

4.4. Econometric results and Discussion

The econometric analysis of the study is mainly deals with the analysis of major factors that determine agricultural productivity and rural household income of the panel sampled of the rural farm households of Ethiopia; and in this chapter, we provide the analyses focusing on the research questions. The first part of this econometric result is about the determinants of agricultural labor productivity analysis, while the second part focuses on the determinants of agricultural land productivity and the third part deals with the determinant of the rural household income based on the model used for the regression.

4.4.1. Econometric Results of the Agricultural labor productivity

There were different demographic and socio-economic factors that were contributing in the determinants of agricultural labor productivity of the rural farm household's in Ethiopia. In order to identify the significant factors, we employ the pooled OLS, the within-group, the fixed effect and the random effect models are applied on the panel data set which we could choose the best among them. However, an F-test of the null hypothesis that all household-specific intercepts are identical rejected the pooled OLS in favor of the fixed effect model and also the random effect model was rejected by the Hausman test.

F-test for labor productivity

An F test has been carried on to choose the best model between the pooled OLS and the fixed effect estimation. The null hypothesis is that all the intercepts are the same and the alternative hypothesis is at least one of the intercept is not the same. The F value of 110.84 (for 14 numerator degree of freedom and 2124 denominator degree of freedom) is highly significant. Therefore, based on the F test, we rejected the null hypothesis in favor of fixed effect.

Test for differing group intercepts -

Null hypothesis: The groups have a common intercept

Test statistic: F (14, 2124) = 110.84

With p-value = P (F (14, 2124) > 110.84) = 3.38

On the basis of the F-statistics test, we decided to use the fixed effect model, and therefore, only the within-group and the fixed effect model results will be presented and discussed.[5] The model is also tested for the possible appearances of Heteroscedasticity and multicollinearity problems. The Heteroskedasticity problem was adjusted by regressing all model used for estimation with robust standard, and the multicollinearity[6] problem was also checked and tested using the observed information matrix (OIM) during the estimation of the variance–covariance matrix. The group wise Heteroskedasticity[7] problem was also checked by using Wald test statistics. As a result we don't find any multicollinearity problem during the estimation for the determinants of labor productivity.

Therefore, The parameters of the within-group estimators of the partial factor labor productivity of the Ethiopian rural farm household indicates that, most of the variables were statistically significant. This implies that the variables used in the panel model of the within-group estimation (Equation 8) are significant determinants of agricultural labor productivity in the sampled rural farm households of Ethiopian during the period of

5 The interested reader can see appendix IV of the random effect regression output for labor productivity

6 The correlation between the variables would appear in the appendix VII

7 The diagnostic test like wald test statistics was also presented in appendix VIII

analysis (2012-2014). However, real asset value per unit of labor, number of oxen per unit of labor, educational level of the household head, sex of the household head, credit access and irrigation were not significant for the determinants of labor productivity.

One known reason for educational level of the household head do not significant is that, out of 2,236 household head there were only about 700 household heads were educated in the survey data set and off these 700 households only 111 household heads were completes grade 8 and above. Regarding to irrigation user, out of the total 2236 sampled household, there were only 308 households were used irrigation during the survey period. The within-group estimate[8], which is equivalent to the fixed effect least square dummy variable (LSDV) estimator was a consistence estimator and almost yields the same results with the fixed effect model estimator.

Despite the fact that, the finding of the within-group estimation model shows that cultivated area of land per unit of labor, the use of chemical fertilizer, the use of pesticide, use of extension program, use of manure, the number of household size and age of the household head are found to the determinants of the agricultural productivity. However, the drought variable was significantly and negatively affects the labor productivity of the rural households in Ethiopia. More specifically, cultivated area of land per unit of farm labor input was a significant contribution for the positive change of labor productivity during period of analysis; when the cultivated area of land per unit of agricultural labor was increased by one percent, the labor productivity increases by 0.83 percent. This result was almost similar with that of fixed effect estimation. The result implies that, the availability of agricultural cultivated land increases labor productivity in the sampled area of rural households. Therefore, it could be good if the government

[8] You can See the within-group estimation table for labor productivity on appendix II for detail understanding

facilitate the access of land to landless, especially for the youngsters those who are within the household.

There is a significant labor productivity difference between chemical fertilize user household and non user. As the household are increases the use of chemical fertilizer inputs by one unit the labor productivity increases by 0.12 units and vis-versal for non user households.

The use of pesticide input in farm production processes was also statistically significant at 1 percent level, which means, as the household increases the use of pesticide by one unit, the labor productivity increases by about 0.5 units. Therefore, accessing and advising the rural household to the use of pesticide inputs during their farm production processes would enhance labor productivity in rural households.

Surprising finding of the within-group model in this study was that, as the number of household member was increased by one unit the labor productivity of the household was increased by 0.22 units and it is also significant at one percent level of significant. One known reason behind this is that, the rural household of Ethiopia uses more family labor than hired labor in their farm production. As a result having more labor with in a household would be able to a high possibility of farm work to increase farm output.

Use of manure is also statistically significant, indicates that as the household increases the uses of manure by one unit the labor productivity increases by 003 units. Therefore, use of manure is important for labor productivity enhancement especially as chemical fertilizer input may not affordable for some poor rural households.

Table 6: The Labor productivity of the within-group, Fixed & Random-effect estimates

	Coefficients		
Explanatory Variables	Within-group	Fixed effect	Random effect
Log of Land in hectare per unit of labor	0.826*	0.831*	0.721*
	(0.023)	(0.032)	(0.023)
Log of Real Asset Value (in birr) per unit of labor	0.019	0.013	0.037**
	(0.018)	(0.025)	(0.017)
Chemical fertilizer (in Kg) per unit of labor	-0.123*	-0.249*	-0.334*
	(0.021)	(0.052)	(0.040)
Number of ploughed oxen per unit of labor	0.061	0.097	-0.255***
	(0.161)	(0.233)	(0.145)
Age of household head	0.025*	0.024*	0.002
	(0.003)	(0.005)	(0.002)
Educational status of household head	0.013	0.017	0.165*
	(0.037)	(0.053)	(0.035)
Household size	0.220*	0.205*	0.018
	(0.014)	(0.020)	(0.058)
Sex of household head (male =1)	-0.012	-0.135	0.042*
	(0.0245)	(0.129)	(0.010)
Pesticide (use =1)	0.046**	0.119*	0.161*
	(0.021)	(0.044)	(0.037)
Drought (yes =1)	-0.098*	-0.247*	-0.240*
	(0.036)	(0.071)	(0.061)
Credit access (yes =1)	0.016	0.063	-0.013
	(0.019)	(0.047)	(0.037)
Extension service (yes =1)	0.033***	0.142*	-0.004
	(0.018)	(0.048)	(0.035)
Irrigation (use =1)	0.0178104	0.057	0.185*
	(0.025)	(0.075)	(0.055)
Manure (use =1)	0.032***	0.074**	0.193*
	(0.018)	(0.045)	(0.036)
Constant	-0.015*	7.252*	8.459*
	(0.026)	(0.294)	(0.158)5
Number of Observations	4353	4353	4353
Prob>F	0.0000	0.0000	0.000
R-squared	0.4128	0.4222	0.3872
corr(a i , X b)		-0.3916	0 (assumed)
sigma_u		1.266	0.879
sigma_e		0.815	0.815
Rho		0.707	0.538

Source: Computed from Ethiopian Socio economic survey data.

Note: Hausman test choose fixed-effect over the random-effects estimation; Standard errors in robust standard to adjust Heteroskedasticity problem: Dependent variable is log of labor productivity measured in output per man-day; *, ** and *** represents the coefficients are significant at 1, 5 and 10 percent level respectively.

The use of extension service increases the farm household labor productivity by 0.03 units as the households were get the service during a production seasons of the survey period. There for, by expanding and encouraging the farm households participating for the use of extension program is still important for the labor productivity in rural households of Ethiopia; since the extension user are more productive than non user.

There was also age of the household head is statistically significant at 1 percent level. This implies that as the age of the household was increased by one more year the labor productivity of the rural household was shows a slight increased by 0.02units. One reason would be more than 47% of the household head age was below 40 years old and the mean of the household head age was 45 years, as a result the possibility of young household head to be matured and increases his/her farm practicing experience would be high which able to increase household's farm labor productivity.

To determine the agricultural labor productivity in rural households of Ethiopia, the fixes effect[9] model was applied. The parameters of the fixed effect estimation model of the partial factor labor productivity of farm household indicate that, most variables were statistically significant. This implies that the variables used in the panel model of the fixed effect estimation (Equation 8) are significant determinants of agricultural productivity in the rural farm households of Ethiopian during the period of analysis

[9] See appendix III fixed-effect estimates table for labor productivity

(2012-2014). However, real asset value per unit of labor, number of oxen per unit of labor, educational level of the household head, sex of the household head, credit access and irrigation were not significant for the determinants of labor productivity.

One known reason for educational level of the household heads do not significant is that, out of 2,236 household head there were only about 700 household heads were educated in the survey data set and off these 700 households only 111 household heads were completes grade 8 and above. Regarding to irrigation user, out of the total 2236 sampled household, there were only 308 households were used irrigation during the survey period.

The result of the fixed effect estimation model shows that, cultivated area of land per unit of labor, the use of chemical fertilizer inputs, the use of pesticide, use of extension program, the use of manure, the number of household size and age of the household head are found to be the determinants of the agricultural labor productivity.

However, the drought variable was significantly and negatively affects the agricultural labor productivity of the sampled rural households. More specifically, cultivated area of land per unit of farm labor input was a significant contribution for the positive change of labor productivity during period of analysis; as the cultivated area of land per unit of agricultural labor increases by one percent, the labor productivity increases by 0.83 percent. This finding is consistence with the finding of Joseph Owuor’s in Kenya. He was concluded that, labor productivity and land productivity are consistent, positively correlated and significant. The result implies that, the availability of agricultural cultivated land increases labor productivity in the sampled area of rural households. Therefore, it could be good if the government facilitate the access of land to landless, especially for the youngsters those who are within the household.

The fixed effect result shows that, there is a significant labor productivity difference between chemical fertilize user household and non user. As the household are increases the use of chemical fertilizer inputs by one unit the labor productivity increases by about 0.25 units and vis-versal for non user households.

The use of pesticide input in farm production processes was also statistically significant at 1 percent level of significant, which means, as the household increases the use of pesticide by one unit, the labor productivity also increases by about 0.12 units. Therefore, accessing and advising the rural household to the use of pesticide inputs during their farm production processes would enhance labor productivity in rural households.

One of the important finding of this study was that, when the drought occurs in one agricultural season in Ethiopia, the labor productivity of the rural household declines by about 0.25 units and it is statistically significant at 1 percent level. This implies that the rain dependant agriculture is risky for the farm household labor productivity enhancement. Therefore, promotion of the use of irrigation system or any other source of water is useful during the drought season so as to increase the labor productivity of rural farm households.

Surprisingly, as the number of household member increases by one unit the labor productivity of the household increases by 0.21 units and it is also significant at one percent level of significant. One known reason behind this is that, the rural household of Ethiopia uses more family labor than hired labor in their farm production processes. As a result having more labor with in a household would be able to a high possibility of farm management work to increase farm output.

Another variable, the use of extension service and manure was also statistically significant at 1 and 10 percent significant level respectively. The use of extension service increases the farm household labor productivity significantly by 0.14 units as the households were got the service during one production seasons of the survey period. It is also consistence with the finding of Asres Elias el.al (2013) in Ethiopia, during their study of the Effect of agricultural extension program on small holder's farm productivity. There for, by expanding and encouraging the farm household participation rate for the use of extension program is still important for the labor productivity enhancement since the extension user households are more productive than non users.

Using manure is also important variables for the rural household labor productivity enhancement, which shows that, the labor productivity increases by 0.07 units as the farm household's uses manure for their farm production process in one production period. This implies that, animal dung is very important as the chemical fertilizer may not affordable for some poor rural farm households. The finding is also consistent with Wassie (2012) in Ethiopia indicated that, manure maintains soil fertility.

There was also age of the household head is statistically significant at 1 percent level. This implies that as the age of the household head increases by one more year the labor productivity of the rural household also shows slight increments by 0.02 units. One reason would be the mean of the household head age was around 45 years and more than 47 percent of the household head age was less than 40 years old as a result the possibility of young household head to be matured and increases his/her farm practicing experience would be high which able to increase household's farm labor productivity.

Hausman-test:

For choice between the fixed effect and the random effect model, this study was employed the Hausman test to select the best estimation model since the selection of between the two model would be problematic. Despite the fact that, the Hausman test clearly shows the P-value is 0.000 which was less than 0.05.

Test: Ho: difference in coefficients not systematic

chi2 (14) = 251.46

Prob>chi2 = 0.0000

Therefore, we reject the random effect model in favor of fixed effect. Due to the fact that, the analysis of this study is made on the bases of the result of the within-group and the fixed effect model, due to the random effect model was rejected in favor of fixed effect model by Hausman test.[10]

4.4.2. Econometric Results of the Agricultural land productivity

Here also there are different demographic and socio-economic factors that were contributing in the determinants of agricultural land productivity of the rural farm household's in Ethiopia. In order to identify the significant factors, we employ the pooled OLS, the within-group, the fixed effect and the random effect models were applied on the panel data set which we could choose the best among them. However, an F-test of the null hypothesis that all household-specific intercepts are identical rejected the pooled OLS in favor of the fixed effect model and also the random effect model was rejected by the Hausman test.

[10] It is also better to see the Hausman test table for farther understanding in appendix VI

F-test for land productivity

An F test has been carried on to choose the best model between the pooled OLS and the fixed effect estimation. The null hypothesis is that all the intercepts are the same and the alternative hypothesis is at least one of the intercept is not the same. The F value of 20.26 (for 14 numerator degree of freedom and 2124 denominator degree of freedom) is highly significant. Therefore, based on the F test, we rejected the null hypothesis in favor of fixed effect.

Test for differing group intercepts -

Null hypothesis: The groups have a common intercept

Test statistic: F (14, 2124) = 20.26

With p-value = P (F (14, 2124) > 20.26) = 3.41

On the basis of the F-statistics test, we decided to use the fixed effect model. And hence, only the within-group and the fixed effect model results will be presented and discussed.[11] The model is also tested for the possible appearances of Heteroscedasticity and multicollinearity problems. The Heteroskedasticity problem was adjusted by regresses of the entire model used for estimation, with robust standard and the multicollinearity[12] problem was also checked and tested using the observed information matrix (OIM) during the estimation of the variance–covariance matrix. The group wise Heteroskedasticity[13] problem was also checked by using Wald test statistics. As a result

[11] The interested reader can see appendix IV of the random effect regression output for land productivity

[12] The correlation between the variables would appear in the appendix VII

[13] The diagnostic test like wald test statistics was also presented in appendix VIII

we don’t find any multicollinearity problem during the estimation for the determinants of land productivity.

The parameters of the within-group estimation model of the partial factor land productivity of the Ethiopian rural farm household indicate that, most of the variable was statistically significant. This implies that the variables used in the panel model of the within-group estimation (Equation 8) are significant determinants of agricultural productivity in the rural farm households of Ethiopian during the period of analysis (2012-2014). However, real asset value per unit of land, educational status of the household head, sex of the household head, credit access and irrigation were not significant for the determinants of land productivity.

One known reason for educational level of the household heads do not significant is that, out of 2,236 household heads, there were only about 700 household heads were educated in the survey data set and off these 700 households, only 111 household heads were completes grade 8 and above. Regarding to irrigation user, out of the total 2236 sampled household, there were only 308 households were used irrigation during the survey period.

The within-group estimate[14], which is equivalent to the fixed effect least square dummy variable (LSDV) estimator was a consistence estimator and almost yields the same results with the fixed effect model estimator.

Despite the fact that, the finding of the within-group estimation model shows that, agricultural labor per unit of cultivated area of land, the use of pesticides and extension service, the household member size, the number of oxen used for ploughed and the age of the household head were found to be the determinants of agricultural land productivity of

[14] See the within-group estimates table detail for land productivity on appendix II

rural households. However, the occurrence of drought during the production season was significantly and negatively affects the rural households land productivity. It was also a slight change when it compares to labor productivity changes during the same period of analysis. It shows that, as the agricultural labor per unit of cultivated area of land increases by one percent, land productivity increases by 0.15 percent. This output was exactly the same with the fixed effect estimation output. The result implies that, the increase of labor-land ratio increases land productivity of rural households. Therefore, it could be good if the government facilitate the access of land to landless, especially for the youngsters those who are within the household.

The within-group result shows that, there is a significant land productivity difference between chemical fertilize user household and non user. As the household are increases the use of chemical fertilizer inputs by one unit the land productivity increases by about 0.12 units and vis-versal for non user households.

The use of pesticide input in farm production processes was also statistically significant at 1 percent level. This means, as the household increases the use of pesticide by one unit, the land productivity increases by 0.05 units. Therefore, accessing and advising the rural household to the use of pesticide inputs during their farm production processes would enhance of land productivity of rural households.

One of the important finding of this study was that, when the drought occurs in one agricultural season in Ethiopia, the land productivity of the rural farm household declines by 0.09 units and it is also statistically significant at 1 level. This implies that the rain dependant agriculture is risky for the farm household land productivity enhancement. Therefore, promotion of the use of irrigation system or any other source of water is useful during the drought season so as to increase the land productivity of rural farm households.

Surprisingly, as the number of household member increases by one unit, the land productivity increases by 0.22 units and it is also significant at one percent level. One known reason behind this is that, the rural household of Ethiopia uses more family labor than hired labor in their farm production processes. As a result having more labor with in a household would be able to a high possibility of farm management work like timely land preparation to increase farm output.

The use of extension service increases the farm household land productivity by 0.03 units as the households were got the extension service during one production seasons of the survey period. There for, by expanding and encouraging the farm household participation rate for the use of extension program is still important for the labor productivity enhancement since the extension user are more productive than non user.

The number of ploughed oxen variable is also statistically significant at 1 percent level and it shows a very little positive change in land productivity as the household use the one extra more ploughed ox, land productivity changes by 0.00069 units. This implies that land productivity is not associated with more cultivating area of land but use of farm practicing is important than cultivating more area of land for land productivity enhancement in rural farm households of Ethiopia.

Use of manure is also statistically significant, indicates that as the household increases the uses of manure by one unit the land productivity increases by 003 units. Therefore, use of manure is important for land productivity enhancement especially as chemical

Fertilizer input may not be affordable for some poor rural households.

There is also age of the household head is statistically significant at 1 percent level. This implies that as the age of the household heads increases by one more year, the land productivity of the rural household is shows a slightly increases by 0.02 units. One reason would be more than 47% of the household head age is below 40 years old and the mean of the household head age is 45 years, as a result the possibility of young household head to be matured and increases his/her farm practicing experience would be high which able to increase household's farm land productivity.

Table 7: **The land productivity of within-group, fixed & random-effect estimates**

	Coefficients		
Explanatory Variables	Within-group	Fixed effect	Random effect
Log of labor per unit of land in hectare	0.149*	0.144*	0.253*
	(0.023)	(0.032)	(0.023)
Log of Real Asset Value per unit land in hectare	0.014	0.013	0.032**
	(0.017)	(0.024)	(0.017)
Chemical fertilizer per unit of land in hectare	-0.125*	-0.250*	-0.335*
	(0.021)	(0.052)	(0.040)
Number of ploughed oxen per unit of land	0.0007*	0.0007*	0.0003*
	(0.0001)	(0.0001)	(0.0001)
Age of household head	0.025*	0.024*	0.002
	(0.003)	(0.005)	(0.002)
Educational status of household head	0.0003	0.018	0.167*
	(0.038)	(0.053)	(0.035)
Household size	0.223*	0.205*	0.043*
	(0.014)	(0.020)	(0.010)
Sex of household head (male =1)	-0.009	-0.179	0.012
	(0.026)	(0.125)	(0.058)
Pesticide (use =1)	0.046**	0.120*	0.162*
	(0.021)	(0.044)	(0.037)
Drought (yes =1)	-0.097*	-0.248*	-0.244*
	(0.036)	(0.071)	(0.061)
Credit access (yes =1)	0.015	0.058	-0.010
	(0.019)	(0.047)	(0.037)
Extension service (yes =1)	0.035**	0.142*	-0.002
	(0.018)	(0.048)	(0.035)
Irrigation (use =1)	0.019	0.056	0.188*
	(0.025)	(0.075)	(0.055)
Manure (use =1)	0.035***	0.088**	0.194*
	(0.018)	(0.045)	(0.036)
Constant	-0.023*	7.340*	8.445*
	(0.027)	(0.289)	(0.159)
Number of Observations	4353	4353	4353
Prob>F	0.0000	0.000	0.000
R-squared	0.1070	0.118	0.062
corr(a i , X b)		-0.401	0 (assumed)
sigma_u		1.265	0.885
sigma_e		0.814	0.814
Rho		0.707	0.541

Source: Computed from Ethiopian Socio economic survey data.

Note: Hausman test choose fixed-effect over the random-effects estimation; Standard errors in robust standard to adjust Heteroskedasticity problem: Dependent variable is log of land productivity measured in output per land-hectare; * and ** represents the coefficients are significant at 1 and 5 percent level respectively.

To determine the agricultural land productivity in rural households of Ethiopia, the fixes effect model was applied. The parameters of the fixed effect estimation model of the partial factor land productivity of the Ethiopian rural farm household indicate that, most of the variables were statistically significant during the survey period of 2012-2014 (see table 7 above). However, real asset value per unit of land, educational status of the household head, sex of the household head, credit access and irrigation were not significant for the determinants of land productivity.

One known reason for educational level of the household heads do not significant is that, out of 2,236 household heads, there were only about 700 household heads were educated in the survey data set and off these 700 households, only 111 household heads were completes grade 8 and above. Regarding to irrigation user, out of the total 2236 sampled household, there were only 308 households were used irrigation during the survey period.

Despite the fact that, the finding of the fixed effect estimation[15] model shows that, agricultural labor per unit of cultivated area of land, the use of pesticides and extension service, the number of household member size, the number of oxen used for ploughed and the age of the household head were found to be the determinants of agricultural land productivity of rural households.

[15] See the fixed-effect estimates table detail for land productivity on appendix III

However, the cause of drought during the production season was significantly and negatively affects the rural households land productivity. The land productivity shows a slight change when it compares to labor productivity changes during the same period of analysis. It indicates that, as the agricultural labor per unit of cultivated area of land was increases by one percent, land productivity increases by 0.14 percent. This output was almost the same with the within-group estimation output. The result implies that, the increase of labor-land ratio increases land productivity of rural households. Therefore, it could be good if the government facilitate the access of land to landless, especially for the youngsters those who are within the household. The finding is also consistence with Joseph Owuor in Kenya.

The result of this study in both, the within-group estimation and fixed effect model, exactly answers the question of the most potent of agricultural productivity so as labor productivity is the most potent for agricultural productivity than land productivity in the rural households.

The use of pesticide input in farm production processes was also statistically significant at one percent level of significant, which means, as the household increases the use of pesticide by one unit, land productivity increases by 0.12 units. Therefore, accessing and advising the rural household to use the pesticide inputs during their farm production processes would enhance the land productivity of rural households.

One of the important finding of this study is that, when the drought occurs in one agricultural season in Ethiopia, the land productivity of the rural household declines by 0.25 units and statistically significant at l percent level. This implies that the rain dependant agriculture is risky for the farm household land productivity enhancement.

Therefore, promotion of the use of irrigation system or any other source of water is useful during the drought season so as to increase the land productivity of rural farm households.

Surprisingly, as the number of household member increases by one unit, land productivity increases by 0.21 units and it is also significant at one percent level of significant. One known reason behind this is that, the rural household of Ethiopia uses more family labor than hired labor in their farm production processes. As a result having more labor with in a household would be able to a high possibility of farm management work like timely land preparation to increase farm output.

Using manure is also important variables for the rural household's land productivity enhancement, which shows that, the land productivity increases by 0.09 units as the farm household's uses manure for their farm production process in one production period. This implies that, animal dung is very important as the chemical fertilizer may not affordable for some poor rural farm households. The finding is also consistent with Wassie (2012) in Ethiopia indicated that, manure maintains soil fertility.

The use of extension service increases the farm household land productivity by 0.14 units as the households were got the extension service during one production seasons of the survey period. There for, by expanding and encouraging the farm household participation rate for the use of extension program is still important for the land productivity enhancement since the extension user households are more productive than non user. This result is consistent with Asres Elias el.al(2013) in Ethiopia.

The number of ploughed oxen variable is statistically significant at 1 percent level shows that, a little positive change in land productivity as the household use the one extra more ploughed ox, land productivity changes by 0.00073 units. This implies that land productivity is not associated more cultivating area of land but use of farm practicing is important for land productivity enhancement in rural farm households of Ethiopia.

There was also age of the household head is statistically significant at one percent level. It implies that as the age of the household was increases by one more year the land productivity of the rural household shows a slight increment by 0.02 units. One reason would be the mean of the household head age was 45 years, as a result the possibility of yang household head to be matured and increases his/her farm practicing experience would be high which able to increase household's farm land productivity.

Hausman-test:

To choice between the fixed effect and the random effect model, this study was employed the Hausman test to select the best model due to the choice between the two model is problematic. The Hausman test clearly shows that the P-value is 0.0000 which is less than 0.05.

Test: Ho: difference in coefficients not systematic

chi2 (14) = 248.21

Prob>chi2 = 0.0000

Therefore, we reject the random effect model in favor of fixed effect. As a result, the analysis of this study was made bases on the result of the fixed effect model.[16]

[16] Interested reader can also see the Hausman test table from appendix VI

4.4.3. Econometric Results of Rural household Income

There were different demographic and socio-economic factors that were contributing in the determinants of rural household income. In order to identify the significant factors, we employ the pooled OLS, the 2SLS, the fixed effect and the random effect models were applied on the panel data set which we could choose the best among them. However, an F-test of the null hypothesis that all household-specific intercepts are identical rejected the pooled OLS in favor of the fixed effect model and also the random effect model was rejected by the Hausman test.

F-test for rural household income

An F test has been carried on to choose the best model between the pooled OLS and the fixed effect estimation. The null hypothesis is that all the intercepts are the same and the alternative hypothesis is at least one of the intercept is not the same. The F value of 3.87 (for 9 numerator degree of freedom and 2217 denominator degree of freedom) is highly significant. Therefore, based on the F test, we rejected the null hypothesis in favor of fixed effect.

Test statistic: F (9, 2217) = 180.99

With P_value = P (F (9, 2217) > 180.99) = 3.87

And hence, only the fixed effect model result was presented and discussed.[17] The model is also tested for the possible appearances of Heteroscedasticity and multicollinearity problems. The Heteroskedasticity problem is adjusted by regresses all model used for estimation, with robust standard and the multicollinearity[18] problem was also checked and tested using the observed information matrix (OIM) during the estimation of the

[17] You can see appendix IV & V the random effect and the 2SLS regression output respectively

[18] The correlation between the variables after and before instrumented is appeared in the appendix VII

variance–covariance matrix. The group wise Heteroskedasticity[19] problem was also checked by using Wald test statistics. We were found an endogenity problem during the estimation of rural household income per-capita among the variables of productivity. To obtain unbiased and consistent estimators, we applied IVreg2 Two Stage Least Squares (2SLS) approach with it's the two conditions of a valid instruments i.e. instrument relevance: $\mathbf{corr(z_i,x_i)\neq 0}$ and instrument exogeniety: $\mathbf{corr(z_i,v_i)=0}$ were fulfilled.

[19] The diagnostic test like wald test statistics was also presented in appendix VIII

Table 8: Rural household income OLS, IVreg2, fixed-effect & IV_Fixed estimates

Explanatory Variables	Coefficients			
	Pooled OLS	IVreg2	Fixed	IV-Fixed
Log of Labor productivity	0.588*	5.295**	0.598*	0.856*
	(0.017)	(2.573)	(0.015)	(0.213)
Log of Land productivity	0.346*	3.317***	0.262*	0.146**
	(0.019)	(2.008)	(0.019)	(0.179)
Total Livestock Units	0.066*	0.199	0.023*	0.022*
	(0.006)	(0.147)	(0.007)	(0.007)
Number of dependant	-0.588*	-1.928*	-0.221*	-0.229*
	(0.064)	(0.825)	(0.092)	(0.098)
Age of the household head	0.004*	0.016***	0.002	0.002
	(0.0009)	(0.008)	(0.003)	(0.003)
Educational status of household head	0.026	0.160	0.031	0.033
	(0.023)	(0.149)	(0.039)	(0.042)
Household size	0.083*	0.222*	0.006*	0.004
	(0.007)	(0.088)	(0.015)	(0.016)
Sex of household head (male =1)	0.317*	0.913	0.231**	0.156*
	(0.039)	(0.709)	(0.102)	(0.125)
Non-farm income	0.202*	0.975**	0.279*	0.283*
	(0.030)	(0.467)	(0.029)	(0.032)
Credit access (yes =1)	0.234*	0.796*	0.041	0.048
	(0.027)	(0.339)	(0.030)	(0.033)
Constant	1.097*	4.481*	2.719*	3.083*
	(0.157)	(2.067)	(.204)	(0.370)
Number of Observations	4309	4309	4309	4309
Prob>F	0.0000	0.0000	0.0000	0.0000
R-square	0.681			
corr(a i , X b)			0.119	-0.033
sigma_u			0.842	0.871
sigma_e			0.535	0.570
Rho			0.712	0.700
Centered R-square		0.898		
Uncentered R-square		0.7714		
Underidentification test (Kleibergen-Paap rk LM statistic):		3.333		
P-value of under identification LM statistics		0.018		
Hansen J statistics		0.153		
P-value of Hansen J statistics		0.6953		

Source: Computed from Ethiopian Socio economic survey data.

Note: Hausman test choose fixed-effect over the random-effects estimation; Standard errors in robust standard to adjust Heteroskedasticity problem: Dependent variable is log of Income in birr value; *, * and *** represents the coefficients are significant at 1, 5 and 10 percent level respectively.

In the 2SLS (IVreg2)[20] regression, due to the two explanatory variables of agricultural productivity was causing an endogenity problem, we used two instrumental variables (a dummy variable if crop was affected due to some household members were got chronic disease (CDS) and a dummy variable if crops were damaged to instrument the agricultural land productivity.

Labor productivity was instrumented by two variables (a dummy variable if crop was affected due to some household members were got chronic disease (CDS) and a dummy variable if crops were damaged to instrument the labor productivity. The identification criteria for all instruments are also fulfilled.

After controlling for the endogenity problem for the productivity variables, in the fixed effect regression result; most of the parameters used to determine the rural household income shows statistically significant during the period of 2012-2014. However, age of the household head, educational status of the household head, number of household size and credit access were not found to significant for the determinants of rural household income in sampled area of Ethiopia.

The IV-fixed effect regression output indicates that, labor productivity, farm land productivity, owing number of livestock (in tropical livestock unit), non-farm income, sex of the household head and number of dependant in the household are found to be significant determinants of the rural household income. But, the number of the household members those who are dependant was found to significantly and negatively affects the

[20] See appendix V for IVreg2 estimates table

household income in rural households. This study output is consistence with the finding of Vincent Leyaro and Oliver Morrissey in Tanzania during their study of the "Protection and the determinants of household income in Tanzania 1991 – 2007."

The agricultural labor productivity which is the farm output per unit of labor input is statistically significant at 1 percent level. The result of the fixed effect model shows that, increasing the labor productivity by one percent, the rural household income increases by 0.86 percent. The output of the fixed effect model shows that, the labor productivity is the most potent than the land productivity variable used in the regression for the household income in the rural Ethiopia. Therefore, the government and other stake holder should give more attention for farther improvements of labor productivity to enhance rural household income.

The agricultural land productivity which is the farm output per unit of cultivated area of farm input was statistically significant at 10 percent level. The result of the fixed effect model shows that, increasing the land productivity by one percent, the rural household income also increases by 0.15 percent. The finding of the fixed effect model shows that, the land productivity is the third contributor for the enhancement of per-capita income next to labor productivity and non farm income in the sampled rural households. Therefore, the government will give more attention to increase the land productivity in rural farm household for farther per capita income and productivity enhancement.

Another variable used for the determinants of rural household income was the number of dependency ratio per households also significant at 1 level stated that, it is negatively affects the household income. More specifically, if the number of dependency ratio increases by one unit, income of rural household declines by 0.23 units. This tells us limiting the number of dependant family member in the household is important to increase the wealth status of the rural household.

The household generated their income from nonfarm activity for their livelihood is also statistically significant at one percent level, which means, as the household got one additional units of nonfarm income the entire household income was significantly increases by 0.28 units. However, the income from the nonfarm was very few when it compares with the agricultural farm labor productivity. Fully concentrating only on farm activity will limit the rural household income and wealth development. The fixed effect result shows that, the labor of the rural household was fully engaged with drought affected farm activity in rural Ethiopia. Therefore, the government should have to be harmonizing the wide gap between farm and non farm income to increase the nonfarm income generating activity, since the farm production is usually associated by drought risk. Extension worker and other stockholder should advise the rural farm household to generate the nonfarm income parallel to their farm production process.

Another variable, the sex of the household head also significant at 1 percent level shows that, there is a difference in income among male headed and female headed household. The result indicated that per-capital income was higher for male-headed households than female headed household by 0.16 units. This implies that empowering of women will be crucial for the household wealth improving in rural Ethiopia.

Owning of livestock at tropical livestock unit also statistically significant at 1 level shows that, as the number of livestock owing (in tropical livestock unit) increases by one unit the income of the rural household raises by 0.02 units.

Hausman-test

To choice the best fitted model between the fixed effect and the random effect, this study was employed the Hausman test to select the best model estimator to avoid the ambiguity of selecting the correct model. The Hausman test[21] clearly shows that the P-value is 0.0000 which is less than 0.05 which leads to the rejection of random effect.

Test: Ho: difference in coefficients not systematic

chi2 (9) = 2.91

Prob>chi2 = 0.0000

Therefore, we reject the random effect model in favor of fixed effect. As a result of this, the analysis of this study is made on the bases of the result of the fixed effect model.

[21] Interested readers can see the Hausman test table for farther understanding under appendix VI

CHAPTER-V

5. SUMMARY, CONCLUSION & POLICY IMPLICATION

5.1. Summary and Conclusions

Using the panel data of Ethiopian Rural Socio-economic Survey (ERSS), this study investigated the determinants of agricultural labor productivity and rural household income in Ethiopia during the period of 2012 - 2014. Three panel data analysis methods are used: the pooled ordinary least square method (POLS), fixed effects (FE) method and random effects (RE) method. Based on Husman test, fixed effect (FE) method was found the most appropriate model. Since it is not possible to include all the rural farm households in Ethiopia, due to limited availability of data and period, only 2,236 households were formulated the two years panel data set from selected sample area of the country.

The determinants of agricultural productivity in rural households do not much vary across labor productivity and land productivity. Cultivated area of land per unit of labor ratio, the number of household member size, the use of fertilizer, the use of extension service, the use of pesticide, the use of manure and age of the household head are the main determinants of the agricultural labor productivity. The fixed effect results show that, land-labor ratio, use of fertilizer, use of pesticide and extension service variables are the most significant variables through which we may improve farm labor productivity of rural households. This could imply that, households' labor productivity gain could be attained if we focus on improving the land-labor ratio, use of fertilizer, use of pesticide and extension service. However, land-labor ratio is more challenging than improving the use of fertilizer, pesticide and extension service with increased rural yang agricultural labor force population pressure. But it is possible by mobilizing the farm labor force to the other potential cultivable area of land.

Similarly, labor-land ratio, use of fertilizer, the number of household member size, the use of extension service, the use of pesticide, the use of manure, the number of oxen used and age of the household head are the main determinants of agricultural land productivity. The fixed effect results show that, labor-land ratio, the use of fertilizer, the number of household member size, the use of manure, use of pesticide and extension service variables are the most significant variables through which we may improve farm land productivity of rural households. This also could imply that, households' land productivity gain could be attained if we focus on improving the labor-land ratio, the use of fertilizer, pesticide inputs and extension service. However, improving labor-land ratio is more challenging than improving the use of pesticide and extension service with increased rural yang population pressure. But it is possible by mobilizing farm labor force to the other potential cultivable area of land.

Off all the variables used in the regression of agricultural productivity, cultivated area of land perunit of labor is the most significant effect on the determinants of labor productivity and fertilizer inputs and the number of household size is found to the most significant effect on the determinants of land productivity in the rural household's of Ethiopia. Therefore this study concludes that, the agricultural labor productivity is the most potent factor of production than land productivity for the change of agricultural productivity in rural households. However, drought variable included in the regression also significantly and negatively affects both labor and land productivity of rural farm households in Ethiopia.

The fixed effect result shows that, both labor and land productivity, household's non farm income, the livestock owning in tropical livestock units and sex of the household head are the main determinates of rural household income in Ethiopia. However, the number of dependant household member significantly and negatively affects rural household income. The result also shows that, labor productivity has the major effect among the variable used in the regression for the change of rural household per capita income enhancement. The finding of the fixed effect regression model supports the view that improvements in agricultural productivity can have substantial positive impacts on household income per capita. Especially improvements in labor productivity of household through better resource allocation and use of necessary inputs can increase the per capita income of the rural households.

There were also a socioeconomic factors that explain the variation in income among the rural households.

5.2. Policy Implication

This study has tried to identify the determinants of agricultural productivity and rural household incomes in Ethiopia. Based on the results obtained from the study, we suggest some policy intervention areas should be required. The policy implications that can be derived from this empirical study are:

- ❖ To increase the agricultural productivity of farm household's, by reducing the drought risk through rural environmental protection, increase land-labor ratio. The possible ways of application could be through different methods like arranging financial sources that can used for the purchase of different variable inputs and developing a work frame for non farm income employment opportunities in the rural labor market as well as shift the excessive farm labor force to the other potential cultivable area.

- To increase the rural household income, needs improvements in land-labor ratio of farmers through better allocation of financial resource.
- The combined effort is needed to design policy interventions for not only increasing labor productivity but also reducing number of dependency ratio of the household and drought risk which adversely affects labor productivity growth.
- Both agricultural labor and land productivity are important for rural household income enhancement but agricultural labor and land productivity alone does not increased rural household per capita income. Increasing the non farm income was also important for the increasing of rural household per capita income.
- Promotion of both farm labor productivity and non farm income are best focusing to speed up the enhancement of rural household per capita income.
- It is better to strengthening the capacity of the local and federal administrative level, about the environmental protection system and rehabilitation program to protect the variations of climate over time, especially in areas adversely affected by a drought factor.

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APPEDIX I: The Summary Statistics of the Variables used for:

i. Labor Productivity

Variable		Mean	Std. Dev.	Min	Max	Observations
logYAL	overall	7.2734	1.422157	-0.8641728	12.30349	N = 4395
	between		1.212821	2.5802	11.47752	n = 2219
	within		0.752935	2.540662	12.00614	T-bar = 1.98062
logAAL	overall	-2.8425	1.072553	-9.603383	1.431316	N = 4400
	between		0.9264496	-7.434907	0.9623305	n = 2222
	within		0.5535296	-5.805481	0.1204708	T-bar = 1.9802
logRAVAL	overall	5.4421	1.317453	0.1576289	11.71787	N = 4358
	between		1.158639	0.1576289	10.67425	n = 2218
	within		0.6447261	2.155436	8.728763	T-bar = 1.96483
OXAL	overall	0.09069	0.196333	0	4	N = 4400
	between		0.1699689	0	2.125	n = 2222
	within		0.108423	-1.784305	1.965695	T-bar = 1.9802
AG	overall	45.5083	15.0025	17	99	N = 4472
	between		14.75149	18.5	98	n = 2236
	within		2.741715	18.50827	72.50827	T = 2
EDU	overall	0.3881932	0.6302763	0	3	N = 4472
	between		0.5937965	0	3	n = 2236
	within		0.2115011	-1.111807	1.888193	T = 2
HHS	overall	5.57335	2.264245	1	16	N = 4472
	between		2.186748	1	15	n = 2236
	within		0.5882241	1.573345	9.573345	T = 2
SEX	overall	0.81306	0.3899077	0	1	N = 4472
	between		0.3809553	0	1	n = 2236
	within		0.0832681	0.313059	1.313059	T = 2
FLT	Overall	0.3349732	0.4720339	0	1	N = 4472
	between		0.4027895	0	1	n = 2236
	Within		0.2461967	-0.1650268	0.8349732	T = 2
PES	overall	0.1733	0.3785492	0	1	N = 4472
	between		0.2794978	0	1	n = 2236
	within		0.2553389	-0.3266995	0.6733005	T = 2
DRT	overall	0.10711	0.3092888	0	1	N = 4472
	between		0.2351609	0	1	n = 2236
	within		0.2009261	-0.3928891	0.6071109	T = 2
CRD	overall	0.28019	0.4491411	0	1	N = 4472
	between		0.3578536	0	1	n = 2236
	within		0.2714722	-0.2198122	0.7801878	T = 2
EXTN	overall	0.35242	0.4777758	0	1	N = 4472
	between		0.400948	0	1	n = 2236

	Within		0.2598969	-0.147585	0.852415	T = 2
IRRN	Overall	0.13797	0.3449066	0	1	N = 4472
	between		0.2970296	0	1	n = 2236
	Within		0.1753675	-0.3620304	0.6379696	T = 2
MANURE	Overall	0.55926	0.4965316	0	1	N = 4472
	between		0.410379	0	1	n = 2236
	Within		0.2795898	0.0592576	1.059258	T = 2

Source: Computed from Ethiopian Socio economic survey data.

ii. Land productivity

Variable		Mean	Std. Dev.	Min	Max	Observations
logYA	Overall	10.11637	1.301436	2.643997	14.85167	N = 4466
	Between		1.143411	5.419458	13.80318	n = 2233
	Within		0.6218049	6.556316	13.67643	T = 2
logALA	Overall	2.842505	1.072553	-1.431316	9.603383	N = 4400
	between		0.9264496	-0.9623305	7.434907	n = 2222
	Within		0.5535296	-0.1204708	5.805481	T-bar = 1.9802
logRAVA	Overall	8.293237	1.456085	3.1551	17.31812	N = 4420
	between		1.255624	4.756974	15.61311	n = 2231
	Within		0.7399866	4.801141	11.78533	T-bar = 1.98117
OXA	Overall	2.466981	56.09307	0	3703.704	N = 4472
	between		39.68986	0	1851.852	n = 2236
	Within		39.64214	-1849.385	1854.319	T = 2
AG	Overall	45.50827	15.0025	17	99	N = 4472
	between		14.75149	18.5	98	n = 2236
	Within		2.741715	18.50827	72.50827	T = 2
EDU	Overall	0.3881932	0.6302763	0	3	N = 4472
	between		0.5937965	0	3	n = 2236
	Within		0.2115011	-1.111807	1.888193	T = 2
HHS	Overall	5.573345	2.264245	1	16	N = 4472
	Between		2.186748	1	15	n = 2236
	Within		0.5882241	1.573345	9.573345	T = 2
SEX	Overall	0.813059	0.3899077	0	1	N = 4472
	Between		0.3809553	0	1	n = 2236
	Within		0.0832681	0.313059	1.313059	T = 2
FLT	Overall	0.3349732	0.4720339	0	1	N = 4472
	Between		0.4027895	0	1	n = 2236
	Within		0.2461967	-0.1650268	0.8349732	T = 2
PES	Overall	0.1733005	0.3785492	0	1	N = 4472
	Between		0.2794978	0	1	n = 2236
	Within		0.2553389	-0.3266995	0.6733005	T = 2

DRT	Overall	0.1071109	0.3092888	0	1	N = 4472
	Between		0.2351609	0	1	n = 2236
	Within		0.2009261	-0.3928891	0.6071109	T = 2
CRD	Overall	0.2801878	0.4491411	0	1	N = 4472
	Between		0.3578536	0	1	n = 2236
	Within		0.2714722	-0.2198122	0.7801878	T = 2
EXTN	Overall	0.352415	0.4777758	0	1	N = 4472
	Between		0.400948	0	1	n = 2236
	Within		0.2598969	-0.147585	0.852415	T = 2
IRRN	Overall	0.1379696	0.3449066	0	1	N = 4472
	Between		0.2970296	0	1	n = 2236
	Within		0.1753675	-0.3620304	0.6379696	T = 2
MANURE	Overall	0.5592576	0.4965316	0	1	N = 4472
	Between		0.410379	0	1	n = 2236
	Within		0.2795898	0.0592576	1.059258	T = 2

Source: Computed from Ethiopian Socio economic survey data.

iii. Rural household income

Variable		Mean	Std. Dev.	Min	Max	Observations
logI	overall	9.749408	1.524925	0.2859606	15.2645	N = 4467
	between		1.349357	3.903745	13.86191	n = 2234
	within		0.7107083	4.593019	14.9058	T = 1.99955
logAL_~d	overall	7.273401	1.422157	-0.8641728	12.30349	N = 4395
	between		1.212821	2.5802	11.47752	n = 2219
	within		0.752935	2.540662	12.00614	T-bar = 1.98062
logL_p~d	overall	10.11637	1.301436	2.643997	14.85167	N = 4466
	between		1.143411	5.419458	13.80318	n = 2233
	within		0.6218049	6.556316	13.67643	T = 2
TLU	overall	3.25565	3.199682	0	32	N = 4379
	between		2.963754	0	26.185	n = 2236
	within		1.223699	-7.45935	13.97065	T-bar = 1.95841
NDR	overall	0.4892578	0.2217558	0	2.5	N = 4472
	between		0.2003826	0	1.55	n = 2236
	within		0.095034	-0.4607422	1.439258	T = 2
AG	overall	45.50827	15.0025	17	99	N = 4472
	between		14.75149	18.5	98	n = 2236
	within		2.741715	18.50827	72.50827	T = 2
EDU	overall	0.3881932	0.6302763	0	3	N = 4472
	between		0.5937965	0	3	n = 2236
	within		0.2115011	-1.111807	1.888193	T = 2
HHS	overall	5.573345	2.264245	1	16	N = 4472

	between		2.186748	1	15	n =	2236
	within		0.5882241	1.573345	9.573345	T =	2
SEX	overall	0.813059	0.3899077	0	1	N =	4472
	between		0.3809553	0	1	n =	2236
	within		0.0832681	0.313059	1.313059	T =	2
NFI	overall	0.2508945	0.4335764	0	1	N =	4472
	between		0.3322678	0	1	n =	2236
	within		0.278588	-0.2491055	0.7508945	T =	2
CRD	overall	0.2801878	0.4491411	0	1	N =	4472
	between		0.3578536	0	1	n =	2236
	within		0.2714722	-0.2198122	0.7801878	T =	2

Source: Computed from Ethiopian Socio economic survey data.

APPENDIX II: The within-group model regression outputs for:

i. Labor Productivity

			Number of obs	= 4353
			F(14, 4338)	= 135.46
			Prob > F	= 0.0000
			R-squared	= 0.4128
			Root MSE	= .57781
Dependant variable **dlogYAL**				
Variables	Coef.	Robust Std. Err.	T	P>t
dlogAAL	0.8263796	0.0226346	36.51	0.000*
dlogRAVAL	0.0185411	0.0176843	1.05	0.294
dFLTAL	-0.1225037	0.0210941	-5.81	0.000*
dOXAL	0.0614081	0.1608906	0.38	0.703
dAG	0.0247202	0.0032333	7.65	0.000*
dEDU	0.0125619	0.0374106	0.34	0.737
dHHS	0.2204596	0.0140607	15.68	0.000*
SEX	-0.0124114	0.0248967	-0.50	0.618
PES	0.045724	0.0208765	2.19	0.029**
DRT	-0.0981085	0.0355037	-2.76	0.006*
CRD	0.0157706	0.0190585	0.83	0.408
EXTN	0.0325491	0.0175368	1.86	0.064***
IRRN	0.0178104	0.0253154	0.70	0.482
MANURE	0.0319913	0.0182609	1.75	0.080***
_cons	-0.0147168	0.0261035	-0.56	0.573

Source: Computed from Ethiopian Socio economic survey data.

*, ** and *** Represents the coefficients are significant at 1, 5 and 10 percent level.

ii. Land Productivity

			Number of obs	= 4353
			F(14, 4338)	= 50.97
			Prob > F	= 0.0000
			R-squared	= 0.1070
			Root MSE	= 0.58321
Dependant variables **dlogYA**				
Variables	Coef.	Robust Std. Err.	t	P>t
dlogALA	0.1485893	0.0227935	6.52	0.000*
dlogRAVA	0.0144823	0.0169253	0.86	0.392
dFLTA	-0.1254732	0.021289	-5.89	0.000*
dOXA	0.0006949	0.0000676	10.27	0.000*
dAG	0.0247294	0.0032335	7.65	0.000*
dEDU	0.0002642	0.0377559	0.01	0.994
dHHS	0.2270027	0.0142555	15.92	0.000*
SEX	-0.0085717	0.0255162	-0.34	0.737
PES	0.0463639	0.0210982	2.20	0.028**
DRT	-0.0974864	0.036188	-2.69	0.007*
CRD	0.0148232	0.0190949	0.78	0.438
EXTN	0.0351465	0.0175842	2.00	0.046**
IRRN	0.0187879	0.0254663	0.74	0.461
MANURE	0.0345733	0.0184261	1.88	0.061***
_cons	-0.022651	0.0269327	-0.84	0.400

Source: Computed from Ethiopian Socio economic survey data.

*And ** Represents the coefficients are significant at 1 and percent level.

APPENDIX III: The Fixed effect model regression outputs for:

i. Labor Productivity

Fixed-effects (within) regression			Number of obs	= 4353
Group variable: NHH			Number of groups	= 2215
R-sq: within = 0.4222			Obs per group: min	= 1
between = 0.1239			avg	= 2.0
overall = 0.1757			max	= 2
			F (14,2214)	= 71.42
corr(u_i, Xb) = -0.3916			Prob > F	= 0.0000
	(Std. Err. adjusted for 2215 clusters in NHH)			
	Dependant variable **logYAL**			
Variables	Coef.	Robust Std. Err.	T	P>t
logAAL	0.8312335	0.0320213	25.96	0.000*
logRAVAL	0.0133082	0.024943	0.53	0.594
FLTAL	-0.2497574	0.0527387	-4.74	0.000*
OXAL	0.0970403	0.2326958	0.42	0.677
AG	0.02477	0.0045449	5.45	0.000*
EDU	0.0174572	0.0525707	0.33	0.740
HHS	0.2050668	0.0200634	10.22	0.000*
SEX	-0.1353254	0.1292333	-1.05	0.295
PES	0.1192905	0.0438299	2.72	0.007*
DRT	-0.2477758	0.0712862	-3.48	0.001*
CRD	0.0625804	0.046786	1.34	0.181
EXTN	0.1422867	0.0475236	2.99	0.003*
IRRN	0.0571032	0.0752781	0.76	0.448
MANURE	0.0740815	0.0448505	1.65	0.099**
_cons	7.251671	0.2943029	24.64	0.000
sigma_u	1.2660167			
sigma_e	0.81526877			
Rho	0.70686903 (fraction of variance due to u_i)			

Source: Computed from Ethiopian Socio economic survey data.

*and ** Represents the coefficients are significant at 1 and 10 percent level.

ii. Land productivity

Fixed-effects (within) regression			Number of obs = 4353	
Group variable: NHH			Number of groups = 2215	
R-sq: within = 0.1178			Obs per group: min = 1	
between = 0.0057			avg = 2.0	
overall = 0.0127			max = 2	
			F(14,2214) = 26.83	
corr(u_i, Xb) = -0.4013			Prob > F = 0.0000	
(Std. Err. adjusted for 2215 clusters in NHH)				
Dependant variable **logYA**				
Variables	Coef.	Robust Std. Err.	t	P>t
logALA	0.1443625	0.0324408	4.45	0.000*
logRAVA	0.0134116	0.0240837	0.56	0.578
FLTA	-0.2501464	0.0526768	-4.75	0.000*
OXA	0.0007391	0.0001016	7.27	0.000*
AG	0.0244693	0.0045081	5.43	0.000*
EDU	0.0181484	0.0525791	0.35	0.730
HHS	0.2051043	0.0200308	10.24	0.000*
SEX	-0.1797385	0.1249404	-1.44	0.150
PES	0.1199316	0.0439239	2.73	0.006*
DRT	-0.2482104	0.0712427	-3.48	0.001*
CRD	0.0582369	0.046626	1.25	0.212
EXTN	0.1420317	0.0475112	2.99	0.003*
IRRN	0.0559351	0.0751174	0.74	0.457
MANURE	0.0886526	0.0444613	1.99	0.046**
_cons	7.340206	0.2885821 2	5.44	0.000
sigma_u	1.265083			
sigma_e	0.81432594			
Rho	0.70704277 (fraction of variance due to u_i)			

Source: Computed from Ethiopian Socio economic survey data.

* Represents the coefficients are significant at 1 percent level of significance.

iii. Rural household Income

Fixed-effects (within) regression				Number of obs = 4309
Group variable: NHH				Number of groups = 2218
R-sq: within = 0.6931				Obs per group: min = 1
between = 0.6281				avg = 1.9
overall = 0.6408				max = 2
				F(9,2217) = 180.99
corr(u_i, Xb) = 0.1192				Prob > F = 0.0000
(Std. Err. adjusted for 2218 clusters in NHH)				
Dependant Variable log of household Income				
Variabes	Coef.	Robust Std. Err.	t	P>t
logAL_prod	0.598	0.015	38.83	0.000*
logL_prod	0.262	0.0192	13.66	0.000*
TLU	0.023	0.007	3.45	0.001*
NDR	-0.221	0.092	-2.40	0.016*
AG	0.002	0.003	0.55	0.582
EDU	0.031	0.039	0.79	0.429
HHS	0.006	0.015	0.39	0.214
SEX	0.231	0.102	2.25	0.024**
NFI	0.279	0.029	9.34	0.000*
CRD	0.041	0.030	-1.36	0.174
Constant	2.719	0.204	13.33	0.000*
sigma_u	0.842			
sigma_e	0.535			
Rho	0.712 (fraction of variance due to u_i)			

Source: Computed from Ethiopian Socio economic survey data.

*, ** and *** Represents the coefficients are significant at 1, 5 and 10 percent level.

APPENDIX IV: The Random effect model regression outputs for:

i. Labor Productivity

Random-effects GLS regression			Number of obs = 4353	
Group variable: NHH			Number of groups = 2215	
R-sq: within = 0.3872			Obs per group: min = 1	
between = 0.2266			avg = 2.0	
overall = 0.2663			max = 2	
			Wald chi2(14) = 1357.93	
corr(u_i, X) = 0 (assumed)			Prob > chi2 = 0.0000	
		(Std. Err. adjusted for 2215 clusters in NHH)		
Variables	Coef.	Robust Std.Err.	Z	P>z
logAAL	0.72095	0.0229535	31.41	0.000*
logRAVAL	0.037467	0.0174838	2.14	0.032**
FLTAL	-0.3339755	0.0403758	-8.27	0.000*
OXAL	-0.255405	0.1454813	-1.76	0.079***
AG	0.001986	0.0015291	1.30	0.194
EDU	0.1653577	0.0354628	4.66	0.000*
SEX	0.0181776	0.0582766	0.31	0.755
HHS	0.0420302	0.0097108	4.33	0.000*
PES	0.1607231	0.0374373	4.29	0.000*
DRT	-0.2401273	0.0608233	-3.95	0.000*
CRD	-0.0131812	0.0373467	-0.35	0.724
EXTN	-0.0044463	0.03509	-0.13	0.899
IRRN	0.1848088	0.0554114	3.34	0.001*
MANURE	0.1510667	0.037359	4.04	0.000*
_cons	8.458825	0.1579212 5	3.56	0.000 8
sigma_u	0.87905233			
sigma_e	0.81526877			
Rho	0.53759222 (fraction of variance due to u_i)			

Source: Computed from Ethiopian Socio economic survey data.

*, ** and *** represents the coefficients are significant at 1, 5 and 10 percent respectively.

ii. Land productivity

Random-effects GLS regression			Number of obs	= 4353
Group variable: NHH			Number of groups	= 2215
R-sq: within = 0.0623			Obs per group: min	= 1
between = 0.1264			avg	= 2.0
overall = 0.1077			max	= 2
			Wald chi2(14)	= 393.23
corr(u_i, X) = 0 (assumed)			Prob > chi2	= 0.0000
(Std. Err. adjusted for 2215 clusters in NHH)				
Dependant variable logALA				
Variables	Coef.	Robust Std. Err.	z	P>z
logALA	0.2532335	0.0234996	10.78	0.000*
logRAVA	0.031889	0.0170858	1.87	0.062**
FLTA	-0.3350488	0.0403792	-8.30	0.000*
OXA	0.0002556	0.0001021	2.50	0.012*
AG	0.0019232	0.0015318	1.26	0.209
EDU	0.1690591	0.035473	4.77	0.000*
HHS	0.0427922	0.0097266	4.40	0.000*
SEX	0.0120519	0.0581699	0.21	0.836
PES	0.162317	0.0373584	4.34	0.000*
DRT	-0.2440668	0.0608953	-4.01	0.000*
CRD	-0.0099751	0.037323	-0.27	0.789
EXTN	-0.0017065	0.0351269	-0.05	0.961
IRRN	0.1881543	0.0554625	3.39	0.001*
MANURE	0.1941276	0.0360707	5.38	0.000*
_cons	8.44501	0.1586831 5	3.22	0.000
sigma_u	0.88475963			
sigma_e	0.81432594			
Rho	0.54138276 (fraction of variance due to u_i)			

Source: Computed from Ethiopian Socio economic survey data.

* and ** represents the coefficients are significant at 1and 10 percent respectively.

iii. Rural Household Income

Random-effects GLS regression				Number of obs = 4309
Group variable: NHH				Number of groups = 2218
R-sq: within = 0.6838				Obs per group: min = 1
between = 0.6820				avg = 1.9
overall = 0.6796				max = 2
				Wald chi2(9) = 3725.20
corr(u_i, X) = 0 (assumed)				Prob > chi2 = 0.0000
		(Std. Err. adjusted for 2218 clusters in NHH)		
Dependant variable log of household income				
Variables	Coef.	Robust Std. Err.	z	P>z
logAL_prod	0.5962495	0.0184582	32.30	0.000*
logL_prod	0.2966337	0.0199329	14.88	0.000*
TLU	0.053194	0.0060266	8.83	0.000*
NDR	-0.4526265	0.0666809	-6.79	0.000*
AG	0.0028306	0.0011088	2.55	0.011*
EDU	0.0187305	0.0241181	0.78	0.437
HHS	0.0714741	0.0074134	9.64	0.000*
SEX	0.3348328	0.0448579	7.46	0.000*
NFI	0.2471586	0.0273305	9.04	0.000*
Constant	1.585985	0.1835205	8.64	0.000 *
sigma_u	0.66019872			
sigma_e	0.53534859			
Rho	0.6033027 (fraction of variance due to u_i)			

Source: Computed from Ethiopian Socio economic survey data.

* Represents the coefficients are significant at 1 percent respectively.

APPENDIX V: IVreg2 regression outputs of Rural Household Income:

2-Step GMM estimation				
Estimates efficient for arbitrary heteroskedasticity				
Statistics robust to Heteroskedasticity				
Number of obs = 4309				
F(10, 4298) = 18.34				
Prob > F = 0.0000				
Total (centered) SS = 9743.805257				Centered R2 = 0.8980
Total (uncentered) SS = 421963.0248				Uncentered R2 = 0.7714
Residual SS = 96444.30671				Root MSE = 4.731
Dependant Variable log of Rural household Income				
Variables	Coef.	Robust Std. Err.	z	P>z
logAL_prod	5.295412	2.573197	2.06	0.040**
logL_prod	3.316667	2.008425	-1.65	0.099***
TLU	.1999762	0.1474644	-1.36	0.175
NDR	-1.928183	0.8253754	-2.34	0.019*
AG	0.0157178	0.008489	1.85	0.064***
EDU	0.1602924	0.148917	1.08	0.282
HHS	0.2220327	0.0880699	2.52	0.412*
SEX	0.9132481	0.7092411	-1.29	0.198
NFI	0.9753107	0.4667622	2.09	0.037**
CRD	0.796504	0.3394939	2.35	0.019*
Constant	4.481645	2.066813	2.17	0.030*
Underidentification test (Kleibergen-Paap rk LM statistic):				3.333
Chi-sq(2) P-val =				0.0189
Weak identification test (Cragg-Donald Wald F statistic):				1.788
(Kleibergen-Paap rk Wald F statistic):				1.667
Stock-Yogo weak ID test critical values: 10% maximal IV size				19.93
15% maximal IV size				11.59
20% maximal IV size				8.75
25% maximal IV size				7.25
Source: Stock-Yogo (2005). Reproduced by permission.				
NB: Critical values are for Cragg-Donald F statistic and i.i.d. errors.				
Hansen J statistic (overidentification test of all instruments):				0.153
Chi-sq(1) P-val =				0.6953

-endog- option:	
Endogeneity test of endogenous regressors:	99.285
Chi-sq(1) P-val =	0.0000
Regressors tested: logAL_prod	
Instrumented: logAL_prod	
Included instruments: logL_prod TLU NDR AG EDU HHS SEX NFI CRD	
Excluded instruments: CDS damage	

Source: Computed from Ethiopian Socio economic survey data.

*, * and *** represents the coefficients are significant at 1, 5 and 10 percent level.

THE IV-FIXED EFFECT REGRESSION OUTPUT's OF RURAL HOUSEHOLD INCOME

Fixed-effects (within) IV regression			Number of obs =	4309
Group variable:			NHH Number of groups =	2218
R-sq: within = 0.6520			Obs per group: min =	1
between = 0.5944			avg =	1.9
overall = 0.6076			max =	2
			Wald chi2(10) =	1.27e+06
corr(u_i, Xb) = -0.0333			Prob > chi2 =	0.0000
logI	Coef.	Std. Err.	z	P>z
logAL_prod	0.8562513	0.2131954	4.02	0.000*
logL_prod	0.1456455	0.1792985	2.85	0.029**
TLU	0.0224592	0.0071252	3.15	0.002*
NDR	-0.229885	0.0984027	-2.34	0.019*
AG	0.0015547	0.0033296	0.47	0.641
EDU	0.0330198	0.0416316	0.79	0.428
HHS	-0.0040588	0.0157763	-0.26	0.797
SEX	0.1558739	0.1254167	2.24	0.021*
NFI	0.2829077	0.0320038	8.84	0.000*
CRD	-0.0483862	0.0329082	-1.47	0.141
_cons	3.083009	0.3699139	8.33	0.000
sigma_u	0.87115208			
sigma_e	0.5702603			
Rho	0.70003137 (fraction of variance due to u_i)			
F test that all u_i=0:	F(2217,2081) = 3.42		Prob > F	= 0.0000

Instrumented: logAL_prod
Instruments: logL_prod TLU NDR AG EDU HHS SEX NFI CRD CDS damage

Source: Computed from Ethiopian Socio economic survey data.

* and ** Represents the coefficients are significant at 1 and 5 percent level.

Appendix VI: Hausman tests for:

i. labor productivity

---- Coefficients ----				
	(b)	(B)	(b-B)	sqrt(diag(V_b- V_B))
	Fixed	Random	Difference	S.E.
logAAL	0.8312335	0.72095	0.1102834	0.0150287
logRAVAL	0.0133082	0.037467	-0.0241588	0.0136178
FLTAL	-0.2497574	-0.3339755	0.0842181	0.0001765
OXAL	0.0970403	-0.255405	0.3524452	0.0729519
AG	0.02477	0.001986	0.022784	0.0045118
EDU	0.0174572	0.1653577	-0.1479006	0.0470322
HHS	0.2050668	0.0420302	0.1630366	0.0198617
SEX	-0.1353254	0.0181776	-0.153503	0.1420381
PES	0.1192905	0.1607231	-0.0414326	0.0259274
DRT	-0.2477758	-0.2401273	-0.0076485	0.0324071
CRD	0.0625804	-0.0131812	0.0757616	0.0254817
EXTN	0.1422867	-0.0044463	0.146733	0.0298674
IRRN	0.0571032	0.1848088	-0.1277056	0.0479
MANURE	0.0740815	0.1510667	-0.0769853	0.0264067
b = consistent under Ho and Ha; obtained from xtreg				
B = inconsistent under Ha, efficient under Ho; obtained from xtreg				
Test: Ho: difference in coefficients not systematic				
chi2(14) = (b-B)'[(V_b-V_B)^(-1)](b-B)				
= 251.46				
Prob>chi2 = 0.0000				

Source: Computed from Ethiopian Socio economic survey data.

ii. land productivity

---- Coefficients ----				
	(b)	(B)	(b-B)	sqrt(diag(V_b- V_B))
	Fixed	Random	Difference	S.E.
logALA	0.1443625	0.2532335	-0.108871	0.0176746
logRAVA	0.0134116	0.031889	-0.0184775	0.0134079
FLTA	-0.2501464	-0.3350488	0.0849024	0.0000173
OXA	0.0007391	0.0002556	0.0004834	0.0001419
AG	0.0244693	0.0019232	0.0225461	0.0045072
EDU	0.0181484	0.1690591	-0.1509106	0.0469179
SEX	-0.1797385	0.0120519	-0.1917903	0.1430588
HHS	0.2051043	0.0427922	0.1623121	0.0198191
PES	0.1199316	0.162317	-0.0423854	0.0258272
DRT	-0.2482104	-0.2440668	-0.0041436	0.0323847
CRD	0.0582369	-0.0099751	0.068212	0.0254132
EXTN	0.1420317	-0.0017065	0.1437382	0.0297469
IRRN	0.0559351	0.1881543	-0.1322192	0.04775
MANURE	0.0886526	0.1941276	-0.105475	0.0262561
b = consistent under Ho and Ha; obtained from xtreg				
B = inconsistent under Ha, efficient under Ho; obtained from xtreg				
Test: Ho: difference in coefficients not systematic				
chi2(14) = (b-B)'[(V_b-V_B)^(-1)](b-B)				
= 248.21				
Prob>chi2 = 0.0000				

Source: Computed from Ethiopian Socio economic survey data

iii. Rural Household Income

	---- Coefficients ----			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	Fixed	random	Difference	S.E.
logAL_prod	0.8562513	0.9557304	-0.0994792	.
logL_prod	0.1456455	-0.0198779	0.1655234	.
TLU	0.0224592	0.0328791	-0.0104198	.
NDR	-0.229885	-0.3832775	0.1533925	0.0631374
AG	0.0015547	0.0022408	-0.0037955	0.0029617
EDU	0.0330198	0.0042035	0.0372233	0.0305973
HHS	0.0040588	0.0553934	0.0594522	0.01261
SEX	0.1558739	0.2350336	0.0791598	0.0911938
NFI	0.2829077	0.2793126	0.0035951	0.0154409
CRD	0.0483862	0.0132204	0.0616066	0.0202318
b = consistent under Ho and Ha; obtained from xtivreg				
B = inconsistent under Ha, efficient under Ho; obtained from xtivreg				
Test: Ho: difference in coefficients not systematic				
chi2(10) = (b-B)'[(V_b-V_B)^(-1)](b-B)				
= 2.91				
Prob>chi2 = 0.0000				
(V_b-V_B is not positive definite)				

Source: Computed from Ethiopian Socio economic survey data

APPENDIX VII: **THE CORRELATIONS BETWEEN THE VARIABLES USED IN THE REGRESION FOR:**

i. Labor productivity

	logYAL	logAAL	logRAVAL	FLTAL	OXAL	AG	EDU	SEX	HHS
logYAL	1.0000								
logAAL	0.4916	1.0000							
logRAVAL	0.1776	0.2839	1.0000						
FLTAL	0.0334	0.0401	0.0466	1.0000					
OXAL	0.0826	0.2944	0.1877	0.0258	1.0000				
AG	-0.0374	-0.0263	-0.0683	-0.0164	0.0033	1.0000			
EDU	0.0923	-0.0233	0.1477	-0.0091	-0.0456	-0.3429	1.0000		
SEX	0.0955	0.1019	0.0227	-0.0438	0.0097	-0.1390	0.2006	1.0000	
HHS	0.0556	0.0250	-0.0111	-0.0253	-0.0241	0.0626	0.0791	0.2781	1.0000
PES	0.0517	0.0225	-0.0120	0.0382	0.0084	-0.0092	0.0546	0.0313	0.0759
DRT	-0.0435	0.0292	-0.0957	0.0298	0.0653	0.0388	-0.0730	-0.0122	0.0259
CRD	-0.0477	-0.0517	-0.0784	0.0025	-0.0593	-0.0434	0.0147	0.0428	0.0608
EXTN	-0.0208	-0.0174	-0.1087	0.0640	-0.0206	0.0172	0.0120	0.0598	0.0718
IRRN	0.0586	-0.0243	-0.0174	-0.0158	-0.0511	0.0248	-0.0020	0.0414	0.0540
MANURE	0.0155	-0.1151	-0.1584	-0.0050	-0.0559	0.0665	0.0322	0.0223	0.1074

	PES	DRT	CRD	EXTN	IRRN	MANURE
PES	1.0000					
DRT	-0.0956	1.0000				
CRD	0.0568	0.0107	1.0000			
EXTN	0.1666	-0.0489	0.1425	1.0000		
IRRN	0.0043	-0.0052	0.0056	0.0964	1.0000	
MANURE	0.1227	-0.0333	0.0804	0.1595	0.0105	1.0000

ii. Land productivity

	logYA	logALA	logRAVA	FLTA	OXA	AG	EDU	SEX	HHS
logYA	1.0000								
logALA	0.2894	1.0000							
logRAVA	0.1782	0.4837	1.0000						
FLTA	0.0158	0.0836	0.0918	1.0000					
OXA	0.0221	0.1204	0.1178	0.0092	1.0000				
AG	-0.0193	0.0263	-0.0429	0.0120	0.0045	1.0000			
EDU	0.1208	0.0233	0.1522	-0.0045	-0.0096	-0.3429	1.0000		
SEX	0.0204	-0.1019	-0.0550	-0.0467	0.0065	-0.1390	0.2006	1.0000	
HHS	0.0404	-0.0250	-0.0287	-0.0304	0.0053	0.0626	0.0791	0.2781	1.0000
PES	0.0382	-0.0225	-0.0277	0.0260	-0.0071	-0.0092	0.0546	0.0313	0.0759
DRT	-0.0721	-0.0292	-0.1090	0.0215	-0.0038	0.0388	-0.0730	-0.0122	0.0259
CRD	-0.0095	0.0517	-0.0331	0.0047	0.0190	-0.0434	0.0147	0.0428	0.0608
EXTN	-0.0085	0.0174	-0.0863	0.0592	-0.0141	0.0172	0.0120	0.0598	0.0718
IRRN	0.0845	0.0243	0.0022	-0.0169	-0.0062	0.0248	-0.0020	0.0414	0.0540
MANURE	0.1126	0.1151	-0.0590	-0.0132	0.0143	0.0665	0.0322	0.0223	0.1074

	PES	DRT	CRD	EXTN	IRRN	MANURE
PES	1.0000					
DRT	-0.0956	1.0000				
CRD	0.0568	0.0107	1.0000			
EXTN	0.1666	-0.0489	0.1425	1.0000		
IRRN	0.0043	-0.0052	0.0056	0.0964	1.0000	
MANURE	0.1227	-0.0333	0.0804	0.1595	0.0105	1.0000

iii. Rural household Income before the productivity variables were instrumented

	logI	logAL_~d	logL_p~d	TLU	NDR	AG	EDU	HHS	SEX	NFI	CRD
logI	1.0000										
logAL_prod	0.7630	1.0000									
logL_prod	0.6602	0.6923	1.0000								
TLU	0.1560	0.0148	-0.1516	1.0000							
NDR	0.0071	0.0649	0.0375	0.0477	1.0000						
AG	0.0195	-0.0438	-0.0225	0.0921	-0.041	1.0000					
EDU	0.1195	0.1018	0.1297	0.0187	0.0316	-0.344	1.0000				
HHS	0.2202	0.0614	0.0493	0.3429	0.2861	0.0594	0.0754	1.0000			
SEX	0.1834	0.0960	0.0232	0.1294	0.0369	-0.1323	0.1999	0.2879	1.0000		
NFI	-0.0059	-0.0800	-0.0231	-0.0146	0.0240	0.1027	0.0093	-0.0410	-0.0965	1.0000	
CRD	0.0498	-0.0498	-0.0102	-0.0130	0.0109	-0.0438	0.0128	0.0605	0.0417	0.0821	1.0000

iV. Rural household Income after the Productivity variables are instrumented

	logI	logL_p~d	CDS	DRT	TLU	NDR	AG	EDU	HHS	SEX	NFI
logI	1.0000										
logL_prod	0.6577	1.0000									
CDS	-0.0271	0.0199	1.0000								
Damage	-0.0839	-0.0724	0.0392	1.0000							
TLU	0.1592	-0.1506	-0.0250	0.0194	1.0000						
NDR	0.0014	0.0352	-0.0069	0.0538	0.0451	1.0000					
AG	0.0159	-0.0189	0.1249	0.0399	0.0845	-0.0270	1.0000				
EDU	0.1205	0.1264	-0.0831	-0.0739	0.0219	0.0276	-0.3434	1.0000			
HHS	0.2228	0.0497	0.0246	0.0233	0.3443	0.2701	0.0431	0.0811	1.0000		
SEX	0.1873	0.0184	-0.0195	-0.0185	0.1336	0.0238	-0.1360	0.2036	0.2931	1.0000	
NFI	-0.0028	-0.0240	0.0213	0.0327	-0.0150	0.0268	0.1001	0.0089	-0.0399	-0.0931	1.0000
CRD	0.0546	-0.0091	0.0414	0.0080	-0.0098	0.0090	-0.0479	0.0154	0.0651	0.0473	0.0845

	CRD
CRD	1.0000

Appendix VIII: Other Diagnostic Test

1. **Heteroscedasticity test for Labor Productivity**

   Modified Wald test for GroupWise Heteroskedasticity
   In fixed effect regression model

   Ho: sigma (i) ^2 = sigma^2 for all i

   Chi (2215) = 4.9e+37
   Prob>chi = 0.0000

2. **Heteroscedasticity for Land Productivity**

   Modified Wald test for GroupWise Heteroskedasticity
   In fixed effect regression model

   Ho: sigma (i) ^2 = sigma^2 for all i
   Chi2 (2215) = 9.6e+36
   Prob>chi2 = 0.0000

3. **Heteroscedasticity for Rural Household Income**

   Modified Wald test for GroupWise Heteroskedasticity
   In fixed effect regression model

   Ho: sigma (i) ^2 = sigma^2 for all i
   Chi (2233) = 8.3e+35
   Prob>chi2 = 0.0000

APPEDIX-X: **The Total sample enumeration area (EA’s) with its respective selected Households during the survey period**

REGION	TOTAL SAMPLED		FINALLY COVERED	
	EA's	HH's	EA’s	HH's
TIGRAY	30	300	30	243
AFAR	10	100	5	4
AMHARA	61	610	58	519
OROMIA	55	550	55	446
SOMALIE	20	200	20	95
BENSHANGUL_GUMZ	10	100	10	96
SNNP	74	740	70	572
GAMBELLA	10	100	10	72
HARARI	10	100	10	92
DIREDAWA	10	100	10	97
COUNTRY_LEVEL	290	2900	278	2236