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Analysis of Fragmented Agricultural Land Size and Its Effects on the Productivity and Farm Income of Small Holder Farmers: The Case of Bahir Dar Zuria Woreda, West Gojjam Zone, Amhara National Regional State, Ethiopia

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BAHIR DAR UNIVERSITY

GRADUATE PROGRAM

INSTITUTE OF LAND ADMINISTRATION

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BY:

MELESE DAMTIE HAILE

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN LAND ADMINISTRATION AND MANAGEMENT.

ADVISORS:

MR. TESHOME TAFFA (ASS. PROF, PRINCIPAL ADVISOR)

MR. WOUBANTE FETTENE (CO-ADVISOR)

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APPROVAL SHEET

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GRADUATE PROGRAM

As a member of the examining board for this thesis, we certify that we have read and evaluated the thesis prepared by Melese Damtie Haile entitled: Analysis of Fragmented Agricultural Land Size and Its Effects on the Productivity and Profitability of Small Holder Farmers: The Case of Bahir Dar Zuria Woreda, West Gojjam Zone, Amhara National Regional State, Ethiopia and it is accepted as fulfilling the thesis requirement for the degree of master of science in Land Administration and Management. The final approval and acceptance of the thesis is contingent upon the candidate's successful defending of thesis and submission of the final copy of thesis to the research and community service coordinator of the institute.

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Name of External Exmainer	Signature	Date

DEDICATION

This thesis work is dedicated to late Brother and Mother Kendie Damtie and Anelye Tawenihe and also to my wife Agrenesh Abebe for taking care of my lovely sons Yared, Nahom and Simone Melese during my absence.

DECLARATION STATAMENT

First, I declare that this thesis paper is my solely work and that all sources of materials used for this paper have been duly acknowledged. This has been submitted in partial fulfillment of the requirements for Master of Science in Land Administration and Management at the Bahir Dar University, Institute of Land Administration. I have duly acknowledged and referenced all materials used in this work.

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Abstract

Land is an essential factor of production for socio-economic and sustainable development. Land fragmentation is the practice of farming a number of spatially separated parcels owned by small holders. Agricultural land fragmentation evolved over centuries in highland areas of the country. Diminution of farm and parcellization of parcels are common under all tenure systems and in every part of the country. The specific objectives of the study were to examine the nature and cause of land fragmentation, to assess the impact of fragmentation of farm land on the productivity and household income of smallholder farmers, to assess the causes and driving force of land fragmentation and also to estimate the minimum average farmland holding size per household that can support subsistence level. The study made use of secondary and primary data sources. In primary data collection structured questionnaire and focus group discussion were employed. Three kebeles were randomly selected in the first stage and 166 sample households' heads were systematically selected. To analyze the effect of fragmentation on productivity and farm income and also to estimate minimum farm land size a multiple linear regression and Cobb-Douglass production function econometric model were used respectively. According to the result of the study average family size is 2.8 adult equivalents with average farmland holding of 1.43 hectares. Average farmland holding is formed from 4.38 parcels scattered over areas. Agricultural land fragmentation parameters, average distance of parcels, oxen power intensity, age of the household, operating capital intensity, number of parcels holding and average size of parcels are not highly significant to influence land productivity. But labor power used intensity is the only variable highly significant to affect the productivity of land. Whereas oxen power intensity, operating capital and age of the household head is negatively affect land productivity, which is against the theory. A farm land size of 0.756 hectare is estimated as a minimum size that can generate minimum food and cash requirement of an average farm family of 2.8 adult equivalents. Variables that are significantly affect net farm income are oxen power used, area of cultivated land area and operating capital.. Land fragmentation has beneficial effects in reducing risks through the spatial diversification of activities and to have access to different types of land. The advantage of land fragmentation should not be overlooked if an attempt to reverse its problems is to be pursued. Female headed households generated lesser net farm income than male headed households, because they had lesser access to some of the factors of production. To overcome the above mentioned problem; the government should focus on to improve farm land productivity by supplying proper farming system, supplying agricultural inputs, find ways to promote off-farm and non-farm employment opportunities.

Key terms: Cobb-Douglass Production Function, Econometric Model, Land Fragmentation and Minimum Farm Size.

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ACRONYMS AND ABBREVATIONS

ADLI: Agriculture Development Lead Industry.

ANRS: Amhara Regional State

BoFED: Bureau of Finance and Economic Development.

CSA**:** Central Statistical Authority.

EEC: Ethiopia Economic Commission

EEPRI: Ethiopian Economic Policy Research Institute

EHNRI Ethiopian Health and Nutrition Research Institute

ETB: Ethiopian Birr.

EPLAU: Environmental protection, Land Administration and Use

EU: European Union

FDRE: Federal Democratic Republic of Ethiopia

FAO: Food and Agricultural Organisation

GOE: Government of Ethiopia.

MoA: Ministry of Agriculture

MOFED: Ministry of Finance and Economic Development.

NATO: North Atlantic Treaty Organization

NGOs: Non-Government Organisations

OLS: Ordinary Least Square

TLU: Tropical Livestock Unit

WoA: Woreda office Agriculture

WoRLAU: Woreda office of Rural Land Administration and use

CONTENTS

APPROVAL SHEET ..... **II**

DECLARATION STATAMENT ..... **V**

ABSTRACT ..... **VI**

ACKNOWLEDGMENT ..... **VII**

ACRONYMS AND ABBREVATIONS ..... **VIII**

1. INTRODUCTION **1**

1.1. Background **1**

1.2. Statement of the problem **2**

1.3. Objectives of the study **3**

1.4. Research questions **3**

1.5. Significance of the study **4**

1.6. Delimitation of the study **4**

1.7. Structure of the paper **4**

2. REVIEW OF LITERATURE **5**

2.1. Land tenure system **5**

2.1.1. Land tenure in Ethiopia 5

2.2. Agricultural land fragmentation 9
2.2.1. Extent of agricultural land fragmentation in Ethiopia 9
2.2.2 Advantages of agricultural land fragmentation 13
2.2.3 Disadvantages of agricultural land fragmentation 14

2.3. Causes of agricultural land fragmentation 14

2.4 Land fragmentation and productivity analysis 15
2.4.1 Descriptive analysis 15
2.4.2. Empirical studies on agricultural land fragmentation 16

CHAPTER THREE: RESERCEH METDOLOGY 22

3.1. Description of the study area 22

3.2. The Research design 23
3.2.1. Selection of the study area 23
3.2.2. Sampling procedure 24

3.3. Sources and method of data collection 25

3.4. Methods of data analysis 26
3.4.1. Econometric model specification 27
2.4.1.1. Working hypothesis and definition of determinant variables in the model 29
2.4.1.2. Net farm income and their detrimental factors 31

CHAPTER FOUR: RESULT AND DISCUSSION 36

4.1. Socio-economic features of the sample farm households 36

4.2. Labor availability 38

4.3. Farm characteristics 39
4.3.1. Farm size and age group 39

4.3.3. Sub division of farm land 41

4.3. Size of parcels 43

4.4. Distance of Parcels from Homestead 44

4.5. Crops grown and yield 45

4.6. Livestock system 45

4.7. Farm households' income 47

4.8. Income from off farm activities 48

4.9. Gender and access to productive resources 49

4.10. Consumption pattern 51

4.10.1. Food consumption pattern 51

4.10.2. Non food items expenditure by sample households 52

4.11. Minimum food and cash requirement 53

4.12. The empirical study 57

4.12.1. Empirical study on the impact of agricultural land fragmentation on farmland productivity 57

4.18.2. Net farm income and estimation of minimum farm landholding size 59

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS 64

5.1. Conclusions 64

5.2. Recommendations 66

APPENDICES 72

LIST OF FIGURES

Figure 1. Map of the Bahir Dar Zuria Woreda. 23
Figure 2. Research conceptual framework. 35

LIST of TABLES

Table 2-1. Agricultural land fragmentation in number of plots per farm in Ethiopia. 10
Table 2-2. Regional patterns of current landholdings in Ethiopia. 13
Table 2-3. Summary of empirical researches. 19
Table 3-1. Selected Kebeles and Sampled Land Holder 25
Table 3-2. Hypothesis sings of the variables that affect the dependent variable in the model 31
Table 3-3. Hypothesis sings of the variables that affect the dependent variable in the model 34
Table 4-1. Demographic characteristics of sampled respondents 37
Table 4-2. Distribution of Sample Household Heads by Size of Labor in Man-equivalents 39
Table 4-3. Average land holding by age group of household heads 40
Table 4-4. Distribution of sample household family size by number of parcels owned 41
Table 4-5. Sub division of farm land in different time periods 42
Table 4-6. Number of parcels, land size and total area per household. 43
Table 4-7. Distance of parcels from homestead in minutes. 44
Table 4-8. Cultivated land and yields of crops grown by sample households in 2015/16 production year. 45
Table 4-9. Distribution of sample household heads by possession of livestock 46
Table 4-10. Income from crop and livestock products. 48
Table 4-11. Income from Off-farm Activities. 49
Table 4-12. Summary of access to resources for sampled households and independent sample T-test for the 2015/16 production year. 50
Table 4-13. Proportion of food Items Consumed per adult equivalent for 2015/16 production year. 52
Table 4 -14. Average non food items expenditure by adult equivalent in 2015/16 production year. 53
Table 4-15. Crop and livestock products in quantity and value required to meet 2100 kcal. 55

LIST OF APPENDICES

Appendix 1. Conversion Factors Used to Estimate Man Equivalent (ME).....72
Appendix 2. Conversion factors used to estimate tropical livestock unit (TLU).....72
Appendix 3. Conversion factors used to estimate adult equivalent.....72
Appendix 4. Average annual price of crop and livestock products.....73
Appendix 5. Regression coefficients and other Statistics, land productivity model.....74
Appendix 6. Regression coefficients (Elasticties) of log transformed net farm income..... 75
Appendix 7. Household questionnaire.....76
Appendix 8. Checklist to be used for group discussion.....90

1. INTRODUCTION

1.1. Background

Land is an essential natural resource, both for the survival and prosperity of humanity, and for the maintenance of all global ecosystems (FAO, 2008).

Farmland fragmentation is a pattern of land use corresponding to the scale of land management. It is one of the main problems facing agriculture in developing countries (Sun and Liu 2010).

Land fragmentation at the household level depends on external policy and market factors, agro-ecological conditions, and farm household characteristics. The resulting level of fragmentation, together with external factors, agro-ecological conditions and farm characteristics, affects agricultural production. Land fragmentation as a phenomenon existing in farm management. It exists when a household operates a number of owned or rented noncontiguous plots at the same time (Wu, Z. *et al*, 2005; Daniel *et al*, 2010).

In Ethiopia a recent study conducted by Ethiopia central statistics authority at a national level 81.71 percent of rural households operate on holdings of 1.23 hectare. In Amhara region about 94.64 percent of rural household has 1.62 hectare of landholding size (CSA,2010).

Agricultural land fragmentation evolved over centuries in highland areas of the country, the major causes being land distribution and redistribution, inheritance, and risky peasant agriculture. Lakew et al. (2000) stated that the major problem regarding land use in Amhara region is the rapid growth of population. This has led to fragmentation of farm lands, decreases in sizes of holdings and productivity, an increasing cultivation of marginal land, a small holding and productivity, a critical shortage of grazing land, etc, while the highlands are over utilized because of the concentration of population.

The study w*oredas* being located in the highly populated zone of Amhara region and is characterized by small farm holding divided into small strips scattered over distant areas. Lakew et. al. (2000) stated that land fragmentation appears to be the most acute problem in Amhara region.

To this end this particular research aim to investigate the issue that as agricultural population increases, farmland decreases in size, the number of parcels increases and has an impact on the productivity and profitability of the land.

1.2. Statement of the problem

Land fragmentation is the practice of farming a number of spatially separated plots of owned or rented land by the same farmer (Mcpherson, 1982). According to Melmed-Sanjak *et al*.,(1998, p.60) "it's a phenomenon of agricultural land distributed in undersized holdings as well as holdings that consist of noncontiguous and spatially dispersed plots of land".

Land fragmentation has been considered to have different advantages and disadvantages and has long history in Ethiopia. Different policy options were issued by the previous and current governments regarding rural land administration. Especially, during the previous government, land fragmentation was considered as an evil to be avoided at any cost (MOA 1989) but currently amalgamation of farms and exchange of parcels among farmers based on their willingness are supported and put as policy options (ANRS, RLAU proc. No. 133/2008).

There are many studies related to land fragmentation in the country at different levels. The studies considered land fragmentation mainly as problem of highland areas where majority of the people reside. Frequent land redistribution made in the past exuberate farm land fragmentation and diseconomies the scale of agricultural production and their returns. Other arguments state that land fragmentation helps households to diversify their crop enterprises, secure household income and food supply. This group of arguments conclude that land fragmentation is not an evil for rural farm households instead it creates an option for household food and income security.

However, these arguments are not supported with empirical evidences in the study area. As a result different arguments and issues raised by policy makers, researchers and development partners whether land fragmentation has an effect on land productivity and profitability and its direction as well. Therefore, This study is initiated to fill the gaps and provide additional knowledge concerning land fragmentation and the direction of its effects.

1.3. Objectives of the study

The aim of this study is to analyze the effect of fragmented agricultural land on the productivity and farm income of on smallholder farms.

Therefore, this study will imitate with the following specific objectives:

1. To examine the nature and cause of land fragmentation based on the current land tenure systems in rural area;
2. To estimate the minimum farmland holding per household that can support subsistence level.

1.4. Research questions

Based on the above objectives, the following research questions for each specific objective are formulated.

I. What is the current level of fragmentation in the study area?
II. How does highly fragmented land impact the productivity and profitability of small holder farms?
III. What are causes and driving force of land fragmentation?
IV. What is the minimum land size per household that can support level of subsistence?

1.5. Significance of the study

The attainment of the objectives mentioned above is important tool for agricultural development of the country. The presence of effective development policy in a given country paves way in attaining sustainable development. Such policy development needs understanding of socio economic conditions of the community before formulation of policy and needs to obtain feed back after formulation and implementation.

Research of land fragmentation can contribute to the understanding of land fragmentation and its effects at household and community levels with respect to the existing attitude towards it. Hence, policy makers will be able to understand and make use of information about merits and demerits of land fragmentation at household and community level. Finally, the result of this research, with its limitation, will be useful for governmental and non-governmental organizations dealing with land use planning, land consolidation and agricultural extension activities.

1.6. Delimitation of the study

The study was conducted in Bahir Dar Zuria Woreda, West Gojjam zone, Amhara regional state where land fragmentation is the main problem. The study was conceptually limited and focused on assessing the influence of fragmented agricultural land and its effect on the productivity and profitability small holder farms in the selected three kebeles of bahir Dar Zuria Woreda.

1.7. Structure of the paper

With the brief introduction given so far, the next five chapters of this report are outlined as follows. The next chapter deals with a review of the literature with more emphasis on the causes and the extent, descriptive and empirical analysis of land fragmentation. In chapter three, the research design and methodology are explained with contains a brief description of study area, sampling technique, sources and method of data collection and analytical tools (models) used in data analysis. Chapter 4, the survey results are discussed. Finally, chapter five gives concluding remarks and recommendations.

2. REVIEW OF LITERATURE

A number of research have conducted on land fragmentation and its effects in different countries with a wide range of issues like, explanations of land fragmentation, effect of land fragmentation on agricultural productivity and profitability, and methods used to test the effects of land fragmentation. In most cases, there are a number of unresolved issues often reflected by opposing findings and will also review the Ethiopia land tenure system from perspective of each regime. In what follows a brief review of literature on each of these points will be presented. Taking no side for the moment, excellent arguments from both sides will be present.

2.1. Land tenure system

2.1.1. Land tenure in Ethiopia

Bruce, L. and Migot-Adholla, S. (1993) argued that Land tenure consists of social relations and institutes governing access to the land and natural resources. Tenure is often described in terms of bundles of rights to do certain things with land or other property.

2.1.1.1. Pre 1975 land tenure system

The Ethiopian empire accommodated a land tenure system that is described as one of the most complex compilations of different land use systems in Africa (Joireman, 2000). The terminology that has become the commonly used classification of the pre-revolutionary land tenure types does not reflect this plethora of local land tenure systems but refers mainly to the imperial administrative classification. It is commonly distinguished between communal (*rist*), grant land (*gult*), freehold, or sometimes referred to as private (*gebbar* tenures), church (*samon*), and state (*maderia*, *mengist*) tenure regimes.

Before 1975 the socio-economic and political system had been known for its feudalistic in nature and dominated by few elite groups; like the nobles, clergy and those who were closer to the Royals. The mode of receiving and access to land had been geared by relationship and attachment to the church.

There was a major difference in land tenure system between the northern and the southern parts of Ethiopia during the time mentioned. For instance in the northern part land tenure is mainly attached to family ties that was traditionally known as *'rist'* and on the other hand the benefit of the ruling class believed to have induced the creation of what is called '*gult*'(fief) right (Teshome, 2009).

Rist land was 'communally' owned and used by all members of the family line and each individual had a right to family line and entitled to part of the *rist* land; traditionally *rist* land cannot be sold. Individuals had a right to claim land by using their heredity through their father or mother or the parents of their spouse proliferating the potential *rist* rights an individual have (Teshome, 2009). *Rist rules* aimed at maintaining continuity in the possession of land to both individually operated and clan lands (Atakilte Beyene 2004); that is why *rist* rights holders usually lacked the right to sell their share outside the family, mortgage, bequeath or transfer it as a gift as the land belonged to the descent group, not the individual. *Rist* is burdened with some ambiguity in the literature. It is usually conceptualized as a genuine Abyssinian collective land tenure system. Even though the *rist* system provided for general tenure security, it granted only very insecure property rights to a particular plot of land. It continuously endangered the security of an individual's effective rights to use a specific plot of land and encouraged fragmentation and successive reduction in individual plot size. At the same time, it sustained and privileged the majority of the rural peasantry direct access to land through its distributive role (Atakile Beyene, 2004).

The *Gult*, a form of private ownership, prevailed mainly in the southern parts of the country, consisting of large holdings granted by the royal leader or provincial authorities. Owners were entitled to collect taxes or labor service from tenant farmers, some of whom had been cultivating the same land under customary or community property rights. *Gult* rights were often provided in lieu of salaries to majestic officials and soldiers. The *gult* system was characterized by greatly concentrated landholdings and absentee ownership, political support, and common share-cropping under destitute terms. Owners could lease, sell, or mortgage land while tenants were subject to numerous restrictions, unreasonable taxes, mandatory

labor services and illogical eviction. All *gult* rights were abolished by the Derg and tenants were entitled to claim the lands that were not reallocated as state farms (Crewett et. al. 2008).

The land tenure system of the imperial regime was largely considered as a hindrance to the country's development in general. It was largely considered as the most important cause of political grievances that led to the overthrow of the regime. Institutional inadequacy and lack of necessary legal framework, absolute arbitrary control of land rights, and lack of well organized and transparent land administration had characterized the Imperial Ethiopian Government's land tenure system. Land concentration for political reasons in the hands of absentee landlords and its underutilization, unchecked and exploitative tenancy, tenure insecurity including arbitrary eviction, diminution and fragmentation of farm holdings, and other problems are noted as features of the Ethiopian land tenure system that hindered the development of agriculture in general and the economy as a whole (Yigremew, 2002).

2.1.1.2. Land tenure after the 1975 land reform

Many observers considered the 1975 land reform of the *Derge* as a radical measure that has effectively abolished the tenant-landlord relations in Ethiopia. The reform was meant to fundamentally alter the then agrarian relations and liberate the peasantry and make it owner of the fruits of his labor. The reform was also expected to increase agricultural production, create employment; distribute land equitably and increase rural income and lay down the basis for the expansion of industry. The basic provisions of the proclamation (proclamation No.31/1975) include: public ownership of all rural lands, distribution of private land to the tiller, prohibition of transfer of use rights by sale, exchange, succession, mortgage or lease, except upon death and only to the wife, husband, or minor children of the deceased. In the case of communal lands, it provides possessor rights over the land the peasants till at the time of the reform. The power of administering land was vested in the Ministry of Land Reform and Administration through Peasant Associations at the grassroots level. The law provides ten hectares of land, as the maximum a family can possess. No able adult person was allowed to use hired labor to cultivate his holdings (Yigremew, 2002).

Especially during the initial period of the reform a considerable proportion of the rural peasantry supported land redistribution. The land tenure during the Derge regime characterized by fragmentation of holdings, diminution of land holding size, tenure insecurity and all these factors leads to land degradation, and inefficient use and allocation of land by way of restrictions on land transfer and to some extent lack of appropriate land use and administration are the most commonly cited problems (Teshome, 2009).

2.1.1.3. Land tenure policies and administration of the current government

The current government like the previous government vested land ownership to state and gave use right to the peasants. After the fall of the *derg* regime in 1991, The Transitional Government of Ethiopia, in its declaration on economic policy in November 1991 (Transitional Government of Ethiopia 1991), announced the continuation of the land policy of the *derg* regime. Many scholars have raised the questions if the 1995 constitution provided any differences to the land reform proclamation of 1975 (Berhanu Nega et al. 2003, Dessalegn Rahmato 2004, Kassa Belay and Manig, w. 2004). There are, nevertheless, some notable differences between the rules of 1975 and 1995. The 1975 proclamation prohibited the lease of land and the hiring of labor and concealed the maximum land size per individual to 10 ha; such provisions are absent in the 1995 document (Yigremew Adal 2001, 56).

To implement the constitutional provision, the federal government enacted proc. 456/2005 concerning rural land, regional governments enacted their own proclamations, ensure equity the constitution guarantees every person who wishes to engage in agriculture to get plot of land free of charge, Peasants have been given more liberated rights of use, lease/rent, donation, and inheritance of land, government restricts the sole power of selling land and mortgage. Consequently, one can observe transferability of land. In line with the national land policy, Amhara region has issued its land policy and declared that land would not be redistributed in the region. This was based on the consensus reached that farmland has already been diminished much (ANRS, RLAU Proc. No 133/2006).

2.2. Agricultural land fragmentation

Agricultural land fragmentation is defined in different ways by different authors. Jacoby (1971), Clout (1972) and Blum (1978) as cited by Bentley (1987), Dessalegn (1994) and Todaro (1997) consider division of farmland in to small farms as agricultural land fragmentation. Some other authors consider farmland fragmentation is a pattern of land use corresponding to the scale management of land. Farmland fragmentation means that a farmer manages more than one plot of farmland around his residence, not connected, but within a certain reasonable distance from one another (Xu *et al*. 2007) and in "an inserted, fragmented and disorganized state because it is hard to connect them into one and carry out concentrated and scale management of them under the influence of artificial or natural conditions" (Sun and Liu 2010).

As can be seen, farmland fragmentation must meet two necessary conditions at the same time, that is, there are many plots of farmland not adjacent to one another and such plots are small. As a study object in economics, farmland fragmentation must meet several conditions at the same time, that is, the farmer has many separate plots of land; the average size of the plots is so small that scale economy of farmland is yet to be realized; division of the plots has nothing to do with terrain (Wang and Zhong 2008). Farm land fragmentation is one of the main problems facing agriculture in many countries, especially developing countries (Sun and Liu 2010). However, this particular study considers both diminution (becoming small in size) and parcellization of farmland as agricultural land fragmentation. In Ethiopia too, agricultural land fragmentation has long history. All of the land tenure systems substantially contributed to land fragmentation.

2.2.1. Extent of agricultural land fragmentation in Ethiopia

Before the land reform of 1975, about 58% of all holdings in the country were less than one hectare in size and accounted for about 18% of total crop land area and 39% of total holdings were medium size' i.e. those between 1 hectare to 5 hectares covered 53% of the total cultivated land (MOA, 1989). A decade has passed after Ethiopian agriculture had been characterized by inadequacy of holding and too often fragmented parcels. Lakew Desta et.al. (2000) argued that most peasants were plagued by inadequate holdings, their parcels were too often fragmented, and soil and water erosion were in frequent hazards.

The Ethiopian subsistence agriculture has not only suffered from continuous decline of cultivated land but also from farm fragmentation. According to CSA (2004) national survey data, the average farm size in the highlands was fragmented into 2.3 plots, each with 0.35 hectares. About one-third of the surveyed farms consisted of 3 or more plots indicating high farmland fragmentation (See table 2-1).

Table 2-1. Agricultural land fragmentation in number of plots per farm in Ethiopia.

Description	One plot	Two plots	Three plots	More than three plots	More than four plots	Average No. of plots	Number
Farmers (percent)	44	23	13	20	11	50	4580
Average farm size per plot (hectare)	0.34	0.37	0.36	0.33	0.32	0.35	

Source: CSA, 2004 reviewed national survey data.

According to EEC/EEPRI (2002), the critics of the land reform of 1975 have argued that one of the negative aspects of the reform is the diminution of holdings partly as a result of redistribution leading to economically unviable economic system. Some have argued that this has already happened (Dessalegn, R., 2009). The process of farm fragmentation has been in part induced by farmers' voluntary actions of sharing part of their farm to children reaching working age and forming their own family farm but without securing any additional alternative livelihood. This implies that smallholders reach to the point where they cannot redistribute their already miniscule and fragmented land to the growing labor within their family.

Ethiopia is a country of smallholder agriculture because population pressure has diminished households' farm size. The question of farm size is related to the degree to which the size of

landholdings can adequately support the livelihood of the farmer and a sustainable intensification of agricultural production. A number of researchers have raised the issue of the gradual conversion of Ethiopian agriculture from small-scale agriculture to micro-agriculture that cannot reduce the poverty of the farmers and even unable to support the life of the farming community EEC/EEPRI (2002). Farm size in all the sample households range from zero (landless) to a high of 5 hectares although those who own the latter are very small in number and usually reside in the less densely populated regions of Somali and Afar. The average landholding size for all the households is about 1.02 hectares per household and this average declines slightly to about 0.96 hectares when we take out the samples from sparsely populated regions of Somali, Afar and Benishangul Gumuz (EEC/EEPRI,2002).

In the 2000 cropping season, 87.4 % of rural households operated less than 2 hectares; whereas 64.5% of them cultivated farms less than one hectare; while 40.6% operated land sizes of 0.5 hectare and less. Such small farms are fragmented on average into 2.3 plots. From this one can suggest that landholding is one of the factors that constrain farm income and the level of household food security. As landholding declines, per capita food production and farm income also decline, indicating that extremely small-sized farms cannot be made productive even with improved technology and certainly not enough to address rural poverty. Such farmers have little or no surplus for investment and for input purchase. The increasing decline of farm size also leads to a reduction of fallowing practice or shortening of fallow cycles, and rotation, with a consequence of declining soil quality and fertility in some highland areas (FAO.,2010) and (EEC/EEPRI ,2002).

The diminishing farm size has not only affected the profitability and level of technology use, but also the sustainability of rural livelihoods. A study carried out at national level, for instance, indicates recently that, the average farm size can generate only about 50% of the minimum income required for the average farm household to lift farmers out of poverty, if current levels of farm productivity and price structure remain constant. The average land holding size in the Ethiopian highlands would thus be insufficient to feed a family of five, even if production could be successfully increased three times using improved technologies (EEC/EEPRI ,2002).

The regional variation in farm holdings is to a certain extent replicated when one looks at holding patterns by major farming systems. The expected landholding size is very small in the *enset* dominant regions of the south where average holding per labor is less than one-fifth of a hectare while *teff* dominated farming areas has the highest average size holding at about a hectare and half per working force. Clearly, given this distribution of land holdings, the claim that the existing land tenure system will reduce landholding size to an unviable proportion through time is discredited. In fact, this is one of the key issues that any land policy (or any development policy) in Ethiopia has to squarely address. Whether the current size holding can provide sufficient income for farmers to enable them to live a life without poverty with increased productivity owing to the use of modern technology is the issue of concern. What is clear from this data is that with the expected increase in the farming population in the coming years, it is difficult to see how the farming population can come out of poverty without a significant creation of non-farm employment in the near future to absorb the additional population.

It is found that the major constraint to food security especially in food deficit areas where more than 25 million Ethiopia's population resides is extremely small farmland (0.57 hectare compared to1.38 hectares in food surplus areas). Of the 184 *woredas (Woredas)* constituting the food deficit area, per household farmland is less than 0.4 hectare in half of them and less than 0.3 hectare in one-third of them. The negative impact of a very small farm sizes is also reflected by low farmland productivity. The average cereal yield is about 1 metric ton per hectare, 20% below the national average, on food deficit areas where the average farm size is less than 0.6 hectare. Similarly, return from the use of modern inputs is also low in these area (EEC/EEPRI ,2002).

Farming households are not uniform throughout the country and significantly differ from region to region depending on farming practices. The prevalence of small holdings size of up to 0.5 hectare in the sample reaches 55 percent in Tigray, 40 percent in Amhara and 34 percent in Southern region. It is lowest in Somali Region (3.1%). Landholding ranges from as low as 0.22 hectares per active farm labor force in Tigray Region to a high of

1.61 hectares in Somali Region (See table 2-2). The highly populated highland parts of Amhara and Southern Nations, Nationalities Peoples' Region/SNNPR have an average holding of about one-third of a hectare while Oromia has an average holding of 0.40 hectare (See table 2-2).

The average farm size is considered to be small to allow sustainable intensification of smallholder agriculture. Since, the high land area including the study Woreda are intensively cultivated and highly populated according to the above data (See table 2-2).

Table 2-2. Regional patterns of current landholdings in Ethiopia.

Percentage of population by region of farming house hold	Farm size holding in hectare							Average Holding Size and Land labor Ratio		
	Land less	0.001-0.5	0.501-0.75	0.7501-1.00	1.001-1.50	1.501-2.00	2.001-3.00	Mean Land size (ha.)	Mean land-labor ratio	Number
National	10	27.6	13.1	12	14	8.1	11.5	1.02	0.38	8540
Tigray	11.1	54.8	14.6	10	5.9	3.3	0.3	0.54	0.22	611
Afar	0	-	-	-	20.5	0.4.	79.1	2.38	0.99	244
Amhara	9.8	40.3	19.1	9.4	14.2	3.5	3.3	0.75	0.3	1703
Oromia	13.6	17.8	11.5	11.9	15.1	11	13.9	1.15	0.4	3905
Somali	6.3	3.1	3.1	-	3.1	3.1	6.3	3.51	1.61	124
SNNPR	17.6	34.3	8.9	11.2	10.6	8	6.3	0.89	0.32	1831
Ben-Gumuz	14.4	-	3.6	13.5	13.5	10	26.1	1.82	0.64	122

Source: EEC/EEPRI, 2002 reviewed data.

2.2.2 Advantages of agricultural land fragmentation

Land fragmentation reduces risk by giving farmers a variety of soils and growing conditions (Papageogion 1956 as cited by Bentley 1987; MOA, 1989). When parcels at different altitudes are cultivated, crops ripen at different times. Farmers can benefit by spreading out the agricultural work (crop scheduling) for different crops with different farm operation. This helps farmers to avoid household labor bottlenecks (Forbs 1976 as cited by Bentley,

1987).

Other study conducted showed that, land fragmentation avoids the risk of complete crop failure and have similar view with the above study concerning advantages of agricultural land fragmentation (MOA,1989; Fassil,1980 and Getachew 2000).

2.2.3 Disadvantages of agricultural land fragmentation

Land fragmentation resulted into uneconomic use of land as well as labor resources. In other words, farm land holding is diminished to the level that it could not support the requirement of the family and fragmented into small parcels scattered over areas (Fassil, 1980; MOA, 1989). As long as peasants lack access to technology and investment, increased area productivity can't manage with population growth. Consequently, production starts diminishing below the subsistence level and chronic poverty becomes a way of life (Todaro, 1997; Getachew, 2000; Lynn-Smith, 1959 as cited in Bentley, 1987).

Spatial distribution of parcels or distance among parcels is considered as a problem because it wastes time in traveling from parcel to parcel, it hinders protecting pests, and very hard to transport farm inputs to distant fields; manure and fertilizers are seldom applied to a more distant ones (MOA, 1989; Fassil, 1980; Getachew, 2000; and Upton, 1979). It is difficult to manage a fragmented holding as a single unit, since it is not possible to give proper supervision to the labor and regular attention to crops and animals on all the parcels when required (Upton, 1979).

2.3. Causes of agricultural land fragmentation

Agricultural land fragmentation (farm size diminution and parcellization) is usually attributed to different factors: namely; inheritance, traditional land tenure arrangements, land distribution and redistribution, population growth, subsistence cropping, etc. These causes are pertinent to Ethiopia.

Pausewang et.al. (1990) stated that land had been distributed for individuals as a membership of kinship group or a community before 1975 land reform. During that period, land rights were conceived as an integral part of community membership included a

collective responsibility for a fair distribution of the agricultural land available. Fassil (1980) also mentioned that land distribution and inheritance were believed to be a cause of land fragmentation and diminution of peasant holding and the latter being the root cause before 1975. Often land areas of different fertility levels or located in different regions were shared among brothers and sisters. It was also possible for a married couple to obtain inheritance of land from the parents of both man and wife.

Getachew (2000) stated that causes of land fragmentation were continuous land distribution and redistribution, preference of peasants to have holding from different locations, division of land among heirs of parents and population growth, which necessitates land redistribution.

2.4 Land fragmentation and productivity analysis

2.4.1 Descriptive analysis

There are many studies related to agricultural land fragmentation. In most of the cases, the studies made were of descriptive types. In this type of analysis the authors described average number of parcels owned, average parcel size, distances of parcels from homestead, the size of farm in general and explained about the effect of above variables on productivity in qualitative terms.

EEC/EEPRI (2002) explained the cause, extent and problem of diminution of farm size and parcellization. According to Ethiopian CSA (2004) national survey data, the average farm size in the highlands was fragmented into 2.3 plots, each with 0.35 hectares. In addition to this MOA (1989) determined minimum farm size by estimating minimum requirement based on assumed expenditure on consumable and non consumable and minimum energy requirement. In so doing minimum farm size was estimated to be 1.53 hectare per household having five members. However the study did not describe parcellization in terms of figure but their cause and problems were described. According to these studies parcellization are in reduction of productivity, which needs remedy like exchange of parcels among farmers and determination of size of parcels "size.

2.4.2. Empirical studies on agricultural land fragmentation

Productivity of a firm is a ratio of the output it produces to the inputs it uses (Tim Coelli et. al., 1998). While discussing about how to measure productivity, they mentioned that it is very simple to measure when a single input and a single output are involved in production process. However, when there is more than one input (which is often the case) then a method to aggregate these inputs into a single index of inputs must be used to obtain a ratio of productivity.

The objective of this study is analyzing the impacts of land fragmentation on farm productivity and profitability. Hence, it became important to define productivity and profitability. Tim Coelli et. al. (1998) stated that it is unfortunate to observe productivity and efficiency used interchangeably. Tim Coelli et. al. (1998) used production frontier or possibility to define efficiency and to show the difference it has with productivity. Production frontier represents the maximum output attainable from each input level. Hence it reflects the current state of technology. Firms are efficient if they operate on the frontier and not efficient if they operate beneath the frontier curve. However, productivity differs even on the frontier, i.e. it can be increased or one can conclude that a firm may be technically efficient but may still be able to improve its productivity by exploiting scale of economies (Tim Coelli et. al., 1998).

To analyze the impact of land fragmentation on farm productivity and profitability, related works will reviewed to have theoretical background for this study. Accordingly, it is review that production function techniques are used by many researchers to analyze productivity of inputs in agriculture.

From the theoretical backgrounds many factors influencing the level of land productivity are discussed. The total product per hectare cultivated land, which can be obtained at a given rate of labor and capital input, according to Upton (1979) is influenced by the natural environment, the inherent fertility of the soil, the topography and the climate of an area under consideration. Frequency of cropping implies double or multiple cropping practices, which are also known to have the effect of raising the total output value of a

given area of land (Ellis, 1988). Changes in land productivity are referred to by Indraranta (1987) as cited by Berhanu (1992) mainly as a result of technological change which includes the use of new varieties, the system of land preparation, cropping patterns which imply multiple cropping, intercropping, relay cropping and intensity of input application.

The economy of most of developing countries is predominantly agricultural. However, the level of agricultural productivity in these countries is low and hinders economic development. In order to adjust resource and attain an increase in farm output and productivity many researchers have carried out studies with respect to the productivity of peasant agriculture. For example, Upton (1979) fitted a Cobb-Douglass production function to empirical data obtained from 118 sample farms on Chewese Reserve in Rhodesia. The function was used to relate the output of each of the three main crops chosen for the analysis. The study inferred that marginal productivity of labor and capital are low and that of cultivated land was high and concluded that cultivated land became limiting factor in production process of the area. Tshiblka, B. (1992) used Cobb- Douglass production function to analyze the relationships between the volume of agricultural output (dependent variable) and labor and capital (independent variables). A positive relationship was expected between the dependent and the independent variables. The conclusion of the study was that labor was the primary production input available to the small farm sector in most of sub-Saharan Africa. Increasing the productivity of this resource remains central to both agricultural growth and overall economic growth of the region. Moreover, the study concluded actions have to be initiated to develop rural capital and credit markets.

Gavian and Fafchamps (1996) in their study of land tenure and allocative efficiency in Niger analyzed the relationships between yield (dependent variable) and distance of parcels from homestead, farm size, households' manpower per hectare, age of household heads (as proxy of experience) and others as independent variables. In the analysis of the relationships, multiple linear regression models were used. They found that fields near homestead had shown higher yield. Labor per hectare and farm size were significant and affected yield, the former positively and the latter negatively.

Wan and Cheng (2001) in their study of the effect of land fragmentation on five major crop production province of China by applying a production function model and analyzed that the highest degree of fragmentation were observed on farm producing rice and the lowest is maize producing farms. The researcher concluded that land fragmentation has adverse effect on output in every crop production.

Sundqvist and Andersson (2006) conducted the same study in the village of southern India to test the relationship between fragmentation and land productivity by applying a multiple regression model. The study indicates that land fragmentation has a positive effect on land productivity. The positive effect on productivity of crops comes from the use and application of fertilizer inputs and work hours spent for farming activities. According to Sundqvist and Andersson (2006) the study showed that there is no a significant correlation between labor productivity and land fragmentation

Berhanu (1992) established the relationships between net farm income from crop farming and cultivated land area, available family labor force, oxen power, direct cost (crop production and animal) irrigated land area and total land productivity, income from livestock and share of coffee and chat income in gross farm income. He found land productivity, cultivated land area and direct cost to be significant variables in the regression. In his analysis of net farm income, Berhanu used Cobb- Douglass production function because it had been found to be the best fit to the data obtained from 368 sample households in Hararghe highlands.

Berhanu finally, concluded that cultivated land is the limiting factor of the production of farming of smallholders of Hararghe highlands. He estimated minimum food and cash requirement for an average family and equated the amount to the net farm income equation and obtained minimum farm size to be 1.18 hectare. In his analysis, Berhanu showed the severe shortage of cultivated land in the study area. The major findings of the models used in productivity analysis in table 2-3.

Table 2-3. Summary of empirical researches.

Author	Year	Problems Analyzed	Economic model used	Location	Major conclusions
Upton	1979	Identifying important factors in production	Cobb-Douglas	Chewese Reserve in Rhodesia	Cultivated land became important factor and limiting factor of production
Tshibaka, B.	1990	Identify factors bound to production	Cobb-Douglass	Zairian basin, Zaire	Labor became more important followed by capital so their productivity needs attention.
Banerjee and Sirohi	1975	Identification of small farmers and develop methods to make them more productive	Quadratic production function	Varsani Woreda, India	Infrastructure and irrigation scheme development are necessary to increase the productivity and decrease minimum farm size required.
Gavian S. and Fafchamps M.	1996	To measure allocative efficiency of farms	Linear-regression	Niger	Cultivated land and labor have shown high variation among farms and not efficiently allocated.
Berhanu Adnew	1992	Effect of farm size variation, and analyzed how the cultivated land support the population	Cobb-Douglass in determination of minimum farm size and analysis of the productivity of inputs	Hararghe highlands, Ethiopia	Concluded there existed shortage of cultivated land and there was difference in land holding and practices among farms of different sizes.
Tim Coelli et	1998	the impact of land fragmentation on farm productivity and profitability	Production frontier model		Conclude that a firm may be technically efficient but may still be able to improve its productivity by exploiting scale of economies

Author	Year	Problems Analyzed	Economic model used	Location	Major conclusions
Wan and Cheng	2001	To examine the effects of land fragmentation on five major crop outputs	Using a production function model.	Four provinces in China	The highest degree of fragmentation is observed on farms producing rice, the lowest on farms producing maize. Land fragmentation has adverse effects on outputs in every crop production.
Sundqvist and Andersson	2006	To test the relation between fragmentation and land productivity	Using multiple regression analysis.	Two contiguous villages in Southern India	Land fragmentation has positive effects on land productivity. This implies that there is a positive relationship between farm size, average plot size and yield.The positive effects, however, were found to be related to the increase in the use of fertilizers and hours worked on the farm in relation to increase in the number of plots. There is no significant correlation between labour productivity and land fragmentation.

The above empirical analyses of land productivity and determination of minimum farm size have given strong background to choose appropriate functional form and establish proper relationships between the variables and the models used.

CHAPTER THREE: RESERCEH METDOLOGY

3.1. Description of the study area

Solomon (1996) indicates that the area in which a farming business survey is to be made depends on the particular purpose of the study. The study area, that is Bahir Dar Zuria Woreda, where this research take place was purposefully selected

Bahir Dar Zuria is one of the *Woreda* in the *Amhara* Region and part of the West Gojjam Zone, this *woreda* is bordered on the south by *Yilmana Densa*, on the southwest by *Mecha*, on the northwest by the *Gilgele Abay River* which separates it from *North Achefer,* on the east *Dera* and on the North by Lake *Tana.*

Bahir Dar Zuria includes the forested *Zege* Peninsula, known for its numerous medieval churches, of which the best known is *Ura Kidane Mehret*, and associated monasteries. Other points of interest include the *Tis Issat falls*, and *Dilde*, better known as the Portuguese Bridge, over the *Abay at Alata*, about half a mile below the falls. A survey of the land in this *woreda* shows that 21% is arable or cultivable, 9% pasture, 8% forest or shrubland, 36% covered with water, and the remaining 26% is considered degraded or other. The major crops produced in this *Woreda* are *Teff,* Corn, Sorghum, Millet, Coffee are important cash crops.

Based on the 2008 national census conducted by the Central Statistical Agency of Ethiopia (CSA,2008), this *woreda* has a total population of 182,730, of whom 93,642 are men and 89,088 women; no urban inhabitants were reported. With an area of 1,443.37 square kilometers, *Bahir Dar Zuriya* has a population density of 126.60, which is less than the Zone average of 158.25 persons per square kilometer. A total of 40,893 households were counted in this *woreda*, resulting in an average of 4.47 persons to a household, and 40,097 housing units. The majority of the inhabitants practiced Ethiopia Orthdox Christianity, with 99.7% reporting that as their religion. The largest ethnic group reported in *Bahir Dar Zuria* was the *Amhara* (99.91). Amharic was spoken as a first language by 99.93%.

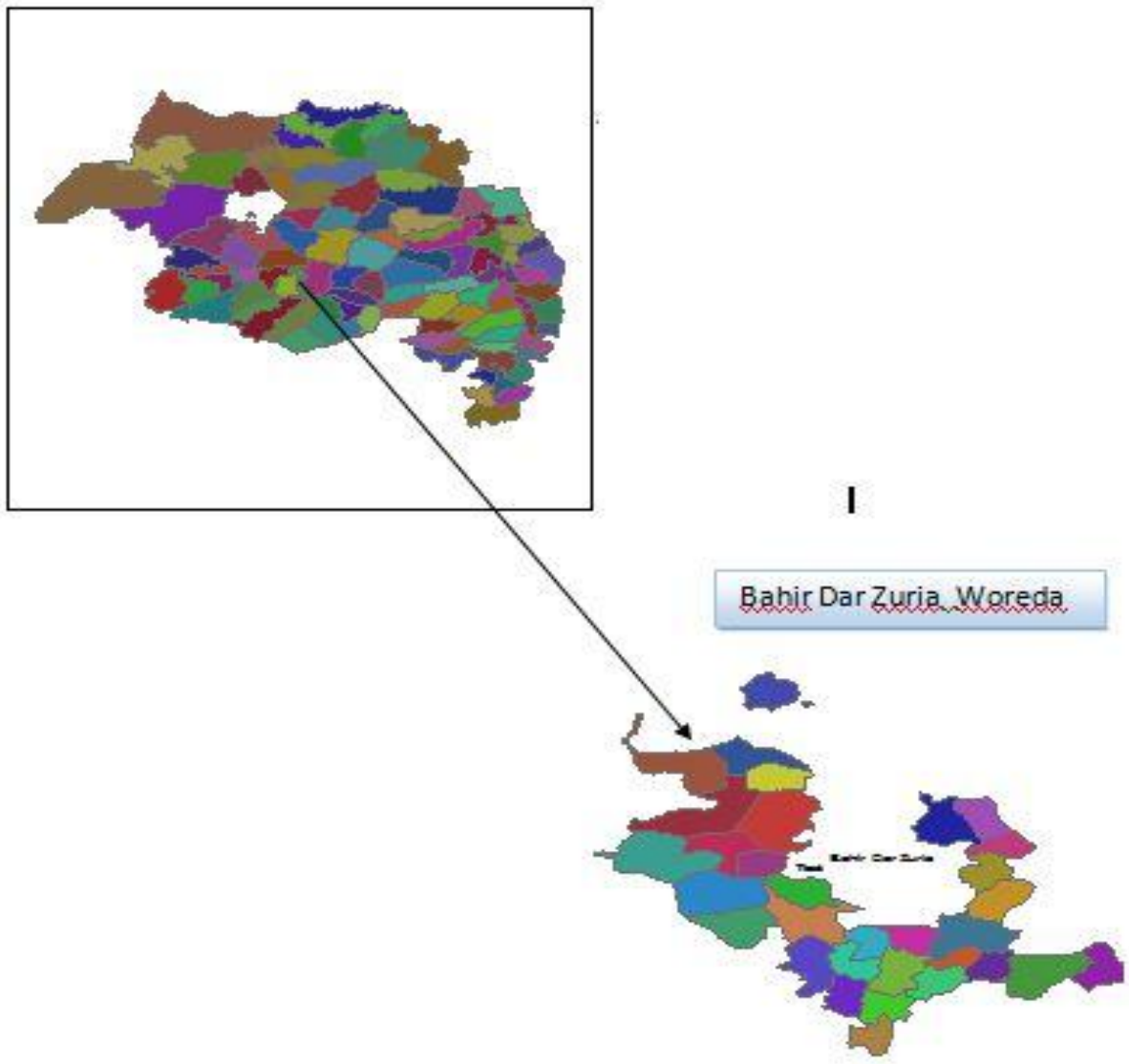

Figure 1. Map of the Bahir Dar Zuria Woreda.

3.2. The Research design

3.2.1. Selection of the study area

Yang (1965) indicates that the area in which a farming business survey is to be made depends on the particular purpose of the study (cited in Solomon, 1996). In this study too, the selected *kebeles* of the model *woreda* namely *Yensa Sositu, Yibab and wogelsa* were purposely selected among forty *Kebele of Bahir Dar Zuria woreda*. This *woreda* was further selected

based on the moderately high population density (137.5 persons per km2) (CSA, 2010) since land fragmentation is high under a high population pressure.

3.2.2. Sampling procedure

The study was designed to be undertaken in *Bahir Dar Zuria Woreda*. Accordingly, sample areas were identified and selected with the support of experts from *woreda* land administration and use office (*WoRLAU*) based on the level and intensity of fragmentation with respect to the number of landholding parcels.

It is stated by some authors that variance, sample design and precision needed are some basic information required in determination of sample size (Kothari, 2004). On the other hand, they indicate that determination of sample size is influenced by practicality in this case by availability of resources, time and required number of units. The sample size in this study was determined based on the practicality of sample determination.

A two stage sampling techniques were applied to select the sample households. At the first stage, three *kebele* were selected purposely among forty (40) *kebeles* found in the *woreda* because the kebeles were undertaking a cadastral survey for second level certification program and also possible to get easily the intensity and level of fragmented parcel data and in the second stage, 166 household heads were selected in a systematic random sampling techniques obtained from *woreda and kebele* land holding registration books. A sample land holders were determined based on Kothari's formula as follow:

$$n = \frac{z^2.p.q.N}{e^2(N-1) + z^2.p.q} \quad \text{.....(Eq.1)}$$

Where: N= size of population,

p = sample proportion of successes,

n = size of sample,

q = 1 – p,

z = the value of the standard variant at a given confidence,

e = acceptable error (the precision). Thus, N= 3742, p= 0.02, Z= 2.005 , e= 0.02

Therefore,

$$n = \frac{(1.645)^2 * (0.8)* (1-0.8)* (3742)}{[(0.05)^2 (3742-1)] + [(1.645)^2 (0.8)*(1-0.8)]} = 166$$

n = 166

Table 3-1. Selected Kebeles and Sampled Land Holder

Kebeles	Total Number of Private and Common Land Holders*				Sampled Land Holder **	
	Male Headed Land Holder	Female Headed Land Holder	Male and Female Headed Land Holder in Common	Total Land Holder	No.	In%
Yensa Sositu	237	267	1052	1556	69	41.58%
Yibab Chencher	225	245	511	981	44	26.22%
Wogelesa	165	222	741	1205	53	32.20%
Total	405	589	1842	3742	166	100%

Source: own sample data (2016).

Note : **Obtained from basic data of the woreda Land Administration and Use registration books.*
***Obtained based on the above sampling techniques*

3.3. Sources and method of data collection

The data used in the study were from primary and secondary sources. To obtain more primary data, structured questionnaire with close and open ended question were prepared. The structured questionnaires were translate to Amharic to allow the enumerator easily to understand and properly to handle the interviews.

The data from secondary sources included the productivity of crop land under different methods were obtained from *kebele* Agriculture offices. To obtain a primary data, a focus group discussion with key informants and a questionnaire survey from 166 sampled land holders were conducted. The key informants were elderly people, *kebele* leaders,

development agents, *kebele* land administration and use committees and experts. The general situation concerning land distribution and redistribution, land transaction and land fragmentation in the *woreda* were assessed based on information from the key informants using checklist (Appendix 6). Types of data collected using structured questionnaire include, household composition, religion, assets, livestock type and number, land use types, crops products, income, consumption, expenditure, farmland parcellization, labor force and oxen power and others (Appendix 5).

Enumerators were selected based on the experience they have and the ability to adapt and speak local language. Moreover, their knowledge of farming was also considered. The enumerator already took deep orientation as to how to undertake the whole process of interviewing, in addition to close supervision was made.

Single visit personal interview was undertaken using two types of questionnaires namely; household and parcel levels. The parcel level questionnaires were used to gather data on fragmentation parameters of each parcel. The household level was used to collect data on household characteristics. The questionnaires were tasted and adjusted as needed. The interview was conducted right after the harvest period. This helps the farmers to use their fresh memory of last production period. It is believed that data collection through frequent visiting is more accurate; however, saving of cost, time and personnel in single visit may be sufficient to justify the loss of accuracy, in some circumstances (Upton, 1979). The data collected in a single visit can serve for the purpose of an approximation of the real situation of the smallholder farmers in the both *Woreda*, as it is primary information obtained as much as possible with close contact to the farmers and observation of their practices and conditions.

3.4. Methods of data analysis

In this study, econometric models and descriptive statistics have been used to analyze the data with respect to a given problem or question under consideration. These models are discussed in general terms in this section. In this study SPSS, STATA and Microsoft Excel and other relevant software's were employed for data analysis.

3.4.1. Econometric model specification

The aim is to specify suitable economic models, i.e. to express the relationship between inputs and output in mathematical form, to empirically explore the real world production function. Among the various tasks in building the structural models of the production function, making decision whether to use single or multiple equation models, choice of relevant variables and functional forms (linear or non linear) are the important ones (Heady and Dillon, 1961 and Sankhayan, 1998;). Attempt has been made to choose relevant variables and functional forms in the analysis of the impact of land fragmentation on farm productivity and to estimate minimum farm landholding size.

Selection of relevant dependent and independent variables is one of the three important tasks in specification of an econometric model. One should make use of the past knowledge available through studies already published on the subject by other research workers making a list of the relevant variables (independent) affecting the production process, and the dependent variable (Sankhayan, 1998). Sankhayan again stated that the number of variables to be included in the model is generally determined by the nature of economic phenomenon under investigation and the purpose of the research. In this study, the relevant variables of interest were chosen based on the objective of the study.

The study of productivity of resources requires the use of production function. Production function is defined as the "concept in economic theory of production function based experiments with crops and livestock and firm productions based on cross-sectional and time series data"(Heady and Dillon, 1961). Product output is a function or is dependent on the input of resource services (Heady, 1952). Hence, the production function concept could be summarized as the set of all possible efficient relations between inputs and output given the current state of technological knowledge. In mathematical terms, the production function is assumed continuous and differentiable.

The choice of an appropriate functional form is also needed. “The functional form and the magnitude of coefficients will vary with soil, climate type and variety of crop or livestock. Hence a problem in each study is selection of functional form which appears or

is known to be consistent with phenomenon under investigation" (Heady, and Dillon, 1961) thus guides on appropriate functional forms may come from previous investigations. So after assessing previous studies on similar topics and taking into account the laws of the production process, power function or Cobb-Douglass and Linear production functions have been selected as appropriate functional forms. Linear production function and Cobb-Dauglas will be employed in the analysis of the impact of land fragmentation on farmland productivity and Profitability and to the minimum farm size, respectively.

After thorough study of previous studies conducted on productivity of resources, a single equation model has been adopted. Most production function research has been based on single equation approach because of its computational simplicity. The implicit form of the single equation model that has been used in this study is given as:

$$\mathbf{Y=f(X_i / X_{i+1}, X_{i+2}, \ldots, X_{i+n}, E)} \quad \text{(Eq.2)}$$

The model indicates that Y, the net farm income or land productivity of all crops produced and X's are factors of production and land fragmentation parameters. The perpendicular bar is used to indicate that all factors to the left of the bar are fixed in quantity. This symbolic representation of the production function does not explain the amount by which Y changes. To express quantitative relationships between variables, the production function must be expressed in functional form. The functional forms employed (Linear and Cobb Dauglas) with definition of variables and hypothesis set are discussed separately for the above two types of analyses (farm land productivity and net farm income and factors affecting) in the following sections.

3.4.1.1. Farmland productivity and their detrimental factors

In this section, some aspects of farmland productivity are discussed. The main interest of analysis in this part is to assess the impact of land fragmentation on farmland productivity. As it mentioned earlier, linear production function is selected and used for this purpose. The function is specified as follows:

$$Y_i = \beta_0 + \beta_1 ADAGP + \beta_2 LPI + \beta_3 OXPI + \beta_4 AGEHH + \beta_5 OKI + \beta_6 CUNP + \beta_7 AVARE \quad \text{(Eq.3)}$$

Where:

$\boldsymbol{Y_i}$ = Average land productivity (Qt./ha)

ADAGP = Average distance of cultivated parcels in walking distance (Minutes)

LPI = Labor power intensity (Man days/ ha)

OXPI = Oxen power intensity (Oxen days / ha)

AGEHH = Age of household head (years)

OKI = Operating capital intensity (ETB/ha)

CUNP = Cultivated number of parcels (No. of cultivated parcels)

AVAREp = Average area of parcels (Ha.)

$\boldsymbol{\beta_0}$ and $\boldsymbol{\beta_i}$ (i = 1,2,3…, 7) are parameters to be estimated. An extra term is added to represent the residual error but it is not included in the above equation assuming it is zero on average. The function is estimated using ordinary least square method (OLS).

2.4.1.1. Working hypothesis and definition of determinant variables in the model

Average land productivity (Qt./ ha):

Average land productivity is total crop produces in quintal divided by total cultivated land area. It is a dependent variable in the regression model.

Average distance of cultivated parcels from homestead (minutes)

It is an average distance of cultivated parcels from homestead, which is measured in waking time (minutes). It indicates average distance of parcels from homestead to cultivate land by a farm family. It is reviewed that distance wastes labor time by traveling between homestead and parcels and it becomes hindrance in transporting agricultural inputs from homestead to parcels. Therefore, this variable is expected to affect farmland productivity, negatively.

Labor power used intensity (man-days/ha)

It is total labor power used in crop production during the study period divided by total cultivated land area. It is an independent variable and expected to affect land productivity, positively.

Oxen power intensity (oxen-days/ ha)

It is total oxen power used in crop production during the study year divided by total cultivated land area. It is an independent variable and expected to affect land productivity, positively.

Age of household head (years)

On family farms the functions of management are provided by the farmer himself. In fact, he may be helped by other members of his family, by professional advisors or even by friends and neighbors. The farmer's age has an influence on management performance although the overall direction of the influence is not clear. As age of household head increases more experience can be obtained and we would expect the decision-making ability to improve. On the other hand, it is generally towards increasing leisure and reducing work (Upton, 1979).

In this study, age is considered as proxy of managerial ability. In this case, an increment in age is expected to increase in farmland productivity positively because more experience can be gained with the increasing age.

Operating capital intensity (ETB/ha)

It is amount of variable cost used in crop production during the study period. It is sum of value of seed, fertilizer, herbicide and cost of hired laborer divided by total cultivated land area. It is an independent variable and expected to affect land productivity positively.

Number of cultivated parcels hold

Number of cultivated parcels holding is an independent variable indicating number of cultivated parcels holding privately. The higher the number of parcels the more problematic they are in management (to undertake close supervision), protecting parcels from pest and theft (MOA. 1989). Therefore, it is expected to affect farmland productivity, negatively.

Average area of parcels hold (ha.)

It is total area of cultivated parcels divided by number of parcels. It is expected to influence land productivity negatively because small sized parcels hinders farm operations like field preparation and planting with oxen (MOA, 1989).

Table 3-2. Hypothesis sings of the variables that affect the dependent variable in the model

Explanatory variables	Expected sign
Average Distance of Cultivated Parcels from Homestead (minutes)	(-Ve)
Labor Power Used Intensity (man-days/ha)	(+Ve)
Oxen Power Intensity (oxen-days/ ha)	(+Ve)
Age of Household Head (years)	(+Ve)
Operating Capital Intensity (ETB/ha)	(+Ve)
Number of Cultivated Parcels Owned	(-Ve)
Average area of parcels holding (ha)	(-Ve)

Source: Own model assumption (2016).

2.4.1.2. Net farm income and their detrimental factors

In this section, factors affecting net farm income are analyzed and minimum farm size is estimated to feed and sustain their family. The Cobb-Douglass production function is selected and employed to estimate minimum farm size and used to analyze the effect of land fragmentation on net farm income of farm family. The Cobb-Douglass production function was fitted to the cross-sectional data collected from sample households.

This function is specified as shown below:

$$Y_i = \beta_o Cula^{\beta 1} Oxpcrfa^{\beta 2} AgHH^{\beta 3} Lpcrfa^{\beta 4} OpK^{\beta 5} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Eq.4)}$$

Where:

Y_i = Net farm income from crop farming (ETB)

Cula = cultivated land area (hectare)

Oxpcrfa= oxen power used crop farming (oxen-days)

AgHH = age of household head (year)

Lpcrfa=labor power used for crop farming (man-days)

OpK = operating capital (ETB)

β_o and β_i (i = 1,2,3,4 and 5) are parameters to be estimated. An extra term is added to represent the residual error but it is not included in the above equation assuming it is zero on average. The power function (equation 4) is transformed into logarithmic form as:

$$\ln Y_i = \ln \beta_0 + \beta_1 \ln \text{Cula} + \beta_2 \ln \text{Oxpcrfa} + \beta_3 \ln X_3\ \text{AgHH} + \beta_4 \ln \text{Lpcrfa} + \beta_5 \ln \text{OpK} \quad \text{(Eq.5)}$$

The ordinary least square method (OLS) is used to estimate the function. Net farm income from farming (crop farming) is used as dependent variable and the estimated equation (net farm income equation) can be solved to estimate minimum farm size.

2.4.1.3. Working hypothesis and definition of determinant variables in the model

Net farm income (ETB)

The farmers in the study area are involved in the production of different crops such as sorghum, *teff*, millet, niger seed, bean, soybean etc. For the purpose of the study the gross income obtained from all crops grown (including main products plus by products) minus variable cost (seed, fertilizer, herbicide and labor cost for hired labor) and land tax (fixed cost) is considered as net farm income. The gross income is the value of output (main products plus by products) of all crops evaluated at average prices obtain from farmers during interview. Whereas, the farm-produce seeds will be evaluated at the prices prevailing in the village (local market) at the time of sowing and the value of the purchase seeds will have been taken at the actual price paid by the farmer in calculating seed cost. Since fixed capital is assumed to play minor role in smallholders farming, gross marginal return minus land tax is consider as net farm income in this case. In many parts of Africa farmers do not incur fixed costs they pay no rent, no wages to their families who make up their regular labor force they have hardly any building and equipment and do not borrow much capital. Practically all-African farmers' costs are variable (Upton, 1979). Net farm income is included in the model as dependent variable.

Area of cultivated land (hectare)

Land is the main factor of production for small holder farmers. Hence, area of cultivated land covered by different crops during the study period is included in the production function as an independent variable. This variable is expected to affect net farm income, positively.

Oxen power used (oxen-days)

In absence of mechanization in agriculture like Ethiopia, oxen power is crucial in ploughing, and planting of croplands. Hence, oxen power is considered as factor of production in this study and is used as an independent variable in production function. Oxen power has been defined in terms of eight hours a day worked by a pair of oxen needed to operate. It has been defined this way because the sample households use oxen power for eight hours a day on average. This variable is expected to affect net farm income positively. Because more utilization of the input means that ploughing and planting could take place properly and timely.

Age of household heads (years)

On family farms the functions of management are provided by the farmer himself. In fact, he may be helped by other members of his family, by professional advisors or even by friends and neighbors. The farmer's age has an influence on management performance although the overall direction of the influence is not clear. As age of household head increases more experience can be obtained and we would expect the decision making ability to improve. On the other hand, it is generally towards increasing leisure and reducing work (Upton, 1979). In this study, age is considered as proxy of managerial ability, an increment in age is expected to increase net farm income because more experience can be obtained with the increasing age.

Labor power used (man-days)

A family labor force is the basic unit of source of labor in the study area. In measuring the labor input, two factors should be born in mind. First, what is required for estimation purposes is a measure of the labor input actually used in deriving the given output, not a

measure of total labor available during the production period. In the study area, male, female, and child labor are involved in different activities of crops production process. It has been assumed that there is difference in strength and skills among the types of labor units mentioned earlier. With this assumption, the family labor were converted into man-days of eight hours on average to have standardized unit of measuring labor unit employ as independent variable in production process during the study period. This factor is expected to affect net farm income positively.

Operating capital (ETB)

In this study, value of seed, herbicide, fertilizer and hired labor cost were used as factor of production concerning capital. Therefore, operating capital is an independent variable in production function and its variation is expect to affect net farm income positively.

Table 3-3. Hypothesis sings of the variables that affect the dependent variable in the model

Explanatory variables	Expected sign
Area of cultivated land (hectare)	(+Ve)
Oxen power used (oxen-days)	(+Ve)
Age of household heads (years)	(+Ve)
Labor power used (man-days)	(+Ve)
Operating capital (ETB)	(+Ve)

Source: Own model assumption (2016).

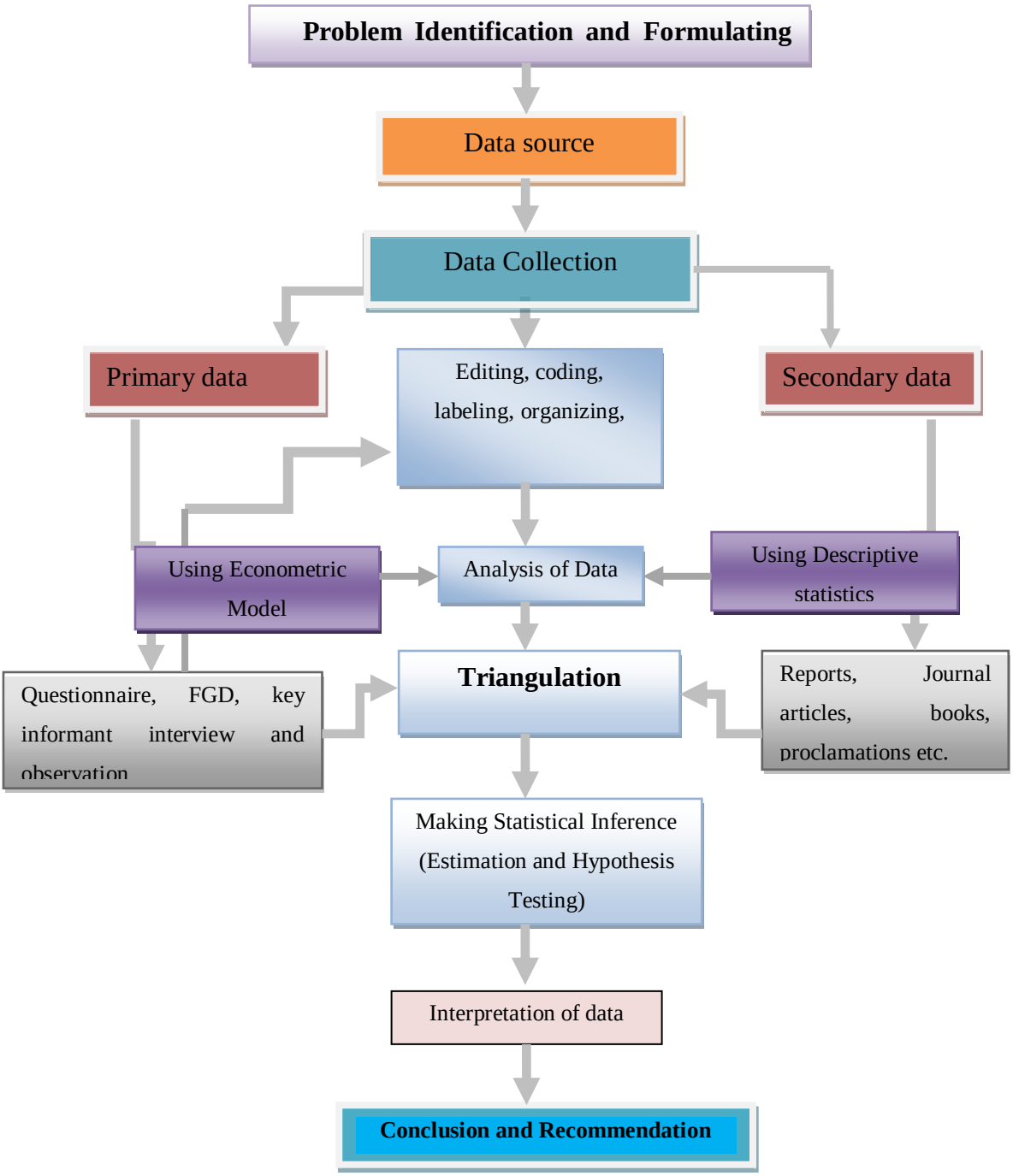

Figure 2. Research conceptual framework.

CHAPTER FOUR: RESULT AND DISCUSSION

This chapter deals with the analysis and interpretation of major findings of the study on the effect of fragmented agricultural land on the productivity and profitability on smallholder farms in *Bahir Dar Zuria Woreda*.

4.1. Socio-economic features of the sample farm households

The Demographic characteristics of sample households such as sex, household size, age and educational status plays a great role in mixed agricultural practice of smallholder farmers in the study area. The total households interviewed in the study were 166, out of these interviewed sample households, 30.12% of them were female headed and the remaining 69.88% were male headed households (See table 4-1).

The average family size of the sample households is 2 with a range from 0 to 10 persons and a standard deviation of 3. About 28.92 % of them have less than four household members and 28.92 % of them have a family members of 1 up to 3, while about one third (34.34%) of the sampled respondents have no family members (See table 4-1).

Education upgrades the ability and changes the attitude of human beings. Educated farmers are expected to adopt technologies and are expected to have better managerial skill. An attempt has been made to assess the educational status of the sample households who had been formally educated The role of education is obvious in affecting household income, adoption of technologies, demographic, health and as a whole the socio-economic status of the family. The survey result shows that 43.98% are not attend education, 31.93% literate, 13.25 % of that they have attended 1-6 grade, while the remaining 10.84 percent have attended from grades 7-12 (See table 4-1). There is high proportion of illiteracy among the population which can be an impediment for the overall development in general and in particular delivery of extension services, introduction of new technical packages which can have a negative impact upon the productivity of the agricultural sector.

Table 4-1. Demographic characteristics of sampled respondents

Variables		Sample kebeles							
		Yensa Sositu		Yibab Chencher		Wogelsa		Total	
		No.	%	No.	%	No.	%	No.	%
Number of sample households	Male	51	73.91	34	77.27	31	58.49	116	69.88
	Female	18	26.09	10	22.73	22	41.51	50	30.12
	Total	**69**	**100.00**	**44**	**100.00**	**53**	**100.00**	**166**	**100.00**
Household family size	Has no Family	19	27.54	23	52.27	15	28.30	57	34.34
	1-3 Family size	21	30.43	8	18.18	19	35.85	48	28.92
	4-6 Family size	25	36.23	10	22.73	11	20.75	46	27.71
	7-9 Family Size	3	4.35	3	6.82	8	15.09	14	8.43
	> 9 Family size	1	1.45	0	0.00	0	0.00	1	0.60
	Total	**69**	**100.00**	**44**	**100.00**	**53**	**100.00**	**166**	**100.00**
	Max.	**10**		**9**		**8**		**10**	
	Min.	**0**		**0**		**0**		**0**	
	Mean	**3**		**3**		**1**		**2**	
	SD	**2**		**3**		**2**		**3**	
Age	22-32	6	8.70	4	9.09	19	35.85	29	17.47
	33-43	19	27.54	10	22.73	18	33.96	47	28.31
	44-54	22	31.88	17	38.64	10	18.87	49	29.52
	55-65	21	30.43	11	25.00	2	3.77	34	20.48
	Above 65	1	1.45	2	4.55	4	7.55	7	4.22
	Total	**69**	**100.00**	**44**	**100.00**	**53**	**100.00**	**166**	**100.00**
	Max.	**84**		**70**		**74**		**84**	
	Min	**22**		**28**		**24**		**22**	
	Mean	**47**		**47**		**39**		**44.68**	
	SD	**14**		**10**		**12**		**12.87**	
Educational status	Didn't attend	29	42.03	19	43.18	25	47.17	73	43.98
	"Literacy"	25	36.23	13	29.55	15	28.30	53	31.93
	Grade 1-6	7	10.14	7	15.91	8	15.09	22	13.25
	Grade 7-8	4	5.80	2	4.55	2	3.77	8	4.82
	Grade 9-12	3	4.35	1	2.27	2	3.77	6	3.61
	Grade 12 Completed	1	1.45	2	4.55	1	1.89	4	2.41
	Total	**69**	**100.00**	**44**	**100.00**	**53**	**100.00**	**166**	**100.00**

Source: Own Survey Result (2016).

Diminution of farmland size and parcellization are phenomenon of long period. Age of household is important to study such a long period phenomenon, more specifically to study the change in farm size and extent of parcellization, sources of land, causes of land fragmentation. Hence, age of heads of sample households was analyzed in this study. The Age of household is important to study for such a long period phenomenon, more

specifically to study the change in farm size and extent of parcellization, sources of land and causes of land fragmentation. Hence, age of heads of sample households was analyzed in this study. Table 4-1 summarizes the age classification of sample household heads. Age of household heads ranges between 84 and 22. the study result shows that an average age of the household heads is 44.68 years with a standard deviation of 12.87 (See table 4-1).

4.2. Labor availability

Labor is among the basic factor inputs and family labor is the main source of labor for farming activities of smallholders. The supply of labor is area of focus in this study because the impact of distance between parcels and homestead and also the number of parcels hold on farm productivity depends on the amount of labor availability. A distinction has to be made between the amount of labor supply at farm family and the amount actually used for farming activities. The size of family labor force depends upon the age at which children are expected to help on the farm or in other productive activity, and whether women and old men are included. Based on the study conducted, there is a sort of labor division in the study area. Ploughing and planting are types of activities belonging to male whereas food preparation and childcare are left to female. In most of other cases than these, female and male work together. Children participate in different farm and non-farm activities.

In this specific study, labor availability of the sample households was computed based on man-equivalents[1] to examine the effect of variation in labor availability among the households. Because of differences in capacity and ability of performing a given activity between sex and age group labor force was standardized to a similar unit (man equivalent). The conversion factor used to standardize labor force is given in appendix 1. The study result shows that, average labor force available per sample household is 2.26 with a standard deviation of 1.92. According to the study, the total labor force available for farming activities in man equivalent is 39.76% (66 HH), 36.14% (60 HH), 18.07% (30 HH)

[1] Man equivalent (ME): is the family labor will converted into man-days of eight hours on average to have standardized unit of measuring labor unit employ. Male, female, and child labor at different age group will involve in different activities, so to estimate the labor force participations standardized unit of ME should be computed .

and the rest 6.02% is up to 1.5, 1.51-3.00, 3.01-5.00 and above 5.01 man equivalent respectively (See table 4-2). The variation in labour force availability among the sample household is 36.6%.

Table 4-2. Distribution of Sample Household Heads by Size of Labor in Man-equivalents

No.	Man-equivalent group	Yensa Sositu		Yibab Chencher		Wogelsa		Total	
		No.	%	No.	%	No.	%	No.	%
1	Up to 1.5	23	33.33	22	50.00	21	39.62	66	39.76
2	1.51-3.00	25	36.23	15	34.09	20	37.74	60	36.14
3	3.01-5.00	20	28.99	4	9.09	6	11.32	30	18.07
4	5.01-7.00	1	1.45	0	0.00	5	9.43	6	3.61
5	>7	0	0.00	3	6.82	1	1.89	4	2.41
Total		69	100	44	100	53	100	166	100

Source: Own Survey Result (2016).

4.3. Farm characteristics

4.3.1. Farm size and age group

One of the standard criteria used in land redistribution among the farm households during land reform of 1975 was family size. During that time, equity was a pillar motive. According to Dessalegn (1994), this criterion aggravated population growth, which caused subdivision and diminution of farmland.

An attempt was made to examine the status of farm size of farmers of *Bahir Dar Zuria Woreda*. According to the group discussion made, newly married households and other landless people have no chance of obtaining land because of the prohibition of land distribution and redistribution and shortage of farmland since 1997. These farmers usually share land with their parents and relatives during marriage and obtain land use access through land transaction systems (sharecropping and renting).

The study result shows that the average farm size of the sample households is 1.435 hectares (See table 4-3). There is considerable variation in land holding by different age groups among the sample households with a coefficient of variation of 68.5%. The result of the study indicates that there is inequality in holdings among farm households despite the free or unrestricted objectives of the 1975 land reform. Average farmland holding is also calculated for different age groups. The highest average farmland holding (1.82 hectares) is reported by households of age group above 65 years, followed by age group of 44-54 years with average holdings of 1.49 hectares. The younger farmers and the older farmers have lesser land holding than the middle aged (Table 4-3).

Table 4-3. Average land holding by age group of household heads

Age group (years)	Average land holding (hectare)							
	Yensa Sositu		Yibab Chencher		Wogelsa		Total	
	Count	Mean land holding in ha.	Count	Mean land holding in ha.	Count	Mean land holding in ha.	Count	Mean land holding in ha.
22-32	6	1.09	4	0.93	19	2.33	29	**1.45**
33-43	19	1.16	10	0.80	18	0.88	47	**0.95**
44-54	22	1.66	17	0.97	10	1.85	49	**1.49**
55-65	21	1.74	11	1.37	2	1.28	34	**1.46**
Above 65	1	1.5	2	2.29	4	1.67	7	**1.82**
Total	**69**	**1.43**	**44**	**1.272**	**53**	**1.602**	**166**	**1.435**

Source: Own Survey Result (2016).

4.3.2. Number of parcels and family size

The number of parcels holding by all sample households ranged from 1 to 14 with an average and standard deviation of 4.38 parcels and 3.25 parcels, respectively. The maximum and minimum number of parcels holding privately is 14 and 1 respectively as depicted in the table 4-4. There is a positive and statistically significant correlation between family size and farmland holding (at a significance level of **0.05** and with a correlation coefficient of **0.82).** Therefore, number of parcel increases, as farm family size increases due to gift and inheritance.

Table 4-4. Distribution of sample household family size by number of parcels owned

Family size	Yensa Sositu		Wogelsa		Yibab Chencher		Total	
	No.	No. of parcels	No.	No. of parcels	No.	No. of parcels	No.	No. of parcels
Has no Family	23	27	21	46	22	21	66	**94**
1-3 Family size	25	72	20	54	15	33	60	**159**
4-6 Family size	20	101	6	66	4	54	30	**221**
7-9 Family Size	1	27	5	24	0	39	6	**90**
> 9 Family size	0	6	1	0	3	0	4	**6**
Total	**69**	**233**	**53**	**190**	**44**	**147**	**166**	**570**

Source: Own Survey Result (2016).

4.3.3. Sub division of farm land

Farm size subdivision and parcellization have continuously happened in the study area. This is because of population growth, land redistribution, inheritance and gifts of land by parents to their children. According to the group discussion conducted with land redistribution had been implemented since 1975 until the declaration of the mixed economic policy in 1990. The redistribution of land had been based on family size, soil type and quality of the farmland from different locations, which diversified crop farming. Based on the group discussion made with land fragmentation has important effects in reducing risks through the spatial diversification of activities and to have access to different types of land.

According to group discussion, inheritance of land has also been one cause of farm subdivision and partition. In the study area, land can be transferred through inheritance and gift to children's and other family members. Female land holders without husband can also inherit land by her turn to sons. In addition to this, it was argued by the discussions that gift of farmland to sons upon marriage has been the cause of subdivision and parcellization.

The total land that the landholders have given to his family members is 29.40 hectares in different period. The maximum and minimum land transferred through inheritance are 3.5 hectare and 0.7 hectare respectively. On the other hand, gift is one of the means to dispose land. So, the result of the study shows that a maximum 2.45 hectare and a minimum of 0.7 hectare land transferred by means of gift (See table 4-5).

In different times of the period since 1975, the farmer hold a maximum of 14 parcels of land with an area of 4.9 hectares and the minimum is 1 parcel with an area of 0.16 hectare as shown in table 4-5.

Table 4-5. Sub division of farm land in different time periods

No. of Parcel owned	Through Land Redistribution				Means of disposition					
	Year obtained				Inheritance			Gift		
	1975		1989							
	Count	Size (ha.)	Count	Size (ha.)	Count	Size (ha.)	To whom dispose (For Sons)	Count	Size (ha.)	To whom disposed (For Sons)
1	44	15.4	38	13.30	10	3.5	19	7	2.45	7
2	37	12.95	42	14.70	6	2.1	15	3	1.05	3
3	43	15.05	46	16.10	8	2.8	14	5	1.75	5
4	49	17.15	50	17.50	4	1.4	13	2	0.7	2
5	37	12.95	65	22.75	7	2.45	17	2	0.7	2
6	26	9.1	55	19.25	2	0.7	6	3	1.05	3
7	6	2.1	69	24.15	4	1.4	21	3	1.05	3
8	40	14	64	22.40	3	1.05	15	3	1.05	3
>8	78	27.3	141	49.35	7	2.45	23	5	1.75	4
	360	**126**	**570**	**199.50**	**51**	**17.85**	**143**	**33**	**11.55**	**32**

Source: Own Survey Result (2016).

Changes in farm size and number of parcels of the sample households had been occurred due to land redistribution and land given to children's and other family members. The sample households obtained 570 parcels of farmland with an area of 199.50 hectares during land redistribution. On the contrary, 84 parcels of the cultivated land area of 29.40 hectares

were taken from the sample households by their sons or family members through inheritance and gift. In general, there is an average increment of number of parcels by 1.55 and diminution of size of farmland with an average area of 0.54 hectare since 1975 (See table 4-5).

4.3. Size of parcels

Diminution of farmland due to subdivision causes diminution of size of parcels for farmland. An attempt has been made to analyze the extent of diminution of parcels and problems related. The correlation test made between the farmland holding size and average size of parcels per farm indicates that there is a presence of a positive relationship between the two (Pearson correlation coefficient of 0.93 with significance level of less than 0.01). As farm landholding increases, with the same magnitude the size of parcels per farm increases. The mean area of parcel (total area of parcels divided by the total number of parcels) is 60 hectare with a standard deviation of 1.15 (See table 4-6).

Based on the group discussion made with key informants regarding the problem of diminution of size of parcels, it is understood that many parcels with small size reduces area of farmland because an area of farmland is left as a border between parcels after division. Besides, many parcels with small size that belong to many households also hinder undertaking of soil and water conservation activities which needs consensus of farmers in a given watershed to be carried out.

Table 4-6. Number of parcels, land size and total area per household.

Size (ha)	Number of Parcel	% of Parcel	Total Area (ha) per HH
0.01-0.25	8	1.40	0.16
0.26-0.50	47	8.25	0.36
0.51-1.00	60	10.53	0.8
1.01-1.50	73	12.81	1.26
1.51-2.00	122	21.40	3.41
2.01-2.5	81	14.21	2.19
2.51-3.00	112	19.65	2.61
>3	67	11.75	2.36
Total	**570**	**100.00**	

Source: Own Survey Result (2016).

4.4. Distance of Parcels from Homestead

Distance is one of the important factors in the analysis of impacts of land fragmentation on farm productivity. As distance of a parcel from homestead increases the return of that parcel is expected to decrease (Bentley, H.M. 1987). In accordance with the objective of the study, distance of parcels form homestead was measured by the time taken to walk from homestead to parcels owned (minutes) by adult person was considered to analyze its impact on farm productivity. Based on the result of the sample survey, about 48.95% of parcels are found near homestead at distance less than 30 minutes. Number of parcels decreases as distances from homestead increases (See table 4-7). Average distance of parcels holding by private land holder were used to assess the impact of distance on farm productivity.

Table 4-7. Distance of parcels from homestead in minutes.

Distance (minutes)	Number of parcels	% of parcels	Total area (ha) per hh
< 15	119	20.88	2.27
15 - 30	160	28.07	1.68
31-45	171	30.00	0.81
46-60	95	16.67	0.74
>60	25	4.39	0.26
Total	**570**	**100.00**	

Source: Own Survey Result (2016).

In rare cases, farmers decide on to exchange their parcels that are located at far distance. According to the study result, a single sample household exchanged a parcel that had been located far from his homestead. The above analyzed distance of parcels includes both types of land use, area under cultivation and fallow. However, it is believed that only the distance of cultivated parcels can affect farm productivity and their distance from homestead was analyzed separately. Accordingly, average distance of operated parcels by each household is about 25 minutes away from homestead with a standard deviation of 12.81 minutes, this indicates that there is a high parcel distance variability in minutes from homestead to farm. The number of parcels decreases as distance from homestead increases.

4.5. Crops grown and yield

Crops are the source of food and cash to the farming families. The study area is located in medium altitude range with good rainfall and diversified soil types, which are favorable for growing different crops. The result of the sample survey shows that cereals like Maize, Teff, and Millet, pulses like chickpea, Soyabean and Bean. Oil crops like Niger seed and vegetables like potato and Pepper grow in the study area. Maize, Millet and Teff are mostly grown cereal crops in the study area.

Major crops grown in the study area during 2015/16 production year were Maize, Millet and Teff and these crops covered 0.62, 0.46 and 0.33 hectare on average per household. This covers 83.5 percent of total area under all crops. There are other crops (pulses oil crops and vegetables) produced as minor ones, which covered 16.5 percent of average cultivated area (See table 4-8).

Table 4-8. Cultivated land and yields of crops grown by sample households in 2015/16 production year.

Crop type	Average area (ha)	% of area	Total Output (qt)	Average Output (Qt./ha)
Maize	0.62	36.72	1,798.25	14.27
Teff	0.33	19.54	834.00	7.07
Millet	0.46	27.24	1,359.75	11.82
Niger seed	0.25	14.81	1.50	0.01
Check peas	0.011	0.65	25.50	0.15
Soyabean	0.003	0.18	11.00	0.07
Bean	0.003	0.18	7.50	0.05
Potato	0.01	0.59	11.00	0.07
Paper	0.0015	0.09	3.50	0.02
Total	**1.6885**	**100.00**	**4,746.50**	**32.66**

Source: Own Survey Result (2016).

4.6. Livestock system

Livestock sector plays key role in the livelihood of farmers of highland areas where farming is mixed. Livestock sector has diverse importance to the farming community of the area. It is a source of income, transportation means, draught power, and serves as accumulation of capital. Besides, their dung is used as fuel and as fertility restoring means when applied on

the field.

The types of livestock kept in the area are cattle, sheep, goats and equines. The sample survey result shows that the average tropical livestock unit per sample household was 4.62 per household with a standard deviation of 3.24. The range of livestock holding size in terms of tropical livestock unit (TLU) [2] regard is from 0 to 21.2 and the variation of livestock holding size is high with a coefficient of variation of 70.24%. Table 4-12 shows that the largest proportion of sample households (37.95%) owned number of livestock ranging from 4.01 to 8.00 TLU. On the other hand, about 27.71% sample households did not possess livestock totally (See table 4-9). The major sources of feed are free grazing on private pastureland, aftermath grazing and natural grass from cut and carry system. The study area is known by traditional and improved practice of livestock rearing system. Much has been done in this sector to improve local breed by crossing with exotic breeds, introducing and disseminating improved feed varieties and by facilitating marketing of animal products by *woreda* office of agriculture with *zonal* agriculture departments and agricultural multi-purpose cooperatives. Nevertheless, according to (WoA, 2016) the sector was still highly constrained with animal mainly caused due to shortage or lack of pastureland attributed to subdivision of grazing land.

Table 4-9. Distribution of sample household heads by possession of livestock

Livestock size (TLU)	Household	
	No	Percent
No possess	46	27.71
Up to 1.00	11	6.63
1.01-4.00	31	18.67
4.01-8.00	63	37.95
8.01-12.00	13	7.83
>12	2	1.21
Total	166	100.00

Source: Own Survey Result (2016)

Oxen power is one of the important factors of production in oxen drawn farming in the *woreda*. Accordingly, oxen power inputs used by sample households were studied. Oxen

[2] Tropical Livestock Unit (TLU): is the total number of livestock holding of the household measured in livestock unit.

power input (oxen-days) was estimated at 8 hours work by a pair of oxen in a day. Average oxen power used by the sample household for farming activity is 21.43 oxen days in 2015/2016 with a standard deviation of 35.5. The result of the study is indicated that there is a high variability of oxen power used by a landholder for farming activity.

4.7. Farm households' income

Farmers of the study area obtained income from different sources namely crop farming, livestock sector and off farm activities. The study result shows that the total average income from all sources is 221,361.67 ETB in 2015/16 production year. The average gross income from crop and livestock farming are 191,678.09 and 29,683.58 ETB, respectively. The average incomes from crop farming covered 81.85% and that of livestock sector covered 14.22 %. The rest 3.92% of the total household income is from off-farm activities (See table 4-10).

The sample survey result shows that the lowest average income obtained from livestock and crop farming are 2,001.26 and 98.28 ETB, respectively and obtained by farmers having the smallest area of land, which is less than 0.34 hectare. Whereas the highest average farm income per cultivated land from livestock and crop farming are 8,049.08 and 59,646.58 ETB respectively, and income derived by farmers having the largest area of land, which is above 3 hectares. Moreover, the study result shows that farm income increases with the increasing size of farm (See table 4-10). The yield of each major crop is found to be good due to the application of organic fertilizer and improved seeds. As a result, the aggregate average land productivity of 17,199.00 ETB per hectare is generated by the sample respondents. The contribution of each source to the average income of the household is needed to examine the extent of subdivision in view of minimum farm size determination (See table 4-10).

Table 4-10. Income from crop and livestock products.

Cultivated Land (ha)	Household heads in the interval of area of land	Average income (ETB)	
		Income from Crop farming (ETB)	Income from livestock (ETB)
0.01-0.25	6	2,001.26	98.25
0.26-0.50	34	2,436.49	2,021.75
0.51-1.00	32	15,479.22	4,958.78
1.01-1.50	26	19,065.39	2,425.54
1.51-2.00	23	26,455.80	2,310.35
2.01-2.5	14	31,577.87	4,618.03
2.51-3.00	20	35,015.48	5,201.80
>3	11	59,646.58	8,049.08
Total	**166**	**191,678.09**	**29,683.58**

Source: Own Survey Result (2016).

4.8. Income from off farm activities

Smallholder farmer in the study area have additional activities to accomplish to generate additional income. The study result shows that there are many off farm activities namely; petty trade, brewery, and labor on others farm. The activities are undertaken by spouses or by members of the households.

Off farm activities are sources of employment and income and contributed substantially to the income of sample households during the study year. On table 4-11, the average income generating different activities during the study year is 24,994.47 ETB. Petty-trade, brewery, and labor on other farm were the first, the second and third major sources of income in terms of the amount of average income generated and number of households involved. During the study period, 4,6 and 11 households are involved in brewery, petty trade and labor on other farm generated 3,387.50, 20,213.33 and 1,393.64 ETB from the respective activities. Average income generated from off farm activities with respect to other sources of income contributed a 3.92 percent (932.92 ETB) per sampled during the study year and have a paramount importance in the livelihood of the farm households of the study area.

Table 4-11. Income from Off-farm Activities.

Source of Income	No. of household engaged	Total off-farm income obtained (ETB)	Average off-farm income (ETB) per households
Brewery	4	13,550.00	3,387.50
Petty trade	6	121,280.00	20,213.33
Labor on others farm	11	15,330.00	1,393.64
Total	**21**	**121,280.00**	**24,994.47**

Source: Own Survey Result (2016).

4.9. Gender and access to productive resources

Females account a substantial proportion of the population of rural areas. They contribute in farming activities in decision-making and in supplying labor. The access of women especially to land rights is through their role as daughter, sister or wife, i.e., by birth or by marriage. But it is important to mention that female headed households have been given land rights in the same way that it is given the male headed households since 1975. However, as stated by Dejene, A. (1994) let alone female in general even female headed households have limited access to productive resources compared to male headed households. Moreover, Dejene, A. (1992), cited in Dejene, A. (1994) mentioned that in Ethiopian women play limited role in agricultural production as compared to their counterparts in many countries in sub Saharan African countries.

In this study, analysis of the difference in resource utilization and allocation by female and male landholder is a paramount importance to understand their differences in terms of productive resource possession and the return derived from them. In doing so, independent sample t-test was conducted in identifying the mean differences in resource possession and their returns between male and female headed households of the study area.

Accordingly, it has been found that there are statistically significant differences in resource possession and allocation between male and female landholders. The independent sample t-test result shows that average labour power (man day), livestock possess (TLU), number of oxen, farm land size (ha.), number of parcel holding, average size of parcels (ha.), number of

oxen possessed, net farm, off farm and livestock income obtained by female headed sample households are significantly lesser than that of male headed households at a significance level of 1 and 5 percent. As a result, female headed household used lesser oxen power and labor input and generated lesser income from crop farming. Average net income obtained by female and male headed is 13,951.92 ETB and 18,130.39 ETB, respectively (See table 4-12). On the other hand, there is no statically significance difference in man equivalent and average distance of parcels from homestead between groups (See table 4-12).

Table 4-12. Summary of access to resources for sampled households and independent sample T-test for the 2015/16 production year.

Variables	Mean Value		Std. Deviation		Levene's Test for Equality of Variances		t-test for Equality of Means		
	Male	Female	Male	Female	F	Sig.	t	df	Sig. (2-tailed)
Adult equivalent	3.03	2.30	2.27	2.35	2.527	0.114	**1.695*(**)**	**164**	**0.092**
Man equivalent	2.41	1.92	1.75	2.21	0.063	0.803	1.350	164	0.179
Labor power used (man-days)	67.56	55.05	74.47	64.95	2.020	0.158	**0.926 ****	**164**	**0.356**
Oxen power (oxen days)	28.97	7.59	43.71	12.76	12.087	0.001	**3.066****	**164**	**0.003**
Farm land size (ha)	1.44	1.18	1.02	0.91	2.023	0.157	**1.413****	**164**	**0.160**
Average distance of parcels (minutes)	24.91	25.80	13.253	11.839	1.103	0.295	-0.408	164	0.684
Number of parcels holding	4.76	3.56	3.36	2.85	3.689	0.057	**1.984****	**164**	**0.049**
Average size of parcels (ha)	1.33	1.17	0.93	0.88	1.222	0.271	**0.906 ****	**164**	**0.367**
Livestock possessed (TLU)	5.29	3.16	3.16	2.97	0.570	0.452	**3.645****	**164**	**0.000**
Number of Oxen	2.58	1.41	1.46	1.48	0.796	0.374	**4.223****	**164**	**0.000**
Net farm income (ETB) obtained	18,130.39	13,951.92	19,418.94	10,311.05	6.49	0.01	**1.29****	**164**	**0.20**
Off farm income (ETB) obtained	1,237.19	341.34	6,049.96	1,307.21	3.50	0.06	**0.94****	**164**	**0.35**
Livestock income (ETB) obtained	4,439.88	2,921.12	6,268.92	4,955.66	2.01	0.16	1.37	164	0.17

Source: Own computation (2016).

***, ** and * Significant at probability level of 1, 5 and 10 percent respectively.

4.10. Consumption pattern

4.10.1. Food consumption pattern

The consumption pattern of a given farming community depends on cropping pattern, which in turn is attributed to the agro-ecologic condition of the area. An attempt has been made to analyze the relationship between cropping pattern and consumption pattern of the farmers of the study area. Based on the sample survey made, the consumption pattern of the study area was identified to estimate the proportion of the contribution of each crop to the minimum energy requirement assumed 2100 kcal per adult equivalent [3] per day so as to estimate minimum farm size. Minimum farm size determination has to consider food habit and type of food available and area needed to produce crops. The households consumed different crops and livestock products in different proportions.

The average amount of each crops and livestock products consumed per adult equivalent was calculated and converted to energy equivalents (kcal) to analyze contribution of each food item consumed by adult equivalent per day during the study year. The contribution of each crops to the total energy consumed is used to estimate proportional share of each in 2100 kcal (minimum energy requirement) used to estimate minimum food expenditure. According to the study, average food expenditure is estimated to be 2,651.36 ETB. All crops consumed during the study year had been produced by the sample households. The consumption pattern shows that cereals covered 83.5 percent of the total expenditure, which was the highest proportion. Crops and livestock products consumed in the study area during the study year are shown in table 4-13.

[3] Adult equivalent: is defined as the ratio of an individual's age compared to the total labor output of a 15 and above year old.

Table 4-13. Proportion of food Items Consumed per adult equivalent for 2015/16 production year.

Food Item	Quantity per Adult equivalent` (Qt/AE)	Expenditure (ETB/AE/year)	Share in %
Maize	0.174	62.68	2.36
Barley	0.98	324.8	12.25
Wheat	0.35	191.88	7.24
Teff	0.85	237.64	8.96
Peas	0.42	127.92	4.82
Potato	0.15	122.64	4.63
Onion	0.1	14.6	0.55
Edible oil	0.65	480	18.10
Milk	8.53	300	11.31
Butter	0.05	360	13.58
Beef	0.04	429.2	16.19
Total		2651.36	100.00

Source: Own computation (2016)

4.10.2. Non food items expenditure by sample households

According to Upton (1979), there is no pure subsistence farming and farmers sell farm products whether surplus or not and buy manufactured items. So, in estimation of minimum farm size estimation of expenditure on non-food items is required in order to estimate minimum cash requirements. Though, families' expenditures figures do not tell much about the living condition of the respondents, i.e. they do not reflect whether their living conditions are above or below a subsistence requirement could be deducted only from the expenses. Accordingly, an attempt was made to collect data on non-food expenditure of sample households. The items were beverages, clothing and foot wear, medication and education, furniture, transportation and miscellaneous items. Average expenditure is calculated from these items for an adult equivalent per year (See table 4-14).

Table 4 -14. Average non food items expenditure by adult equivalent in 2015/16 production year.

Items	Amount of expenditure (ETB)	Share in %
Beverages	275	15.28
Clothing and foot wear	450	25
Medication and education	350	19.44
Furniture	300	16.67
Transport	250	13.89
Miscellaneous	175	9.72
Total	**1,800.00**	**100**

Source: Own computation (2016).

Among the items, clothing and footwear took considerable share of 25 percent followed by Medication and education, furniture beverage, transport beverages of total non-food and other miscellaneous expense retrospectively. The average non-food expenditure per adult equivalent was 1,800.00 ETB in 2016 and used as minimum cash requirement to estimate subsistence requirement.

4.11. Minimum food and cash requirement

Smallholder farm lands are different from region to region in terms of productivity, the income earned from similar farm sizes differs accordingly. The minimum income approach is a popular approach used to determine minimum farm size and the approach recognizes the difference between qualities of farmlands. The minimum income is the amount of income needed for minimum food and cash requirements. The aim of subsistence farmers is to satisfy the food needs of and their families. Moreover, they need clothing and a few minor consumer goods other than farm investments (Upton, 1979).

In the assumption of minimum food and cash requirement, first minimum energy required per adult equivalent per day under assumed minimum living conditions was made. Because energy requirement varies according to age, sex, body weight, activity and climate. Thus, adult equivalent was used to standardize the differences.

A review of other source was made to determine the minimum energy requirement that has to be used to determine minimum farm size in Bahir Dar Zuria woreda district. Many studies recommended a per capita minimum energy requirement of about 2100 Kcal (Alemneh, 1985 cited in Abebe, 2000). Berhanu (1992) also used 2100 Kcal/day per adult equivalent as a minimum energy requirement to estimate minimum farm size for smallholders of Hararge highlands. In this study too, minimum daily energy requirement per day per adult equivalent is assumed to be 2100 Kcal and used to determine minimum farm size.

The sources of the calorie needed depend much on the food habit and on the available type of food items. The assessment made on the consumption pattern of the sample households of the study area (section 4.10) is used as a ground to assume the contribution of each crop to the minimum energy requirement (2100 kcal). The respective proportional contribution of each crop in consumption pattern of an adult equivalent during the study period assumed to contribute the same way in minimum energy requirement (2100 kcal) needed per adult equivalent per day. This assumption helps to consider the food habit and cropping pattern of the study area in the course of minimum farm size determination. Based on the sample survey result concerning the consumption pattern of the study area and the assumption made, the share of minimum daily energy requirement (2100 kcal) is assumed to be 22.98 % for large cereals (Teff), 21% for small cereals (Barley, Maize, and Millet), 37.6% for pulses, 7.09% for vegetables (Potato and Onion), 2.74% oil crops and 5.41 % percent for animal products (milk, butter and beef). The energy content of the items was calculated based on the energy content of different crops and animal products by EHNRI (2000)

The rough share of major cereals, pulses oil crop, vegetables and livestock products, and their respective quantities required per adult equivalent and average prices for valuation of the physical quantities are given on table 4-15. The average prices obtained by interviewing the sample farmers have been used for the valuation (See table 4-15).

Table 4-15. Crop and livestock products in quantity and value required to meet 2100 kcal.

Crop type	Quantity per year (Qt/AE)	Average price (ETB/Quantity)	Value (ETB)	Share in %
Maize	0.185	332.00	61.42	1.51
Barley	1.04	562.00	584.48	14.40
Millet	0.364	567.00	206.38	5.08
Teff	0.868	1,075.00	933.1	22.98
Peas	0.848	1,800.00	1,526.4	37.60
Potato	0.154	1,000.00	154	3.79
Onion	0.141	950.00	133.95	3.30
Edible oil	1.39	80.00	111.2	2.74
Milk	8.53	25.00	213.25	5.25
Butter	0.05	130.00	6.5	0.16
Beef	0.089	1,450.00	129.05	3.18
Total			**4,059.74**	**100.00**

Source: Own computation (2016).

Based on the respective share of different types of cereals and pulses and their energy content 2.46 quintal of cereals and 0.848 quintal of pulses are required to provide 92.5 % the minimum energy requirement of 2100 Kcal per day per adult-equivalent. The amount of cereals and pulses required is estimated to be 3,311.78 ETB per-adult-equivalents per year. The other sources, edible oil and vegetables contributed 9.83 % and livestock products (milk, meat and butter) contributed 8.59% to minimum energy required which is 2100 kcal per adult equivalent, and amounted to 399.15 ETB for oil crop and vegetables and 348.80 ETB for livestock products, respectively. In summary, the total amount of money income required to meet the annual minimum food requirement has been estimated to be 4,059.74 ETB per adult equivalent per year (See table 4-15).

Minimum farm size is also assumed to provide minimum cash requirement in addition to minimum food required. Hence, its estimation requires data on non-food expenditure by households, which was gathered during sample survey. Farmers commonly sell portion of farm output whether it is surplus or not and use the money to cover some essential expenses. Expenditures are influenced by different factors where the most important one may be income level. However, minimum cash requirements could be estimated from the

expenses reported by the farm families based on the assumption that some of the expenditures are common and more important to every farm family. These are expenditures on clothing, liquor, and others like medication and non-consumable goods.

The average expenses reported by the sample cases are 275.00, 450.00, 350.00, 300.00, 250.00 and 175.00 ETB per adult-equivalent per year for Beverages, clothing, medication, furniture, transport and other non- consumable goods, respectively (See table 4-14). These amount overheads to 1,800.00 ETB, which is taken as an approximation of the minimum cash requirement. Therefore, minimum food and cash requirement per an adult equivalent per year under the assumed minimum living condition has been estimated at 6,309.74 ETB per year. Average family size of a farm family in the study area is 2.8 adult equivalents and hence the minimum income required per average size of farm family is 17,667.27 ETB. However, the income of the farm family is highly supplemented by other sources, viz., off-farm and non-farm activities like petty trade, brewery and labor on other farm.

The average gross income of a farm family from farming and off farm activities during the study period was 29,644.40 ETB where income generated from crop farming, livestock farming and off farm activities covered 81.84, 14.24 and 3.92 %, respectively. It is assumed that the sources contribute at the same proportions to the estimated minimum income required (17,667.27 ETB) per average size of farm family. With this assumption in mind, 14,458.87 ETB is expected from crop farming which is 81.84 percent of minimum income required (17,667.25 ETB). Hence, farm size that generates 14,459.13 ETB is considered as minimum size estimate and can support average farm family under assumed minimum living condition.

After estimation of subsistence requirement, minimum farm size is estimated using econometric analysis in section 4.12.2. Econometric analysis is used to assess factors determining net farm in line with building net farm income equation used to estimate minimum farm size and to assess the impact of land fragmentation parameters on farm productivity.

4.12. The empirical study

4.12.1. Empirical study on the impact of agricultural land fragmentation on farmland productivity

In this section, impact of agricultural land fragmentation on farmland productivity is analyzed. As mentioned in section 4.8, the impact of land fragmentation is analyzed by identifying the determinate variables on factors influencing land productivity using linear production function (equation 2). This is done based on the relationships established between land productivity (dependent variable) and the independent variables. Before running the model to estimate the equation of land productivity, the association between explanatory variables was checked using variance inflation factor (VIF), which shows how variance of estimate is inflated because of the presence of multicollinearity (Gujurati, 1995).

In all cases, there is no serious problem of multicollinearity (See table). All values of variance inflation factor are below five percent and assumed to be minimum because value of variance inflation factor less than 10 does not bring serious problem of multicollinearity (Gujarati,1995). except that cultivated number of parcel and average area of parcel have a collinarity problem.

The OLS method applied to the selected variables provides the regression results summarized in appendix 5. The F-statistic ratio is highly significant at probability level of one and five percent. This shows that the null hypothesis formulated (all values of coefficient are equal to zero) is rejected. The results of analysis show that there is considerable variation in output, which is not explained by the production function. As shown by value of adjusted coefficient of multiple determinations, only 16.3 percent of variation in land productivity is explained by variations in the independent or explanatory variables included in the model. However, the regression result show that there is one variables significant in explaining variation in land productivity. This variable is labor power intensity (man days/ ha).

Based on the result of the regression model, labor power used intensity is highly significant to affect the productivity of land. keeping other variables constant, as a labour power apply to in a given land in hectare is increase by a one adult person, average crop productivity will increased by 0.049 kilogram per hectare.

Operating capital is the amount of variable cost used in crop production during the study period. It is sum of value of seed, fertilizer, herbicide and cost of hired laborer divided by total cultivated land area. As shown in appendix 5, an increment of operating capital by a one ETB per hectare there will be a reduction of crop output by 0.000072 kilogram per hectare. This result indicates that adding more operating capital by a one ETB above the optimal level for the production of crop, there will be a cost for the farmers in the study area. The result is against the hypothesis. The possible reason for this result might be add a unit variable cost in birr on fragmented parcel, average cost will increases in turn total productivity will be decline this will leads to marginal productivity to become less than equal to zero.

The farmer's age has an influence on management performance. As age of household head increases more experience can be obtained and we would expect the decision-making ability to improve. Age is considered as proxy of managerial ability. In this case, an increment in age is expected to increase in farmland productivity. But, according to the result of the regression model, an increment of by one year, there will be a reduction of crop output by 0.115 kilogram per hectare. The result of age of the household is found to be against the hypothesis. As discussed in section 4-1 age classification of sample household heads ranges between 84 and 22 and average age of the household heads is 44.68 years with a standard deviation of 12.87. The probable reason for the negative effect of age against crop land productivity might be retirement of landholder to manage agricultural practices on time, low level of educational background may leads to the reluctant to accept new agricultural extension systems and better farm operation practices etc. Hence the negative effects will leads to yield reduction.

Agricultural land fragmentation parameters, average distance of parcels, oxen power intensity, age of the household, operating capital intensity, number of parcels owned and average size of parcels are not highly significant to influence farmland productivity. This might be because of the presence of abundant labor power and working time, where time spent to walk from homestead, protecting parcels from wild life and bird attack and close supervision does not reduce working time of farm activities. On the other hand as discussed in section 4.4; 48.95 percent of a average cultivated land under crop are found near homestead at a distance less than 30 minutes and also average distance of operated parcels by each household is about 25 minutes away from homestead with a standard deviation of 12.81 minutes, this indicates that there is a high parcel distance variability in minutes from homestead to farm .

4.18.2. Net farm income and estimation of minimum farm landholding size

In this section, net farm income equation is used to estimate minimum farm land holding size. As explained in section 3.4.1.2, log transformed Cobb-Douglas production function (equation 4) was employed in estimating net farm income equation. In other words, log transformed independent variables defined in section 3.4.1.2 are regressed on log transformed net farm income (dependent variable).

Before running the regression model, the association between explanatory variables is checked using Variance Inflation Factor (VIF). In all cases, there is no serious problem of multicollinearity (See appendix 6). All values of variance inflation factor are below five and assumed to be minimum because value of variance inflation factor less than 10 does not bring serious problem of multicollinearity (Gujarati, 1995).

The OLS method was applied to the log transformed values. The regression results are summarized in appendix 6. The regression equation fitted to the data as shown by F-statistic, which is highly significant at 5 and 10 percent probability level. This shows that the null hypothesis formulated (all values of coefficients are equal to zero) is rejected. The coefficient of multiple determinations for the model is also significant at 5 percent probability level. As shown by value of adjusted coefficient of multiple determinations, only 4.51 percent of the variation in net farm income is explained by variation in the

independent variables included in the model. The possible reason for low explanatory power of the model might be due to the inability of capturing important determinate variables. However the estimated regression model can serve the objectives, which is analysis of the effect of land fragmentation on farm income. The regression result shows that three out of five independent variables included in the model significantly influence net farm income. These are area of cultivated land, oxen power used for crop production and operating capital expend for crop production.

Based on the above result, it is vivid that cultivated land area is one of the major liming resources upon which the farmers in the study area depend for their living. Variation in area of cultivated land (cropped land) is found significantly influencing variation in net farm income (at probability of 5 percent). The elasticity estimate of net farm income is 0.642 with respect to cultivated land area indicating that, other things being the same, a one hactare increase in the area of cultivated land will be associated with a 0.642 increase in net farm income in ETB.

Oxen power input negatively influences net farm income (at 10 percent probability level). The elasticity estimate of this variable shows that a one percent increase of in oxen power input (oxen days) leads to 0.23 percent reduction in net farm income all other factors held constant. The result of oxen power input is found to be against the hypothesis and the common understood logical reasoning might be oxen owners give higher cash income from oxen rental services and hence higher out their oxen for others. This negatively affects their own farm work ending in farm income reduction.

The other limiting factor of crop production of the study area is operating capital used. Operating capital is significantly related to net farm income (at 5 percent probability level). The elasticity estimate of this variable shows that a one birr (ETB) addition of operating capital expend for a given fragmented parcel there will be a 0.364 percent reduction in net farm income in ETB, all other factors held constant. The result is against the hypothesis. The possible reason for this result might be framers with more cash on hand to engage themselves on other off farm activities, non crop farm activities, etc and may reduce time and energy invested on crop production.

The variation in labor use (man days) and age of the house hold head have no significant contributions in explaining variation in net farm income of the sample households. This shows that labor input is not limiting factor in crop farming of the study area and it could be abundant resource. The distribution of agricultural work over time attributed to the existing crop schedule of major crops of the study area would also be contributed for labor power not to be limiting factor of production. The probable reason for the negative effect of age against crop land productivity might be retirement of landholder to manage agricultural practices on time, low level of educational background may leads to the reluctant to accept new agricultural extension systems and better farm operation practices etc. Hence the negative effects will leads to low level of income.

The above estimated net farm income model was used to estimate minimum farm size. Whereas minimum farm size estimation is needed to examine the extent of subdivision of farms into smaller farms in the study area and how the livelihood of the people is affected due to diminution of farmland.

In the estimation of minimum farm size, an attempt has been made to estimate an area of cultivated land that generates subsistence requirements per average farm family adult equivalents. The amount of money mentioned was equated with right hand side of the estimated net farm income equation. Then the equation was solved for cultivated land by keeping other variables constant at their average values (average for the sample households). The reason of using average values is that it is assumed to estimate minimum farm size that can generate subsistence requirement for an average farm family. The estimated net farm income equation to be solved to estimate minimum farm size is as follows:

$$\ln Y_i = 12.6 + 0.64 \ln Cula - 0.23 \ln Oxpcrfa - 0.13 \ln AgHH + 0.08 \ln Lpcrfa - 0.36 \ln OpK \quad \text{(Eq.7)}$$

Where Where:

Y_i = Net farm income from crop farming (ETB)

$Cula$ = cultivated land area (hectare)

Oxpcrfa= oxen power used for crop farming (oxen-days)

AgHH = age of household head (year)

Lpcrfa=labor power used for crop farming (man-days)

OpK = operating capital (ETB)

By solving equation 7, farmland size of 0.756 hectare is obtained as minimum size that can generate minimum food and cash requirement of an average farm family of 2.8 adult equivalents. Based on this result, out of the total sample households, 43 of them (37.07 percent) holding farmland size less than the minimum farm size (0.47 hectare) as discussed in section 4.3.2. Therefore, one can infer that land holding by the households less than the minimum required land size failed to support the farmers and their family at estimated minimum food and cash requirement and current land productivity.

The minimum farm size is estimated under the existing technology, productivity and prices of inputs and farm produces. However, there are yield increasing inputs and practices that can improve the productivity of land considerably. According to *Bahir Dar Zuria Woreda* office of agriculture (2016), these inputs had been introduced and showed promising output in the farming of the study area. The use of improved seeds of major crops like Maize and *Teff* with the application of fertilizer and also application of fertilizer with a local seeds was proved to bring yield increment in the study area. It should be stressed that the concept of the minimum size as discussed here is to indicate tendencies and extent of subdivision of farms into smaller farms in the study area. The idea of estimation of minimum farm size is a temporary view as in the long run, it depends on the dynamic or changing nature of factors affecting minimum farm size.

The major factors affecting farm size are family size, land and labor productivity, farmers' terms of trade, cropping intensity, and change in production pattern (Abebe, H.G.2000; Berehanu, A. 1992). According to them, the increase in family size, declining land and labor productivity, decreasing cropping intensity, change in production pattern and terms of trade which is not in favor of farmers tend to increase minimum farm size required where the opposite tend to decrease minimum farm size required. The role of livestock and off farm activities is also important in increasing or decreasing minimum

farm size. When the contribution of livestock and off farm activities increases in the overall income of the farm family, minimum farm size decreases and increases when the contribution decreases.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The objective of the study is to answer the question such as what is the current level of fragmentation, how does highly fragmented land impact the productivity and profitability of small holder farms, what are causes and driving force of land fragmentation and what is the minimum average farmland holding size per household that can support level of subsistence.

Change in the size of farms and number of fragmented parcels hold is observed in the study area. About 67.2 percent of average number of parcels per household is located at distance less than walking time of 25 minutes. Therefore, it is possible to conclude that higher proportion of average parcels is found moderately near to farm homestead.

Bahir Dar Zuria Woreda is known with diversification of crops farming. Maize, *Teff,* and Millet are major crops grown and covered 83.5 percent of average cultivated land per household during the study year. The yield of each major crop is found to be good due to the application of chemical fertilizer and improved seeds.

Livestock and off farm activities are sources of employment and income and contributed substantially to the income of sample households during the study year. In addition to this in a mixed farming economy, especially livestock is the most important sector which supports the crop production. It serves as a liquid asset for farmers` immediate cash need and adds an important source of animal protein.

It has been found that there are statistically significant differences in resource possession and allocation between male and female landholders. As a result, female headed household used lesser oxen power and labor input and generated lesser income from crop farming.

Based on the regression result, it concludes that cultivated land area is one of the major liming factors upon which the farmers in the study area depend for their living. Variation in area of cultivated land (cropped land) is found significantly influencing variation in net farm income. This shows that cultivated land area is one of the limiting factor of crop production in the study area. Net farm income can be increased by increasing cultivated land holding. However, this is not possible because of scarcity of land and the restriction of land redistribution program. The other limiting factor of crop production in the study area is operating capital used and is oxen power used are significantly and negatively affect net farm income.

The study result revealed that 0.756 hectare of land is estimated as a minimum farm size that can generate minimum food and cash requirement of an average farm family of 2.8 adult equivalents. Out of 166 sample households 43 of them having a 0.47 hectare of average a farm land holding size which is less than 1.43 hectares of average land holding size per land holder during 2015/16 production year.. Therefore, one can infer that land holding by the households could not support the farmers and their families at assumed minimum requirement. Redistribution of land worsens diminution of farmland. All lands of the *woreda* are found under different land uses (cultivated, grazing, settlement and forest etc.) and there is no uncultivated arable land left. Hence, there is no potential of accommodating additional farm households in the area.

It is noted that land fragmentation has a beneficial effects in reducing risks through the spatial diversification of activities and to have access to different types of land. The advantage of land fragmentation should not be overlooked if an attempt to reverse its problems.

5.2. Recommendations

Hence, after summarizing the findings of this study, the possible recommendations that can be made from this study are as follows:

- The government should put in place a law that fixes a minimum allowable land size ceiling to discourage further diminution and also law makers should review and amend the legal frameworks pertaining to inheritance and gift to tackle the structural causes of land fragmentation.
- Farmers promote themselves a voluntary based amalgamation to increase their farm size with the adjacent land holders by entering into agreements in exchanging parcels.
- Government should expand and deliver quality education, training in a technical and vocational education center to improve the efficiency, intensive and wise use of the land.
- Promotes the establishment and expansion of new emerging rural town center, should undertake integrated infrastructural development, enhance rural finance institution, manufacturing, service sector development for the creation and diversification of non-farm income sources, value adding activities based on local products and employment opportunities to prevent further land fragmentation.
- A short and long-term livelihood needs and interventions of the small holder farmers should be identified and a specific cluster based intensive commercialization of agriculture pursuant to the agro-ecology and land suitability of the area should be designed and implemented
- A high level policy makers should identify seeks better alternatives to implement joint farming system to counteract the possibility of further land diminution by combining parcels so as to increase the scale and depth of farm operation.

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Appendices

Appendix 9. Conversion Factors Used to Estimate Man Equivalent (ME).

Age group	Male	Female
< 10	0.00	0.00
10-14	0.35	0.35
15-50	1.00	0.80
> 50	0.55	0.50

Source: Here (1986) Tohnson (1982), Ruthernberg (1983) and Nair (1985) cited in Storck et al (1991)

Appendix 10. Conversion factors used to estimate tropical livestock unit (TLU).

Species	TLU Equivalents
Camels	1.0
Cattle	0.7
Sheep /goat	0.1
Horse /mules	0.8
Donkey	0.5
Source: - ILCA (1990)	

Source: - ILCA (1990)

Appendix 11. Conversion factors used to estimate adult equivalent.

Age group	Male	Female
< 10	0.60	0.60
10 – 13	0.90	0.80
14 – 16	1.00	0.75
17 – 50	1.00	0.75
>50	1.00	0.75

Source: Stock et. a.l (1991)

Appendix 12. Average annual price of crop and livestock products.

Crops	Annual Average Market price in ETB/Qt.
Teff	1075.00
Barly	563.00
Wheat	567.00
Maize	332.00
Bean	821.50
Millet	592.50
Nuge	3,700.00
Paper	12,000.00
Potato	373.00
Check Pea	1,650.00
Soyabean	2,425.50
Oxe	6,352.00
Cow	4,985.00
Sheep	
Female *Enat*	934.33
Muket	1,780.33
Wotetie	738.67
Tebot	683.5
Kibe	683
Goat	
Female Enat	777.50
Muket	2,097.33
Wotetie	646.17
Tebot	507.00
Kibe	562.33
Oxe	6,352.00
Cow	4,985.00

Appendix 13. Regression coefficients and other Statistics, land productivity model.

Model: Independent Variables	Unstandardized Coefficients		t-value	Sig.	95.0% Confidence Interval for B		Colinearity Statistics	
	B	SE			Lower Bound	Upper Bound	(1/VIF)	VIF
(Constant)	21.344	6.920	3.084	0.003	7.645	35.043		
Average distance of cultivated parcels in walking distance (minutes)	-0.096	0.111	-0.866	0.388	-0.315	0.123	0.972	1.029
Labor power intensity (man days/ ha)	0.049	0.011	4.505 *(* *)	0.000	0.028	0.071	0.794	1.259
Oxen power intensity (oxen days / ha)	-0.014	0.017	-0.791	0.430	-0.048	0.020	0.921	1.086
Age of household head (years)	-0.115	0.120	-0.957	0.340	-0.354	0.123	0.895	1.118
Operating capital intensity (ETB/ha)	-0.000072	0.00	-0.80	0.425	0.000	0.000	0.850	1.176
Cultivated number of parcels	-1.969	3.885	-0.507	0.613	-9.660	5.722	0.017	59.066
Average area of parcels (ha)	16.359	14.513	1.127	0.262	-12.370	45.089	0.017	58.306
Dependent Variable: Total Land Productivity (ETB/ ha)								
Observation	**166**							
F Ratio (6, 164)	**4.585 * (**)**							
Prob > F	**0.000**							
R-squared	**0.208**							
Adj R-squared	**0.163**							
Root MSE	**42269.683**							

Source: Own computation (2016).

* (A probability table value of 2.58) and ** (A probability table value of 1.96) Significant at probability level of 1 and 5 percent respectively.

Appendix 14. Regression coefficients (Elasticties) of log transformed net farm income.

Model	Unstandardized Coefficients		t-ratio	Sig.	95.0% Confidence Interval for B		Colinearity Statistics	
	B	SE			Lower Bound	Upper Bound	(1/VIF)	VIF
(Constant)	**12.66**	2.67	**4.745**	0.0000	7.3818	17.9472		
Cultivated land area	**0.642**	0.25	**2.542****	0.0123	0.1420	1.1418	0.71	1.40
Oxen power used crop farming	**-0.23**	0.118	**-1.944*****	0.0542	-0.4645	0.0042	0.99	1.01
Age of household head	**-0.134**	0.622	**-0.215**	0.8301	-1.3647	1.0973	0.96	1.04
Labor power used for crop farming	**0.078**	0.144	**0.541**	0.5895	-0.2070	0.3627	0.67	1.48
Operating capital	**-0.364**	0.170	**-2.141****	0.0342	-0.7006	-0.0276	0.55	1.81
a. Dependent Variable: Net farm income from crop farming (ETB)								
Observation	**166**							
F Ratio (5, 124)	**2.22 ** (***)**							
Prob > F	**0.057**							
R-squared	**0.0821**							
Adj R-squared	**0.0451**							
Root MSE	**2.0178**							

Source: Own computation (2016)

(A probability table value of 1.96) , and * (A probability table value of 1.645) significant at a probability level of 5 and 10 percent respectively.

Appendix 15. Household questionnaire

Household Level Questionnaire to the analysis of fragmented agricultural land size and its effects on the productivity and farm income of small holder farmer.

Part one:

Kebele_____

Farmer's Name_____

Enumerator's Name _____

Date_____

Questionnaire No. _____

1.Current Household Composition and Characteristics.

	Name of Household members	Relation to Household Head	Sex	Age(In years)	Currently Attending School	Level of Education	Main current activity (For ten years and above)	Major secondary activity (For ten years and above)	Level of income (Wealth catagory)	Religion	Ethnic Group
	(Write the head of the household first)	1.Head 2. Spouse 3.Child 4. Grandchild 5. Mother/Father 6. Brother/sister 7.Others (Specify) --------	1. Male 2. Female	0 if less than one Year old	1.Yes 2. No	1. Didn't attend 2. Participated in "Literacy" prog. 3. Grade 1-6 4. Grade 7-8 5.Grade 9-12 6. 12 Complete 7. Over grade	1.Formally employed 2. Causal labor 3.Artisian 4. Cultivator 5. Herder 6. Trader 7. Students 8. Housework 9.Not working	1.Formally employed 2. Causal labor 3.Artisian 4. Cultivator 5. Herder 6. Trader 7. Students 8. Housework 9.Not working	1.V.poor 2. Poor 3.Average 4. Good 5. V.good	1.Muselem 2. Christian 3.Traditional 4. None 5. Other (Specify)----	
1											
2											
3											
4											
5											
6											

Part Two: Land Tenure system and Parcel Level

2.1. Do you have land for cultivation?

1. Yes 2. No

2.2. If yes, how did you get access to the land?

1. kebele allocation 2. Inheritance/donation 3. Rent

4. share cropping 5. Other (specify)-------

2.3. What is the total size of your current land holding?

1. One timad 2. Two timad 3. Three timad 4. Other (specify) --------

2.4. Of the total land you have what part is

1. Cutivated area? ------timad 2. Grazing area?----------timad

3. Fallow? --------timad. 4. Forest area? ------timad

5. Others (specify)----------

2.5. Is there any restriction to use the land?

1. Yes 2. No

2.6. If yes for question no. 2.8, please explain the reason/s

_____

_____

_____

2.7. Is the existing land tenure system good or bad?

1. Good 2 . Bad

2.8. If good, what is its strength of the tenure system?

1. The use right 2. The modification right

3. The transfer right 4. Other rights (specify) ----------

2.9. If bad what are its weaknesses?

1. The use right 2. The modification right

3. The transfer right 4. Other rights (specify)

2.10. How do you locally classify land?

1.By fertility 2.By infertility (poor soil type)

3.By average soil type 4. By homestead

5. By distance from home 6. Other (specify)----------

2.11. How many timad of your land falls under the above classification?

1.Fertile land ----------timad 2.Infertile land ---------timad

3.Average type --------timad 4.Homestead --------timad
5. Other-------

2.12. When did you establish the household?

1. Before 1966 E.C 2. Between 1966- 1976 E.C
3. Between 1977- 1982 E.C 4. After 1983 E.C

2.13. The size of your land holding during establishment of the household?

1. One timad 2. Two timad 3. Three timad 4. Four timad

5. Other (specify) ----------

2.14. What was the size of the land during subsequent years after establishment until now?

1. During Haile Selassie regime---------- 2. During Derg regime----------

3. During the current regime----------

2.15. Does the local tenure practice have implication on productivity?

1.Yes 2. No

2.16. If yes, what are the implications?

A. Increase productivity; reason out the implication in the increase of productivity

_____

_____

_____

B. Decrease productivity; reason out the implication in the increase of productivity.

_____

_____

_____

2.17. Parcel Level Information

2.17.1. Inventory of parcels owned, leased in and leased out entered in spss

Parcel number		**1**	**2**	**3**	**4**	**5**	**6**	**7**
Parcel name								
Land use type								
Local measurement								
Size (ha.) in 2015								
Distance from	Renter							
	Rentee							
Sources, mode of acquisition, and disposition								
Year obtained and size (ha)	Year							
	Size							
Duration of agreement								
Location relative to dwelling								
Soil type								
Fertility								
Slope								
Quality								
Waking time to (minutes/ hours)	Residence							
	Nearest road							
	Nearest							
Reason for change in size								

2.17.2. Changes in Farm and Grazing Land Size and Number of Parcels

Description		Cultivated land	Grazing land
Parcel num.ber	Year 2003 E.C		
	Year 2004 E.C		
	Year 2005 E.C		
	Year 2006 E.C		
	Year 2007 E.C		
Reasons for change			
Total area (ha)	Year 2003 E.C		
	Year 2004 E.C		
	Year 2005 E.C		
	Year 2006 E.C		
	Year 2007 E.C		
Reasons for change			

2.17.3. Terms of the Nature of Parcel Acquisition/Disposition and the Forms of Agreement by year for each Parcel. Excel table form note entered in spss

Parcel number		1	2	3	4	5	6	7
Parcel name								
Nature of parcel acquisition /disposition								
If payment was fixed in 2006/07 E.C Production Year	Mode of payment							
	Amount paid							
	Value (ETB)							
If payment was not fixed what is the land owner's share in % in 2006/07 E.C Production Year	Crop							
	Residue							
If the land owner share cost what was the % or amount in 2015	Labor							
	Oxen							
	Equipment							
	Seeds							
	Other inputs							

2.17.3.1. If cultivated and grazing lands were obtained; What was the mode of acquisition?

spss entered

1. Gift 2. Inheritance 3. Exchange 4. Rent

2.17.3.2. For question no. 2.18.3.1. From whom did you get?_____

A. If it was through rent, what were the benefits of renter? And also the mode of land rent?

_____

_____

____

B. If it was through exchange, why was it undertaken?

_____

_____

_____

C. How far were the exchange formal, and who were the mediators?

_____

_____

_____

D. If the household rented in and rented out their land in 2015, what would be the reasons for doing so?_____

Part Three: Crop Production:

1. What is the total area you cultivated last year? ----------timad (2006/2007 E.C production yaear).

   1. Owned ----------timad 2. Rented----------timad

   3. Share cropped--------timad. 4. Received as a gift-------timad.

   5. Other (specify)-----

2. Do you think that your piece of land is enough to support your family?

   1. Yes 2.No

3. If no to No 2, state your reasons

   1. The land is infertile 2. The size of the land is small 3. Erratic rainfall

   4. Lack of agricultural inputs to increase productivity 5. Others (specify) ----------

4. What portion of the cultivated land is allotted to

   1. Annual crops----------timad 2. Perennial crops----------timad 3. Other (specify)-

4.1. List the type of crops you cultivated and their average production for the last 2 years

Type of crops	2006/07 E.C Production Year		2007/2008 E.C Production year	
	Area	Production	Area	Production
Annual Crops				
1. Cereal cops				
2. Pulses				
3.Cash crops				
4. Root crops				
5. Others				
Perennial				
1.Eucalyptus				
2.Coffee				
3.Fruit trees				
4. Others				

5. Do you use any irrigation scheme?

   1.Yes 2. No

6. If yes to no. 5, what type is it?

1. Modern 2. Traditional 3. Both modern and traditional

7.If yes to no. 6, what types of crops did you produce using irrigation?

Type of Crops 1.Cereal crops 2. Pulse and Oil 3. Cash crops 4. Root crops 5. Other vegetables 6. Eucalyptus	2006/07 E.C Production Year		2007/2008 E.C Production year	
	(Area) Timad	Production (Quintals)	(Area) Timad	Production (Quintals)

8. Have you obtain credit last year for purchasing of agricultural inputs?

1. Yes 2. No

9. Did you use modern inputs in last year cropping season?

1. Yes 2. No

10. If your answer to question no. 9 is yes, what type (s) of improved inputs did you use?

1. Fertilizer 2. Chemicals (Insecticides, Herbicide, etc.)

3. Seeds 4. Other, specify _____

11. If your answer to question no. 9 is yes, when do you used?

1. Rainy season. 2. with irrigation. 3. On both seasons

12. If your answer to question no. 9 is No, why?

1. High price (expensive). 2. Lack of supply. 3. Shortage & dalliance in supply.

4. Lack of credit service. 5. Fear of debt burden 6. Not useful.

7. Other, specify _____

Con't….. Inputs utilization and crop output on each parcel for the year 2006/2007 production.

Parcel number		Parcel Number													
		Own Parcel							Rented in parcel						
		1	2	3	4	5	6	7	1	2	3	4	5		7
Parcel name															
Method of cropping															
Crop(s) type															
Area (ha)															
On seed (kg)	Local														
	Improved														
Seed bought (kg)	Local														
	Improved														
Fertilizer (kg)	DAP														
	Urea														
Pesticide	Unit														
	Amount														
	Value (ETB)														
Herbicide	Unit														
	Amount														
	Value (ETB)														
Fungicide	Unit														
	Amount														
	Value (ETB)														
Manure	Unit														
	Amount														
	Value (ETB)														
By-product	Unit														
	Amount														
	Value (ETB)														
Yield	Actual														
	Maximum														
	Minimum														
	Modal														

Part Four: Human labor and oxen power access for crop production the 2006/2007 E.C production year.

1. Did you have enough family labor to do all the farm activities?

1. Yes 2. No

2. If your answer to question 1 is No, how do you solve (overcome) the difficulties?

1. Hiring labor. 2. Labor sharing with neighboring /friends / parents

3. Reducing the area to be cultivated 4. Other, specify _____

3. If you hired labor last year, what was the number of workers hired? _____

4. If you hired labor last year, how much was the total payment (in Birr) for the workers? _____ in ETB.

5. Did anyone in the house-hold sell their labor in the last production year?

1. Yes 2. No

6. If your answer to question 2.23.5 is yes, what total amount of Labor Day spent?_____ and how much income was received? (In ETB) _____

7. What was the main source of labor for the farming activities?

1. Family labor only 2. Hired labor only 3.Both 1 and 2

8. Did you face shortage of oxen power in 2015?

1. Yes 2. No

9. If yes, in which periods of the year and for which operations?

_____

_____

10. How did you overcome the problem?

_____

_____

11. Labor and oxen power inputs on each parcel in 2006/2007 production year (person-days and oxen-days) by Crop.

Number of Labor and oxen power availability on each parcel for the year 2006/2007 production year

Labor source	Labor type	Parcel Number												
		Own Parcel							Rented in parcel					
		1	2	3	4	5	6	7	1	2	3	4	5	6
Family labor	Men													
	Women													
	Children													
Hired labor	Men													
	Women													
	Children													
Share cropping partner labor	Men													
	Women													
	Children													
Exchange labor	Men													
	Women													
	Children													
Labor donation	Men													
	Women													
	Children													
Oxen	Owned													
	Hired													
	Exchanged													
	Donated													
	Shared in													
	Borrowed													

Inserted code number:

1= ploughing, 2 = planting, 3 = weeding, 4 = applying manure, 5 = applying fertilizer, 6 = herbicide and pesticide application, 7 = guarding, 8 = harvesting and heaping and 9 = threshing

Con't…….

Crop type	Land preparation				Planting				Weeding			Harvesting		Threshing	
	Family labor	Hired labor	Labor exchange	Oxen pair	Family labor	Hired labor	Labor exchange	Oxen pair	Family labor	Hired labor	Labor exchange	Family labor	Labor Exchange	Family labor	Labor Exchange

Part Five: Livestock

1. Inventory of livestock owned during the years 2007.

Animal Types	2007							
	Begin No.	Sold No.	Died No.	Slaughtered No.	Bought No.	Born No.	Received No.	End No.

2. Livestock production status during 2006/2007 production year.

2.1. Livestock Production, Income and Consumption Expenses from Sales of Live Animals and their Products.

Animal type and their products	Type of live animal or products		Quantity consumed				Quantity Bought		Quantity Slaughter		Quantity sold	
			Own		Purchased/aid							
	Qty (qt)	Value (ETB)	Qty (qt)	Value (ETB)	Qty (qt)	Value (ETB)	Qty (qt)	Value (ETB)	Qty (qt)	Value (ETB)	Qty (qt)	Value (ETB)

3. What are the possible reasons for decreasing, increasing or no change in the number of type of animals?

_____

_____

_____

4. Do you think your animals have had adequate feed during different seasons in the year 2006/2007 production year?

   1. Yes 2. No

5. If the answer is no for question number 7,

   5.1. What were the most important reasons for the shortage of animal feed and also the most difficult months? _____.

   5.2. What were the most difficult months and why these months were difficult? _____

   _____

   5.3. What are the primary and secondary feed sources during wet and dry seasons?

   5..4. List all types of feed and rank them according to their importance descending order.

Part Five: Farm equipments and sustainable land management activities

1. List farming equipments used for agricultural activities Selected Farm Equipment /Durable Goods Owned (number at the beginning of 2007)

Type of equipment	Number	Unit price ETB)	Present value (ETB)

2. Did you face shortage of farm equipment in 2006/2007 production year?

   1. Yes 2. No

3. If yes, in which periods of the year and why in these periods?

4. What were the reasons for shortage of farm equipment?

5. How did you overcome the problem?

6. Investments and land management practices that are found on parcels in 2007 E.C. Complete the table if applied only.

Item		Parcel	Reasons for application
Investment	Irrigated		
	Traditional SWC		
	Modern SWC		
	Tree planting		
Practices	Mulching		
	Green manure		
	Manure/compost		
	Crop rotation		
	Others (specify)		

Appendix 16. Checklist to be used for group discussion.

1. What are the advantages of land fragmentation?
2. What are the disadvantages of land fragmentation?
3. Which parameters of land fragmentation are considered as a serious problem and which are not? Why?
4. What are the possible proposed solutions to over come the problem of land fragmentation?
5. What are the causes of land fragmentation?
6. Did land redistribution take place in your kebele?
7. What were the bases for land redistribution and how fair was the redistribution?
9. How do landless and newly formed households live?
10. Has farm size been decreasing from time to time? Why?
11. How and to whom land can be transferred?
12. What happens to the land of childless individual in case of his death?
13. How land is transferred among family members in case of death of husband?
14. How land is shared between family members in case of divorce?
15. Who is responsible for the reallocation?
16. Does land transferring contributes to land fragmentation? Y/N
17. If yes to question 16, how?
18. Mention crop calendar of crops grown in the district.