COLLEGE OF DEVELOPMENT STUDIES

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THE CONTRIBUTION OF EUCALYPTUS WOODLOTS TO THE LIVELIHOODS AND FOOD SECURITY OF RURAL HOUSEHOLDS IN NORTH MECHA WOREDA, ETHIOPIA

BY

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JUNE, 2022

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ADDIS ABABA

DECLARATION

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This is to certify that the thesis prepared by Gebeyaw Tsegaye, entitled: the contribution of eucalyptus woodlots to the livelihoods and food security of rural households in North Mecha *Woreda*, Ethiopia. To Submitted in fulfillment for the requirement for the Degree of Master of science (Food security and development studies) complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

Thesis advisor	Date	Signature
Name of the Examiner	Date	Signature
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Chairperson of the center of graduated program coordinator

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GebeyawTsegaye

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Abbreviations and Acronyms

CA	Comparative analysis
CSA	Central Statistical Agency
DA	Development Agent
EHNRI	Ethiopian Health and Nutrition Research Institute
ETB	Ethiopian Birr
FAO	Food and Agriculture Organization
HFBM	Household Food Balance Model
HH	Households
HHHs	Household Heads
MLR	Multiple Linear Regression
SD	Standard deviation
TLU	Total livestock unit

Abstract

Eucalyptus woodlot planting and growing has become the most popular and common practice in rural households of Ethiopia. This study was conducted to investigate the contribution of eucalyptus woodlots to the livelihoods and food security of rural households in North Mecha Woreda, Ethiopia. Field observation, household survey and key informant interview were used to generate primary data and secondary data were found from books, academic research papers and Woreda agricultural office documents. Data were analyzed using descriptive statistics, multiple linear regression and Household Food Balance Model. Eucalyptus was planted on 29% of farm lands and about 95% of households grew eucalyptus on their fertile crop lands. The Multiple linear regression model result indicated that eucalyptus value per labour and land(0.011), household heads participation on off farm activity (p=0.000), farm size (p=0.000), fertilizer cost and access (0.011) and market access (p=0.004) and natural and physical characteristics of eucalyptus were found to be significant to determine rural farmers' preference to eucalyptus woodlots. Eucalyptus contributed about 40.3% of the total annual financial income to households' livelihood and it was the primary source of fuel wood and construction material. The Household Food Balance Model showed that, from the total study participants, 84.6% were food secure. Households with high eucalyptus woodlot land size were more food secure. Generally eucalyptus woodlot farming and its sale enhances households', food availability and increases food security of rural farmers. Thus, farmers should use their lands in appropriate and sustainable way in order to create multiple advantages in different seasons and years and should allocate eucalyptus woodlots far from crops because its non-compatibility with crops, government and concerned bodies should give extension services and market access to maximize eucalyptus contribution.

Keywords: Eucalyptus woodlots, income, fertile croplands, Fuel wood, livelihood, Household food security, North Mecha*Woreda*

CHAPTER ONE: INTRODUCTION

1.1. Background of the study

Eucalyptus is classified in the Myrtaceae family and it is an exotic and hottest tree species (Rassaeifar *et al*., 2013). It is a large genus of evergreen aromatic flowering trees, which has over 600 species (Jahan *et al.,* 2011) and it is one of the most planted woody species in the world next to Pinus and Cunninghamia (Mekonen *et al.,* 2007). Similarly, eucalypts is one of the most fast growing trees in the world which provides wood for various functions such as construction, fuel wood, transmission poles, pulpwood and farming equipment. It was expanded from Australia to Europe 200 years ago (Grupo, 2009) and was cultivated in Africa, in Southern African in the early 19th century for the fuel wood source (Jaleta *et al.,* 2016). In the 1890s, it expanded in different parts of Ethiopia and became one part of the country's farming system (Pohjonen and Pukkala, 1990). It was widely introduced in Ethiopia during the regime of King Menelik II in1895 to solve the increasing demand of wood for construction poles and fire wood in Addis Ababa (Moges, 2010). Hence, Ethiopia is one of the 10 pioneer countries in East Africa that introduced the eucalyptus trees (Dessie, 2011). In 2005 total estimated plantation forest in Ethiopia was about 419,000 hectares and in 2010 it had been about 972,000 hectares, during which eucalyptus covers 56% of the entire plantation area (Bekele, 2011). In Ethiopia Small-holder farmers planted eucalyptus on the largest area of their farm lands which is 0.5 million hectares more than in East African (Dessie *et al.*, 2019).

The environmental impact and economic role of eucalyptus expansion by smallholder farmers are the two major debates in Ethiopia: Soil acidifications, allopathic effect, nutrient depletion, excessive water utilization by the tree species are some environmental impacts (Tadesse and Tafere, 2017; Hailu *et al*., 2003). However, others focused on the economic importance of eucalyptus because of its fast growth rate, high biomass production, coping ability, diseases resistance and easy the later debate focuses on the importance of the species because of its fast growth, high biomass production and coping ability (Mekonnen *et al*., 2007). Similar studies in central Ethiopia indicated that eucalyptus produced one fourth of annual cash income and 74% of fire wood sold and yielded better income than other trees and agricultural crops (Getahun, 2003).

Today, even the debates among experts continue on its ecological disadvantages, eucalyptus growing is showing amazing expansion by smallholder farmers in the central highlands of Ethiopia in general and Amhara Region in particular. For instance, about 92,000 hectares of land covered by eucalyptus in Amhara Region and 67% of farm forestry developed by smallholder (Lemenih, 2010). The preference to eucalyptus by smallholder farmers is due to a number of advantages gained from the tree. The tree species are preferred more than others due to its fast-growth, coping ability, and easy cultural management, poorly palatable to animals, the demand for its wood products with reasonable prices, and their adaptations to a wide range of ecological conditions (Moges, 2010; Mulugeta, 2010).

In the Amhara Region, especially in North Mecha *Woreda,* fertile croplands have been converted to eucalyptus woodlots each year. Even though farmers in the area are much interested in continuing with eucalyptus plantation, the government officials and Development Agents (DA) prohibit plantations, especially on croplands. However, the contribution and effect of eucalyptus trees to household livelihood and food security in the study area had never been investigated. Therefore, this study aims to investigate factors driving farmers to prefer eucalyptus woodlots, economic advantage of eucalyptus to households' livelihood, its role for and food security of small-scale farmers in the North Mecha *Woreda.*

1.2. Statement of the problem

In Ethiopia, eucalyptus woodlots production by smallholder farmers is the common activity. Especially, in the highland parts of the country, it is one of the activities used for both subsistence and income generations (kebebew and Ayele, 2010). It is the dominant plant species in the country and widely used and contributing to the national consumption of construction poles and farm implement wood sources (Zerga and Berta, 2016).This shows the significance of smallholder plantation products on the livelihoods of rural households. Moreover, commercial value and market demand of eucalyptus products, firewood, charcoal and poles were higher than other tree species (Dessie*et.al,* 2019). This is why most Ethiopian smallholder farmers preferred to plant and sell eucalyptus woodlots than other tree species (Odoul and Nung"ole, 2012). However, growing eucalyptus woodlots on fertile soils should be highly discouraged in due to its negative effect on growing crops (Kebebew, 2010; Jagger and Pender, 2003). On the other hand,

there is an information gap among farmers growing eucalyptus woodlot and the factors that make eucalyptus more preferable by smallholder farmers.

Various empirical studies have been conducted regarding the contribution and impact of eucalyptus trees to household livelihood and food security. For instance, Mekonen *et al*., (2007) indicate its potential to raise farm incomes, reduce poverty, and increase livelihood and food security. Eucalyptus contributes up to 72% of total household annual cash income in central highlands of Ethiopia (Mekonnen*et.al*, 2007). However, some studies forwarded the negative effects of planting eucalyptus. For instance, Jaggere *et al*. (2003) discussed that eucalyptus has a negative net income, leading to depletion of soil nutrients. Hence, it affects the livelihood stats, food security of the community as well as the next generation because of its adverse effect and the competition of eucalyptus for crop field (Getachew, 2016).

Even with different controversies, today, eucalyptus plantations are showing an amazing expansion each year on fertile croplands in the study area, which is one of the most crop productive *woreda*. Many existing researches working on eucalyptus expansion in Ethiopia, especially in Amhara region focused on negative ecological aspects like environmental, ecological aspects and its effect on crop production (Dessie *et.al*, 2019). However, less attention was given to the socio-economic importance of plantation by small-holders like factors that make eucalyptus preferable. Nevertheless, limited studies have been conducted in the selected study area, North Mecha *Woreda.* The major research gap identified in this area include limited available information on determinant factors that make eucalyptus woodlots more preferable by smallholder, its economic contribution households' livelihood, contribution of eucalyptus to food security status, mismatches between Development Agent and smallholder farmers. The purpose of this study is therefore to fill the research gap by analyzing the contribution of eucalyptus woodlots to household food security and livelihood.

1.3. Objective of the Study

1.3.1. General objective

The main objective of this study was to investigate the contribution of eucalyptus woodlots to the livelihoods and food security of rural households in North Mecha *Woreda*, Ethiopia

1.3.2. Specific objectives

1. To determine the prevalence of eucalyptus woodlots on farm lands of rural households
2. To identify determinant factors of farmers to prefer eucalyptus woodlots in the study area
3. To analyze economic advantages of eucalyptus woodlots to households' livelihoods in the study area
4. To measure the food security status of study households planting eucalyptus woodlots on their farm land

1.4. Research Questions

- Why do farmers prefer planting eucalyptus woodlots on their farmland?
- What are the factors that make eucalyptus preferable by rural households?
- Do eucalyptus woodlots have economic advantages to smallholder farmers livelihood?
- Are there differences in livelihood and food security status of households based on the amount of eucalyptus woodlots on their farm land?

1.5. Scope of the Study

The study was conducted at household level mainly based on demographic, socioeconomic and institutional information of households. It was conducted in three *kebeles* of North Mecha *Woreda*, Amhara national regional state, Ethiopia. The period of study from December 2020 to December 2021 production year. The study was household level analysis focused mainly on demographic and socio economic information of households. Since, the study was cross sectional study, using quantitative and qualitative data and the analysis did not include dynamic impact of eucalyptus plantation over time. The study also carried out in rural households and focused on prevalence of eucalyptus, determinant factors for farmers' preference to eucalyptus woodlots, economic advantages of eucalyptus woodlots to livelihood of smallholder farmers and assesses

household food security status of small scale farmers in the *woreda*. In this study the livelihood contribution of eucalyptus was focused only its income contribution and economic advantages to rural households.

1.6. Limitation of the study

Considering financial constraints and time limitation this study was limited to the contribution of eucalyptus woodlots to the livelihoods and food security of rural households in North Mecha *Woreda,* West Gojjam zone, Amhara regional state. The number of sampled households was relatively small to represent the total 48,441households of the *Woreda.* From the total of 4,023 households, in the selected *kebeles*, only 196 household heads were selected for the survey which is about 4.9% of the total households of the selected *kebeles*. The sample size may small; this is due to time and resource constraints. The studies addressed only food security at access levels and livelihood contribution of eucalyptus was measured only by its economic advantage, these are other limitations of the study. There was limitation of published documents because North Mecha *Woreda* is newly emerged when Mecha *Worda* is subdivided into two *woredas.*

In addition, inaccessibility of development agents in their office for the key informant questions of the survey, lack of willingness of some household heads to respond to truth information causes some limitation to the finding of the study.

1.7. Significance of the Study

Identifying the contribution of eucalyptus for livelihood and food security, determinant factors for make it its preferable, food security status and coping mechanism for food insecurity would have much significance to the agricultural development institutions, other development stalk-holders and local food security agency to design policies that increase total income and food security status of households. Since the study was conducted using cross-sectional data with both theoretical and empirical emphasis, students who are interested in the area can get valuable information. Furthermore, this research intended to study the contribution of eucalyptus woodlots to livelihood and food security in North Mecha *Woreda,* which was conducted at household level and may be used as baseline information for studies with the same thematic, socio economic and geographical areas.

1.8. Ethical Consideration

In this research, an appropriate acknowledgment and citation have been made for any concepts or ideas taken from the literature and the issues of plagiarism have been checked the thesis is compliance with the Addis Ababa University plagiarism policy. I also took a formal letter of support written by Addis Ababa university center of food security studies to North Mecha *Woreda* governmental concerned body. Explanation had been given to household heads about the purpose of the research. Verbal consent from the respondents has been requested before conducting the interview. I informed confidentiality of individual household farmers' information to be ensured. Participation in this study was entirely voluntary and that they were free to withdraw from the study at any time without any dissent.

1.9. Organization of the thesis

This thesis was structured in five main chapters. Chapter One contains introduction of the study including background of the study, study significance, statement of the problem and objective of the study, the Second Chapter presents literature reviews related to eucalyptus and its contribution on livelihood and food security and conceptual framework. Chapter Three discusses the study design and research methods such as sample size determination, sampling procedure, data type, source and instruments, data collection procedure, data analysis methods and description of the variables. Chapter Four contains the result and discussion part of the research and Chapter Five contains conclusions and recommendation of the study.

CHAPTER TWO: REVIEW OF THEORETICAL AND RELATED LITERATURE

2.1. Concepts on eucalyptus woodlots, livelihood and food security

2.1.1. Food security concepts

The concept of food security has become a focal issue to the academician, development practitioners, and policymakers since the 1948 declaration of human right. According to Article 25 of the declaration, food is considered as one of the core elements of an adequate standard of living. Food security is a dynamic concept and it has new integrated dimensions and new levels of study continuously over the years. In 1974(Rome) the world food and agriculture organization (FAO) defined food security by focusing on availability of basic foodstuffs. Its main concern is diminishing fluctuations in supply and costs. During the 1980s, a crucial dimension was added to the concept of food security: access to food, analyzed at the household and individual level. The current definition in use was adopted from the 1996 world food summit which emphasizes the multi dimensionality of food security; food security exists when all people at all times have physical and economic access to sufficient, safe and nutritious food to satisfy their dietary needs and food preferences for an active and healthy life (Roetter & Keulen, 2007). This definition widely established the four pillars of food security; availability, accessibility, utilization and stability. On the other hand food insecurity is a situation where people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life (FAO, 2014).

2.1.2. Eucalyptus woodlot

A woodlot is a land a parcel of woodland used for small-scale production of forest products. The word eucalyptus comes from the Greek words “Eu” and “Kalypta” which means “Well” and “Cover”. Itis one of the diverse genus of flowering plant species in the world which belongs to *Myttaceae* family, *Myrotideae* sub family and consists of more than 700 species (FAO, 2006).

2.1.3. Livelihood

Livelihood may be defined as a level of wealth and of stock and flow of food and cash that provide social and physical wellbeing and security against becoming poorer. Sustainable livelihood is ensured when it cope with and get over stress and shocks, ready to maintain its capabilities and assets to supply livelihood opportunities for future generation (Chambers &

Conway, 1992). The livelihoods framework encompasses the skills, assets (both material and social) and therefore the approaches which can be employed by individuals and communities so as to survive. A livelihood framework is a tool to upgrade our understanding of livelihoods, specifically the livelihoods of the poor. It was developed over a period of several years by different institutions and investigators.

Sustainable livelihoods frame has seven guiding principles. They do not define solution or ordain approaches. Rather, they are flexible and adaptable to different native conditions. These coaching principles are (Serrat, 2017):

- Being people-centered: Sustainable livelihoods framework/ approach (SLA) begins by analyzing people's livelihoods and how they change over time. The people themselves actively share throughout the program cycle.
- Be holistic: SLA acknowledges that people take up numerous strategies to secure their livelihoods, and that many mummers are involved; for illustration the private sector, ministries, community-grounded associations and transnational institutions.
- Be dynamic: sustainable livelihood tries to understand dynamic nature of livelihoods and factors influence them.
- Form on strengths: SLA builds on people's perceived strengths and occasions rather than concentrating on their problems and requirements. It supports existing livelihood strategies.
- Promote micro-macro links: SLA examines the influence of policies and institutions on livelihood options and highlights the need for policies to be informed by perceptivity from the native level and by the priorities of the poor.
- Encourage broad hookups: SLA counts on broad hookups drawing on both the public and private sectors.
- Aim for sustainability: sustainability is useful when poverty reduction is to be lasting.

2.2. Theoretical foundations

2.2.1. Forestry theory

Understanding of the theory of farm forestry expansion into farming systems by individual initiatives and deforestation of natural forests are an essential element to understand the contribution of eucalyptus to livelihood and food security of rural households and determinants factors for its expansion. The major theories considered in this study includes: general

explanation of eucalyptus expansion and livelihood approach. The theory mainly underlines environmental deterioration, population growth, decline of natural forests by long lasting deforestation, accessibility of resources for crop production and fast growing ability of eucalyptus as the causes of eucalyptus expansion.

Forestry farming is an integration of trees by farmers on their own land either as a part of crop production system through plantation, regeneration or conservation for commercial purposes like timber production or several non-commercial purposes like source of own fuel wood. It is a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm and range land, diversifies and sustains smallholder production for increased social, economic and environmental benefits (Leakey, 1996).

Rapid population growth and environmental degradation are the causes for long lasting deforestation in Ethiopia. To prevent the spreading of environmental instability fast growing exotic tree species have been established. These results in the gap of forestay products make households to cultivate eucalyptus which is one of such exotic tree species that is adaptive, fast growing with wide range of productive and different uses (Lisanework, 1994).Eucalyptus is source of various goods such as timber, wood fuel and other products which are transacted in the market. Still the information is not sufficient to accurately understand the livelihood and economic importance of eucalyptus plantation. There are arguments on planting eucalyptus. Some people recognized that eucalyptus trees have several uses due to fast growing rates, resistance to browsing and its potential to raise farm incomes, reduce poverty, increase livelihood and food security (Mekonen*et al.*, 2007). On the opposite, the planting of eucalyptus tree has been criticized because its negative net income, leads to depletion of soil nutrients and affects livelihood and food security of the community as well as the next generation because of its adverse effect and the competition of eucalyptus for crop field (Jagger & Pender, 2003; Getachew, 2016).

2.2.2. Food security theories

Food is both human right and basic need (Bezu, 2018).The state of food insecurity (SOFI) report indicated that, about 702 to 828 million people were affected by hunger in 2021 and around 2.3 billion people in the world were moderately or severely food insecure around the world and

11.7% of the global population faced food insecurity at severe levels (FAO *et al.,* 2022).Food insecurity theory mainly emphasizes the impact of population growth, conflict and instability, urbanization and climate change on the performance of food security situation.

Malthusian and anti-Malthusian theories

Malthusian and anti-Malthusian theories are two theories found on rival position on the relation between food availability and population growth. Malthusians stated food insecurity is due to the presence of too many people compared to the amount of food produced. However the Maltusian theory has faced various critiques from different scholars the theory fails to allow means of improving food security (Abi, 2015).On the other hand Ester mainly reacting against the Malthusian theory of relationships between population growth and food security, argued successfully that technological development could boost food production enough to keep up with population growth for many years.

The entitlement approach/ theory

Malthusian and anti-Malthusian approach that center mainly on food supply was extremely claimed by Amartya Sen and he caused a huge stir when it challenged the popular concept that famine was because of shortage of food. According to Sen the famine that killed millions of individuals in Bengal in the year 1943 and the subsequent famine occurred in Africa and Asia was not because of shortage of food (Osmani, 1993). The Sen's entitlement approach relies on three conceptual categories, namely; the endowment set, the entitlement set and the entitlement mapping. The traditional view of famine analysis broke by Sen's Food availability Decline approaches (FAD approach). The FAD approach was a response to the Malthusian focused on population growth as a problem by itself. According to the FAD approach, the reason behind famine was that food production was broke geographically or in time (Rubin, 2009).

According to Sen (1977), famine is caused undue to shortage of food however because of failure of entitlement. An individual suffers from failure of food entitlement once his entitlement set does not contain enough food to change him to avoid starvation within the absence of non-entitlement transfers, like charity. Therefore famine happens. Since entitlement set is derived by applying E-mapping on the endowment set, the entitlement failure and therefore famine can occur only through some adverse modification either in endowment or E-mapping or both. Therefore there are 2 forms of famines- one is caused because of change in endowment and the different due to change in E-mapping. We are able to distinguish four forms of famines caused because of either of the following reasons: endowment loss, failure of production, exchange failure; and transfer failure (Nayak, 2005).

Osmani maintains his general claim that every famine involves a failure of food entitlements, by holding that violent removal of access is also removal of entitlement, in the sense of loss of ability to find food using legal means. Sen and Osmmani entitlement approach was criticized by de Waal. In his book De Waal stresses that patterns of response are very locally specific, depending on local social economy, ecology, and social values (Gasper, 1993). De Waal concludes that famine famines are sufficiently diverse which requires heterogeneous approaches (De Waal, 1990).

2.2.3. The sustainable livelihood theory

There were numerous early cross-disciplinary research efforts on development studies and livelihood thinking however, in the 1990s the term 'sustainable livelihood' was entered in development discourses. Increased attention to poverty reduction, people centered approaches, and sustainability in the political arena and development theory and practice resulted in the widespread adoption and adaptation of livelihood definitions, models, and frameworks (Bennett, 2010). Robert Chambers and Gordon Conway in 1992 introduce the sustainable livelihoods within the actor-oriented approaches to development, the framework of environmental and social sustainability, and the rhetoric of poverty reduction. The ability to feed oneself, one's access to commodities, and the length of one's life, for example, all contribute to one's capability to function (Sen, 1984). Chambers and Conway incorporate the former narrow concepts of poverty with the fundamental ideas of capabilities by Amartya Sen (1984; 1987) and defined sustainable livelihood as follows

> *Livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living: a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term. (Chambers & Conway, 1992)*

The British Department for International Development (DFID) developed other sustainable livelihood approach derived from Chambers and Conway's earlier definition and Rennie and Singh (1996) by adding natural resource dimension:

> *"A livelihood comprises the capabilities, assets and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base."* (DFID, 2000)

The DFID Sustainable Livelihoods Framework presents a number of factors that impact on livelihood strategies and outcomes and also emphasizes many relationships between these factors. Central to the framework is a pentagon of interchangeable livelihood assets or capitals (Bennett, 2010):

- **Natural capital**: the natural resource stocks from which resource flows useful for livelihoods are derived (e.g., land, water, wildlife, biodiversity, environmental resources).
- **Social capital**: the social resources (networks, membership of groups, relationships of trust, access to wider institutions of society) upon which people draw in pursuit of livelihoods.
- **Human capital**: the skills, knowledge, ability to labour and good health important to the ability to pursue different livelihood strategies.
- **Physical capital**: the basic infrastructure (transport, shelter, water, energy, and communications) and the production equipment and means which enable people to pursue their livelihoods.
- **Financial capital**: the financial resources which are available to people (whether savings, supplies of credit or regular remittances or pensions) and which provide them with different livelihood options.

2.3. Empirical literature reviews

2.3.1. Origin and evolution of eucalyptus plantation

Eucalyptus is one of the diverse genus of flowering plant species in the world which belongs to *Myttaceae* family, *Myrotideae* sub family and consists of more than 700 species. It is the third largest genera used in plantation forestry globally next to Pinus and *Cunninghamia* (FAO, 2006). It is native to Australia which was expanded to Europe, in Portugal, 200 years ago in (Grupo, 2009). Nowadays, different eucalypt species are cultivated particularly throughout the tropics and subtropics including the Americas, Europe, Africa, and the Mediterranean basin, the Middle East and other Asian countries like India and China. Eucalyptus was planted firstly in southern African early 19th century to as source of fuel wood in Africa (Jaleta *et al*., 2016) and now a day it is widely planted in South Africa, Kenya, Ethiopia, Zimbabwe and Tanzania (Dessie and Erkossa, 2011).Eucalypts was widely introduced in Ethiopia during the regime of King Menelik II since 1895 for solving wide demand of fire wood and construction poles in Addis Ababa (Moges, 2010).

Despite the wide socio-economic and environmental benefits of eucalyptus to the world and in Ethiopia, there are still many various opinions among different stakeholders concerning the disadvantages and advantages of planting eucalyptus. It is difficult to find common agreement on

its disadvantages. Some totally oppose, some support strongly, some totally oppose and others have doubts. For example, Gil *et al.* (2010) reported that eucalyptus plantation has negative impacts if it is planted on wrong sites, On the other hand it may have more advantages than disadvantages when it is planted in right sites like marginal and degraded lands. Planting eucalyptus increases soil acidity and gradually reduces soil nutrient content (Limenih & Teketay, 2004; Teketay, 2000), has negative net income due to high labour cost of woodlots and lack of proper woodlots market access in Tigay region, Northern Ethiopia (Jagger & Pender, 2003).

2.3.2. Expansion of eucalyptus woodlots in Ethiopia

In Ethiopia, the planting of eucalyptus features a long history. Still nowadays, plantation establishment in the country is predominantly eucalyptus (Bekele, 2011). Ethiopia, with an area of 110 million hectare, is one of the largest countries in Sub Saharan Africa. Historical sources indicated that about forty two million hectare or equivalent of 35% of Ethiopia's land area might once have been covered with forest (Ketsela, 2012).Within the early 1950s, the forests that remained coated nineteen hectares or 16% of the area and within the 1980s, coverage was about 3.6% and the most recent estimate of the land coated with forests is 3.37% of the country.

The main factor for deforestation is fast increment that results in a rise within the demand for crop and grassland, wood for fuel and construction. Lack of a viable land use policy and corresponding law aggravated the speed of deforestation. As an example, new settlements in forests area unit increasing from time to time leading to conversion of wooded land into agricultural and other alternative land uses. The public industrial plantations aimed toward meeting timber demands within the face of declining natural forest resources. The current total land estimate forest is seventy six thousand hectares. Eucalyptus is that the main species in these plantations covering 56%, followed by *cupresseslustanica* (32%) of the land area, *juniperusprocera* (2%), *pinuspatula* (1.8%), and 8% of total forest area was covered by other species (Bekele, 2011).

In 2005 total estimated forest area in Ethiopia was covering 419,000 hectares and in 2010 it had been covered 972,000 hectares, that eucalyptus covering fifty six percent of the total plantation space (Bekele, 2011). Likewise, within the Amhara region, plantation forest is increasing considerably. As an example, out of the 92,000 hectare of land coated with eucalyptus

plantations in Amhara Regional State, about 67% is farm forestry developed by farmers within the last 20 years was eucalyptus (Lemenih 2010).

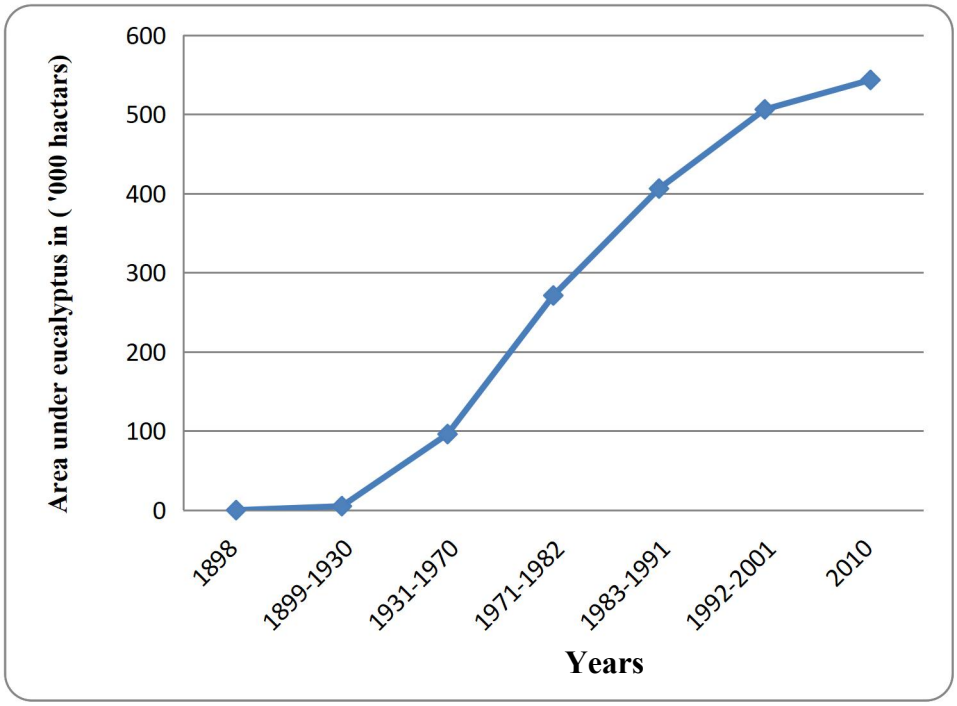

Figure 2.1: Eucalyptus growing in Ethiopia: in years 1898 -2010
(Source: Gil et al., 2010 & Bekele, 2011)

2.3.3. Driving factors to plant eucalyptus

Increasing demand for wood products within the market, inaccessibility of wood on farm, high rate of biomass production, wider adaptability and simple for cultivation, declining of land productivity, its non-palatability to livestock, declining of off farm employment opportunities are the most important driving factors of eucalyptus expansion. Eucalyptus can grow on all varieties of soil. This is also advantageous for rural households to benefit from unproductive land for crop production (Ketsela, 2012).

Eucalyptus does not need intensive management that reduces labour price for numerous products and services. It is the foremost valuable trees for fuel wood, charcoal, timber, poles, posts, mine props, plywood, paper pulp, fiber board, and production of essential oil, shade and shelter, decorative functions and as a supply of nectar for honey production. Another advantage of eucalyptus is its performance in degraded lands, marshy space, barren and exhausted soil and in dry areas (Pohjonen and Pukkala, 1990). A genus is additionally acknowledged for its smart

coppicing ability, it always forms a dense and productive stand if allowed to re-grow (Selamyihun, 2004). Moreover, eucalyptus species have proven to be simply flexible to a completely different environment and climate compared to different plant species are found to be liable to some pathogens which may slow rate of growth and also high survival rate. Leaves and other parts of eucalyptus are not/less palatable to most animals like cattle or livestock and wild animals thus, it should be established and grow with no physical harm (Getahun, 2003; Jagger and Pender, 2003).

As compared to most different typically used exotic tree species eucalyptus species are not sensitive for the attack of different tree diseases/pathogens, pests and environmental pressure (nutrient and water insufficiency). The reason for this is often the species by itself encompasses a power to resist serious communicable disease and environmental factors and also high coppicing and survival ability in all soil resources (Getahun, 2003). Excessive coppicing capability and its efficiency to convert the offered soil resource to biomass production additionally contribute to its higher survival (Getahun, 2003; Jagger and Pender, 2003).The root collars of eucalyptus can proof against fire although the aerial half or above ground parts burnt.

If the planting sites have good condition of nutrient and water eucalyptus can starts to supply output from third or fourth year based on the intention of the farmers (Getahun, 2003; Pohjonen and Pukkala, 1990).The raise of its demand and its best survival ability attracts rural farmers' attention (Mekonen *et al.,*2007). The expansion rate of eucalyptus depends on completely different management factors like growing site, amount of rain, spacing and other ecological circumstances. Basically in Ethiopia eucalyptus takes over around 25 percent of the household annual cash income and farmers choose eucalyptus because of its cost effectiveness to enhance the livelihoods of rural farmers. Fast growth in need for and its great survival attracts rural farmers' attention (Mekonen *et al*., 2007).

2.3.4. Benefits of eucalyptus tree farming

Eucalyptus has several socio-economic benefits including financial, employment and security. It generates high income to rural households in central Ethiopia and it could generate one fourth of annual cash incomes (Mekonnen *et al.,* 2007). Security is another important contribution of this tree. It is an important guarantor for farmers who want to keep up the ownership of their rural land while living in urban areas. Eucalyptus is one among the exotic plants that convert water

and other available resources to biomass and it is suitable for the advantage of rural small scale farmers in support of their daily livelihoods. As a result of its fast development, farmers prefer eucalyptus to resolve the growing demand for wood and wood products. Due to its various benefits farmers began to change even their fertile farmland to eucalyptus plantation to get income and address the ever-increasing shortage of wood products (Lemenih, 2010; Negussie, 2004).

Rural farmers of Ethiopia agree eucalyptus is like “cash deposited in the bank, a tree bank”, “and existence savior”. They regard it as a means to generate income easily from time to time, once they face a shortage of cash even as they withdraw money from the bank. Giving only environmental focus encompasses a different disadvantage for poor farmers but instead it's necessary to think about both social and ecological issues so as to attain economic targets for rural farmers. The crucial reason why farmers see eucalyptus as safe investment is its continued demand and good survival (Lemenih, 2010)

Raising the use eucalyptus is one of the factors for growers to expand eucalyptus plantations at the expenditure of another land uses (Engda *et al*., 2008) and additionally as a results of the existence of high demands for eucalyptus product the trend of expansion of eucalyptus growing on crop lands are raising. The sell worth for eucalyptus poles has grown up to be fifteen times higher over the last twenty years (Dessie and Erkossa, 2011) due to importance of eucalyptus for domestic construction-boom, reduction of crop yields, growth of population, and land degradation (Mekonnen *et al*., 2007), high demands for eucalyptus product increase the trend of expansion of eucalyptus plantation on crop lands are increasing. Growing eucalyptus help local communities to diversify and increase their farm income, and hence, farmers favor to plant eucalyptus for household use (construction, firewood, farm implements), sell, soil conservation and a gully stabilization, to remove marshy land, and ensure land tenure security (Dessie and Erkossa, 2011). Eucalypts became common among farmers in rural components of Ethiopia where they grow eucalyptus as a vital land use possibility at the farm level, contributing 50% of family financial gain relative to major agricultural crops (Kebebew and Ayele, 2010). In northern Ethiopia, eucalyptus supplies twenty percent of family income to rural farmers excluding its value for family consumption (Kelemu & Tadesse, 2010).

2.4. Conceptual framework

The conceptual framework of the study focused on the interaction of rural farmers demographic and socio economic characteristics, physical factors, institutional frameworks, farmers' perception, natural conditions and their implication on farmers' decision on using their farm land for eucalyptus woodlots plantation. Scholars have developed different theories and assumptions on expansion of eucalyptus and factors that make it more preferable. As indicated in the conceptual framework below, the eucalyptus woodlot farming depends on the access to the different types of assets like physical, human, social, financial and natural capital. The review of literature leads to the design of a conceptual framework describing the relationship between dependent and independent variables. The essence of conceptual framework is the foundation for the data collection process and shows the necessary data to be collected, processed, and analyzed. The conceptual framework used in this research focused to link the factors associated with expansion of eucalyptus woodlot farming like demographic and socio economic factors, natural factors, institutional factors and farmers' perception with rural households' sustainable livelihood and food security status.

Demographic and socioeconomic factors: household head age has positive or negative relationship with commercial value and the preferable ability of eucalyptus (Dessie *et al*., 2019).The decision of farmers to plant eucalyptus increase with increase in age of farmers because the elder has less ability to harvest crops (Tefera & Lerra, 2016). But, Ashiraf *et al*. (2014) indicated tree planting decrease with increase of age of farmers. Household head sex and educational level have also positive or negative relationship with commercial value and the preferably of eucalyptus. The small sized household family is less likely to involve in eucalyptus woodlot farming than larger sized household family because it does not require intensive management hence reducing the labour cost (Ketsla, 2012).

Farm size, livestock ownership, labour availability and off farm activities are some economic factors for eucalyptus expansion. Lower land ownership may lead farmers to other off farm activities by planting their farm land with eucalyptus. On the other hand high land ownership may lead farmers to eucalyptus farming to diversify their income source. When compared with other tree species, the economic advantages of eucalyptus are higher due to its fast growth rate to

generate income. The income found from eucalyptus woodlot s can contribute to alleviate food insecurity (Ketsla, 2012).

Physical factors: Eucalyptus is the main source of fire wood and construction material for rural households. So, availability of eucalyptus plantation within the farmers' own land holding or purchasing from the nearby villages saves the time they cost for fuel wood collection. With a fast increasing population, there is immediate need for construction of various types (Zerga and Berta, 2016). Planting of eucalypts by poor households contributed about 28% of household's income and provided quite 90% of the wood required for household consumption within the central highlands of Ethiopia (Mekonnen *et al*., 2007).

Natural factors: Eucalyptus good survival rate, growing ability in different ecologies, growth rate makes it more preferred by small-scale farmers. Different parts of eucalyptus are less palatable most browsers like cattle and wild animals. Its growth and survival rate is high, leaves and barks of eucalyptus are not/less palatable to most browsers such as cattle or livestock and wild animals and can be establish and grow without any physical damage (Getahun, 2003). It can grow on a variety of soils from fertile to infertile and degraded soils from water logged to dry conditions (Ketsla, 2012).

Institutional factors: farmers planted eucalyptus woodlot because of the increasing market demand of its products, the income generation potential and the value of soil fertilizer increases yearly. So it is difficult to be profitable using this expensive fertilizer. This means the extension service has a negative relation with eucalyptus plantation. Social factors have positive or negative relations. As a positive relation, eucalyptus farming, particularly smallholder farmers, is the question of survival, social welfare and livelihood betterment (Zerga & Berta, 2016). However, it negatively affects social relations because it is going to create conflict between farmers who planted eucalyptus on their farmlands and neighboring farmers who allocated farmlands to crop production. The allopathic nature of eucalyptus may cause reduction in crop production of neighboring farmers.

Farmers' perceptions have positive or negative relations. Positive relation is farmers growing eucalyptus to solve a question of survival and social insurance (Zerga & Berta, 2016). However, it may affect social relations negatively because it may create conflict between eucalyptus grower and crop cultivator neighboring farmers.

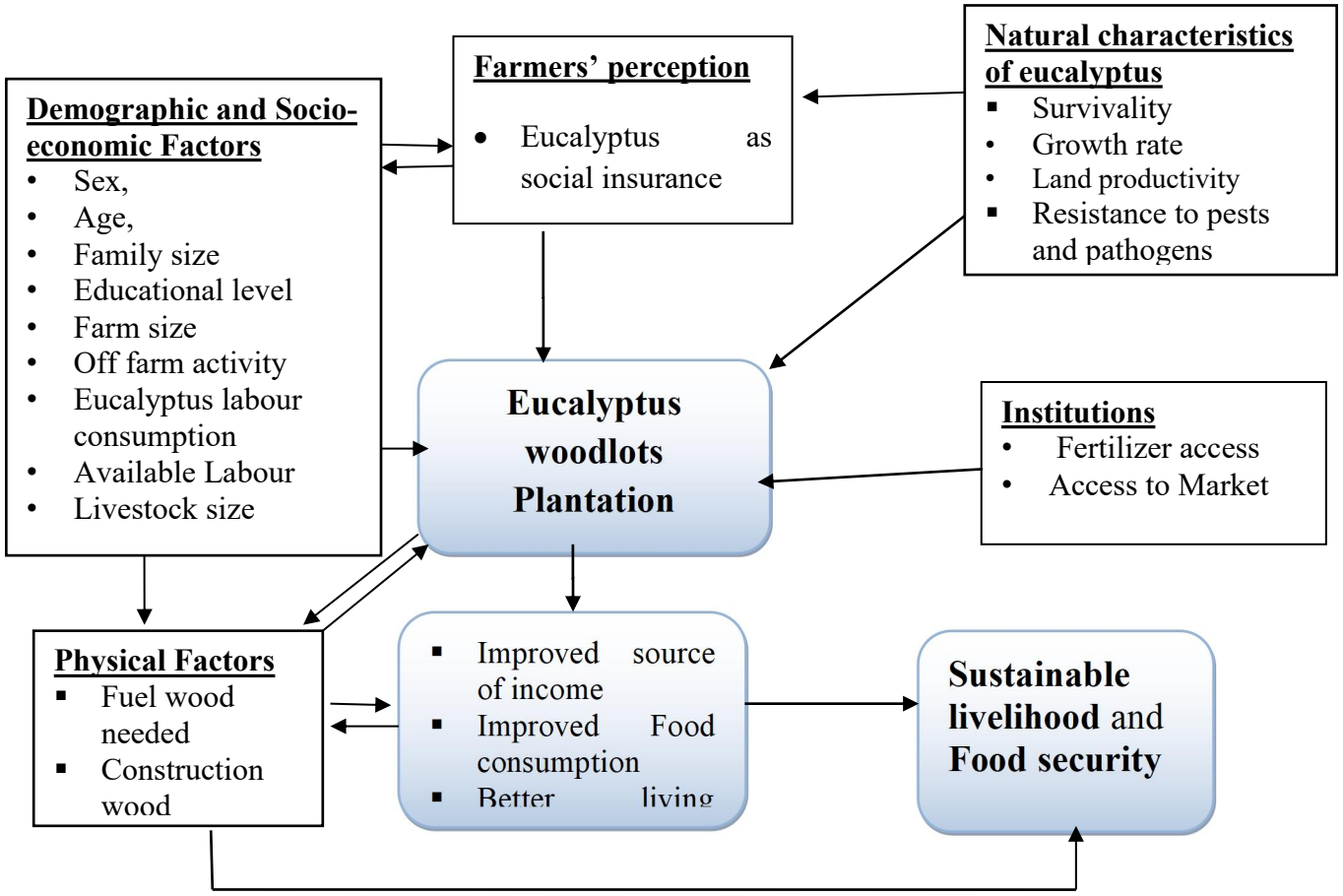

Figure 2.2: Analytical framework: derived from related literature review

CHAPTER THREE: DESCRIPTION OF THE STUDY AREA AND RESEARCH METHODOLOGY

3.1. Description of the study Area

3.1.1. Location

North Mecha *Woreda* was one of the *woredas* of West Gojjam Zone, which is found in Amhara regional state in Ethiopia. The *woreda* is new and emerged when the former Mecha *Woreda* was divided into two sub woredas (South Mecha *Woreda* and North Mecha *Woreda*). The capital of North *Mecha* is Merawi town that is located 525km North West of Addis Ababa, the capital city of Ethiopia, and thirty four kilometer South East of Bahir Dar, the capital town of Amhara region. Geographically, North Mecha is located at 11^{o} 11' N to 11^{0} 38' N latitude and 36^{0} 59' E to 37^{0}23' E longitude. The *woreda* is situated at an altitude ranging from 1800 to 2500 meter above sea level (Belay & Wale, 2019).

3.1.2. Biophysical characteristics

The *Woreda* receives an average annual rainfall ranging from 1000 to 2000 mm and average daily temperature is 24^{o}c. The total land coverage of the *Woreda* is 1,124.3 square kilometer. The Woreda has a high potential of water resources including the Koga irrigation scheme. According to North Mecha *Woreda* agricultural and natural resource office, the climatic condition of the Woreda is 20% *dega* and 80% *woynadega*.

3.1.3. Demography

The *Woreda* is divided into 33 rural and 5urban kebeles. According to the *Woreda* and Amhara regional state population projection, the total population of North Mecha *Woreda* in 2021 was 261,507 of whom 128,572 are male and 132,935 are females. A total of 48,441 households and an average of 5.4 persons to a household live in North Mecha.

3.1.4. Socioeconomic characteristics

Livelihood in North Mecha *Woreda* depends largely on agricultural production and petty trade (Molla *et al*., 2014). Mixed farming is the major socioeconomic activity of the *woreda*. Both crop production and livestock husbandry are practiced side by side. The major crop products

seasonally harvested include sorghum, maize, millet, teff, wheat and other legume groups and the farming is subsistence and practiced in fragment land holdings. The main livestock types raised in the *woreda* are cattle, equine and poultry husbandry are mainly practiced (Salew and Munshea, 2018). Farm forestry is another farming activity of households. Eucalyptus farming is the main farm forestry activity practiced by farmers. In Mecha *Woreda* fertile crop lands are changed to eucalyptus woodlots due to financial benefit generated with minimal labor and inputs and fear of crop yield production from neighboring eucalyptus woodlots (Yitaferu *et al*., 2013).

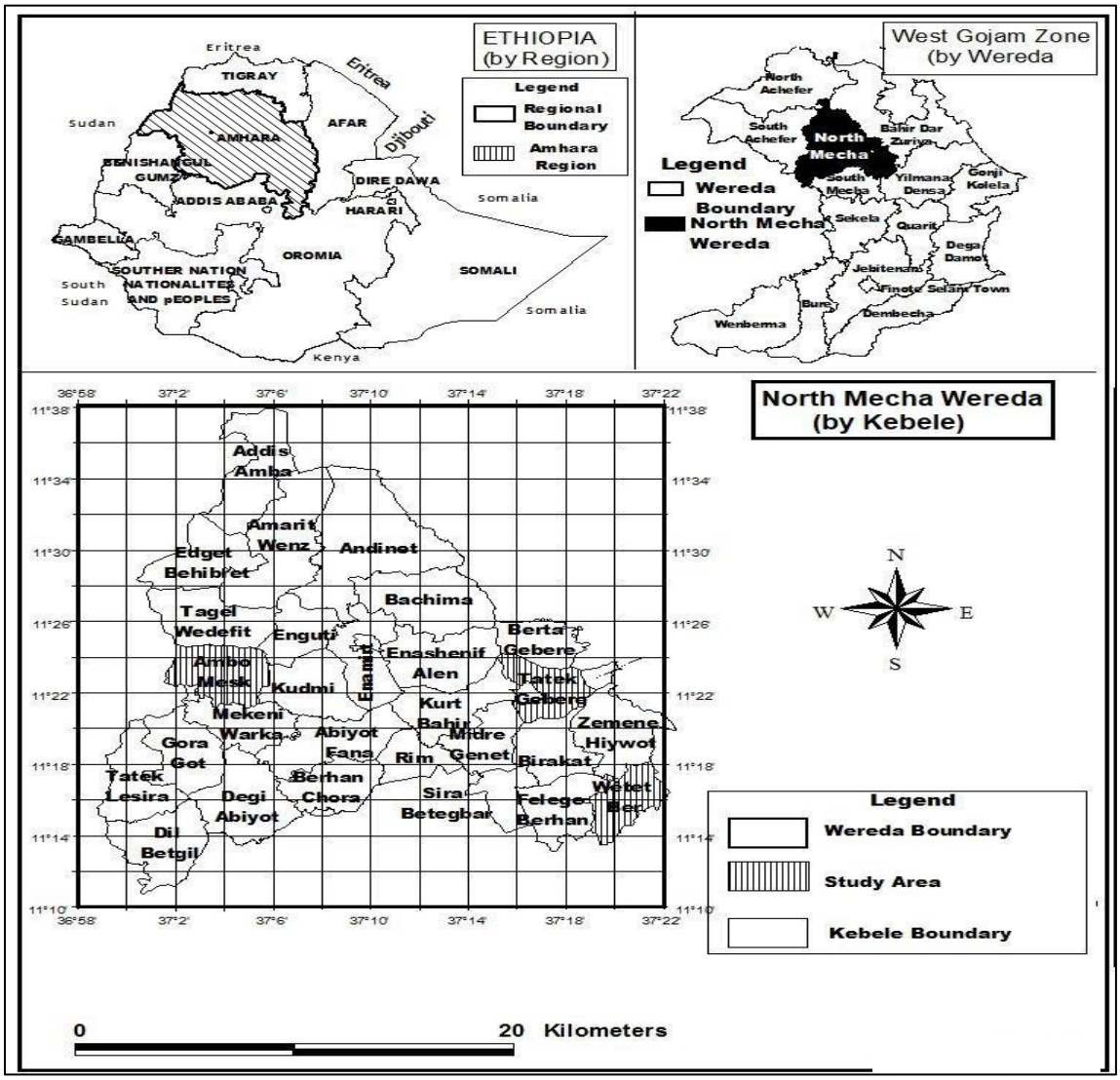

Figure 3.1: Location of study area; North Mecha *Woreda*

3.2.Research methods

3.2.1. Research design and approaches

The study has cross-sectional study design. Cross-sectional surveys were used to gather information on population at a single point in time. Moreover, mixed research (triangulation aproach), both qualitative and quantitative approaches was used to answer both open-ended and close-ended research questions outlined and address the specific objectives. The coverage of eucalyptus woodlots and different food crops on farmers' crop lands will be described in percent.

3.2.2. Data types and sources

Both quantitative and qualitative data was collected from primary and secondary sources for this study. The data included several issues such as socioeconomic, institutional and demographic characteristics of households, their land size, magnitude of eucalyptus production, and economic contribution of eucalyptus plantation, sustainable livelihood and food security status of households. Besides, data was obtained from published and unpublished literature such as books, journals, articles, reports and e-resources. Documents from the *Woreda* agricultural office and other relevant reports were also being reviewed to support the primary data.

3.2.3. Sample size determination and sampling techniques

This study used multi stage sampling techniques. At the first stage, the *woreda* was purposely selected as a study area. Because eucalyptus woodlots plantation expansion is increasing and there is more conversion of crop fields and grazing land to Eucalyptus woodlots in all areas of the woreda (Yitaferu *et al*., 2013).The other reason was that the researcher is familiar with the study area, knows well about the status of the eucalyptus expansion in the *woreda.* At the second stage, three *kebeles* were purposely selected from 33 total rural *kebeles* by the consultation with *Woreda* agriculture office experts due to fast expansion of eucalyptus in farm lands of the *kebles.*

At the third stage, 196 sample households (69 in *Ambomesk*, 56 in *Tatek Gebere* and 71 in *Wotet Ber*) were selected from the three *kebeles* using proportionate sampling techniques and interviewed using structured questionnaires. However, it is obvious that one of the challenges of a researcher is how to decide what should actually be the sample size to be selected from a

population. Even, high sample size is advantageous in terms of accuracy of the study. However, sample size depends on a number of considerations of which the homogeneity of population, resources limitation for the study and the precision required are the most important ones (Tefera, 2010). If there is a resource limitation, investigators may use a larger precision (e.g. >10%) (Naing *et al*, 2006). Taking this concept into account, in this study 7% precision is used to determine sample size (Abiye, 2020).

The sample size of the study was determined using statistical formula for population size (N) greater or equal to 10,000 simplified formula recommended by (Kothari, 2004).

$$n = Z^2 \frac{pq}{e^2}$$

$$n = 1.96^2 \frac{0.5*0.5}{(0.07^2)} = 196$$

Where, n is sample size to be computed, p = population proportion, Z= level of confidence and e = level of precision.

A proportionate sampling technique were used to select samples from each *kebeles*, because the total number of household heads that are participating in agricultural activities in each *kebele* was different (Table 3.1)

Table 3.1: sample size distribution in selected kebeles

Selected Kebeles	Total Number of households	Sample households
Ambo Mesk	1,433	69
TatekGebere	1,143	56
WotetBer	1,447	71
Total	4,023	196

3.2.4. Data collection techniques

Primary data have been collected from household heads through surveys and key informant interviews. The interview schedule considered semi-structured questions have been translated into local language and pre tested prior to the actual data collection and secondary data such as documents from *Woreda* agricultural office, *Woreda* food security office and other relevant reports reviewed to support the primary data and have detailed information.

Household survey questionnaire: A household survey was conducted using both open ended and closed ended questionnaires. The survey was conducted to gather determinant factors for eucalyptus expansion such as demographic and socio-economic characteristics of households, physical & institutional factors, economic activities (eucalyptus woodlots, crop production, food security profiles, and major sources of household food (agricultural and non-agricultural food sources). The survey was administered with sample farming households by using a standard questionnaire after obtaining the consent of the respondents as a research ethics. The questionnaire was translated into Amharic language for the purpose of simplicity and ease of communication between the enumerators and the respondents. Data collectors have been well oriented on the issue of data collection procedures and ethics. Pilot study was undertaken from10 respondents for pre-testing the questionnaire in order to estimate the time needed to complete and validity of the data to be collected. Then, the questionnaire was edited in light of pilot study.

Key informant interview (KII): Key informants were selected to gather information such as current eucalyptus debates, reasons for eucalyptus expansion and policies which prohibit eucalyptus planting. Interviews with key informants were carried out using an interview checklist. The KIIs included 3 DA team leaders and one agricultural expert and 3 *Kebele* administrators were interviewed to obtain relevant information related to eucalyptus plantation and livelihood and food security issues.

Field observations: Field visit was performed by researchers to support supplementary information obtained through other primary and secondary data collection tools. Checklist notes and photographs used to record what the researcher observed about eucalyptus expansion and seedlings.

3.2.5. Data analysis techniques

Data was coded and entered into excel and was exported to SPSS version 20 for analysis. The study employed both qualitative and quantitative techniques to analyze the data collected. Qualitative techniques used to describe data that was acquired through observations, key informants and questionnaires. Descriptive statistics, econometrics models such as multiple linear regression models and household food balance model were used for this analysis. The information gathered from key informants and personal observation was analyzed qualitatively.

Descriptive analysis

The annual income from eucalyptus was collected from households. Comparative analysis (CA) is one of the evaluation methods for comparing the economic contribution of different products, such as eucalyptus woodlots with agricultural crops and other income sources. Descriptive analysis was used for this purpose.

Econometric analysis

After the descriptive statistical analysis multiple linear regression models were used to identify significant variables determining the preferably of eucalyptus woodlot s in the study area. The multiple linear regression (MLR) models permit estimating relation between dependent variables and freelance variables. The MLR model was selected due to its simplicity and practicality (Dessie *et al.,* 2019). The model is important to test both economic theories and non-experimental data because it can be accommodate many dependent variables which may be correlated (Maddala & Lahiri, 1992).To find out the determinant factors that make eucalyptus preferable small-scale farmers in the study area, functional relationship is specified in the equation below

$$y = \beta\ 0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \ldots + \beta k Xn + \varepsilon k$$

Where, y= dependent variable Where, y = dependent variable explained by different explanatory variables, Xn = independent variables, β0= intercept of regression model, βk = parameters and εκ = error.

Then, the linear regression model can be written as

$\mathbf{y} = \mathbf{X}\beta + \varepsilon$

In general, the variance inflation factor for the j^{th}regressor coefficient can be computed as

$$VIF = \frac{1}{1 - Rj^2}$$

Where, Rj^2 is that the multiple correlation coefficients between explanatory variables, the larger the value of Rj^2, the higher the value of VIF (X_j) causing co linearity within the variable (X_j). Likewise, the multi-collinearity between discrete variables is often calculated using the contingency coefficient. The worth ranges between 0 and 1, 0 indicating no association between the variables and value near to 1 indicating a high degree of association between variables.

Food Security Analysis

For this study, the Household Food Balance Model (HFBM) was used to quantify available food in households and to determine per capita kilocalorie consumed per year in the household. The HFBM was modified from the Regional Food Balance Model (Degefa, 1996) sited by Abi & Tolossa (2015). The net available food per household per annum, as reported from household recall, was converted into dietary energy equivalent using Ethiopian health and nutrition research institute EHNRI/FAO (1998)'s food composition table for use in the case of Ethiopia. Then, annual kcal availability per household was converted to daily kcal per adult equivalent. Medically suggested level of calorie per adult equivalent (2100 kcal/day/person for Ethiopia) was used as a cut-off purpose for food insecure and food secure households set by the Ethiopian government. The model was given by the subsequent mathematical expression.

NFA= (GP+GB+FA+FG) - (HL+GR+GS+GG)

Where,
NFA= Net food available/year/household
GP= total grain produced /year/household
GB= Total grain bought/year/household
FA= Quantity of food aid obtained/year/household

FG= total food obtained through gift or remittance/year/household

HL= postharvest losses/year

GR= quantity of grain reserved for seeds/year/household

GS= Grain sold/year/household

GG= Grain given to others/year

3.3.Description of study variables

Dependent Variable

The dependent variable of this study is eucalyptus woodlot size which is continuous variable expressed in numbers.

Explanatory variables: land size used **for** eucalyptus as explanatory variable of the study, it was expected to be predicted by the following explanatory variables;

- **Age of household head (AGE):** Age is a continuous explanatory variable which has values in numbers and negatively or positively affects land size used for eucalyptus adoption. The decision of farmers to plant eucalyptus increases with increase in age of farmers because the elder has less ability to harvest crops (Tefera & Lerra, 2016; Dessie, 2019).Tree planting decrease with increase of age of farmers (Ashraf *et al.,* 2015).
- **Household head sex (HSEX):** it is dummy variable which has values 1 for female headed households and 0 for male headed households. Female headed households expected to have a positive effect on expansion of eucalyptus (Ketsla, 2012). On the other hand male headed households were most probably participating in tree cropping than female headed households (Kassie, 2018).
- **Educational level of household head (HEL):** education has an important role to livelihood improvement of rural households'. It is a dummy variable with values 1 for household heads who can read and write (literate) and 0 for those who cannot read and write (illiterate). According to Edesa (2021) & Gizachew (2017) educational level has positive relation with expansion of eucalyptus wood lots by rural.
- **Family size (FAZ):** it is a continuous variable which refers to the total numbers of persons living in a household. This variable may have a positive or negative impact on

eucalyptus expansion. According to Tefera & Lerra (2016) family size has positive relation with eucalyptus adoption. Family size had negative impact on decision making of farmers to adopt eucalyptus (Ashraf *et al*., 2015).

- **Availability of Labour (AVL):** is one of the variables which can determine the cultivation of eucalyptus by rural farmers. It is a dummy variable which has values 1for labor is available for farming activities and 0 otherwise. Availability of labour has a negative relation with eucalyptus plantation because allocating farm lands for woodlot production due its less labour intensive and fewer prices than crop production (Dessie *et al*., 2019).
- **Participation on off-arm activity (PAROA):** This is a dummy variable that indicates participation of household heads on additional activities rather than farming and has values if household head participate off- farm activities and 0 if not participate. It has positive relation on eucalyptus expansion which indicates off-far participant farmers have higher probability to cultivate eucalyptus woodlots than non-participants (Mekonnen *et al*., 2007).
- **Labour need for eucalyptus (EVL):** is a dummy variable that has value 1 for high value per unit of land and labour and low for otherwise. The cost of labor for tree planting and management are comparatively low, particularly in years after the trees are established (Jager & Peneder, 2003).
- **Land holding size (FARZ):** It is a continuous variable which indicates the amount of land owned by households in hectares. According to Tefera & Lerra (2016) households with high farm size have more probability to prefer eucalyptus. For this study, households with large land holding size have a positive influence on eucalyptus plantation.
- **Social value (ESV):** Social factors have positive or negative relations. As a positive relation eucalyptus tree farming, particularly for small holders is the question of survival, social insurance, and livelihood betterment (Zerga & Berta, 2016). On the other hand farmers may plant eucalyptus due to being afraid of neighboring woodlots on their crop production.

- **Fertilizer access (FAC):** It is a dummy variable and one of the determinant factors of eucalyptus expansion with values 1 for cost of fertilizer is cause for eucalyptus woodlot expansion and 0 for otherwise.
- **Market access (EMA):** it is a dummy variable which has values 1 market is accessible and 0 if otherwise. The expansion of eucalyptus increased due to available market for eucalyptus woodlots and its products. According to (Derbe, 2018) market access has positive relation with expansion of eucalyptus by rural farmers.
- **Livestock ownership (TLU):** is a continuous variable which indicates wealth status of households in livestock in this study households with less size of livestock are more likely to plant eucalyptus woodlots.

Table 3.2: variables and their characteristics

Variable	Code	Type	Description with measurement Unit	Expected sign
Household head Age	AGE	Continuous	In years (household head)	±
Household head Sex	HSEX	Dummy	1 for male and 0 otherwise	±
HH Educational level	HEL	dummy	1 for literate, 0 for illiterate	±
Family size	FAZ	Continuous	Number of family members (in number)	-
Availability of labor	AVL	dummy	1 available for farming activities and 0 if not	±
Participation on off farm activity	PAROA	dummy	1 if participate and 0 if not participate	±
Labour need for eucalyptus	VLL	dummy	High=1, Otherwise=0	-
Farm size	FARZ	Continuous	Total land for eucalyptus and other farming activities	+
Social value	SOIN	dummy	1 if preferable due to social value , 0 if not preferable	+
Fertilizer access	FAC	Dummy	1 if higher cost of fertilizer is cause for eucalyptus expansion and 0 if not	_
Access to market	EMA	Dummy	1 if accessible and 0 if not accessible	+
livestock ownership	TLU	continuous	Total numbers of different livestock in TLU	±

CHAPTER FOUR: RESULTS AND DISCUSSIONS

This chapter describes and discusses the results of the study. It has five sub-sections. The first section describes the characteristics of study households. The descriptive statistical results show the demographic, socio-economic and institutional characteristics of study households. The second subsection presents the prevalence of eucalyptus; the section shows factors that make eucalyptus woodlot plantation more preferable among small-scale farmers. The economic advantage of eucalyptus woodlots will be presented in sub-section four. Finally, in sub-section five the study presents the food security status of study households.

4.1. Characteristics of study households

4.1.1. Demographic and socioeconomic characteristics of study households

The demographic characteristics of rural households of the study area is presented and explained in (Table 4.1) by different variables. Among the study participants, 77% were male headed and 23% were female headed households. However, it does not fully mean that male headed households participate in eucalyptus production than female headed households but it indicates most households are male headed. Regarding the educational status, the majority (52%) of the sampled farmers were illiterate, whereas, 32% of household heads were only able to read and write and only 16% of household heads were attending formal education from primary to secondary education. Only 31% of the respondents thought there was labour availability and 69% of them answered there was shortage of labour for farming activities.

When respondents were asked about labour needed for eucalyptus plantation compared with crop production, about 9 (4.6%), 25(12.7%) of respondents answered high, medium respectively and most respondents about 160 (82.7%) were answered as eucalyptus plantation needed lower labour forces than crop production. This result indicates less labour demand for eucalyptus woodlot production as compared with crop production. Crop production is labour intensive and needs labour for each year production. This indicates that the higher labour needed for crop production may cause the expansion of eucalyptus by rural households. About 32.7% of respondents were participating in off farm activity and 67.3% were not participating. The survey result also shows that eucalyptus woodlot is better for a stable land use system practiced for many years. Most study households (about 68.4%) thought eucalyptus woodlot is more

preferable to be socially insured than crop production but 31.6% of them did not prefer eucalyptus for social insurance.

When the respondents asked whether they have their own land or not, all (100%) responded as they have their own farm land for crop production or/and eucalyptus plantation (Table 4.1). However, when they asked whether enough land for crop and eucalyptus production or not, most (98%) of them responded they did not have enough land for both farming activities; they cultivate eucalyptus because it is less labour intensive and as a source of additional income.

Table 4.1: Demographic and socio economic characteristics of respondents (n=196)

Variables		Number of respondents	Proportion (%)
Sex	Male	151	77
	Female	45	23
Educational status of household head	Unable to read and write	102	52
	Only able to read and write	63	32
	Formal education	31	16
Availability of labour for farming activities	yes	61	31
	No	135	69
Labour needed for eucalyptus production	High	9	4.6
	Mid	25	12.7
	Low	162	82.7
Participation of household heads in off-farm activities	yes	64	32.7
	No	132	67.3
Eucalyptus Social value	yes	134	68.4
	No	62	31.6
Land possession	Yes	196	100
	No	0	0
Land is enough for crop and eucalyptus	Yes	4	2
	No	192	98

Source: household survey (2021)

As can be observed from the survey data (Table 4.2), the age of respondent households ranged from 28 to 69 and the mean age was 45.45 years with standard deviation of 10.27. The distribution of the respondents by household family size ranged from 2.0 to 8.0 with an average of 4.27 (4) persons per family and standard deviation is about 1.33. The number of family members participating in farming activities varied from zero to 6 persons and mean 1.087 with standard deviation 0.86. The minimum livestock owned by households was zero and maximum was 7.4 with mean and standard deviation 2.8 TLU and 2.07 TLU, respectively.

Table 4.2: Distribution of households by HHHs age, family size and farming activity participation and livestock ownership

Variables	Minimum	Maximum	Mean	SD
Household head age (years)	28.0	69.0	45.45	10.27
Household family size (Number)	2.0	8.0	4.29	1.33
HH members participate in farming activities (Numbers)	0.0	6.0	1.087	0.864
Total livestock (TLU)	0	7.4	2.8	2.07

Source: household survey (2021)

Based on the results presented in Table 4.3, all farmers had their own land. The sum of farm land possessed by 196 respondents was 250.51 hectares. From the total land of respondents, 63.28% (with mean of 0.81 and S.D of 0.62) of land used for crop production, eucalyptus was planted on 29.12% (mean=0.37 and S.D= 0.22) of the land and 7.6% of the land with mean of 0.098 and standard deviation 0.12 was utilized for grazing. The maximum land owned by the respondents was about 4.0 hectares and minimum was 0.2 hectares with mean 1.28 and standard deviation 0.75 respectively. At national level the average household land holding size in rural areas is 1.77 hectares (CSA, 2013). This indicates that most farmers in the area consist of a small fraction of land area, which is less than the national average and not sufficient for both crop production and eucalyptus plantation. This implies that limited land size with large family size tends to the farming households to engage in nonagricultural activities to enhance food security within the study area.

Table 4.3: Total land owned by farmers and its usage

Land usage	Minimum (hectares)	Maximum (hectares)	Sum (Hectares)	Percent	Mean	Std. Deviation
For crop	0.000	3.300	158.525	63.28%	0.81	0.62
For eucalyptus	0.000	1.000	72.950	29.12%	0.37	0.22
For grazing	0.000	0.500	19.035	7.6%	0.098	0.12
Total farm size	0.200	4.000	250.510	100%	1.28	0.75

Source: household survey (2021)

4.1.2. Institutional characteristics of study households

As indicated in Table 4.4, respondents were asked whether they have access to fertilizer for their crop production, most respondents about 91.8% were answered as fertilizer is available for crop production but 73% of respondents thought the cost of fertilizer is high and 26.5% and 0.5% of respondents thought medium and low respectively. About 91.8% of respondents answered that the higher cost of fertilizer is the main cause of eucalyptus expansion. About 66.8% of respondents cultivated eucalyptus due to its highest market access.

Table 4.4: Shows whether fertilizer access for crop and eucalyptus production cause for eucalyptus expansion or not and its market access the study in the area (n= 196)

Variables		Number of respondents	Proportion (%)
Fertilizer access	Yes	180	91.8
	No	16	8.2
Cost of fertilizer for crop production	High	143	73
	Mid	52	26.5
	Low	1	0.5
Cost of fertilizer causes eucalyptus expansion	Yes	180	91.8
	No	16	8.2
Market access	Yes	131	66.8
	No	65	33.2

Source: household survey (2021)

4.2. Prevalence of eucalyptus woodlots

The survey result shows that out of 196 sample households 186 (95%) planted eucalyptus on their farm lands whereas 10 (5%) households did not plant eucalyptus on their farm land. Eucalyptus covers about 29% of farm lands of the study areas. The key informant A at Ambomesk *kebele* indicated *"development agents prohibit us no to plant eucalyptus on our farm land but I want to plant half of my farm land eucalyptus woodlot because the cost of fertilizer is too expensive and it is difficult to be profitable by crop production. Expansion of eucalyptus is high and almost all households which have farm land grow eucalyptus and no other alternative species can replace the contribution of eucalyptus. "*Another key informant at Tatek Gebere *kebele* indicated that the "*expansion of eucalyptus on his kebeles is high in each year but in this*

year the cost of eucalyptus decreased due to the civil war in Tigray and Amhara regions because there was high demand of eucalyptus products by Tigray region. He said they named 'MEKELE' to three or four year 8meters abrade eucalyptus product." This indicates most of the rural households of the *woreda* had eucalyptus woodlots on their farmland. The result is lined with results of different studies. The study conducted by Gizachew (2017) in Chencha district, Southern Ethiopia indicated about 58% of households had eucalyptus woodlots and other study indicated 88% of rural farmers planted eucalyptus tree on their farmland and most (74.8%) establish eucalyptus as woodlots (Jember *et al*., 2012). According to Alebachew *et al.* (2014) all farmers of the *woreda* were utilized their farm land for combination of eucalyptus planting and other agricultural activities.

Figure 4.1: Eucalyptus woodlots at different sites of study area
Source: Researcher field observation (2021)

4.3. Factors that make eucalyptus woodlots preferable by rural households

4.3.1. Natural characteristics of eucalyptus

As can be observed from the survey data in Table 4.5, most respondents about 97.4% responded that eucalyptus can highly survive, at different bad conditions like climate change, snow and drought; only 2.6% answered the survivability of eucalyptus as medium level. It can be grown and established without any physical damage compared to other woody species. It has high

coppicing ability and can convert available soil resources to biomass production (Ketsela, 2012; Jagger and Pender, 2003). Additionally, once planted eucalyptus can regenerate after coppicing again and again for years but crop cultivation requires much energy, time, and cost for cultivation year to year (Emiru, 2016).

About 92.3% and 7.7% of respondents responded that the growth rate of eucalyptus is high and medium respectively compared with other plant species. Eucalyptus can start to give output from the third or fourth year (Kebebew and Ayele, 2010). About 83.7% of respondents replied that the weed and pest resistance ability of eucalyptus is high and 16.3% medium resistance compared with crops. Compared to most other commonly used tree species eucalyptus is not sensitive for the attack of different diseases and pests. About 36.2%, 57.1% and 6.7% responded that its easiness to cultivation is high, medium and low respectively. But 99% perceived that it is less compatible with crops. This indicates the better natural characteristics of eucalyptus, one of the causes for its choice and expansion by small scale farmers.

Table 4.5: Households' response on natural characteristics of eucalyptus which make it preferable by smallholder farmers

Eucalyptus nature	HHHs responses		
	High	Mid	Low
Survive in different conditions	191 (97.4%)	5 (2.6%)	0
Growth rate	181 (92.3%)	15 (7.7%)	0
Weed resistance	164 (83.7%)	32(16.3%)	0
Better and easy for cultivation	71 (36.2%)	112 (57.1%)	13 (6.7%)
Compatible to grow with crops	0	2(1%)	194 (99%)

Source: household survey (2021)

4.3.2. Physical characteristics of eucalyptus

Since a large percentage of Ethiopian households are wood dependent, smallholder farmers mainly grow eucalyptus for their cooking, heating, construction and farm implement tools (Jember *et al*., 2012). The cultivation of eucalyptus in the North Mecha *Woreda* has also similar purposes. In the study area, eucalyptus trees are cultivated with a priority objective of income source, construction of housing, and household fuel wood needs.

Eucalyptus as the source of construction

Nowadays, because of fast population growth there is a high need for construction of different types. As shown in the study area 100% of rural farmers were building their house using eucalyptus. The same result was reported that eucalyptus contributes 100 % each for construction poles and posts (Mekonen, 2010). It was also reported that eucalyptus contribute 92 %, 74 %, 85 %, 40 %, 83 % and 91 % of construction poles, timber, fire wood , charcoal, post and farm implements wood sources respectively for rural livelihoods (Mekonnen *et al.*, 2007). This indicates these kinds of large amounts of wood needed may be possible only through eucalyptus, which is available in smallholders' woodlots. Generally, in the study area, construction and eucalyptus plantation are not separable since it is fast growing, less labour and capital intensive, multipurpose and coppice itself in large quantities in a short period and sustainable way.

Eucalyptus as the source of fuel wood

In this study 100% of the respondents answered, they did not face fuel wood scarcity. The amount of fuel wood source and its consumption depends on households' eucalyptus woodlot availability. In surveyed areas, the question of scarcity in fuel wood supply, as reported by farmers, is already solved. Farmers used eucalyptus primarily as fuel wood instead of animal dung and crop residues. The positive effect of the eucalyptus tree is that it has replaced crop residues and animal dung which are advisable to fertilize the soil as a source of bio fuel. According to the key informants, it has also reduced the rate of natural forest deforestation.

Household fire wood source seems largely dependent on eucalyptus plantation. All the key informants indicated *"there are no other alternative plant types which can replace eucalyptus to fulfill wood needed by households for different purposes"* Table 4.6 also indicates this reality. All of respondents from the three selected *kebeles* ranked eucalyptus cultivation as the primary important means of firewood. However, 82.6% and 0.5% of the surveyed households ranked crop residues and animal dung as the second source of household fuel respectively and from the total household heads 70.4% and 1% ranked animal dung and crop residues as the 3rd source of household fuel respectively. Hence, households' fuel from eucalyptus is greater than fuel

generated from others. Thus, eucalyptus plantation is the question of survival, insurance and livelihood subsistence of rural farmers.

Table 4.6: Households' Response on fuel sources (in rank)

Fuel Sources	Number of respondents by stating rank (multiple response)			
	Primary	Secondary	Tertiary	Quaternary
Eucalyptus	196 (100%)	0	0	0
Animal dung	0	1(0.5%)	138(70.4%)	0
Crop residues	0	162(82.6 %)	2(1%)	0
Others	0	0	0	0

Source: Survey (2021)

4.3.3. Econometric model for household characteristics

Before the analysis, test of multiple regression assumptions were carried out.

- **Multico-linearity test:** is inter-correlation among predictors. According to Tabbachnick and Fidell (2001), when the tolerance value and VIF of the regression is less than 0.1 and greater than 10 respectively, it indicates the presence of multi co-linearity on the data. All the VIF values are less than 10; all the tolerance values are greater than 0.1, indicating there is no serious correlation among study variables (Annex 5).
- **The values of the residuals are independent:** Durbin-Watson statistic to test the assumption that our residuals are independent or not. Durbin-Watson Values below 1 and above 3 leads to invalid analysis. In this thesis Durbin-Watson value is 1.77, indicating residuals are independent.
- **Linearity assumption and homoscedasticity:** Was tested using scattering plots of the residuals and non-linearity and hetroscedasticity were not problem for the regression analysis.
- The model was significant at (P=0.000) with the value of R^2 (0.36) a pretty good proportion and the independent variables employed in the model determines the preferable ability of eucalyptus woodlots 36%.

The multiple regression model result presented in Table 4.7 indicates the significant factors that build eucalyptus woodlots preferable by rural farmers in the study area.

From the 12 variables included in the model, five variables specifically; labour need to eucalyptus plantation (0.011), household participation in off farm activity (p=0.000), farm size (p=0.000), fertilizer cost (0.011) and market access (p=0.004) were found to be significant

factors that make eucalyptus woodlots preferable by rural households. Regarding the relationship of variables with expansion of eucalyptus by farmers; household participation on off-farm activity, farm size and market access had positive relationship, whereas, cost of fertilizer and eucalyptus value per labor and land had negative relationship.

Participation in off-farm activity: is significant at (p=0.000) and 1% significance level with standardize coefficient (b) =0.177 and have positive relation with eucalyptus preferences implies that as the household participation on off-farm activity increases by one unit land usage for eucalyptus increase by 0.177 hectares; and eucalyptus plantation becomes more preferable and results in expansion of eucalyptus increase. The possible explanation for this result could be the tendency of off farm activity participant household heads to cultivate eucalyptus woodlot because once it grows it does not need any follow up compared with crop production. The result is in line with the study Dessie *et al*., (2019). They reported that farmers participating in off farm activities have higher tendency of allocating farm lands for woodlot production as it requires less investment than crop production (Tree planting is not as labor intensive as different agricultural production activities, farmers whose main supply of financial gain is non-agricultural are more likely to plant trees on farms.

Total land size: the land size owned by farmers and eucalyptus woodlot expansion were positively related at (p=0.000) and 1% significant level with standardize coefficient (b) is 0.143 which indicates when land owned by households increased by one unit land usage for eucalyptus increase by 0.14 hectares. The possible reason is that individuals that have large land size may be interested to plant and grow eucalyptus woodlot. This means land availability is a critical factor in household tree planting. Ayele (2009) and Gizachew (2017) reported a similar result. They reported that tree growing on farm parts needs agricultural areas and tree growing depends on availability of land. They explained possession of enough land by units provides enough households to grow crops for food and additional to plant eucalyptus and the total land holding of the households had positive and significant effects on the farmers' decision to provide and cultivate eucalyptus woodlot on the farmlands. Similarly, previous studies noted that determinant factors towards growing and managing eucalyptus were affected space and land possession(Tefera & Lerra, 2016; Jenbere *et al*., 2012).Land holding size affects farmers'

decision to plant trees significantly and positively. The findings of this study are in line with the common assertion that area of landholding and area of tree plantings are positively related (Negussie, 2004; Abebe, 2005; Tolera *et al*., 2008)

Labour need to eucalyptus plantation: was also significant at 5% significant level with (p=0.011) and negatively correlated with expansion and preferable ability of eucalyptus woodlots indicating that within a small amount of labour we can cultivate large amounts of eucalyptus compared with crop production. The possible reason for this is eucalyptus does not need intensive management therefore reducing the labor cost for various products and services (Ketsla, 2012). Labor is the primary input for tree planting. However, when compared with other land uses like annual crop production, the cost of labor for tree planting and management are comparatively low, particularly in years after the trees are established (Jager & Pender, 2003).

Fertilizer access: the multiple regression result showed that fertilizer cost was significant at 5% significant level with (p=0.011) and household's decision to plant eucalyptus woodlots increase while fertilizer access goes to decrease. Households that were less accessible for fertilizer for their crop production were more likely to adopt eucalyptus woodlots on their farmland compared with rural farmers who were accessible for soil fertilizers. This indicates as they initiated to expand eucalyptus plantation on their farm land rather than cultivating crops because they did not need fertilizer for eucalyptus plantation, which has the highest cost of biomass.

Market access: associated significantly and positively with preferable ability of eucalyptus woodlots by rural farmers 1% significant level with (P=0.004). This is due to easier supply of seedlings and sale of woodlots products with low transaction cost. Farmers planted eucalyptus woodlot due to the high demand of eucalyptus products and income generation potential of the activity. According to (Gil *et al.,* 2010) Households sell their eucalyptus at farm, and farmers are price takers and few farmers have started transporting and selling their eucalyptus in the nearby town market. Similar result was stated that, farmers who have market access able to get required inputs for eucalyptus woodlot production easily and they could sale products at write time and with reasonable price, which influences farmers positively to adopt eucalyptus on their land which enables them to improve their livelihood (Derbe *et. al*, 2018).

Table 4.7: MLR model result of determinants that make eucalyptus woodlots preferable by small scale farmers

Variables	Un standardized Coefficients		t	Sig.
	B	Std. Error		
Household head sex	-0.032	0.037	-0.848	0.398
Household head age	-0.002	0.002	-0.975	0.331
Household head educational level	-0.015	0.034	-0.431	0.667
Family size	0.018	0.013	10.368	0.173
Labour need to eucalyptus plantation	-0.092	0.035	-20.586	0.011**
Availability of labour	-0.026	0.030	-0.888	0.376
Eucalyptus social value	-0.022	0.028	-0.766	0.445
Participation of off farm activity	0.177	0.036	4.959	0.000***
Total farm land size	0.143	0.029	4.957	0.000***
Fertilizer access	-0.125	0.049	-2.553	0.011**
Eucalyptus Market access	0.084	0.029	2.877	0.004***
Total livestock owned	-0.002	0.009	-0.204	0.839
(Constant)	0.293	0.107	2.745	0.007***
Number of obs.=196; F(12,183)= 8.432 ; Prob>F (P=0.000) R-squared=0.36 ; Method =Inter				

Dependent variable is **land size used for Eucalyptus (in ha.)** woodlot plantation and the stars *** and ** shows the values statically significant at1% and 5% significance level respectively

4.4. Economic Advantage of the eucalyptus to households' livelihoods

The major income source identified by the households in the study area includes crop production, livestock, eucalyptus, petty trading, regular employment, temporary employment and other non-farm activities. From these major sources, income from eucalyptus sale constitutes the largest share. In Figure 4.2 the contribution of eucalyptus to the total annual households' livelihood financial income at the year 2020/21 is 40.3% followed by crop production (22.8%).

The contribution of eucalyptus to the household livelihood presented on the figure represent only its financial contribution, and its contribution in providing wood for construction, fuel and other uses of eucalyptus are not calculated which would rise its overall contribution much higher than 40.3% followed by crop production (22.8%). The key informant in Tatek Gebere *kebele*

indicated that *"He prefer eucalyptus due to its economic advantage and to solve wood products they need and also he can sell on his farm and he can decide the price. He grows eucalyptus mainly as source of additional income."* This indicates that eucalyptus is the primary source of income for rural households and the income generated from eucalyptus was highly greater than other income sources such as crop production, livestock and other non-farm activities. Even, Eucalyptus give return after 4years and farmers must wait for some years to get income from eucalyptus, different studies analyzed it as secondary source of income (Almayehu *et al*., 2018; Teketay, 2000; Mekonnen, 2007, Zerga & Woldetsadik, 2016). But, other studies showed eucalyptus as the primary source of household income (Kibebew & Ayele, 2010).

Some studies reported that eucalyptus has its own contribution for the improvement of livelihood through economic growth. According to Kelemu and Tadesse (2010) in North Shewa zone, eucalyptus contribute 20% of the total income compared other crops and Almayehu *et al*. (2018) in Sidama Zone, found contribution of eucalyptus was about 35% of total livelihood income of the households, which is the second income contributor next to home based agroforestry. Another study by Asnake (2001) revealed that at least 26% of family income was generated from eucalyptus woodlots which makes it second income contributor next to crop production. Similar studies show that it had a greater income contribution for rural households. Eucalyptus contributes about 50% of household income compared with other income sources (Kibebew & Ayele, 2010). In the areas, such as Chelia District of the Oromia region, eucalyptus farming is contributing up to 87 % of household cash income (Edesa, 2021). For poor households of some areas income up to 72 % is reported to be contributed from eucalypt sale (Birhanu and Kumsa, 2018). The highest cash income generated from eucalypt is driving conversion of farmlands in many areas (Jenbere *et al*., 2012). Thus eucalyptus woodlot growing is a question of survival, insurance and livelihood subsistence for rural households (Zerga & Woldetsadik, 2016)

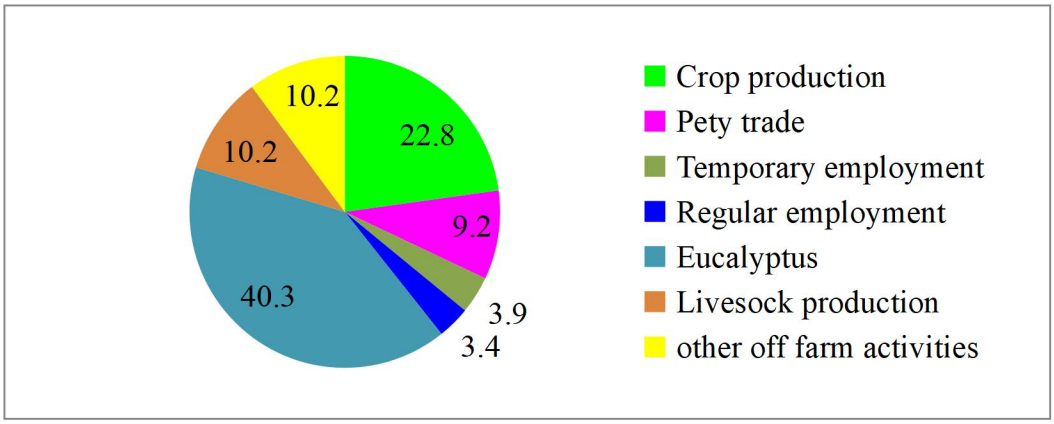

Figure 4.2: Income generated from different sources
Source: household surveys (2021)

Based on the survey results, the average household income generated from eucalyptus per hectare per year was about 24,168.9 ETB. Similarly, a study conducted in the highlands of Ethiopia stated that the average benefit per hectares per year was about 15,105 ETB (Kestela, 2012). Small-scale farmers used eucalyptus for construction of houses and fuel wood or generate income by selling parts. Study participants pointed out that having eucalyptus woodlots is considered a 'live bank account'. This is due to the fact that farmers sold out eucalyptus during high-income needs or guaranteed as collateral to take loan from banks (Mekonnen, 2010).

4.5. Households' food security status

As indicated in the survey result, cereals and grains are commonly used as the main source of dietary energy for households. Farmers also produced fruit, vegetables and oil seeds but rarely used for home consumption. As a result, following Abi &Tolossa (2015), cereal and pulses were considered as the main sources of dietary energy supply for the study households. The Household Food Balance Model result shows that the total amount of energy available for the households was 783,391,603 kcal. Corn (maize), millet and *teff* contributed 53%, 18.9% and 8.9%, respectively to the total dietary energy supply (Table 4.8).

Table 4.8: Net available food for households

Food source	Net available grain for consumption (Kgs)	Total dietary energy equivalent (kcal)	Contribution value to total energy supply (%)
Teff	19,435	69,732,780	8.9
Maiz	109,750	415,074,500	53.0
millet	40,785	147,967,980	18.9
Barely	10,733	39,797,964	5.1
Wheat	4,970	18,036,130	2.3
Berbere	9,760	9,106,080	1.2
pea	4,050	14,389,650	1.8
vetch	13,225	45,890,750	5.8
bean	1,800	6,325,200	0.8
Lentil	225	792,450	0.1
Milk	22,087	16,278,119	2.1
Total	245,460	783,391,603	100

Source: Survey (2021)

Based on the result presented in Table 4.9, about 2.6% of households got less than 1500 Kcal, 12.8% of households got 1500-2099 kcal and 84.6% of households got dietary energy above the minimum requirement. Availability of dietary energy among households ranged from 1020.6 kcal to10500.6 kcal, which indicates a wide gap between minimum and maximum value of available energy.

Table 4.9: Dietary energy distribution in kilocalories (kcal) of sample households

Dietary energy (Kcal)	N	Percentage	Minimum Dietary energy (Kcal)	Maximum Dietary energy (Kcal)	Mean Dietary energy (Kcal)
900-1499	5	2.6	1020.6	1487.7	1264.34
1500-2099	25	12.8	1509.0	2079.9	1826.3
exactly 2100	0	0	0	0	0
>2100	166	84.6	2105.3	10500.6	3443.2

Source: Survey (2021)

The Household Food Balance Model result presented in Table 4.10 showed that 11.6%, 8.9% and 24% of households got below minimum dietary energy requirements whereas 88.4%, 91.1%, 76.1% of households got above the minimum dietary energy requirements in *Ambomesk*, *Tatek Gebere* and *Wotet Ber kebeles* respectively. This indicates that out of the total study participants, 84.6% had dietary energy above minimum requirements (food secure) and 14.4% had dietary energy below the minimum requirements (food insecure). The total calorie available per adult equivalent per day varied from 1020.6Kcal to 10500.6Kcal with mean and standard deviation of 3172.5 and 1308.3 respectively. This result indicated that the majority of households in North Mecha *Woreda* were food secure. Consistently, the participatory rural appraisal report of Mecha district indicated that the *woreda* is considered as one of the most food secure and surplus producing woredas in Amhara region (Molla *et al*., 2014). Similarly, the majority of the study households in West Belesa, Northern Gonder, Amhara Region (Yehuala *et al.,* 2018) were found food secure. On the contrary, the study conducted by Negash & Alemu (2013) showed high prevalence of food insecurity in rural households of the *woreda*.

Table 4.10: dietary energy available in each *kebeles*

Kebele	No.	HH dietary energy status		Total energy (Kcal)	Minimum dietary energy (kcal)	Maximum dietary energy (kcal)	Mean	St.Dev
		Above min requirements	Below min requirements					
Ambomesk	69	61 (88.4%)	8 (11.6%)	218915.6	1020.6	7224.6	3172.7	1166.4
TatekGebere	56	51(91.1%)	5(8.9%)	191217.2	1465.2	10500.5	3415.7	1512.7
WotetBer	71	54 (76.1%)	17(24%)	211618.6	1327.7	9360.5	2980.5	1250.4
Total	196	166(84.6%)	30(15.3%)	621813.4	1020.6	10500.5	3172.5	1308.3

Source: Survey (2021)

The result presented in Table 4.11 showed that the mean farm size used by food secure and food insecure households were 0.38 and 0.36 with standard deviation of 0.22 and 0.19 respectively. Regarding the calorie available per adult equivalent per day, food secure households got 3,432.7 Kcal of energy whereas the available energy in food insecure households was about 1,732.6 Kcal with standard deviation of 1251 and 269.6 respectively. The result indicates when households

increase eucalyptus woodlot on their farm land more calories were available to their family and becomes food secure. This shows food secure households had more eucalyptus woodlots and more available calorie to their family than that of food insecure households. The basic premise here was that when farmers had more land size for eucalyptus woodlots households had possible advantages of increasing their income source by selling eucalyptus which, in turn, would enhance households' food availability. The sale of eucalyptus woodlots assists smallholder farmers bring food shortage gap at household level.

In addition, farmers that have eucalyptus woodlots did not sell crop products because they cover the cash needed for different purposes by eucalyptus sale. As a result, growing eucalyptus at farm level in the form of woodlot is very common practice among smallholder farmers. However, some studies forwarded the negative effects of planting eucalyptus on food security (e.g. Jagger and Pender, 2003). It affects livelihood and food security of the community as well as the next generation because of its adverse effect and the competition of eucalyptus for crop fields (Getachew, 2016).

Table 4.11: Relation between eucalyptus woodlot s and households' food security

Food security status	Variables	N	Mean	Std. Deviation
Food Secure Households	Land size used for eucalyptus	166	0.38	0.22
	Calorie available per adult equivalent per day	166	3,432.7	1250.97
Food insecure Households	Land size used for eucalyptus	30	0.36	0.19
	Calorie available per adult equivalent per day	30	1,732.6	269.6

Source: Survey (2021)

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1. Conclusions

This study investigated the contribution of eucalyptus trees to household food and livelihood status in the North Mecha *woreda* of Amhara region. The findings revealed that most households in the study area planted eucalyptus on their farm lands and hence, the prevalence and expansion of eucalyptus was high. It was reports that eucalyptus plantation covered 29% of farmland. Thus if the expansion continues by this rate it could cover most crop lands in a short period of time. Based on the study conducted, it was possible to conclude that eucalyptus woodlot production was expanding highly on cropland of rural farmers due to rapid growth and higher biomass production of the tree in a short period of time for the requirement of fire wood, construction material and the attractive financial income found from woodlot production than crop production.

The results also showed that natural characteristics of eucalyptus such as survival ability, growth rate, weed and pest resistance ability, easiness to cultivate and household characteristics such as participation of household head on off farm activity, farm size owned by smallholders, market access, value per unit labor and land and cost of fertilizer are significant factors which make eucalyptus preferable by smallholder farmers. In addition the requirement of eucalyptus for construction and household fuel wood are factors making eucalyptus preferable. This implies socio-economic factors, institutional factors and natural characteristics were significantly determining the expansion of eucalyptus woodlots and make it preferable by rural households. But demographic factors and farmers' perception were not significantly determined the expansion of eucalyptus woodlots by rural households.

The result of the study also indicates that eucalyptus have a high contribution for economic improvement of households. The majority of households' income was generated from the sale of eucalyptus woodlots. About 40.63% of income of the study households has generated from eucalyptus woodlots, which was higher than other sources. Therefore, eucalyptus plantation especially for rural farmers is a question survival and livelihood improvement.

It was also observed that the majority of households in the study area were food secured implying that the majority of the households achieve the recommended kilocalories per day per

adult equivalent. Households that grew more eucalyptus woodlots on their farmland have gotten relatively higher dietary energy. Farmers that have eucalyptus can cover their financial need by the sale of eucalyptus and use crop products for their daily consumption. Therefore based on the study conducted, it was possible to conclude that contribution of eucalyptus woodlots in the study area towards rural households' livelihood is very high and eucalyptus woodlot farming and its sale enhances households' food availability and increases livelihood and food security of rural households.

5.2. Recommendations

From the conclusion of the study, it can be recommended that;

- Development agents and experts should promote and provide better eucalyptus species to increase its commercial value.
- To minimize its negative impacts of eucalyptus on neighboring crops, farmers should grow and manage eucalyptus in appropriate site of farm lands and growing eucalyptus as the form of woodlot is very important to reduce natural forest deforestation. In addition, farmers should allocate eucalyptus farming land which are not suitable for crop production, far from crops because it is not compatible with crops.
- Agricultural extension agents should provide training on eucalyptus plantation since they are important for providing valuable information and expertise support on how farmers fulfill their requirements by maintaining environmental conditions through minimizing the adverse impacts of Eucalyptus.
- Government should provide fertilizers with reasonable price to rural farmers for their crop production if they would like to convert eucalyptus land to crop production and increase market access for crop products. Since eucalyptus has better and incentive price, it is important to take measures which are needed to facilitate market access for wood and other products of eucalyptus. Farmers in the study area as well as Ethiopia planted eucalyptus without any support of the government due to its negative impact, so environmentalists should justify plant species which can fit with biologically and financial demand.

- Policymakers should take the right and careful decision by assessing the overall socioeconomic and ecological aspects of eucalyptus woodlot based on the interests of various stakeholders including rural farmers.
- This study focused only on the contribution of eucalyptus to livelihood and food security as income aspects, thus researchers should further study the social, ecological and environmental dimensions of eucalyptus woodlots plantation.

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Appendices

Annex 1: Adult Equivalent Conversion Factor

Age group (years)	Male	Female
≤10	0.6	0.6
11-14	0.98	0.86
15-18	1	0.75
>18	1	0.75

Source: Storck et al. (1991)

Annex 2: Total livestock unit conversion factor

Animal type	TLU equivalent
Cow	1
Calf	0.25
Heifer	0.75
Oxen	1
Bull (woyifen)	0.34
Sheep/ goat	0.1
donkey	0.7
Mule	1.1
Horse	1.1
Chicken	0.01

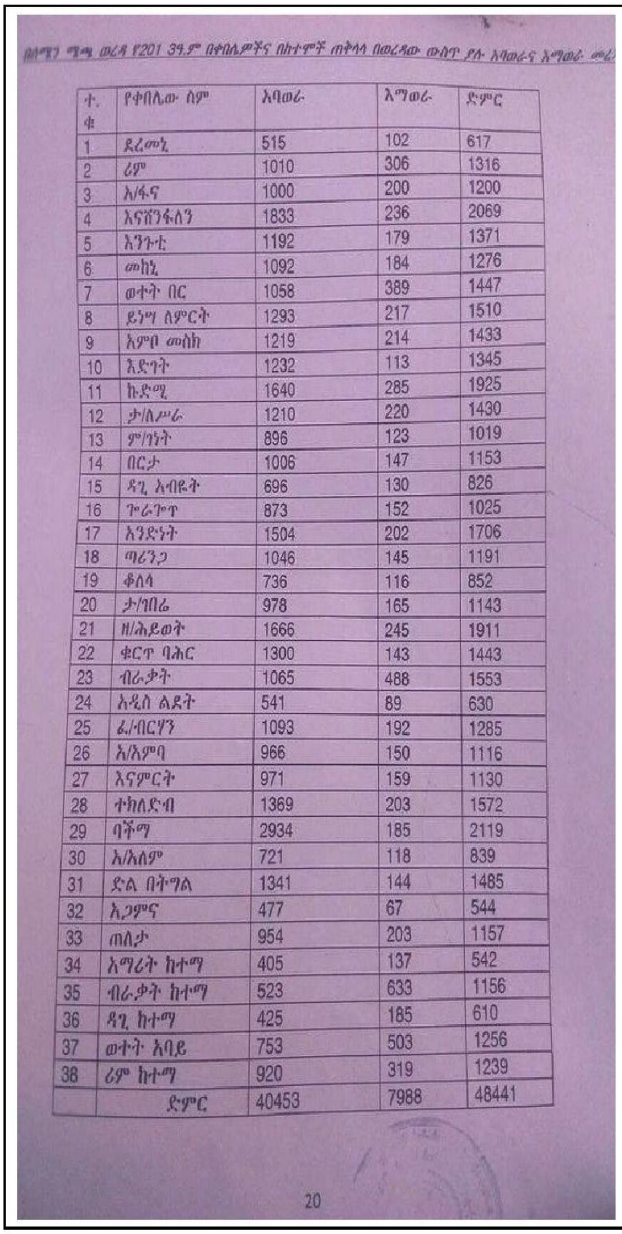
Source: Storck et al. (1991)

Annex 3: Food Composition Table Use in Ethiopia

Food item	Local name	Food energy (Kcal/kg)
Tef	T'yef, nech	3,588
Corn (maize)	Beqqollo,nech	3,782
millet	Dagussa,dibilliq,	3,628
Barely	Gebs, t'qur	3,708
Wheat	Sindye, nech'	3,629
Chili un spiced	Berberrye,zala	933
pea	Ater ,difin	3,553
vetch	Guwayya,dereq	3,470
bean	Baqyla,derq,difin	3,514
Lentil	Missir,difin	3,522
Milk	Yelamwotetyalitefela	737

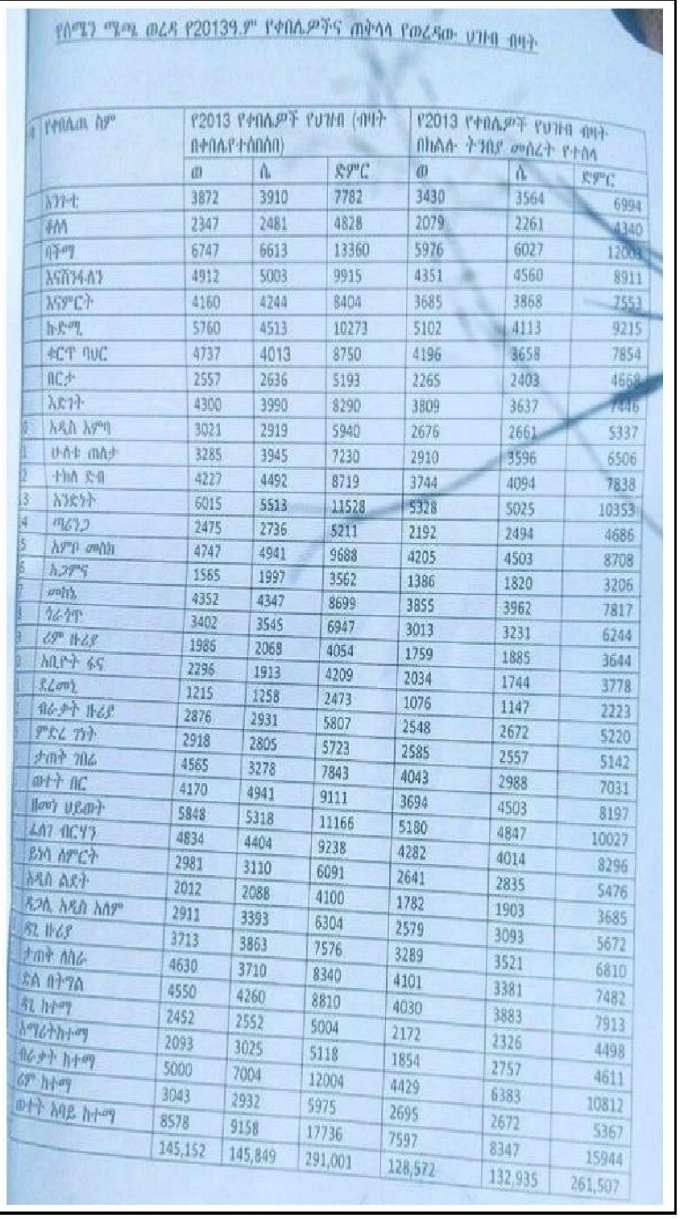
Source: Ethiopian nutrition institute (ENI) and Ethiopian Health and Nutrition Research Institute (EHNRI), 1968-1997

Annex 4: Households and population size of each kebeles in North MechaWoreda



ተ.ቁ	የቀበሌው ስም	አባወራ	እማወራ	ድምር
1	ደረመኒ	515	102	617
2	ሪም	1010	306	1316
3	አፋና	1000	200	1200
4	እናሽንፋለን	1833	236	2069
5	አንጉቲ	1192	179	1371
6	መከኒ	1092	184	1276
7	ወተት በር	1058	389	1447
8	ይንግ ለምርት	1293	217	1510
9	እምባ መስክ	1219	214	1433
10	እድጎት	1232	113	1345
11	ኩድሚ	1640	285	1925
12	ታ/ለሥራ	1210	220	1430
13	ም/ገነት	896	123	1019
14	በርታ	1006	147	1153
15	ዳጊ አብዬት	696	130	826
16	ጉራጉጥ	873	152	1025
17	አንድነት	1504	202	1706
18	ጣሪንጋ	1046	145	1191
19	ቆለላ	736	116	852
20	ታ/ገበሬ	978	165	1143
21	ዘ/ሕይወት	1666	245	1911
22	ቁርጥ ባሕር	1300	143	1443
23	ብራቃት	1065	488	1553
24	አዲስ ልደት	541	89	630
25	ፊ/ብርሃን	1093	192	1285
26	አ/አምባ	966	150	1116
27	እናምርት	971	159	1130
28	ተክለድብ	1369	203	1572
29	ባኾማ	2934	185	2119
30	አ/አለም	721	118	839
31	ድል በትግል	1341	144	1485
32	ኢጋምና	477	67	544
33	ጠለታ	954	203	1157
34	አማሪት ከተማ	405	137	542
35	ብራቃት ከተማ	523	633	1156
36	ዳጊ ከተማ	425	185	610
37	ወተት አባይ	753	503	1256
38	ሪም ከተማ	920	319	1239
	ድምር	40453	7988	48441

20



የቀበሌዉ ስም	የ2013 የቀበሌዎች የህዝብ (ብዛት በቀበሌየተሰበሰበ)			የ2013 የቀበሌዎች የህዝብ ብዛት በክለሉ ትዝብያ መሰረት የተሰላ		
	ወ	ሴ	ድምር	ወ	ሴ	ድምር
እንጉቲ	3872	3910	7782	3430	3564	6994
ቆለላ	2347	2481	4828	2079	2261	4340
ባኾማ	6747	6613	13360	5976	6027	12003
እናሽንፋለን	4912	5003	9915	4351	4560	8911
እናምርት	4160	4244	8404	3685	3868	7553
ኩድሚ	5760	4513	10273	5102	4113	9215
ቁርጥ ባህር	4737	4013	8750	4196	3658	7854
በርታ	2557	2636	5193	2265	2403	4668
እድጎት	4300	3990	8290	3809	3637	7446
አዲስ አምባ	3021	2919	5940	2676	2661	5337
ሁለቱ ጠለታ	3285	3945	7230	2910	3596	6506
ተክለ ድብ	4227	4492	8719	3744	4094	7838
አንድነት	6015	5513	11528	5328	5025	10353
ጣሪንጋ	2475	2736	5211	2192	2494	4686
አምባ መስክ	4747	4941	9688	4205	4503	8708
ኢጋምና	1565	1997	3562	1386	1820	3206
መከኒ	4352	4347	8699	3855	3962	7817
ጎራጉጥ	3402	3545	6947	3013	3231	6244
ሪም ዙሪያ	1986	2068	4054	1759	1885	3644
አቢሶት ፋና	2296	1913	4209	2034	1744	3778
ደረመኒ	1215	1258	2473	1076	1147	2223
ብራቃት ዙሪያ	2876	2931	5807	2548	2672	5220
ምድረ ገነት	2918	2805	5723	2585	2557	5142
ታጠቅ ገበሬ	4565	3278	7843	4043	2988	7031
ወተት በር	4170	4941	9111	3694	4503	8197
ዘመነ ሀይሙት	5848	5318	11166	5180	4847	10027
ፈለገ ብርሃን	4834	4404	9238	4282	4014	8296
ይንግ ለምርት	2981	3110	6091	2641	2835	5476
አዲስ ልደት	2012	2088	4100	1782	1903	3685
ጻጋሊ አዲስ አለም	2911	3393	6304	2579	3093	5672
ዳጊ ዙሪያ	3713	3863	7576	3289	3521	6810
ታጠቅ ለስራ	4630	3710	8340	4101	3381	7482
ድል በትግል	4550	4260	8810	4030	3883	7913
ዳጊ ከተማ	2452	2552	5004	2172	2326	4498
አማሪትከተማ	2093	3025	5118	1854	2757	4611
ብራቃት ከተማ	5000	7004	12004	4429	6383	10812
ሪም ከተማ	3043	2932	5975	2695	2672	5367
ወተት አባይ ከተማ	8578	9158	17736	7597	8347	15944
	145,152	145,849	291,001	128,572	132,935	261,507

Annex 5: MLR model result of determinants that make eucalyptus woodlots preferable by small scale farmers

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	0.293	0.107		2.745	0.007		
HSX	-0.032	0.037	-0.061	-0.848	0.398	0.682	1.466
HAG	-0.002	0.002	-0.080	-0.975	0.331	0.523	1.912
HEL	-0.015	0.034	-0.034	-0.431	0.667	0.573	1.744
FAZ	0.018	0.013	0.108	1.368	0.173	0.561	1.783
VLL	-0.092	0.035	-0.159	-2.586	0.011	0.928	1.077
AVL	-0.026	0.030	-0.056	-0.888	0.376	0.885	1.129
SOIN	-0.022	0.028	-0.046	-0.766	0.445	0.957	1.045
PAROA	0.177	0.036	0.380	4.959	0.000	0.599	1.670
FARZ	0.143	0.029	0.491	4.957	0.000	0.359	2.788
FCCP	-0.125	0.049	-0.157	-2.553	0.011	0.925	1.081
EMA	0.084	0.029	0.181	2.877	0.004	0.887	1.127
LTU	-0.002	0.009	-0.018	-0.204	0.839	0.443	2.256

Dependent variable is land size used for Eucalyptus woodlot plantation

Annex 5: Research questionnaires

A QUESTIONNAIRE FOR THE SELECTED KEBELE'S HOUSEHOLD HEADS IN MECHA WOREDA

Dear respondent,

My name is _____. I am professional and now I am collecting data from households for the research being conducted to assess "the contribution of eucalyptus woodlots to the livelihood and food security of households in North Mecha*Woreda,* Ethiopia" developed by GebeyawTsegaye who is working on his thesis for the partial fulfillment of Masters of Science in Food Security and development Studies in Addis Ababa University College of development study. The information you will give is purely for academic purposes and will be treated with confidentiality which will be held to be used only for the analysis of this research.

Your participation is purely voluntary and has no monetary value. The report produced will be intended mainly for academic purposes shared with the University and North Mecha*woreda*administration to understand the contribution of eucalyptus woodlots to the livelihood and food security of households use for decision making to support the design for appropriate interventions. There for, I am asking you to help me by responding the questions honestly and in accordance with the actual situation of your household and thoughts, assisting the enumerator sincerely to complete the questionnaire. I will strictly follow to keep your personal information confidentially. Thank you for taking 15 - 20 minutes and answering the questionnaire.

Thank you for your cooperation!

a) structured questionnaires for Household survey

Code No _____

Kebele _____ Date of interview: _____

I. Demographic characteristics

1. Sex of respondent? A. Male B. Female
2. Age of household head _____years.
3. Household head educational level A. illiterate B. literate C. if other specify educational level _____
4. How many persons live in your family? Female _____ Male _____ Total _____
5. How many of family members fully engaged in farming activity? _____
6. What do you think about availability labour for your farming activity?

   A. available B. Not available

II. Socio-economic factors and farm characteristics

7. Do you think eucalyptus is preferable to be socially insured? A. Yes B. No
8. What do you think about per unit labour and land of eucalyptus?

   A. High B. Medium C. Low
9. Do you involve in off-farm activities? A). Yes B). No
10. If yes for question 9, what type of off-farm activity you participate

No.	Activities	Monthly income
1.	Salary employment	
2.	Petty trade	
3.	Handcraft	
4.	daily labor	
5.	Charcoal making	
6.	others	

11. Do you have your own land? A. yes B. No
12. if yes total size of your farm land _____ha/gemed
13. If yes for "11" for what purpose(s) do you use your land?

No.	Land purpose	A. yes B. No	Size in ha/gemed
1.	For crop production		
2.	Eucalyptus plantation		
3.	For grazing land		
4.	Others		

14. Do you have enough plot of land for growing both eucalyptus and crops?

A. yes B. No If not, why you grow eucalyptus?_____

_____

15. What is your main source of income? (multiple response)(2012/13 EC)

Main Income source	Annual income/ ETB
Selling crop product	
Eucalyptus	
Selling livesock	
others	

III. Institutional Factors

16. Do you have fertilizer access for crop production? A. Yes B. No

17. If "yes" what do you think about the cost of fertilizer? A. High B Medium C. Low

18. Do you think high cost of fertilizer for crop production cause for expansion eucalyptus?

A. Yes B. No

19. What do you think about the market access of eucalyptus? A. accessible B. not accessible

IV. Characteristics of eucalyptus

a. Natural characteristics

20. Which tree species do most people plant in this kebele? A. Eucalyptus B. others

21. If Eucalyptus for "19" why do you think it is more preferable? (multiple answers)

Reasons for Eucalyptus preference	Farmers' weight for preference		
	High	Medium	Low
Highly Survival			
Fast growth rate			
Pest/disease/weed resistance			
Ease of cultivation & Adaptability across all soil types			
Compatibility with crops			
Commercial potential			
Other (specify)			

b. Physical characteristics

22. Do you think there is shortage of fuel wood in your households? A. yes B. No

23. What is your main source of household fuel wood?

No.	Fuel wood source	Rank
1.	Eucalyptus	
2.	Cow dung	
3.	Crop residues	
4.	Others (specify)	

24. What type of material you use to build your own house? A. eucalyptus B. others

25. Number of livestock you owned

No.	Type of live sock	Number of livestock	No.	Type of live sock	Number of livestock
1.	Cow		6	Sheep/Goat	
2.	Oxen		7	Donkey	
3.	Haife		8	Horse / mule	
4.	Calf		9	poultry	
5.	Bull		10	Others	

V. Household Food security assessment

Household food availability for the last one year December 2020 to December 2021

No	Commodity	Annual harvest (qt)	Purchased from market (qt)	Borrowed (qt)	Food aid Obtain (qt)	Gift or remittance (qt)	losses due to grain pests, disaster, thievery (qt)	Reserved for seed (qt)	Sold (qt)	Given to others (qt)
1.	Teff									
2.	Maize									
3.	Barely									
4.	Wheat									
5.	Finger millet									
6.	Bean									
7.	Pea									
8.	Chickpea									
9.	Lentil									
10.	Oily seed									
11.	Other									

1. Do you milk any animal (Cow) for the last year? A. Yes B. No
2. How many animals milked? _____
3. How much milk was produced per day?_____litter.
4. How long they milked? _____month
5. What major purpose is of milked? A) Consumption B. sale C. both D. other
6. Do you have a food shortage problem in your household in last year? A) Yes B). No
7. If yes, for how many months per year did your household face shortage of food and which month?_____ _____
8. If yes for question "6"What is the cause of food insecurity? (Multiple responses are possible)
   A. Drought
   B. Incidence of pest, diseases, weed

C. Un seasonal rain
D. soil ferity decline
E. Food coast increase
F. other (specify)

9. Number of average meals per day in the household? _____

b) Checklist Questionnaire for *Kebele* administers, experts and development agents

1. What is your opinion on the current eucalyptus debates?
2. What do you think about expansion of eucalyptus in your *kebele?* Could you forward your opinion about reasons for eucalyptus expansion in the area?
3. What are the specific economic advantages of the eucalyptus woodlots for households of your *kebele*?
4. How do you think the importance of eucalyptus farming to improve livelihood and the food security?
5. Is there a policy which prohibits eucalyptus planting in the region/ *woreda* level? Do you support eucalyptus plantation by smallholder farmers?
6. What alternative do you suggest to fulfill the shortage of wood in the area?

c) Field Observation checklist

1. Physical Environment (Eucalyptus expansion, price etc.)
2. Infrastructures (road, market access, etc.)

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