COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR FOOD SECURITY STUDIES

CONTRIBUTIONS OF EUCALYPTUS PLANTATIONS IN THE HIGHLANDS OF ETHIOPIA

BY: LEMESSA NEGERI GUSU

A THESIS SUBMITTED FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FOOD SECURITY AND DEVELOPMENT

JANUARY 2023

ADDIS ABABA, ETHIOPIA

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR FOOD SECURITY STUDIES

CONTRIBUTIONS OF EUCALYPTUS PLANTATIONS IN THE HIGHLANDS OF ETHIOPIA

BY: LEMESSA NEGERI GUSU

THESIS ADVISOR: MESSAY MULUGETA (PhD)

A THESIS SUBMITTED FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FOOD SECURITY AND DEVELOPMENT

JANUARY 2023

ADDIS ABABA, ETHIOPIA

Declaration

I, Lemessa Negeri Gusu, hereby declare to Addis Ababa University School of Graduate Studies that this thesis is a product of my original research work, and it has not been submitted to any other university for any academic degree. Materials and information other than my own are dually acknowledged.

Name: Lemessa Negeri

Signature: _____

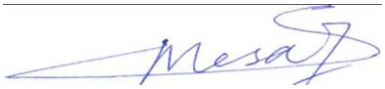
Place: Addis Ababa University, College of Development Studies, Food Security Department

Date of submission: _____

Approval Page

As a supervisor of the thesis, I certify that I have read and evaluated the thesis by Lemessa Negeri entitled 'Contributions of eucalyptus plantations in the highlands of Ethiopia' and recommend for Open Defense as fulfilling the requirements for the degree of Master of Science in Food Security and Development.

Signed for the approval of the thesis of Lemessa Negeri

Messay Mulugeta (Ph.D)		20 Nov 2022
Supervisor	Signature & date	

As member of the Examining Board of the Thesis Open Defense, we certify that we have read and evaluated the thesis prepared by Lemessa Negeri entitled 'Contribution of eucalyptus plantations in the highland of Ethiopia' and recommend that it is acceptable as the thesis required for the degree of Master of Science in Food Security and Development.

Name, Chairperson _____	_____	_____
	Signature	Date
Name, Internal Examiner _____	_____	_____
	Signature	Date
Name, External Examiner_____	_____	_____
	Signature	Date

Final approval and acceptance of this thesis is contingent upon the candidate's submission of the final copy by incorporating all the comments by Examining Board to the Council of Graduate Studies (CGS) through the Centre Academic Committee (CAC) of the Centre.

_____

Chairperson of the Centre or Graduate Program Coordinator

Acknowledgements

First and foremost, Hallelujah, I am grateful to God's grace for the good health, well-being, and His willingness to help me in all direction during my engagement in my education. My second sincere appreciation goes to my advisor, Dr. Messay Mulugeta for his continuous and profound dedication, encouragement and support from the beginning of my study to the end of this thesis. His being an incredible advisor and listener, his openness and readiness at any time to help, support and guide through all my studies has greatly contributed to what is obtained of my today's outcome. Also, I would like to express my sincere gratitude to my lecturers at the Addis Ababa University's College of Development Studies for their valuable assistance.

Thirdly, I would like to extend my deepest appreciation to my wife Bizunesh Nemomsa, and all my brothers and sisters for their unpayable price and unwavering support to help me make my dream come true. It definitely wouldn't be easy without them by my side.

Last but not least, my gratitude goes to the interview participants in this study for their willingness, time and full cooperation in providing the necessary data and generously sharing their experiences without any tiredness and hesitation.

Additionally, I want to express my gratitude to everyone who helped out with this research in some way, whether directly or indirectly.

Abstract

The objective of this study was to come-out with the benefits of eucalyptus plantions to household livelihoods and food security through a comparative analysis of eucalyptus growers and non-growers in Girar Jarso Woreda, highland of Ethiopia. Data for the study was obtained both from primary and secondary sources through document reviews, household surveys, focus group discussions, key informant interviews, and field observations. The study utilized HFIAS, MAHFP and CSI as the main food security assessment tools in addition to exploring the economic contribution of eucalyptus plantation to household livelihood and food security through household survey. Data was analysed qualitatively and quantitatively after administering the survey on 165 sampled households. According to this study, 100%, 91% and 69% of the eucalyptus grower households reported they plant eucalyptus trees for the purpose of mainly to generate additional income, meet own in-kind needs (construction, fencing & firewood requirements), and to replace the declining crop yield, respectively. The study revealed that eucalyptus takes only 14% of the total land holding per HH even if it is the second most source of income for the households. Respondent households indicated that income from eucalyptus products contribute to household food security through covering food needs during months of food gap, immediate cash during shocks, purchase of agricultural inputs and in-house food and non-food items for the households. The study using the HFIAS scale indicated that only about 45% and 34% of the respondents fall under food secure households both for eucalyptus growers and non-growers, respectively. Observed through a regression analysis that food insecurity increases with increasing age and family size of the households, whereas household land holding size for non-eucalyptus growers, have significantly shown an inverse relationship with increasing household food insecurity. Income from eucalyptus didn't show any significant relationship with increasing or decreasing food insecurity. The study from consumption coping strategy showed that about 20% and 14% of the households behave to practice high coping strategy both for eucalyptus growers and non-growers, respectively. The assessment using the MAHFP indicated that compared to non-eucalyptus growers, euclyptus growers have more sustaining household livelihood and better food security status due to the significant contribution of eucalyptus plantation. Eucalayptus plantations in the highlands of Ethiopia needs high government attention due to its dominant plantation and the high dependence of households for their livelihoods and food security.

Key words: ***eucalyptus, livelihood, food security, coping strategy, household***

Table of contents

Contents

List of figures

Page

List of Tables

Page

List of appendices

Acronyms

AAU	Addis Ababa University
ACF	Action Contre la Faim International
CDS	College of Development Studies
CSA	Central Statistical Agency
CSI	Coping Strategy Index
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
FGD:	Focus Group Discussion
GJANRO	Girar Jarso Agriculture and Natural Resources Office
GoE	Government of Ethiopia
HH	Household
HFIAS	Household Food Insecurity Access Scale
KII	Key Informant Interview
MAHFP	Months of Adequate Household Food Provisioning
OXFAM	Oxford Committee for Famine Relief
TLU	Tropical Livestock Unit
UFLC	Ukraine Food Security and Livelihood Cluster
UN	United Nations
VIF	Variance Inflation Factor
WFP	World Food Programme

CHAPTER 1: BACKGROUND OF THE STUDY

1.1 Introduction

Eucalyptus, one of the most diverse genus of flowering plants in the world belongs to the family *Myrtaceae* (subfamily *Myrtoideae*) and comprises about 900 species (Bayle, 2019). Eucalyptus plantations are gaining popularity as a means of replacing forests on a global scale, and in Ethiopia in particular. But, the role eucalyptus plays in meeting the food security needs of a large portion of Africa's food insecurity under current practices is not sustainable because forests are experiencing a high rate of depletion on this continent (Gbetnkom, 2009). This comes from the fact that global challenges such as climate change, deforestation, overgrazing, and natural disasters are exacerbating poverty and causing social tensions (FAO, 2017). Due to this fact, Ethiopia is among the top five countries in the world growing eucalyptus trees abundantly (Zerga & Berta, 2016), where eucalyptus dominates forest development gains in the last century (Jaleta et al., 2016).

Despite the Ethiopian highlands' suffering from severe deforestation and biomass fuel crisis, eucalyptus globulus is the prominent tree in government and community plantations due to its rapid growth through coppice, resistance to being eaten by cattle, and simply easy sawing and potting seedlings (Zewdie, 2008; Lemenih, 2010; Dereje et al., 2012). Lemenih (2010) indicated in his study that the high yield per unit area, easy silvicultural management, good demand for its wood with reasonable prices, and its adaptations to a wide range of ecological conditions make eucalyptus preferable by growers. Other studies identified that farmers mainly plant eucalyptus trees for their fast growth, drought resistance, and potential to raise farm products, increase food security, and diversify farm incomes (Zerga & Woldetsadik, 2016; Muluneh, 2011). With its four to five harvest cycle (Zhang & Wang, 2021), eucalyptus provides households with multiple benefits, such as equipment and firewood for cooking, improves food security by providing inputs to other food-producing parts of the agricultural system, generates income, and creates employment opportunities for different age groups.

Due to these multiple benefits as evidenced by scholars, farmers are now expanding their eucalyptus forest plantations to arable land. They do this when the productivity of the land begins to decline and when they cannot afford to invest in agricultural inputs to improve the productivity of the land, as well as when the food security of their families is at risk (Gizachew, 2017; Sete & Abreham, 2021). This significant contribution of eucalyptus wood products to household incomes has incentivized many

parts of Ethiopia to convert arable land into eucalyptus plantations (Tesfaw et al., 2021; Dereje et al., 2012). It is observed from these studies that households in the rural areas are highly dependent on eucalyptus plantations in addition to their normal crop and livestock production activities.

In the study area, Girar Jarso Woreda, the main economic basis of the population is mixed subsistence agriculture, which produces both grain and livestock. But, with increasing land degradation and an increasing human population, subsistence farming alone is not in a position to satisfy the needs of farmers in meeting their livelihood and food security. For example, studies by Abi (2011) at Girar Jarso Woreda indicated that low agricultural productivity is due to various interrelated issues such as a decrease in crop and animal production, degradation of natural resources, and the existence of poor social services, which negatively affect food production. Similarly, studies by Mamo & Haile (2016) revealed that households residing in this area repeatedly prone to seasonal food insecurity even during the periods of good rain and harvest season, because they live on marginal, moisture stressed, heavily degraded, and less productive land that has been influencing them to face persistent food shortages. In order to copewith such challenges, households in these areas increasingly choose to adopt eucalyptus woodlots while the farmland's fertility is declining (Derbe et al., 2018).

On the contrary to the contribution of eucalyptus farming to household livelihood and food security, there are debates among scholars on the side effects of eucalyptus plantation. Studies by Zerga et al., (2021) indicated that farmers already understood the side effects of eucalyptus in relation to soil erosion, soil fertility, microclimate change, wildlife conservation, competition with other land uses and stream volume, including the seriousness of increasing shortage of grazing land, reduction of cattle number, and productivity of other crops. But, other studies are now recommending the need for substantial research and adequate information before making conclusive arguments on its impacts as responses at different sites are complex (Ibid). Given the specific livelihood and food security related challenges in the study area, this study was focusing on its benefits to come-up with how the plantation of eucalyptus is contributing to the household livelihood and food security of the sampled households. Therefore, it aims to assess and identify the benefits of eucalyptus farming to household livelihoods and food security in the highlands of Ethiopia with particular focus to Girar Jarso Woreda in Oromia regional state.

1.2 Statement of the problem

The main causes of food insecurity in Ethiopia in the rural context include, environmental degradation, increasing population pressure, small land size and lack of animal power, which in general lead to constrained grain production and food security (Lirenso, 2009). One can also observe the decreasing grazing land for livestock and the increasing demand for firewood and construction materials, which lead to the increased need for farm tree plantations. Farm trees have multiple functions in rural livelihoods, offering significant economic and environmental benefits through increasing a household's income from sales of wood products and managing risk from diversified agricultural production, which in turn spreads the risk of agricultural production failure (Gebreegziabher et al., 2010). Farm trees, such as eucalyptus plantations, reduce the stress on natural forests, bridge the gap between demand and supply for pulp and firewood, meet the growing demand for wood, and preserve the world's biodiversity (Kaur & Monga, 2021; Bekele, 2015). As studies indicated, eucalyptus plantations contribute 92%, 74%, 85%, 40%, 83%, and 91% to construction, poles, timber, firewood, charcoal, posts, and farm implements wood sources respectively for rural livelihoods (Mekonnen et al., 2007).

The main objective of this study was to relate these aforementioned benefits of eucalyptus to existing challenges in the specific study area. To the knowledge of the researcher, no studies were conducted indicating the benefits of eucalyptus plantation by comparing eucalyptus growers and non-growers towards household livelihoods and food security in the high lands of Ethiopia; specifically at Girar Jarso Woreda. Hence, the study was intended to find the contribution of eucalyptus farming to household livelihood and food security at Hariro microwatershed of Girar Jarso Woreda. Furtheremore, the study has made comparisons on household food security status and livelihood coping strategies between eucalyptus growers and non-growers in the study area. In this context, the term ‘non-growers’ was to mean households who don’t consider eucalyptus farming as their main income source and/or are not growing more than 40 trees of eucalyptus per household (GJANRO, 2022), and this was decided in consultation with the Woreda Agriculture and Natural Resources Office. Other households out of this category are called growers. This was to differentiate the farmers who grow a small number of eucalyptus just for land demarcation, fencing, etc from those who grow for various economic benefits. Those households with below 40 tree stands but planted for the aim of economic benefits were considered to eucalyptus grower households. Therefore, this study was the

pioneering study in its findings by assessing the eucalyptus farming benefits to household livelihood and food security where it also included a comparison of their food security status and consumption coping strategies between eucalyptus growers and non-growers. The study also uses different methodological approaches that uses comparison of eucalyptus growers and non-growers.

1.3 Objectives of the study

The overall objective of the study was to make a comparative analysis of household livelihood and food security benefits of eucalyptus plantations at Hariro microwatershed in Torban Ashe Kebele of Girar Jarso Woreda.

With the indicated overall objective, the specific objectives of the study were to:

1. assess the benefits of eucalyptus plantations to household livelihoods and food security
2. determine the food security status of households both for eucalyptus growers and non-growers
3. identify the household consumption coping strategies of eucalyptus growers and non-growers

1.4 Research questions

The study was intended to answer the following main research questions:

- ✓ To what extent do eucalyptus plantations contribute to household livelihoods in the study area?
- ✓ What are the contributions of eucalyptus to household livelihood?
- ✓ What are the benefits of eucalyptus plantations to household food security?
- ✓ Is there a difference between the food security status of eucalyptus growers and non-growers?
- ✓ What are the difference in food consumption coping strategies between eucalyptus growers and non-growers?

1.5 Significance of the study

Eucalyptus plantation plays a significant role in reducing both poverty and unemployment among poor people in different parts of our country. Nevertheless, little research has been done to assess the benefits of eucalyptus plantations to households' livelihoods and food security. The study considered both eucalyptus growers and non-growers to better examine how eucalyptus farming provides benefits to household livelihoods and food security. The study result has high significance in providing information on the benefits of eucalyptus plantation to the society including local government bodies.

The study provides with scientific knowledge in designing land use policy, environmental policy, and tenure system that helps towards improving household livelihoods and food security suggesting possible scientific recommendations. Hence, since very few studies have been conducted in the sector in general and in the study area in particular, the result can serve as a stepping-stone for both the scientific community and development practitioners who are interested in this and other related topics. Furthermore, it provides an input for decision makers and concerned stakeholders in Ethiopia and anywhere in the world.

1.6 Scope and limitations of the study

The study was conducted at Hariro microwatershed of Girar Jarso Woreda, in the North Shewa zone of Oromia regional state. This area is one of the highlands of Ethiopia where there is dense eucalyptus plantations, high land degradation, and subsistence farming. It would have been good if the study cover large areas in order to have more insightful coverage that could increase representation of the study sample, but dealing with the topic in a larger geographic area requires a large amount of money and time. Hence, so as to make the study area narrower and manageable within the allotted resources, it was limited to assessing the household livelihood and food security benefits of eucalyptus plantation and analysis of the difference in the food security status of the respondents at this specific study site. The other limitation of this study was its use of HFIAS data that was collected only once. The main reason for this was the current political security issues and time limitations per the schedule of schooling period.

1.7 Ethical considerations

The study has carefully considered the ethics recommended for the successful implementation of the research. Accordingly, voluntary participation and informed consent (be it verbal or formal) was applied. Similarly, problems related to gender, persons with disabilities, culture and religion were taken into account. I have also considered for the AAU anti-plagiarism policy in my thesis writing. Furthermore, before moving to the field for data collection, the CDS ethical clearance was obtained.

1.8 Risk management

In order to safely conduct the study, all the possible COVID-19 protection measures were taken into consideration. These include provision and use of protective face masks for all participants of the study, use of sanitizers in all the processes of data collection, conduct interviews in open air with at a

recommended distant, conduct workshops at open air, consideration of keeping water and soap at discussion venues, avoid public transport and taking other protection measures. Furthermore, the current security conditions were taken in to consideration through proactively information gathering, formal communication with relevant government bodies, and not to get closure to risk zones or conflict areas.

1.9 Data validity and reliability

In order to assure the validity and reliability of the data which may boost the study's credibility, pilot testing and test of internal consistency using Cronbach's alpha was conducted. The prepared questionnaires were translated in to local language, 'Afan Oromo' for the convenience of data collection during household survey and to reduce communication barriers in translating to local languages. The use of mixed research approach provides an added value to the study. That is, in addition to the use of quantitative data collection tools through both structured and unstructured questionnaires, the qualitative approach provides as a triangulation mechanisms to the data obtained quantitatively.

1.10 Organization of the paper

In total, there are five main chapters to this thesis. The first chapter discusses about background of the study with specific topics related to statement of the problem, research questions, objectives of the study, significance of the study, scope and limitations of the study, and ethical considerations during the study process. The second chapter discusses the theoretical and empirical basis of the research topics on the areas of the concept of food security, the concept of livelihoods, perspectives of food security analysis and trends, and the paradigm shifts in food security approach. The conceptual framework of the research is also demonstrated. The third chapter provides illustrations related to the description of the study area and the overall methods of the study. It presents the research approaches, techniques of data collection and analysis. The results and discussion parts are presented and illustrated under chapter four while chapter five consists of the conclusion and major recommendations as the main takeaways out of the study.

CHAPTER 2: RELATED LITERATURE REVIEW

2.1 Theoretical foundation

2.1.1 Paradigm shifts in food security approach

The evolution of food security got attention from food surplus disposal from 1940-50 to freedom from hunger and malnutrition in 1990s. Though the concept emphasized at the 1974 World Food Conference, the focus was on increasing production in food-deficit countries and establishing a coordinated system of national and international grain services. This overlooked the demand side, the access of vulnerable groups to enough food for a normal life (Maxwell & Smith, 1992). Better perception of food security crises subsequently led to a shift in focus from food availability to a broader approach (Peng & Berry, 2018). The recent concept of food security has given more attention to households and individuals than its availability at international, national, regional, woreda or kebele levels. Increasing food production, supply and sufficiency at broader levels does not necessarily ensure that each and every individual is food secure (Mulugeta, 2010).

Today, more than 800 million people around the world sleep hungry every night. Most of them rely on agriculture to make a living and support their families (USAID, 2022). According to FAO (2009), it is estimated that to feed the world's population, which is expected to exceed 9 billion by 2050, agricultural production must increase by 70 percent over this period. To overcome this challenge, changes in approach of meeting food security has been tried. In general looking, there have been four identified main shifts (Jember & Asmamaw, 2014) when thinking about food security since the World Food Conference of 1974. These include; from the global and the national to the household and the individual; from a food first perspective to a livelihood perspective; and from objective indicators to subjective perception (Maxwell, 1994) and from vulnerability to resilience (Jember & Asmamaw, 2014) . The descriptions for these are outlined hereunder.

(A) Shift from food availability decline to food entitlement decline and to response failure

As concluded by Dagnachew (2012), the main focus was on increasing the volume of food availability at national level either through domestic production or through import to bridge the food gap. It also emphasized on how to increase food productivity to assure food availability at the national level that leads to the emergence of the Food Availability Decline (FAD) approach.

(B) Food Availability Decline (FAD)

This approach is based on the assumption that food availability is primarily attributed to a number of factors like rapid population growth and the resultant land fragmentation as well as natural hazards. It doesn't give anything about people's income and purchasing power that would be affected very much by fluctuations in market prices of food (Tolossa, 2005) as cited in Dagnachew (2012). This approach is useful in analysing famine as a consequence of production failure.

(C) Food Entitlement Decline (FED)

It was a proposed alternative approach to the FAD approach and , neglect cultural preferences and tastes in food consumption. As stated by Mulugeta (2010), like the FAD approach, the FED approach has also been criticised for its failure to take into account intra-household food distribution and for excluding relief as a source of entitlement. Depending on the local social customs and norms, a shortage of food at the household level may impact the children, women and men very differently (FAO, 2008c).

(D) Shift from a 'food first' perspective to a livelihood perspective

The second paradigm shift is from a food first perspective to a livelihood perspective, and beyond that to a preoccupation with the long-term resilience of livelihoods (Maxwell, 1994). The main reason for this shift of thinking are the empirical findings on food security, which shows that people who are food insecure respond to the problem of food scarcity by focusing on long-term livelihood goals rather than meeting immediate food needs (Dagnachew, 2012).

(E) Shift from objective indicator to subjective perception

The implication is that nutritional adequacy is a necessary but not sufficient condition for food security. Thus, it suggests that it is not just the quantity of food entitlement that matters, but also the 'quality' of entitlement (Maxwell, 1994). The idea of including qualitative aspects of food security in this shift suggests that, 'it is not just the quantity of food entitlement that matters, but also its quality' (Devereux and Maxwell 2001: 21) as cited in Aschhalew (2012).

(F) Shift from vulnerability to resilience

Food diversification is important for strengthening the food system's resilience. Depending on the type of the shock, the population(s) affected, and the amount of their access to vital assets and services, the foods required for building resilience may vary substantially (Frankenberger et al., 2012). It also showed that over time, the degree to which communities and households are able to do so will result in either increasing susceptibility or increased adaptive capability and resilience. Studies demonstrated that asset creation, diversification of businesses, and access to enhanced technology are all favorably and significantly connected with the dynamics of food security resilience (Tefera et al., 2017). It also entails anticipating future shocks and making the appropriate measures to cope with and control those shocks without causing food insecurity or losing production capacity. In general, food security has come through long way of growth of theoretical concepts before it takes its current understanding where it clearly considers social, physical and economic accessibility by all including to each and every individual, plus the sufficiency, safety and nutritiousness of the food.

2.2 Conceptual foundation

2.2.1 The concept of food security

The emergence of food security concerns were traced back to the global food crisis of 1972-1974, where it recognized the right to food as an essential component of an adequate standard of living (UN, 1948). Later on after many definitions by scholars and with a growing concern, food security was defined at the World Food Summit in 1996 as ‘When all people, at all times have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life‘ (FAO, 2006). There are around 200 food security definitions and 450 indicators (Mohamed, 2017). The understanding of food security goes to the four key food security pillars. They are also called food security dimensions. These include, physical availability of food, economic and physical access to food, food utilization and stability of the other three dimensions over time (FAO, 2008a). It further classified food security based on the duration as transitory food insecurity where the ability to produce or access enough food to maintain good nutrition suddenly diminishes and chronic food insecurity as where people are unable to meet the minimum dietary requirements for a long period of time (Mulugeta, 2010; FAO, 2008). Food insecurity can also be described as being an insufficient access to adequate food. Households with a per capita daily

kilocalorie intake greater than 2,100 kilocalories are considered to have adequate food consumption (UFLC, 2018). The overarching objective of food security initiative is to lessen the degree to which a household is susceptible to any condition that results in a lack of food, or to increase community resilience and livelihood capacities in the face of shocks. (Swindale & Bilinsky, 2010).

For the purpose of this study, only food availability and food access were taken in to consideration out of the four food security pillars. This is becuase, eucalyptus plantation through its income contribution is directly related with food availability and food access. That is income obtained from sale of euclayptus products can directly goes to purchase of food grains availing the food to the household. Food access is related with income of the household. Eucalyptus also contributes to food availability through use of the income to purchase agricultural inputs and important farm implements for more production. Furthermore, the study of all the food security pillars needs more financial and time budget than the existing available capacity to conduct the study. Accordingly, the concepts of food availability and food access are more clearly indicated below.

(A) Food availability

Food availability can be from domestic production, commercial imports, commercial aid programs, or food stocks that are consistently available to individuals or within their reach (Anderson et al., 2015). Food availability in rural Ethiopia is highly seasonal and is largely a function of local production, cereal imports by the GOE, and food aid imports. Inadequate rainfall reduces both food availability and access, as poor households depend on agricultural labor for income to purchase food (Ibid). For each item included in the food balance sheet, food availability at household level is the net quantity remaining after production, storages, and imports have been added up and exports deducted (Jember & Asmamaw, 2014). Eucalyptus contributes to food availability through making farm utilities (equipment) and through its role by increasing farm incomes, reduce poverty, increase food security, and diversify household livelihood systems (Mekonnen et al., 2007; Mekonnen, 2006; Kelemu & Tadesse, 2010). Other study has also shown that as grain prices fall, farmers prefer to sell eucalyptus products for higher prices (Zerga & Woldetsadik, 2016) and this highly contributes to food availability through protecting the already stored grains by the household and through purchase of agricultural inputs. Though large numbers of farmers make a living from crop production, the average annual income from the production and sale of fuel wood is higher than the average annual income from crop

production; showing that smallholder forestry has an important role in reducing poverty (Mitku, 2020; Kelemu & Tadesse, 2010)

(B) Food access

Household food access is defined as the capacity to obtain food of sufficient quality and quantity to satisfy the nutritional needs of all household members for repoductive lives (Swindale & Bilinsky, 2010). It is the resources (asset or income) the households have to obtain foods, either through own production or through purchase, and is largely related to household income and own production (Anderson et al., 2015). According to this source, food access and food availability are strongly interrelated as limited food availability in one area leads to increased prices, which restricts access for households who are net buyers of food. Eucalyptus for a household is related to food access through its presence as an asset or through its income contribution that capacitates the household to purchase food. In addition to covering the household's livelihood, eucalyptus generates significant income, especially for marginalized and poor households. On average, eucalyptus product sales accounted for up to 5% of annual household income for relatively wealthy households, 20% for middle-class households, and 72% for poor households. Overall, with the study conducted at Lode Hetosa Woreda, income from the sale of eucalyptus products in the study area ranks second after agriculture and accounts for 28% of total annual household cash income (Mekonnen, 2006). According to this study, eucalyptus has large contribution to improving household food security. It is also reported that selling eucalyptus products and generating income helps farmers fill the food shortage at the household level (Birara et al, 2019).

The sale of forest products increases household income, improves their livelihood by contributing to diversifying farming systems and rising farm incomes and thereby increasing food security (Zerga and Woldetsadik, 2016). According to this study, eucalyptus plantation is considered as a means of livelihoods; because income generated from eucalyptus woods are becoming equally valuable or in some cases more than crop production such as cereals, pulses, fruits and vegetables. Eucalyptus' ever-growing contribution to rural household incomes demonstrates that eucalyptus has both real and potential roles to contribute even higher than crop and livestock do in improving the livelihood and financial incomes of rural households (Kelemu and Tadese, 2010). This study in North Shewa zone of Amhara region also indicated that of all the major household income sources, income from the sale of eucalyptus accounts for the largest share. Even if many farmers establish their livelihood on crop

production, the average annual income from wood fuel production and selling is larger than average annual income from crop production that shows small-scale plantation forestry play important role in reducing poverty (Alemu, 2020).

2.2.2 The concept of livelihoods

A livelihood comprises of 'The capabilities, assets (including, both material and social resources) and activities, required for a means of living. It 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, 2001). The sustainable livelihood framework has five key components: vulnerability context, livelihood assets, transforming structures and processes, livelihood strategies and livelihood outcomes (Kollmair & Gamper, 2002). Livelihood strategies are a breadth and combination of actions and choices that people engage in order to attain their livelihood goals. Depending on the policies and institutions in place at work, a change in asset status may help or hinder other efforts (Ibid). In a diversified household livelihoods, if one productive activity does not provide enough, or fails completely, there are other sources of livelihood that the family can regain back. They use their different capabilities and the tangible and intangible assets and entitlements to which they have access as a basis for different livelihood sources and activities (Satgé et al., 2002). In the rural context, land can be used for one or more crops, and low-value crops can be substituted with higher-value crops. For example, tree planting is currently seen as an alternative strategy to secure livelihoods. According to FAO (2002), eucalyptus tree farming has a substantial contribution towards rural livelihoods. It plays a vast role in income diversification by allocating eucalyptus plantation to rugged areas that are not conducive for crops seems the best land use system and considered as alternative means of income diversification (Zerga and Woldetsadik, 2016).

(A) Livelihood vulnerability contexts

The external environment in which humans live is referred to as the vulnerability context. Critical trends, shocks, and seasonality, all of which people have little or no control over, have a substantial impact on people's livelihoods and the availability of assets (DFID, 2001). A shock is an occurrence that disrupts the usual operations and/or activities of socioeconomic agents, poses problems, and puts household food security at risk (Gershon et al., 2019). Individuals, households, and communities may be affected by shocks that are irregular, unpredictable, and fluctuate in strength. Despite the fact that many shocks have climatic causes, the principal causes can be classed as natural, economic, political,

health, and technological. Forexample, with the study conducted in Girar Jarso Woreda, crop yield and productivity has been dropping due to poor soil fertility and high crop losses that are caused by insect pests and diseases. Likewise, the potential benefits of livestock productions have reduced due to the frequent occurrenece of livestock diseases (WAO, 2010) as reported in Abi & Tolossa (2015).

A household with a wider range of assets and income-generating activities is more resilient to shocks and stresses and is more likely to recover than one with fewer assets and livelihood activities (FAO, 2008b). Income of household increases through diversification of livelihoods which in turn also increases the opportunity of the household to withstand shocks. That is, as a person's assets increase, they are better able to protect themselves from shocks and their vulnerability decreases (OXFAM, 2017). When there is a drought or other adverse shock that reduces household incomes, the ability to sell trees could be a valuable source of needed income and a preferable alternative to selling of livestock or suffering hunger. Where communities are prevented from being able to take advantage of this option, food security may be reduced (Jagger & Pender, 2000). According to Samuel & Sylvia (2019), diversification of livelihoods enables farmers in rural households to develop other ways to increase their income levels and minimize their vulnerability to various livelihood crises. Forexample, farmers consider their eucalyptus as a bad time or risk recovery mechanisms when money is needed for various purposes (Zerga et al., 2021). With the study conducted in Kuyu, an adjacent Woreda to Girar Jarso, planting of woodlots mainly exotic trees such as eucalyptus trees for different purposes are one of the household adaptive mechanisms to the environmental dynamics (Mulugeta & Legese, 2013). The study indicated that development of woodlots by households require little commitment of resources and are more environmentally friendly. Ethiopia's rural livelihood systems are extremely vulnerable to climate change. Food insecurity patterns are seasonal and tied to rainfall distribution, with hunger levels falling sharply after rainy seasons. Climate related shocks affect productivity, which together with high levels of poverty and low levels of technology, leave people with limited choices or resources to adapt (Anderson et al., 2015).

(B) Livelihood assets

The livelihood framework highlights five key asset categories which are used to build livelihoods including; human asset, social asset, natural asset, physical asset and financial asset (DFID, 2001). As indicated in FAO (2008c; P:62), social assets are social resources which people draw upon in pursuit of their livelihood objectives such as social networks, family ties, and the support provided by

religious, cultural and informal organisations. Natural asset refers to land and the natural resource base, including fuel wood, building and weaving materials, grazing, climate, soils and land capabilities, biodiversity, etc. Physical asset includes farm equipment, shelter and infrastructure, telephones, radio, television and the internet, etc. Financial asset is capitals and entitlements that have a cash value. It includes income, remittances, sources of credit, pensions, savings, cattle, stores of seed, crops and food, etc. The livelihood assets build the resilience of a household. That is physical, human, and financial capital, as well as access to essential services, information, input, markets, and income diversity, all affect household resilience (Tefera et al., 2017).

Human assets are assets that includes; skills, knowledge, the ability to labour, the education and health status of the household members. For example, incomes obtained from off-farm, livestocks, agricultural crops and eucalyptus are household financial assets (Ermias et al., 2021). Rural households consider eucalyptus as an important income sources and use it in the form of financial security against any sort of unforeseen financial problems (Gizachew, 2017). It is revealed that eucalyptus is the primary source of cash income for smallholder growers, accounting for 45.76% of total annual income (Tesfaw et al., 2021). Thus, growing eucalyptus trees, particularly for small holders, is a matter of survival, insurance, and livelihood improvement (Zerga and Woldetsadik, 2016). A study conducted by Zerga & Woldetsadik (2016) in Eza Woreda shown that with money earned from the sale of eucalyptus tree products, farmers began purchasing cows and oxen, particularly in the highland areas. At household level, land, trees and water are the basic food making assets that people use to make a living. As such, ownership of land determines the household abilhity to make livestock and agricultural production including eucalyptus plantation.

For this particular study, only food availability and food access were considered from the four food security indicators such as food availabillity, food access, food utilization and food stability. One reason for this focus was to reduce the scope of the study so that it can be managed within the time and budget limitation planned for the study. The second reason was that eucalyptus plantation is highly related with food access and food availiability through its contribution through eucalyptus income for various in-house food and non-food items including purchase of grains. It also contributes to food production through purchase of agricultural inputs including farm implements.

2.3 Perspectives of food security analysis and trends

In only three decades, Ethiopia has seen three major famines and other famine-like crises. Accordingly, famine and drought directly affected about 25 million people between 1958 and 1977 with which between three and five million individuals were estimated to have died. The famine of 1984/85 alone claimed the lives of 300,000 people. Similarly, an estimated 58 million people were estimated to be impacted by hunger between 1973 and 1986 (Balcha, 2001). On the other hand, looking through the historical perspectives of food security across the last three political regimes of Ethiopia (the Imperial reign of Haile Selassie, the Communist Derg regime under Mengistu and the Ethiopian People's Revolutionary Democratic Front) onwards, food production was generally perceived to have continually declined (Odi, 1974). In Ethiopia, droughts remain one of the key drivers of food insecurity which were a cause for 12 major drought-induced food security crises since 1950. The main impacts of droughts include crop damage, loss of pasture and water sources, loss of animals, hunger, disease outbreaks, asset depletions, malnutrition, price fluctuations and migration (Anderson et al., 2015). Land degradation, limited household resources, low levels of farm technology, a lack of employment opportunities, and population pressure are some of the main causes of food insecurity in Ethiopia (FDRE, 2003) as cited in (Fikre et al., 2017). Ethiopia is a country where millions of people have been exposed to famine mainly because of armed conflict (Balcha, 2001). Today, instigated from civil war and the declined capacity to transportation assistance, Ethiopia's Tigray region continues to experience one of the world's worst food security emergencies, requiring emergency humanitarian assistance to save lives (NET, 2022). Staple food prices are significantly above average in Ethiopia, with a progressive increase in prices since January 2022.

2.4 Conceptual framework

In order to better understand the contribution of eucalyptus plantations to household livelihoods and food security, livelihood options (mainly household livelihood types, income sources, vulnerability contexts, and livelihood strategies) and the food security pillars (mainly food availability and food access) are taken in to consideration. Of the livelihood options, the various household income sources, land size, eucalyptus plantations, major sources of income for purchase of agricultural inputs and in-house consumption items, income investment of eucalyptus, its saving contributions, and the major shocks are among the key areas of focus in this study. Thus, these were given due consideration because of their high importance in learning the relationship between eucalyptus-people-livelihoods-

food security. Because, people mainly use eucalyptus through its wood resources and income benefits that contributes to the productivity of other livelihoods and improvement of food security. That is, the income from eucalyptus provides people with purchase of food grains, improved seeds, fertilizers, livestock, pesticids, farm implements, start of off-farm activities, etc. while the wood resources provide with housing, firewood, fencing, farm equipment, home equipments and other many benefits. Accordingly, the key variables for this study are indicated in the below conceptual framework with its dependent variables as household food security. The household food security is seen in terms of household food sufficiency from production and the accessibility of food to the household through their respective livelihood income sources. Therefore, taking these in to account, the following conceptual framework is used (see Figure1below) by modifying from Abi & Tolossa (2015).

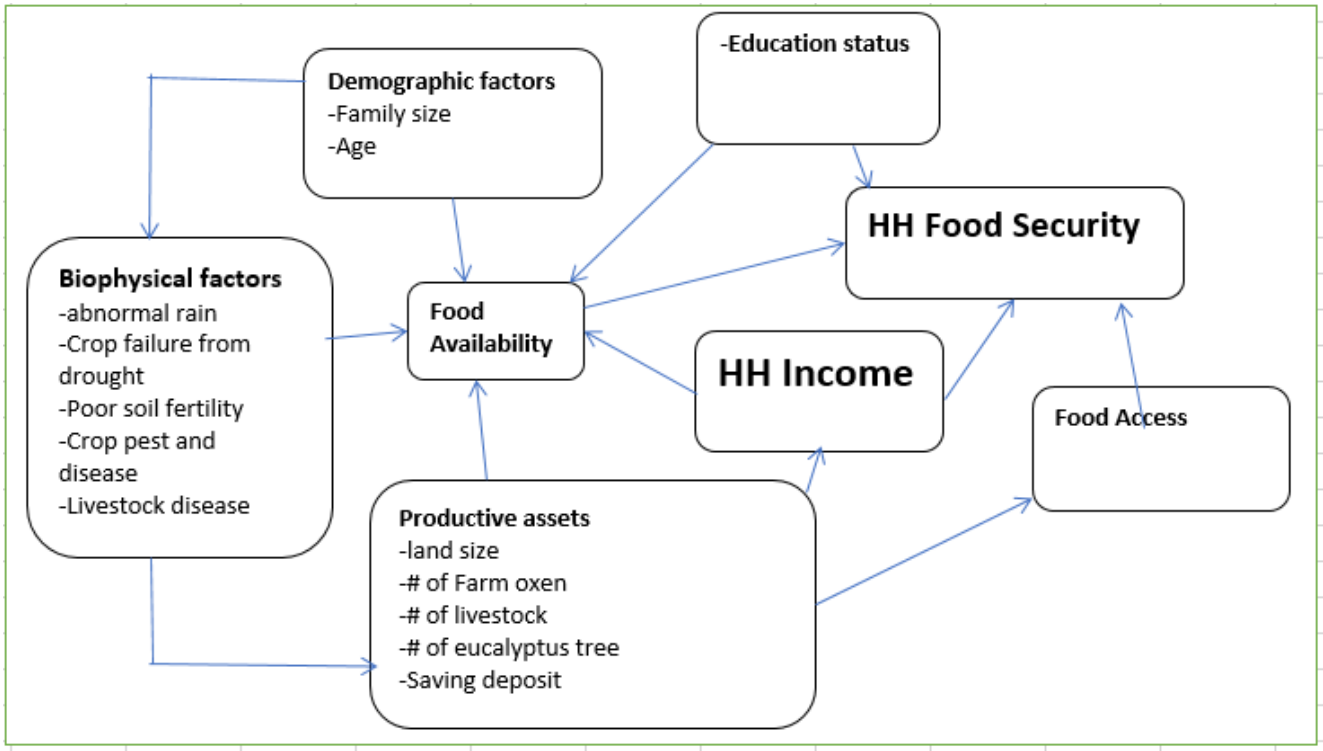


Figure 1: Conceptual framework modified from Abi & Tolosa (2015).

CHAPTER 3: DESCRIPTION OF THE STUDY AREA AND THE RESEARCH METHODS

3.1. Description of the study area

The study was conducted at Girar Jarso Woreda of North Shewa Zone in the Oromia region. The Woreda is described hereunder:

Girar Jarso Woreda is located at 112 km away from Addis Ababa in the North along the road to Bahirdar, with an area of 401.9 km^2. As in Table 1, with the average annual rainfall data that varies between 854-1497 mm, the Woreda has an average annual temperature ranging from 8°C - 21°C. The total population of the Woreda is 67,312 (Male=34,467 and Female=32,845) with a population density of 156 persons per km^2 (CSA, 2008). According to the projected report of CSA (2021), the population of Girar Jarso Woreda is 92,448 (Male=47,140 & Female=45,308) with an average family size of 5. The average household landholding size is identified to be 3.2ha. Mixed agriculture system is the backbone of household economy and is done largely by those who have land and livestock. The agriculture is rain based and is characterized by low yield output because of low use of farm inputs, traditional way of farming practice, low soil fertility, swampy and other related challenges. The livestock sub-sector is one of the components of the agricultural system. Agricultural products are used at home and some are sold to make money to meet other household needs, educate children, and contribute to social affairs (Mamo & Haile 2016).

Table 1: Rainfall and temperature data of the last 24 years in the study area

Rainfall data from 1995-2018	Rainfall (RF) in mm			Temperature (T) in °C	
	Maximum RF	Minimum RF	Mean	MinimumT	MaximumT
1995-2000	1497	1025	1195	8	20
2001-2006	1144	938.37	1098	8	21
2007-2012	1217	1040	1136	8	21
2013-2018	1284	854	1064	8	21

Source: National Meteorological Agency of Ethiopia, 2022 *(1995-2018)*

According to these recent reports of the rainfall data, both the maximum and the minimum rainfall has decreasesd within the last 20 years. The mean rainfall data has clearly shown this. The temperature

data also show that the minimum and maximum temperature was slightly increasing in the last two decades.

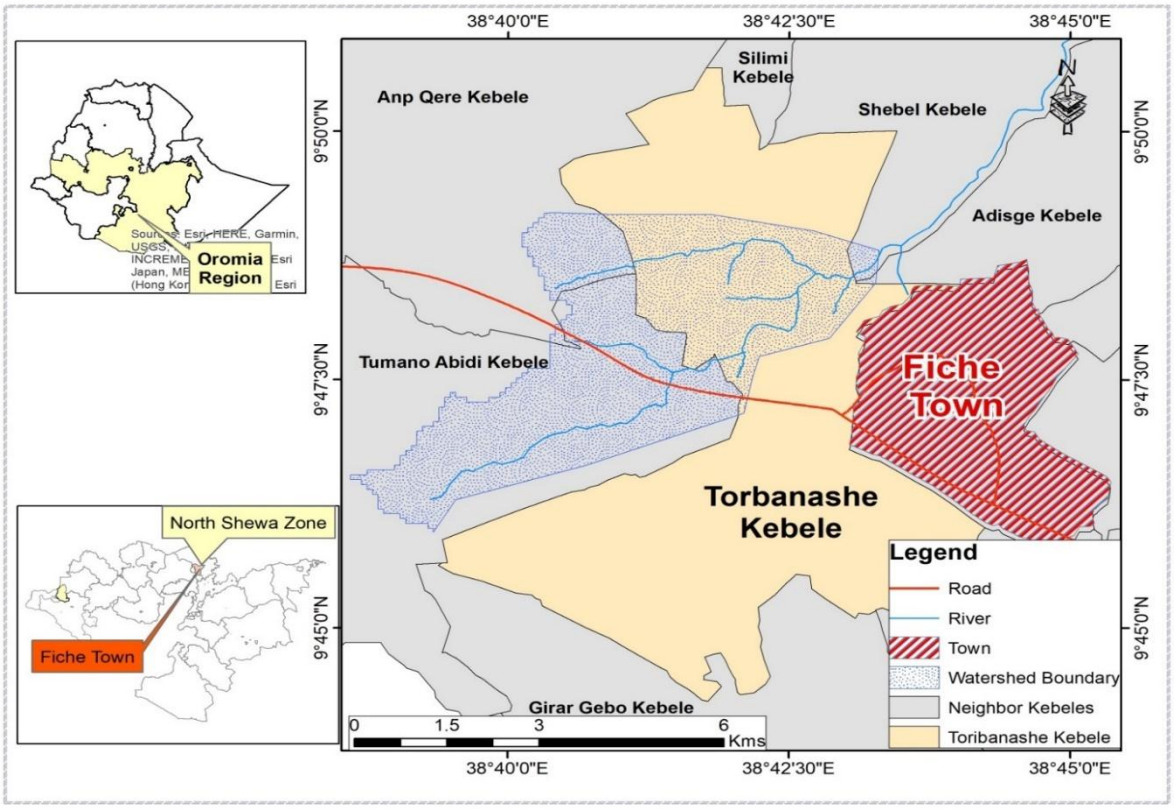


Figure 2: Map of the study area (Torban Ashe kebele – Girar Jarso Woreda)

3.2. Research Methods

3.2.1. Research design and approach

For this particular research, a sequential mixed method design was used where the result of one type of data provides a basis for collection of another type of data (Cameron, 2009). That is, the data was collected in sequences of two where the result of one depends on the other. In this case, the data for food consuption coping strategy of the households was collected based on the assessment results of Household Food Insecurity Access Scale (HFIAS). Accordingly, the consumption coping strategy was done to those households with HFIAS food category results of moderate and severe food insecure households. The research also used mixed research design. The study used the combination of both descriptive and inferential statistics to thoroughly describe or summarize the sample of the population and to relate the sample to the population (Dibekulu, 2020; Creswell, 2014) based on the information obtained from the household survey.

3.2.2 Data types and sources

In this study, both quantitative and qualitative approaches of data collection was employed. According to Creswell (2014), a mixed research approach was used to gather data which helps for a broader understanding of the research problem than quantitative or qualitative data alone. This ensures the data accuracy for the the assessment of the household livelihoods and food security benefits of eucalyptus plantations at Torban Ashe Kebele. Hence, the researcher employed mixed research approach in order to utilize both quantitative (household survey) and qualitative (observation, FGD, KII) tools that is helpful for triangulation and confirmation of the data.

In order to fully accommodate important data for the study both primary and secondary data sources were used. Tools used for primary data collection includes; household survey, Key Informant Interview (KII), Focus Group Discussions (FGD) and field observations. Similarly, document reviews and accessing relevant second-hand data from governmental organizations were used as a secondary data sources for the study. Hence, available documents at national, regional, Woreda and kebele level were reviewed and used to generate secondary sources of information.

3.2.3 Sampling techniques and sample size determination

Sampling techniques

The study area, Girar Jarso Woreda, was selected purposively using purposive sampling technique. The Woreda, for it is amongst the highland Woredas of Ethiopia, was selected purposively for having high dominance of eucalyptus plantations and for having various interrelated rural livelihood and food security challenges, including problems associated with high land degradation and poor soil fertility, as also justified by Abi (2011). Of the total 17 Kebeles of Girar Jarso Woreda, Torabn Ashe Kebele, where Hariro microwatershed found, was purposively selected due to its repeatedly prone to seasonal food insecurity, marginal, moisture stress, heavy land degradation and less productive land that has been influencing the households to face persistent food shortages (Mamo & Haile, 2016). Amongst the three watersheds in the kebele, Hariro microwatershed was purposely selected based on its proximity to the main road and the security problems in the other two watersheds of the Torban Ashe kebele. Budget scarcity and time constraints were also the other reasons taken into consideration.

Participants of the household survey were identified based on a range of sampling techniques. Accordingly, of the total households residing in the watershed, only households having land (n=280

HHs) were considered to be part of the sampling frame. Then, inclusion and exclusion sampling criteria (Patino & Ferreira, 2018) was further applied to classify the participants as eucalyptus growers and non-growers, 189 and 91 respectively. Based on this and from the prepared list, systematic random sampling was applied to both the included and excluded households. Systematic random sampling is used when the sampling frame is available in the form of a list. The selection process then begins by selecting a random position from the list and proceeding from there. Then, selecting every n^{th} item until the desired number is obtained (Kothari, 2004; Creswell, 2014). Accordingly, 100 eucalyptus growers and 65 non-growers were systematically identified as the sampling size of the study.

The participants for focus group discussions and key informant interview were identified using a purposive sampling technique. It equally included both from men and women, eucalyptus growers and non-growers, different age groups and experience taken into consideration as per the need for the data needed. Experts from woreda and Kebele were also included. The discussions were facilitated based on the KII and FGD guide prepared for this purpose.

Sample size determination

Too large a sample implies a waste of resources, and too small a sample diminishes the utility of the resources (Cochran, 1977). For determination of sample size of the household survey, the following formula was applied for computation based onYamane's (1967) formula is indicated in Israel (1992) was used. Thus, using a margin of error of 5%, confidence level of 95% and response distribution of 50%, the estimated sample size is 165.

$$n = \frac{N}{1 + N\,(e2)} = \frac{280}{1 + 280\,(5\%)^2} = 165$$

Where n is the sample size, N is the population size, and e is the level of precision or margin of error using a 5% level of error or 95% level of confidence.

Therefore, the sample size for the study was 165 households. Accordingly, of the total sample size, proportional to sample size was used as per the sampling frame for eucalyptus growers and non-growers 100 and 65 households, respectively. Based on this, data on household socio-economic information, HFIAS, and coping strategies were collected using a recruited enumerator.

3.2.4 Tools of data collection

In order to fully accommodate important data for the study, two of the important (primary and

secondary) data sources were used. The instruments that have been used to collect the primary data sources include household survey, Key Informant Interview (KII), Focus Group Discussions (FGD) and field observations to assess household livelihoods and food security benefits of eucalyptus for growers and to compare these with non-growers. The secondary data sources were document reviews in which data collected from document review was used to have detailed information about the socio-economic conditions and the general benefits of eucalyptus plantation as per the local context of the study area. For the qualitative data collection, the following techniques were used and can be summarized as follows:

(A) Questionnaire surveys

For quantitative data collection, a well organized household survey questionnaires were prepared to interview the sampled households on the benefits of eucalyptus farming to household livelihoods and food security both for eucalyptus growers and non-growers. The questionnaires were structured and unstructured to generate qualitative and quantitative data from the respondents. Through these questionnaire surveys, data on age, land holding size, income sources, annual incomes, livestock ownership, number of eucalyptus, and major shocks, and other relevant points were asked. For data collection through these questionnaires, a total of 100 eucalyptus growers and 65 non-growers were interviewed.

(B) Key informant interview (KII)

To have a well understanding on the benefits of eucalyptus plantations to household livelihood and food security, in-depth interviews with key informants who were selected on the basis of their knowledge and experience about the socio-economic conditions, livelihood options, farming conditions, eucalyptus plantations and food security status of the households in the area were interviwed. Accordingly, 7 key informant interviewees (one community member, one kebele administartor, two Kebele development agents and three Woreda officials) were interviewed.

(C) Focus Group Discussion (FGD)

In order to explore data that cannot be explained statistically, relevant topics were made available for discussion to each of the focus group discussions having 6-8 individuals that has utilized a pre-

prepared guide. For qualitative data collection, fourfocus group discussions were conducted, two from growers and two from non-growers.

3.2.5 Techniques of data analysis

Descriptive statistics like frequencies, percentages, means and standard deviations were used to make the analysis on the socio-economic and income sources status of the households. As inferential statistics, chi square was used to see the association across discrete explanatory variables of the study. To measure the benefit of eucalyptus tree plantations on livelihood and food security of households, descriptive analysis technique, and ordered logit model for ordered variables was employed for analysis. STATA version 16 and SPSS version 20 softwares were used for the analysis. Qualitative analysis was used to analyze data that has been acquired qualitatively. The data from the Household Food Insecurity Access Scale (HFIAS) and the Coping Strategy Index (CSI) were analyzed using ordered logit regression and descriptive statistics. Thus, the percentage of households classified in to the different food security categories and the households‘ coping strategies status were identified. Analysis used for the food security data were summarized as follows:

(A) Household Food Insecurity Access Scale (HFIAS)

The analysis has categorized the household food security status in to four indicators (1 = Food Secure, 2=Mildly Food Insecure Access, 3=Moderately Food Insecure Access, 4=Severely Food Insecure Access) that considers a recall period of 30 days. The analysis used the following formula:

HFIAS category, FS = 1	if [HFQ1a==0 | HFQ1a==1 & HFQ2 ==0 & HFQ3==0 & HFQ4==0 & HFQ5==0 & HFQ6==0 & HFQ7==0 & HFQ8==0 & HFQ9==0]
HFIAS category, MiFI = 2	if [HFQ1a==2 | HFQ1a==3 | HFQ2a==1 | HFQ2a==2 | HFQ2a==3 | HFQ3a==1 | HFQ4a==1] & [HFQ5==0 & HFQ6==0 & HFQ7==0 & HFQ8==0 & HFQ9==0]
HFIAS category, MoFI = 3	if [HFQ3a==2 | HFQ3a==3 | HFQ4a==2 | HFQ4a==3 | HFQ5a==1 | HFQ5a==2 | HFQ6a==1 | HFQ6a==2 & HFQ7==0] & HFQ8==0 & HFQ9==0
HFIAS category, SFI = 4	if [HFQ5a==3 | HFQ6a==3 | HFQ7a==1 | HFQ7a==2 | HFQ7a==3 | HFQ8a==1 | HFQ8a==2 | HFQ8a==3 | HFQ9a==1 | HFQ9a==2 | HFQ9a==3]

Where FS represents food secure, MiFI represents mildly food insecure, MoFI represents moderately food insecure, SFI represents severely food insecure, Q is the HFIAS questions, 1a, 2a, 3a…represent the frequency of each HFIAS questions.

The aim here was to explore the prevalence of household food insecurity experience in terms of access between eucalyptus growers and non-growers. Therefore, in order to obtain data for this objective, the Household Food Insecurity Access Scale (HFIAS) was used as an assessment tool that was collected through the household survey. Accordingly, a total of 165 households (both for eucalyptus growers and non-growers) were surveyed. The HFIAS uses nine questionnaires that were pre-tested with some key informant interviews to contextualize the tools after which the data were collected through a household survey. The assessment assisted in determining the food security status of households as well as categorizing the households as food secure, mildly food insecure, moderately food insecure and severely food insecure households (Coates et al., 2007) both for eucalyptus growers and non-growers. This supplemented the data obtained through household surveys and qualitative approaches.

(B) Months of Adequate Household Food Provisioning (MAHFP)

The ability of a household to meet its food needs as it manages its resources over the course of a year may vary due to a variety of factors, which would include inadequate crop production by the household due to poor soils or a lack of labor, loss or decrease in income sources such as employment, social obligations, or natural disaster (Swindale & Bilinsky, 2010). This assessment is intended to identify the months, in which access to food is limited (i.e., production) as the respondents are all farmers. As a sign for a measure of household food availability, MAHFP was employed to measure household food provisioning (Nkonde et al., 2021). This technique only uses two questions to identify months of food shortage by considering twelve months recall period of the last year (Swindale & Bilinsky, 2010). The respondents were asked to think back over the previous 12 months, starting with the current month, i.e from April 2022 to March 2021. It was collected from the 165 households (both eucalyptus growers and non-growers) through the household survey. Added with the data from the other assessment tools, it gives a better understanding to know the food gap as well as the contribution of eucalyptus to household livelihood and food security.

The tabulation of the responses was done by adding the total months. First, the MAHFP for each household in the sample is calculated: The MAHFP was calculated as 12-n for each household, where n represents the number of months of food gap in a year. Accordingly, it was calculated as twelve months minus the total number of months out of the previous 12 months that the household was unable

to meet their food needs. Values for A through L is either "0" or "1." Note that if the answer to Question 1 is No, then responses A-L of question two should be coded as zero (0).

(12) - Sum (A + B + C + D + E + F + G + H + I + J + K + L)

Second, an average for all the households in the sample is calculated. The denominator should include all households interviewed, even those who did not experience any months of inadequate household food provisioning.

$$\text{Average MAHFP} = \frac{\text{Sum of the MAHFP for all households in the sample}}{\text{Total Number of Households}}$$

(C) Household Coping Strategies

In order to collect data for this objective, a weighted coping strategy interview tools were used. It is very useful tool to get whether the household food security status is in declining or improving (CARE/WFP, 2003). In combination with other food security tools such as HFIAS, it provides a good indicator to know how the households behave to cope with food insecurity. The analysis was conducted statistically and then with an ordered logistic regression.

3.2.6 Variables and method of quantification

Descriptions of variables

The dependent variables for this study are: a) household livelihoods which is normally attributed by household income per annum, b) household food security, which are contributed by the various household livelihoods. Accordingly, the dependent variables that were influenced by the independent variables were household income and food security. Whereas the independent variables considered to influence the dependent variables as per the researcher and literature review were indicated in Table 2 below.

Table 2: Description of variables and their signs

Description of variables	Variable.	Variable category	Types of variables
Household food security status: 1=Food secure, 2=mildly food insecure, 3=moderately food insecure, and 4=severely food insecure	HHFS	Categorical	Dependent variable
Age of household head in year	AHH	Continuous	Independent variable
Household family size in number	FSN	Continuous	Independent variable
Land holding size in Ha per household	LHS	Continuous	Independent variable

Land use types in Ha for eucalyptus per household	LUTE	Continuous	Independent variable
Annual income per household in ETB	AI	Continuous	Independent variable
Re-invested amount of average annual income from eucalyptus products in ETB	RII	Continuous	Independent variable
Reasons for planting eucalyptus trees: 1=For commercial/income generation, 2=to replace declining crop yield, 3= for land demarcation and fencing, 4= for soil and water conservation, 5= has social value	RPE	Categorical	Independent variable
Use of income generated from eucalyptus sales: 1=For farm equipments, 2=for purchase of improved crop inputs 3=for purchase of grains for food 4=for purchase of livestock/oxen/feed, 5=for engaging in off-farm	UIE	Categorical	Independent variable
# of livestock holding per household in TLU	LH	Continuous	Independent variable
# of farm oxen per household	FO	Continuous	Independent variable
# of eucalyptus trees planted per household	NEP	Continuous	Independent variable
#of months of household food gaps	MFG	Continuous	Independent variable
Coping Strategy Index Score described as Low, Medium, High	CSI	Categorical	Independent variable

CHAPTER 4: RESULTS AND DISCUSSIONS

The results of the quantitative and qualitative analysis are presented in this chapter of the thesis, along with an explanation of the findings. The chapter is structured on the themes of the particular objectives and results. The chapter starts with information on the demographics of the research respondents, present statistical analysis and provide explanation for statistical outputs. Descriptive and inferential statistics are included depending on the requirement of each topic under discussion accompanied by triangulation of variables and results to provide a detail perspective on the household livelihood and food security benefits of eucalyptus, months of adequate household food provisioning, and coping strategies of the study. In addition, major income sources, investment of income from eucalyptus, and other important data for this thesis are systematically presented in this chapter.

4.1 Age, family size and education

Participants of the study, both for eucalyptus growers (N=100) and non-growers (N=65), the highest ages were 75 and 70 years while the lowest ages were 22 and 27 years with mean ages of 44 and 42 respectively. As shown in Table 3, more than 60% of the respondents in both groups were between the ages of 31-50. The average family sizes of the households were 6 for eucalyptus growers and 5 for non-growers. Note that in the absence of the head of the household, housemates and other family members were asked to answer questions from the household questionnaire regarding the household.

Table 3: Distribution of eucalyptus grower and non-grower households by size of landholding

Age, family size & educational status the of HHs		Growers		Non-growers	
		Freq	%	Freq	%
Age range	22-30	5	5	7	11
	31-50	63	63	40	61
	Above 50	32	32	18	28
	Max	75		70	
	Min	22		27	
	Mean	44		42	
Family size	Max	10		9	
	Min	2		1	
	Average	6		5	
Educational status	Literate	49		48	
	Illiterate	51		62	

4.2 Household landholding size

As summarized in Table 4, about 29% of the respondents from eucalyptus grower households (N=100) have a farmland holding of below one hectare, whereas this accounts to 53% for non-eucalyptus grower households (N=65). This means that compared with eucalyptus growers, non-eucalyptus growers have less landholding size per household. This may hinder them not to practice plantation of eucalyptus on their farmland. It might also mean that landholding size may determine the participation of households to plant eucalyptus. A report from Tigrai region indicated that a farmland per household declined from 1.15 to 0.90 ha or 78% over the time period from 1998 and 2016 (Holden & Tilahun, 2020). Compared to the national average landholding size of 0.84ha (CSA, 2021), the average landholding size of 1.6ha and 1.3ha both for eucalyptus growers and non-growers respectively show larger land size but still small compared to the average holding size in the area which is found to be 3.2ha.

As reported during the focus group discussions, households with less parcel of landholding limit themselves only to agricultural practices rather than planting eucalyptus. The study conducted in Kuyu Woreda, nearby Woreda to this study area shown that insufficient landholding by households can affect agricultural production thereby affect the food security status of the households (Mulugeta, 2009). The study by Mulugeta (2009) also shown that if the current rate of population expansion continues, the future shortage of farmland will be more severe, which will surely have an impact on the corresponding grain production per household. The challenge can be more observed on non-eucalyptus grower households as they have less amount of farmland compared to those eucalyptus growing households.

A summary from the focus group discussions revealed that households hold the same farmland size for years were facing an increasing family size where the same farmland shared to children resulting to affect household livelihood and food security. With this dependence of these rural households on land the size of which could not be expanded and the decreasing productivity of land, it will be difficult to expect improvement in the livelihood and food security of the households. According to this study, more than 58% and 55% of the households have landholdings of less than the average landholdings both by eucalyptus growers and non-growers respectively. This indicates that there are highly fragmented farmland that can affect agricultural production that could directly effect food security of the households. The subsistence agriculture has been challenged by farmland shrinkage as a result of population growth (Takada et al., 2022) which is very similar to this study findings.

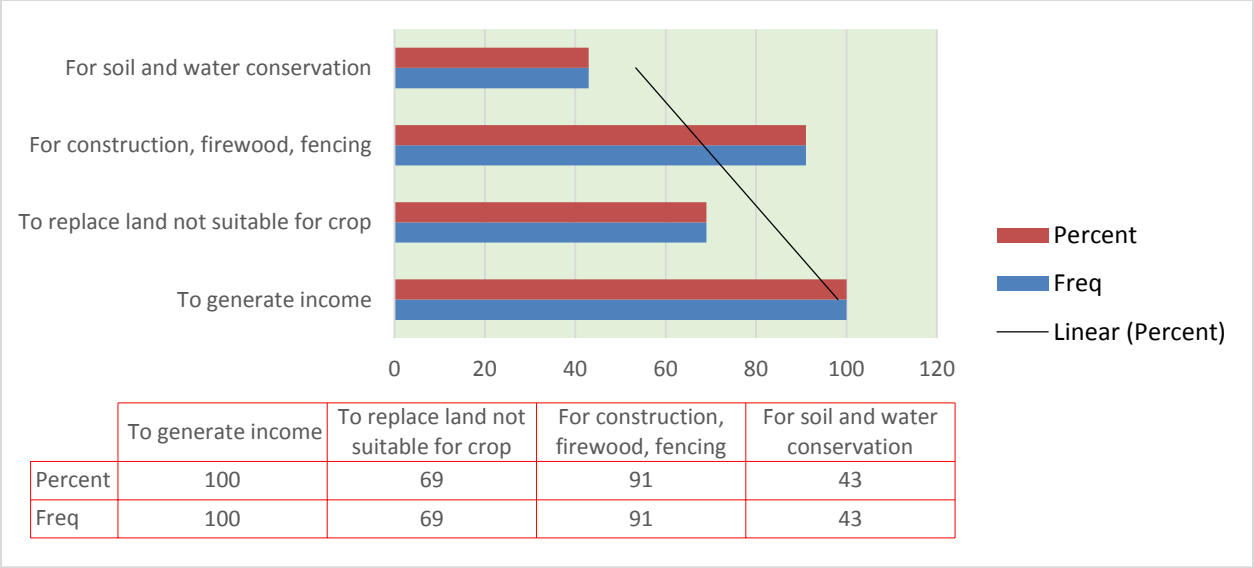
Table 4: Distribution of eucalyptus growers and non-growers by size of landholding

HH land holding size	Growers		Non-growers	
	Freq	Percent	Freq	Percent
<1	29	29	28	43
1-2	47	47	26	40
2-3	18	18	10	15
>3	6	6	1	2
Total	100	100	65	100
Av.holding/HH	1.6		1.3	
Av.holding used for crops	1.12	70	1.15	86
Av.holding used for grazing	0.25	16	0.18	14
Av.holding used for eucalyptus	0.22	14	0	0

Source: Field survey, 2022

4.3 Households' reasons for planting eucalyptus trees

Why do farmers plant eucalyptus trees? Rural households mainly in the highlands of Ethiopia plant eucalyptus trees for many reasons including economic, environmental and social values. As shown in Figure 3, the study revealed that participants plant eucalyptus trees for the purpose of increasing household income, for meeting own construction, fencing & firewood, and to replace the declining crop yield that account for 100%, 91% and 69% (N=100) of the study participants. As the researcher observed during primary data collection, there were no indigenous trees that can replace euclayptus for construction, fencing, firewood and for various tools for farm implements in the study area. As a result, eucalyptus trees were dominantly planted and being used for filling such gaps. As it is the dominant tree in the area, eucalyptus woodlots have been planted by the local community for many reasons as aforementioned above including for its social benefit. Similar study also indicated that farmers plant eucalyptus trees mostly for fire wood, construction, source of income and farm tools (Zerga & Berta, 2016). Observation from the focus group discussion also revealed that with the current decreasing farmland productivity, eucalyptus plantation is the question of sustaining household livelihoods and surviving one's family. Studies by other scholars also shown that eucalyptus tree farming, particularly for smallholder farmers, is the question of survival, insurance and livelihood sustenance (Zerga & Woldetsadik, 2016).



	To generate income	To replace land not suitable for crop	For construction, firewood, fencing	For soil and water conservation
Percent	100	69	91	43
Freq	100	69	91	43

Figure 3: Purpose of growing eucalyptus (multiple response, N=100)

As shown in Figure 4, the farming land in the watershed was observed to be very eroded resulting in decreasing of the farmland that would probably contributing to decrease crop yield. In addition to expansion of eucalyptus plantations to farming land and unsuitability of the land for crop production, households in the study area are motivated to plant eucalyptus trees on eroded and gully areas that would increase the potential benefit of the land to the household.

Figure 4: Farmland degradation & importance of eucalyptus trees (source: field survey, 2022)

4.4 Contribution of eucalyptus to household livelihood and food security

4.4.1 Contribution of eucalyptus to household livelihood

(A) As a wise land utilization

According to this study, majority of the households‘ land have been utilized for crop production which accounts for 70% and 84% both for eucalyptus growers and non-growers respectively. Table 5 clearly indicated that of all the land use types owned by a household, 14% was covered by eucalyptus plantation which is very small portion compared to other land use types though it has high economic benefits to households. Though it accounts for small portion of household landholding size, it is contributing to have high economic benefit to the eucalyptus planting households. It is an additional household livelihood option for the eucalyptus growers that could contribute to additional household income.

Asked with whether they plant this eucalyptus on land suitable for other agricultural land, 89% of the respondents reported they were planting eucalyptus trees on land that was not suitable for crop production. Only 11% of the respondents reportedly have planted eucalyptus on land that was considered suitable for crop production. This indicates that eucalyptus plantation is a means for utilizing unsuitable land whereby additional household income can be generated. Other studies also indicated that increased allocation of land for the production of eucalyptus is one of the indicators for increased importance of eucalyptus for livelihood (Bezabeh et al., 2019). Identified during the focus group discussion that one of the main reasons for eucalyptus plantation in the area was that it has some valuable benefits to household in terms of converting unsuitable land into productive land and becomes a means for household income generation. The study also showed that farmers plant eucalyptus trees on degraded farmlands, gully areas, around boundary areas, and homesteads. This has helped many of the housheolds to consider eucalyptus as one of the main sources of livelihood income and contribution to food security. The agro-climatic compatibility of the eucalyptus tress in the area also has made a comparative advantage for the households to utilize land that is not suitable for crop production, which has to be encouraged since their adverse effect with food crop lands is negligible in such conditions.

(B) As a main source of household income

The major income sources of the households in the study area include livestock, crop production, eucalyptus plantation and off-farm activities such as engagement in construction works in the nearby town. Livestock production (64%) and eucalyptus plantation (20%) for eucalyptus growers and

livestock production (67%) and off-farm activities (32%) for non-eucalyptus growers were found to be the most commonly practiced livelihoods contributing majorily to household annual income. That is, this study found 20% annual cash income from eucalyptus per household compared to 28% by Mekonnen (2006). Other studies also indicate that eucalyptus income make-up 87% of the overall households' income, whereas agricultural income provides 13% (Yadeta, 2021).

On the other hand, with the continuous eratic rainfall (characterized by heavy rain and snow) added with scarcity of rain that resulted to crop pests and disease in the study area has contributed to low crop productivity. Studies conducted in Girar Jarso Woreda indicated that crop yield and productivity has been dropping due to poor soil fertility and high crop losses that are caused by insect pests and diseases (WAO, 2010) as reported in Abi & Tolossa (2015). In such situation, eucalyptus has contributed much to generate income benefiting household livelihoods and food security. As can be observed from Table 5 for eucalyptus growers, majority of the income sources for the households were below 3000 ETB except from livestock. Income from crop production was the least household livelihood income source in the area due to the varous reasons as evidenced during the focus group discussions. The discussion group reported.

"The yield from our land is decreasing due to the increasing erosion, eratic rainfall, incapability to afford the cost of agricultural inputs and crop diseases. Furthermore, within the last two years, there were low crop yield mainly from crop diseases and pests that was induced due to eratic rainfall. "

Table 5: Average annual household cash income of the respondents

Types of respondents	Income category	Livestock		Crop		Labor		Eucalyptus	
		#HH	%	#HH	%	#HH	%	#HH	%
Eucalyptus growerss	<3000	12	12	96	96	83	83	64	64
	3000 – 6000	31	31	4	4	15	15	24	24
	6000-9000	30	30	0	0	0	0	6	6
	>9000	27	27	0	0	2	2	6	6
	Total	100	100	100	100	100	100	100	100
	Av.cash income	7,177		379		1,445		2,296	
	Proportion of income (%)	64		3		13		20	
Non-eucalyptus growers	<3000	5	8	65	65	32	49		
	3000 – 6000	23	35	0	0	27	42		
	6000-9000	23	35	0	0	1	1		
	>9000	14	22	0	0	5	8		
	Total	65	100	65	100	65	100		

Source: Field survey, 2022

(C) As a household livelihood protection

Households in the highlands of Ethiopia plant eucalyptus trees for various reasons mainly for filling their household daily needs. Commercial growers normally sale eucalyptus products when it is mature enough to give high economic return. However, smallholder farmers normally sale eucalyptus products in conditions of high financial needs for their livelihood continuation with more or lesss comparable maturation of the tree taking in to account of the use types. As in Table 6, respondents of this study replied that they sale eucalyptus products mainly when farm inputs are highly needed, when sale of livestock are cheap and when sale of grains are cheap on the market that accounts for 26%, 25% and 21% respectively. This reveals that eucalyptus plantation help protect other livelihoods. That means, in addition to its normal economic return to the household, sale of eucalyptus products during low market value of other livelihood products would enable the households to save the livelihoods, ensure high economic value of the other livelihoods and can protect their livelihoods from unwise utelization. Had they don't have eucalyptus, they would have been saling their basic assets on cheap that could affect their livelihoods and food security. Besides, the study indicated that households prefer to sell eucalyptus products when there is a reduction in the prices of grains to sale it latter at high price (Zerga & Woldetsadik, 2016).

Table 6: Household conditions of saling eucalyptus products

Conditions of saling eucalyptus	**Growers (N=100)**	
	Frequency	**%**
Sale euclayptus when livestock is cheap	25	25
Sale euclayptus when grain is cheap	21	21
Sale euclayptus when farm implements are needed	26	26
Sale eucalyptus when emergency	20	20
Sale euclayptus when no daily wage	8	8
Total	100	100

Source: Field survey, 2022

(D) As a main sources of cash saving

Households in the study area involve mainly in various agricultural activities with few engagements in off-farm activities. The main livelihood income sources for cash savings both for eucalyptus grower and non-grower households were income from sale of livestock, income from sale of crop yield, income from sale of eucalyptus products and income from off-farm activities. Of all the non-grower

respondent households (N=65), 71% of them said they have savings. The main sources for cash saving were mainly these aforementioned livelihoods. Majority (75%) of the eucalyptus grower households said they have cash savings from their various livelihood options. This study revealed that income from livestock and eucalyptus accounts for 73% and 62% as the first and the second livelihood income sources of cash savings for eucalyptus growers. It is also identified that the main income sources for cash saving for non-eucalyptus growers were livestock and off-farm activities accounting for 57%and 43% respectively. Interestingly, eucalyptus grower households have additional income sources from eucalyptus plantations compared to their non-eucalyptus grower counterparts. It further indicated that income from sale of livestock and livestock products were the main income sources while income from sale of grains were the lowest income source both for eucalyptus grower and non-grower households. Contribution of eucalyptus plantation is considered of many benefits to the households. Studies by other scholars also indicated that the sale of forest products increases household income, improves their livelihood by contributing to diversifying farming systems and rising farm incomes and thereby increasing food security particularly in less favored areas of Ethiopia (Zerga & Woldetsadik, 2016).

(E) As a re-investment income source to household livelihoods

Household food security is affected by various livelihoods and environmental conditions including existing man made and natural factors. As discussed earlier, eucalyptus plantation as a potential livelihood option is an essential livelihood alternative for generating income at household level. The income generated from eucalyptus products are re-invested into various household livelihood options. As indicated in the study findings as in the below Figure 5, more of the income generated from eucalyptus plantation were re-invested in other livelihoods mainly to livestock and savings accounting for 25% and 21%s respectively. It can also be observed that income from eucalyptus plantation was re-invested in purchase of grains for consumption indicating that it was contributing to household food security. It can also be identifed that the income generated was re-invested in use for covering school or taxation costs, emergency costs, for savings at bank, and for purchase of inputs for crop production. It can be concluded that the income generated from eucalyptus products able to protect other livelihoods or or save it from its unwise use and for contributing to household food security. Therefore, the income obtained from eucalyptus products help in diversifying and expanding other livelihoods.

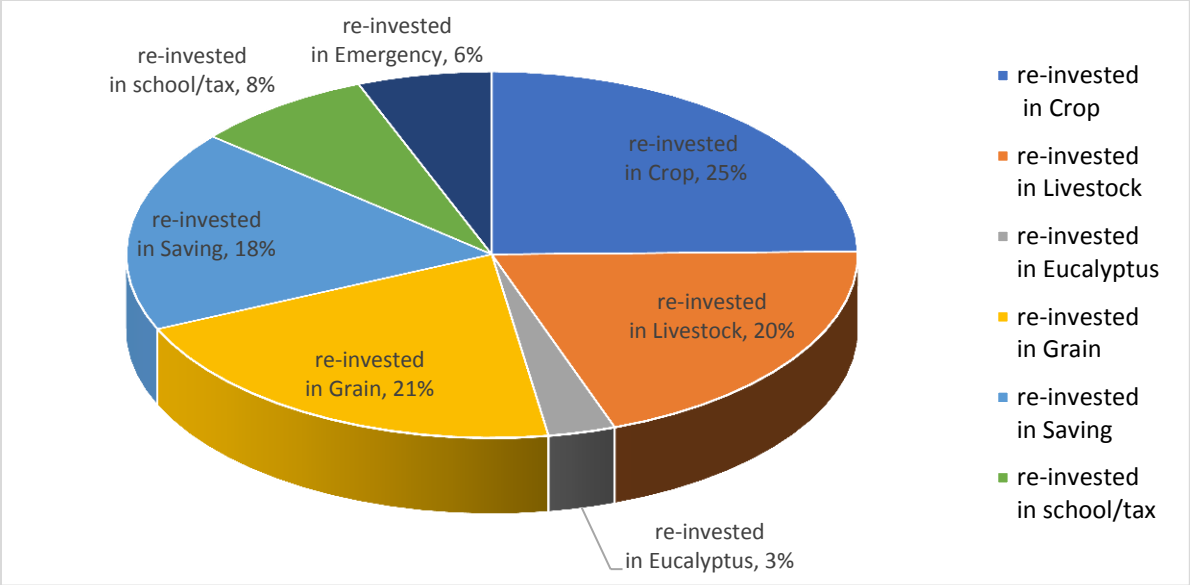


Figure 5: Eucalyptus income re-invested in various livelihoods

4.4.2 Eucalytpus contribution to household food security

(A) As a main income source for purchase of agricultural inputs

As shown in Table 7, both eucalyptus growers and non-growers have their own means of getting income for purchase of their various agricultural inputs. For eucalyptus growers, sale of livestock and eucalyptus products account for 92% and 77% respectively as the main household income sources for purchase of the various agricultural inputs, whereas non-eucalyptus growers reported that income from sale of livestock and livestock products, and income from off-farm activities account for 100% and 66% respectively, which they use it for purchase of their various agricultural inputs. Thus, the study shows that eucalyptus was the second most income sources contributing to the production of agricultural foods for eucalyptus growing households. The study also indicated that households with less means of income will have less capacity to purchase agricultural inputs. Thus, households with eucalyptus plantation have more capacity to purchase agricultural inputs indicating the better they are to meet their food needs. Smallholders who only engage in farming activities do not earn enough money to support their families and buy farm inputs, and as a result, are considered to be food insecure (Beyene & Muche, 2010). As disucussed earlier, income from crop production is found be the lowest contributor for purchase of agricultural inputs such as seeds, fertilizers and other related expenses, of course because of the low yield resulted from rainfall variability. This time, eucalyptus growers have benefited more and sustained their family compared to non-grower households.

Table 7: Eucalyptus as the main income source for purchase of agricultural inputs

Most income sources for agricultural inputs	Responses	Growers		Non-growers	
		Frequency	%	Frequency	%
Sale of livestock	Yes	92	92	65	100
	No	8	8	0	0
Sale of crop yields/grains	Yes	27	27	5	8
	No	73	73	60	92
Sale of eucalyptus products	Yes	77	77	0	0
	No	23	23	0	0
Income from off-farm activities	Yes	55	55	43	66
	No	45	45	22	34

Source: Field survey, 2022

(B) Eucalyptus as the main income source during shocks

The study revealed in Figure 6 that livelihoods of the households in the study area were getting vulnerable due to the various shocks mostly related to abnormal rain, crop pests and diseases, and poor soil fertility resulting in decreasing crop yield. Among these, abnormal rain was the most common shock affecting livelihoods and food security of the respondents in both study groups; this accounts to 100% of the respondents. Reported by the focus group discusions, abnormal rain has highly affected the last two year's crop production that has resulted household food insecurity. Because of this, many of the communities have been engaging in other livelihood options such as off-farm activities to increase their household income.

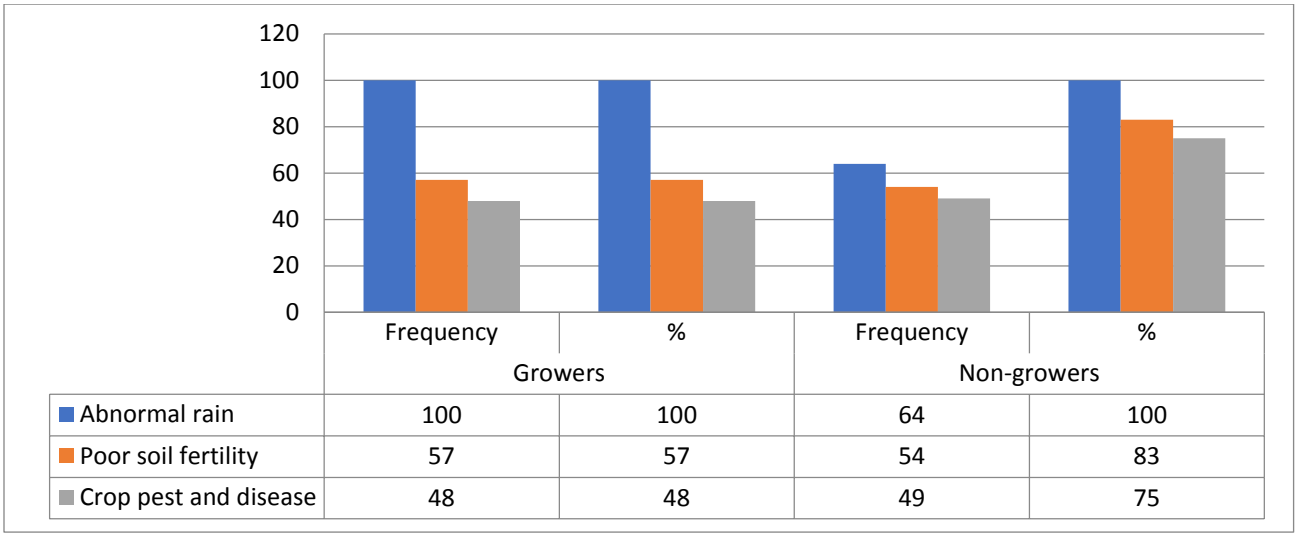


Figure 6. Most frequent shocks in the study area (Multiple response)

As in Figure 7, the study revealed that livestock production and its products contributed 89% and 97% income for recovering from shocks both for eucalyptus growers and non-growers respectively. Income from agricultural production contributed the least contributor to household livelihood and food security during shocks. Livelihoods of the households in the study area were getting vulnerable to the increasing shocks arising from abnormal rain, crop pests and diseases, increasing land degradation and poor soil fertility resulting in decreasing crop yield.

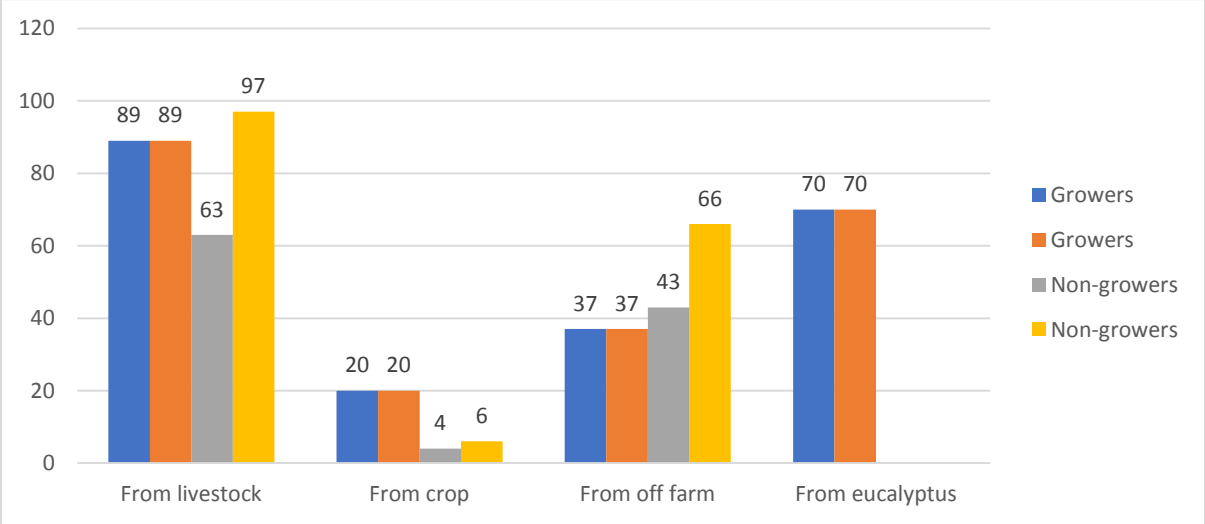


Figure 7: Most income sources during shocks (multiple responses)

(C) Eucalyptus as a main income source for filling in-house food and non-food items

The income sources for the rural households are sale of their own agricultural production or off-farm activites which is used for all expenses including food needs and other associated costs of the household. As indicated in Table 8, 95% and 85% of the respondents from eucalyptus growers and non-growers respectively fill their financial needs from livestock and livestock products that would be used for purchase of in-house food and non-food items. For eucalyptus growers, income from sale of eucalyptus products were reported to be the second most livelihood income source used for purchase of in-house food and non-food items such as teff, oil, coffee, sugare, utensils, etc. at household level; this accounts to 74%. It is therefore can be said that eucalyptus growers have more options of livelihood income that could enable them to be stronger enough to cover their in-house food needs and other associated expenses.

Table 8: Most income sources for covering in-house food & non-food items

Most income sources for covering in-house food & non-food items	Responses	Growers (N=100)		Non-growers (N=65)	
		Frequency	%	Frequency	%
Sale of livestock	Yes	95	95	55	85
	No	5	5	8	12
Sale of crop yields/grains	Yes	45	45	24	37
	No	55	55	26	40
Sale of eucalyptus products	Yes	74	74	0	0
	No	26	26	0	0
Income from off-farm activities	Yes	57	57	49	75
	No	43	43	16	25

Source: Field survey, 2022

(D) Saves stored grains from sale during bad market season

As indicated in Table 6 above, 26% % of the households sale eucalyptus when there is a bad market season. That is, they sale eucalyptus when the price of grains are cheap on the market to save stored grains. This helps protect the grain the household has for feeding their family. As obtained from the focus group discusssions, in addition to saling their eucalyptus products during cheap market period for grains, many households also sale eucalyptus products when grains are expensive on the market to fill household food needs. As indicated on Figure 5, 21% of the income obtained from sale of eucalyptus was used for purchase of grains for use in household food consumption. It is observed that income from eucalyptus is used for covering food gap during shocks.

4.5 Food security status and its determinant factors

The Household Food Insecurity Access Scale (HFIAS) prevalence is a categorical indcator of food insecurity access scale that was calculated for the study participants. Accordingly, the HFIAS assessment is summarized as follows. As pointed-out in Figure 8, many of the respondent households were food secure with 45% and 34% for eucalyptus growers and non-growers, respectively. The study was conducted during the month of April at which there can be a good food availability. However, it was unfortunate that there exists scarcity of food grains in the area due to the crop failure that resulted from shortage of rain for the last two consequative years. This means that during the bad season of the year, the food insecurity status of the households will increase. Due to this the dependence of eucalyptus growers during this scarce food season was high.

An ordered logit regression was applied to STATA version 16 to identify the determinant factors that affect the food security situation of the study participants after relevant statistical tests were conducted to evaluate validity of the ologit model.

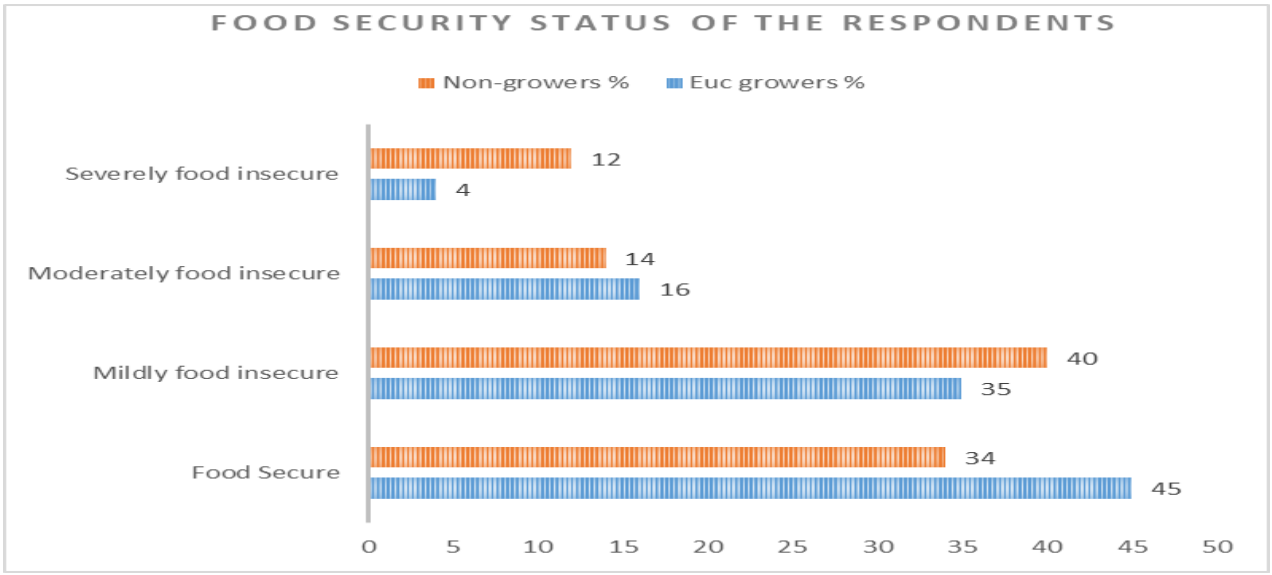


Figure 8: Food security status of the respondents

Computation of ordered logistic regression

The ordered logistic regression model utilized the maximum likelihoods estimation whereby in the iteration zero, a point where no predictors are used, indicates the likelihood of the null model. The iteration increased until the successive iteration ends. The probability of the overall model was zero indicating that the overall proportional odds model was statistically significant that it also confirmed at least one of the predictors' coefficients was not equal to zero. At 95% confidence interval, LR Chi-squared of 125.32 and 118.72 were the Likelihood Ratio (LR) Chi-Square tests for eucalyptus growers and non-growers respectively indicating at least one of the independent variables in the ologit regression coefficient was not equal to zero. The number in the parenthesis indicates the degrees of freedom of the Chi-Square distribution used to test the LR Chi-Square statistic explained by the number of independent variables (12 predictors) used in the model. The LR Chi-square was statistically significant as the probability of the overall model was zero both for eucalyptus growers and non-grower households.

After confirming the significance of the overall model (with probability of zero), statistically significant predictors (independent variables) were identified for further interpretation. The

statistically significant variables at 95% and at 99% confidence level for eucalyptus growers were age of the household head, family size, and CSI score. Similarly, the significant variables for non-eucalyptus grower households were household head, family size, land size, and CSI Score.

The HFIAS categories are ordered in the ordered logistics model from the less food insecure (food secured) to a high level of food insecurity (severely food insecure). With the food security situations are ordered in terms of orders of severity of food insecurity situation, the coefficients of the predictors have to be interpreted accordingly. This shows that the negative sign in the coefficient means that with an increase in one unit of the predictor would result in a reduction in the ordered log-odds of being in severe food insecurity by the rate of the coefficient while other independent variables held constant. Hence, the positive sign in the coefficient tells us that with a unit increase in the predictor would result in a higher ordered log-odds of being in severe food insecurity category while other independent variables held constant.

When the ages of the household heads increase by one unit, the food insecurity category increases by 0.0738 and 0.3377 for eucalyptus grower and non-grower households respectively in the ordered log-odds scale while the other variables in the model held constant. For both eucalyptus growers and non-growers, when the family size of the household increases by one unit, this would result respectively in a 0.6387 and 0.6964 increase in the ordered log-odds of being in a severe food insecurity category while all other predictors held constant. In the case of non-eucalyptus growers, an increase of land size per household by one unit would result in a 2.3040 reduction in the ordered log-odds of being in a severe food insecurity category while all other predictors held constant. This also indicate that the more the household has more land size especially in the case of household with small land size, there would be a better food security of the household. That is, it would help the household for different livelihood options that may contribute to various income sources thereby increase household food security.

When the average annual household income from eucalyptus increases by one unit, it would result in reducing in the ordered log-odds of being in a higher HFIAS category (food insecurity) by a unit of -0.0004 while other variables kept constant. It was also observed both for eucalyptus grower and non-grower households that when the CSI score of the household increases by one unit, it would result in increasing in the ordered log-odds of being in a higher HFIAS category (food insecurity) by a unit of 0.0835 and 0.1032 respectively while other independent variables held constant. This means that an increase in coping strategy of the household would happen when the household faces food insecurity.

This is also a symptom that the more households involve in dangerous coping strategies, the more their food security situation is worsened.

The ordered logit model estimates one equation over all levels of the dependent variable. It is therefore good to ensure whether the one-equation model is valid or not. To validate if the one-equation model in ologit is valid or not, the model was checked for the proportional odds assumption which is one of the assumptions that has to be validated for ologit estimation. These assumptions include the dependent variable is ordered (which is in this case the food security status as in the level of food secure, mildly food insecure, moderately food insecure and severely food insecure), one or more of the independent variables are either continuous, categorical, or ordinal, and no multicollinearity. As the dependent variable is categorized into the four food security categories and there are continuous and categorical independent variables in the model, the first two assumptions were fulfilled. Similarly, a multicollinearity test and proportional odds test was conducted. The multicollinearity test was conducted to check if there was a strong relationship among the independent variables using a correlation matrix and verified by a VIF (Variance Inflation Factor) test to know if the VIF values are less than 10 for all independent variables. There was no multicollinearity problem in the data as independent variables had no strong relationship and the VIF values were at recommendable level for all independent variables.

Table 9: Ordered logistics regression of food insecurity status on the HFIAS scale against predictor variables

Variables	Euc growers				Non-Euc growers			
	Coef.	SE	z	P>|z|	Coef.	Std.	z	P>|z|
Age of the HH head	0.0738	0.0363	2.03	0.042*	0.3377	0.0930	3.63	0.000**
Family size	0.6387	0.1705	3.75	0.000**	0.6964	0.3368	2.07	0.039*
Land size	0.1202	0.3863	0.31	0.756	-2.3040	0.8775	-2.63	0.009**
Land size for eucalyptus	-0.3229	2.2439	-0.14	0.886				
# of eucalyptus planted	0.0000	0.0002	0.18	0.855				
Annual HH income from eucalyptus	-0.0004	0.0002	-1.97	0.049				
Annual HH income from livestock	-1.8000	0.0001	-0.02	0.981	0.0005	0.0002	1.96	0.050
Annual HH income from crop	0.0002	0.0003	0.51	0.609	-0.0014	0.0010	-1.45	0.146
Av. annual HH income from labor	-0.0001	0.0001	-1.01	0.310	-0.0001	0.0001	-1.14	0.255
TLU oxen	-0.6894	0.4041	-1.71	0.088	-0.2253	0.5833	-0.39	0.699
TLU	-0.0505	0.1259	-0.40	0.688	-0.2849	0.2830	-1.01	0.314
CSI Score	0.0834	0.0270	3.09	0.002**	0.1032	0.0407	2.53	0.011*

*Where Coef. = coefficients of the ordered logistics regression of the predictors, SE = standard error, z = z-score for the statistics and p = probability. * = statistically significant variables at 95% confidence interval and ** = statistically significant variables at 99% confidence interval*

Table 10 was obtained by adding the OR option in the ordered logistic regression model on STATA. As the ordered logit estimation coefficients estimated a single equation over the level of influence on the dependent variable, the odds ratios informed us the change in the dependent variable in a cumulative sense. Proportional odds ratio tells, for a one unit increase in the independent variable, the odds of severe food insecurity versus the combined food security status of mildly food insecure, moderately food insecure and food secure is greater or lower by the proportional odds.

For a one unit increase in family size of both eucalyptus grower and non-grower households, the odds of the high food insecurity categories versus the combined middle and low level of food insecurity are 1.8940 and 2.0065 times higher, given that all other predictors kept constant. Likewise, for a one unit increase in family size for eucalyptus growers and non-growers, the odds of the combined severe and moderately food insecurity versus the low level of food insecurity (better food security) are 1.8940 and 2.0065 higher, given that other variables kept constant. For a one unit increase in the landholding size of the non-eucalyptus growing households, the odds of the severe food insecurity category versus the combined mild food insecurity, moderate food insecurity and food secure households are 0.0999 times higher, given other predictors kept constant. While, for a one unit increase in the landholding size of the eucalyptus growing households, the odds of the combined severe and moderately food insecurity versus the low level of food insecurity (better food security) are 0.0999 higher, given other variables kept constant.

For a one unit increase in the average annual household income from eucalyptus for the eucalyptus growing households, the odds of the severe food insecurity category versus the combined mild food insecurity, moderate food insecurity and food secure households are 0.9996 times lower, given other predictors kept constant. While, for a one unit increase in the average annual household income from eucalyptus for the eucalyptus growing households, the odds of the combined severe and moderately food insecurity versus the low level of food insecurity (better food security) are 0 .9996 lower, given other variables kept constant. For a one unit increase in the ages of the household head of both eucalyptus grower and non-grower households, it can be said that for a one unit increase in the ages of the household head, the odds of the high food insecurity categories versus the combined middle and low level of food insecurity are 1.0766 and 1.4018 times greater, given that all of the other variables in the model are held constant. While, for a one unit increase in the ages of both eucalyptus growing and non-growing households, the odds of the combined severe and moderately food insecurity versus the

low level of food insecurity (better food security) are 1.0766 and 1.4018 higher, given other variables kept constant.

For the coping strategy index (CSI) of both eucalyptus grower and non-growing households, the odds of a one unit increase of the score of the severe food insecurity versus the combined mildly food insecure, moderately food insecurity and food secure households are 1.087041 and 1.1087 times higher, given all other independent variables are kept constant. Likewise, for a one unit increase in the CSI score, the odds of the combined severe and moderately food insecurity versus the low level of food insecurity (better food security) are 1.087041 and 1.1087 higher if all other variables are kept constant.

Table 10: Odds ratio of the ordered logistics regression of food insecurity status on the HFIAS scale against predictor variables

Variables	Eucalyptus growers				Non-Eucalyptus growers			
	OR	SE	z	P>|z|	Coef.	Std.	z	P>|z|
Age of the HH head	1.0766	0.0392	2.03	0.042*	1.401785	0.1303	3.63	0.000**
Family size	1.8940	0.3229	3.75	0.000**	2.0065	0.6759	2.07	0.039*
Land size	1.1278	0.4356	0.31	0.756	0.0999	0.0876	-2.63	0.009**
Land use for eucalyptus	0.7240	1.6247	-0.14	0.886				
Total eucalyptus planted	1.0000	0.0002	0.18	0.855				
Av. annual HH income from eucalyptus	0.9996	0.0002	-1.97	0.049				
Av. annual HH income from livestock	1.0000	0.0001	-0.02	0.981	1.0004	0.0002	1.96	0.050
Av .annual HH income from crop	1.0002	.0003	0.51	0.609	0.9986	0.0010	-1.45	0.146
Av. annual HH income from labor	1.0000	0.0001	-1.01	0.310	1.0000	0.0001	-1.14	0.255
TLU oxen	0.5019	0.2028	-1.71	0.088	0.7982	0.4656	-0.39	0.699
TLU	0.9507	0.1197	-0.40	0.688	0.7521	0.2128	-1.01	0.314
CSI Score	1.0870	0.0294	3.09	0.002**	1.1087	0.0451	2.53	0.011*

*Where OR Represents Odds ratio of the ordered logistics regression, SE for standard error, z is the z-score for the statistics and p is probability. * Represents statistically significant variables at 95% confidence interval and ** represents statistically significant variables at 99% confidence interval.*

4.6 Food consumption coping strategy of the respondents

Consumption coping strategy index (CSI) is a food security assessment tool that measures the behaviour of households over the past seven days when they did not have enough food or money to purchase. It is an experience-based indicator managed to be asked within the last seven days of recall period on consumption coping strategies of the household. Prior to conducting the assessment, a series of questions were listed, locally contextualized, weighted and ranked with four focus groups by including both from eucalyptus growers and non-growers. Next, the researcher used the HFIAS food

insecurity status (Food Secure, Mildly food insecure, Moderately food insecure and Severely food insecure) of the respondents as a main tool to identify legible households for the study. Accordingly, a total of 37 out of the total sampled households were identified for a CSI assessment as a legible participant. The lists of coping behavious were identified and tested with key informants before ranking with the focus group discussions. As summarized in Table 11, the ranking of the individual behaviour by the four focus group discussions indicated that consumption of seed stock and skipping entore day without food were observed to be the most coping behaviours.

Table 11: Coping strategies ranked by focus groups

Coping Strategy	Focus group ranking for each individual behavior					
	FGD1	FGD2	FGD3	FGD4	Average	Consensus ranking
Sell eucalyptus before its maturity period	1	1	2	1	1.3	1
Rely on less preferred food	1	1	1	1	1	1
Borrow food or rely on relatives	2	1	1	1	1.3	1
Purchase food on credit	1	1	2	1	1.3	1
Consume seed stock	4	4	4	3	3.8	4
Send children to eat with neighbors	3	4	3	3	3.3	3
Limit portion size at meal	3	2	2	2	2.3	2
Restrict consumption by adults for small children to eat	2	4	3	3	3	3
Feed working members in the expense of non-workers	2	3	3	3	2.8	3
Reduce number of meals eaten a day	2	1	3	2	2	2
Skip entire day without food	4	4	3	4	3.8	4

Source: Field survey, 2022

After ranking for the individual behaviours, household survey was conducted to assess the coping behaviours of the respondents who were categorized into moderately food insecure and severely food insecure households following the HFIAS categorization result. As indicated in Table 12, the results for the HFIAS and the coping strategy assessments were indicated both for eucalyptus grower and non-grower households. Accordingly, a consumption coping strategy assessment was conducted for 16% moderately food insecure and 4% severely food insecure eucalyptus growing households. Similarly, a coping strategy assessment was conducted for 14% moderately food insecure and 12% severely food insecure non-eucalyptus growing households. In general, the CSI assessment was done for 37 (22%) of the total sampled households.

The CSI assessment result then categorized the households as households with high coping strategy (CSI score >100), medium coping strategy (CSI score 50-100) and the remaining households as low

coping behaviour (CSI score<50). The study revealed that moderate and severe food insecure households have medium to high coping strategy accounting 20% and 26% for eucalyptus growers and non-growers, respectively. The study reveals that majority of the households practice low coping strategy.

Table 12: Legible households for individual coping behaviour assessments

HFIAS category	Eucalyptus growers (N=100)					Non-eucalyptus growers (N=65)				
	FS Status		Levels of CSI			FS Status		Levels of CSI		
	Freq	%	low	Medium	High	Freq	%	low	medium	High
Food secure	45	45	45			22	34	22		
Mildly food insecure	35	35	35			26	40	26		
Moderately food insecure	16	16	0	14	2	9	14	0	8	1
Severely food insecure	4	4	0	4	0	8	12	0	6	2
Total	100	100	80	18	2	65	100	48	14	3

Source: Field survey, 2022

The study result and discussions made with focus groups indicated that households in the astudy area respond to food problems by adapting various coping strategies. The study participants were all landholders and depend on production (mainly crop and livestock) with occational off-farm activities as they reside nearby to the Fiche town. Eucalyptus grower households have additional livelihood options from euclayptus, whereas non-eucalyptus growers did not have this. Becuase of the scarce food grains in the area arised from crop failure in the previous years, many of the households practice various coping startegies to adapt to the challenges of food for consuption.

As indicated on Figure 9, the three most coping behaviour were skipping the entire day without eating, consuming seed stock held for the next season and sending children to eat from neighbors. The three lowest coping mechanisms were relying on less preferred and less expensive foods, borrow food, or rely on help from a friend or relatives and purchase food on credit. As evidenced by this study, non-eucalyptus growers practice more severe coping mechanism than eucalyptus growing households in order to overcome the effects of food insecurity. Foster (2001) indicated that households practice coping behaviour to to mitigate the effects of not having enough food to meet the households's needs.

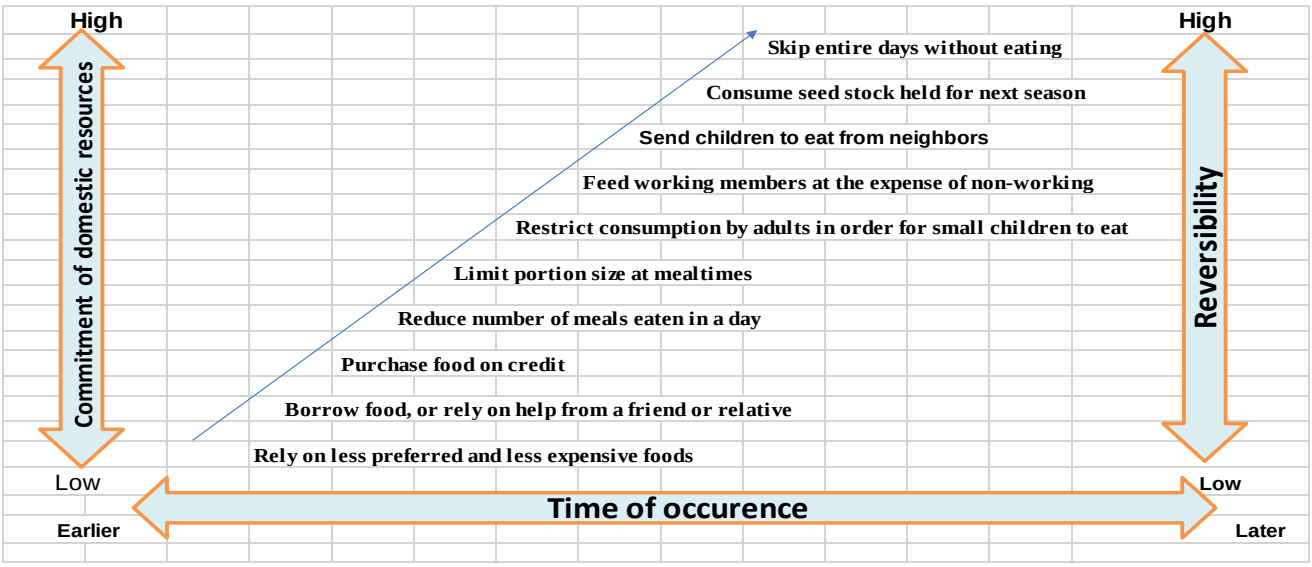


Figure 9: A model of coping strategy to food insecurity in the context of the study area adapted from Mulugeta (2012) situation from Frankenberger (1992).

4.7 Months of Adequate Household Food Provisioning

Months of adequate household food provisioning (MAHFP) is a tool to capture changes in the household's capacity to have food for themselves in such a way as to ensure that food is available above a minimum level throughout the year. It helps categorize the households as food secure and not food secure based on identifying the months of household food gap. HHs with less than 9 MAHFP are considered to be below the poverty line, and they typically strive to meet their food demands through a variety of coping techniques (ACF, 2011). This study identified that the sampled households have month/s of food gap during which they need to find food or income sources to fill their family consumption gaps. As indicated hereunder in Figure 10, majority of both eucalyptus grower and non-grower households have 1-3 months of food gap accounting for 82% and 71% respectively. Compared to eucalyptus growers, more number (14%) of non-eucalyptus growers have four to six months of food shortage. Thus, compared to eucalyptus growing households, non-eucalyptus growing households face more months of food gap. This may be attributed to smaller land holding size, limited number of livelihood options and other factors such as number of family sizes and ages of the household heads. The number of MAHFPs fluctuates depending on household income, assets, and cash earnings available for food purchases (Ibid). It can be affected by improved agricultural production, storage, and other activities that increase the household's purchasing power.

The study also identified that the average months of adequate household food provisioning were 11 and 10 for eucalyptus growers and non-growers respectively. This means that the study participants are found to be food secure as the average months of food provisioning was more than the threshold of nine months. The households engage in various income generating activities to cover the food gaps. As discussed earlier, income of non-eucalyptus growing households were mostly dependent on livestock and off-farm activities unlike eucalyptus growing households who have additional livelihood option, i.e from euclayptus plantation. As indicated in Table 13, the study identified that income from livestock contributes the highest during such gaps accounting 70% and 77% for eucalyptus growers and non-growers respectively. Compared to non-eucalyptus grower households, eucalyptus growers have better livelihood options to generate income, such as income from sale of eucalyptus products. In both groups, livestock was identified to be the main income sources to cover their household food gaps with euclayptus the second most income sources for eucalyptus growers. As reported by the focus group discussions and key informant interview participants, food gaps were commonly observed during the months August through October though recently the case expanding to a greater number of months in a year due to crop failure. Food grains available to some extent from production and mainly available for purchase from the market during the study month. The major income sources such as livestock and eucalyptus products were good to generate income during this month of the year that observed to be the major income source for purchase of grains.

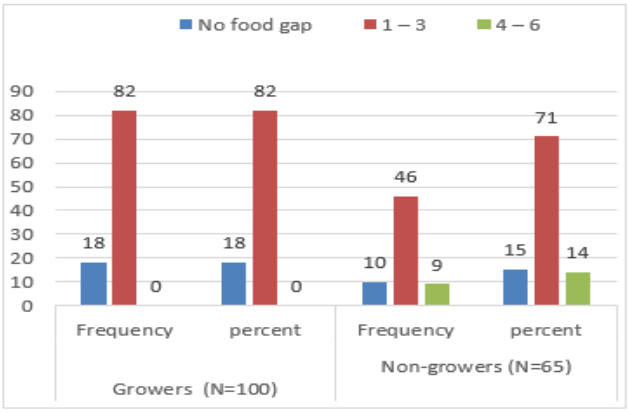


Figure 10: Months of HH food gap

Table 13: Sources of income for covering food gap

Income sources	Response (Yes/No)	Growers (N=100)		Non-growers (N=65)	
		Freq	%	Freq	%
From livestock	Yes	72	72	50	77
	No	28	28	15	23
From credit	Yes	15	15	7	11
	No	85	85	58	89
From Off-farm	Yes	52	52	40	62
	No	48	48	25	38
From eucalyptus	Yes	62	62	0	0
	No	38	38	0	0

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study believed to have a contribution in pioneering the benefits of eucalyptus plantation to household livelihood and food security through its comparative analysis of eucalyptus-household livelihoods-food security relationships. The researcher tried to focus on one of the less studied topic, the economic contribution of eucalyptus plantation in the highlands of Ethiopia. Communities in the highlands of Ethiopia mostly practice eucalyptus plantation as their main economic dependence resulting from the good agro-climatic conditions of the tree. The study area, Girar Jarso Woreda is among the highlands of Ethiopia where eucalyptus plantation is highly dominating more than other indigenous trees. In this area, eucalyptus plantation is one of the main livelihoods and contributor to household food security. The study identified that the households plant eucalyptus trees mainly to increase household income, meet own construction, fencing & firewood, and to replace the declining crop yield.

It was observed that eucalyptus is benefiting the households through helping them for efficient utilization of their land, protection of their livelihoods, diversification, and expansion of their income sources. Income from eucalyptus was found to be the second most annual household income. Income from eucalyptus was found to be a means for covering household food gaps, help recover during shocks, and a high contributor in fulfilling agricultural inputs and covering the day-to-day expenses of in-house food and non-food items. The assessment using the HFIAS scale revealed that about 55% and 66% of the respondents were categorized under food insecure households both for eucalyptus growers and non-growers, respectively. Regression analysis on the food security status using HFIAS indicated that age and family size of the households have shown positive relationship with increasing food insecurity while household land holding size, average annual household income from eucalyptus and livestock, tropical livestock unit of oxen have shown an inverse relationship with increasing household food insecurity. The study from consumption coping strategy indicated that moderate and severe food insecure households have high coping strategy both for eucalyptus growers and non-growers, respectively. The assessment using the food security tool, months of adequate household food provisioning have shown that the average months of adequate food provisioning were 11 and 10 months for eucalyptus growers and non-growers, respectively. This indicates that the sampled households were found to be above the food security threshold of nine months.

5.2 Recommendations

Observed from the study findings, eucalyptus plantations have a significant contribution to household livelihoods and food security. The study tried to address participants both from eucalyptus growers and non-growers which is very helpful in exploring the various benefits of eucalyptus to household livelihoods and food security. Thus, based on the findings of the study, the following recommendations have been forwarded for further focus and actions by researchers, development practitioners and policy makers.

- This study findings explored the various benefits of eucalyptus plantations to household livelihood and food security. However, due to the time, budget and security reasons that limited the researcher from covering large area, there needs to conduct similar studies in other highland areas of Ethiopia or in other areas/contexts as well to reach vast areas and for further findings.

- There is high domination of eucalyptus trees in the highlands of Ethiopia and high dependence of households as their main livelihood options. They mostly use a land that are not suitable for crop production which help them for appropriate utilization of land. Further studies can focus on the relationship between eucalyptus plantation and land management in the highlands of Ethiopia.

- The potential benefits of eucalyptus to household livelihood and food security were clearly identified in this study. It was found to be the second most income source for the households for covering food gaps and recovering from shocks. If this comes to be true, why there is less focus from the government in providing special attention to eucalyptus plantation? It will be good to have such a focus.

- This study identified that there are both eucalyptus growers and non-growers in the same community. It was found that those from non-eucalyptus growers have less economic sustenance than those of eucalyptus growers, especially during crop failure. Thus, it needs to encourage them to practice eucalyptus plantation appropriately while practicing their livestock and crop production. Extension services backed by appropriate policy could probably contribute a lot in this case.

References

Abi, M., & Tolossa, D. (2015). Household food security status and its determinants in Girar Jarso Woreda, north Shewa zone of Oromia region, Ethiopia. *Journal of Sustainable Development in Africa*, *17*(7), 118–137.

ACF. (2011). *Food Security and Livelihood Monitoring and Evaluation Guidelines. A PracticaL guide For FieLd WorKerS*.

Alemu, M. (2020). *Mitku Alemu Mengistu. Annual Income Contribution of Wood Fuel Production from Small-scale Plantation Forest Experience from Farmers in Fagta Lekoma, Awi zone, Amhara, Ethiopia. Journal of Energy and Natural Resources. Vol. 9, No. 3, 2020, pp. 98-102. doi: 9*(3), 98–102. https://doi.org/10.11648/j.jenr.20200903.12

Anderson, Stephen, and, & Farmer, E. (2015). *USAID O FFICE OF F OOD FOR P EACE Food Security Country Framework for Ethiopia. FY 2016 – FY 2020. Washington, D.C.: Food Economy Group, 2015*.

Awoke, D. A. (2020). Prioritizing Apple Production Constraints in Sinan Woreda, Ethiopia:A Constraint Facing Index (CFI) Approach. *International Journal of African and Asian Studies*, *68*, 1–5. https://doi.org/10.7176/jaas/68-01

Balcha, B. (2001). *Food Insecurity in Ethiopia The impact of socio-political forces*. www.humsamf.auc.dk/development

Bayle, G. K. (2019). ECOLOGICAL AND SOCIAL IMPACTS OF EUCALYPTUS TREE PLANTATION ON THE ENVIRONMENT. *J. Biodivers. Conserv. Bioresour. Manag.*, *5*(1), 93–104.

Bekele, T. (2015). Integrated Utilization of Eucalyptus globulus grown on the Ethiopian Highlands and its Contribution to Rural Livelihood: A Case Study of Oromia, Amhara and Southern Nations Nationalities and People's Regional State Ethiopia. *CRDEEPJournals International Journal of Basic and Applied Sciences Tsegaye Bekele*, *4*(2), 80–87. www.crdeep.com

Beyene, F., & Muche, M. (2010). Determinants of Food Security among Rural Households of Central Ethiopia: An Empirical Analysis. *Quarterly Journal of International Agriculture 49 (2010), DLG-Verlag Frankfurt/M., No. 4: 299-318*.

Bezabeh, E., Belay, B., & Daniel, F. (2019). *Analysis of Eucalyptus Role in the Livelihoods of Ethiopian Rural Households*. www.premierpublishers.org,

Cameron, R. (2009). A sequential mixed model research design: Design, analytical and display issues. *International Journal of Multiple Research Approaches*, *3*(2), 140–152. https://doi.org/10.5172/mra.3.2.140

CARE / WFP. (2003). The Coping Strategies Index: A tool for rapidly measuring food security and the impact of food aid programmes in emergencies 1 Eastern and Central Africa Regional Management Unit, CARE Vulnerability Assessment and Mapping, World Food Programme. *The Coping Strategies Index: Field Methods Manual. Nairobi: CARE and WFP.*, *September*, 23–25. http://www.fao.org/3/a-ae513e.pdf

Coates, J., Swindale, A., & Bilinsky, P. (2007). Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide. *Washington, DC: Food and Nutrition Technical …*, *August*, Version 3.

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative and Mixed Methods Approaches* (4th ed.).

CSA. (2008). *Summary and Statistical Report of 2007 Population and Housing Census*.

CSA. (2021). Report on Land Utilization by Private Peasant Holdings in 2020/2021 Meher Cropping

Season. *Statistical Bulletin*, *21*.
Dagnachew, A. S. (2012). Broken promises. Food Security Interventions and Rural Livelihoods in Ethiopia. In *Industry Week* (Vol. 246, Issue 20). https://doi.org/10.7748/ns.15.24.12.s31
Derbe, T., Yehuala, S., & Agitew, G. (2018). Factors Influencing Smallholder Farmers Adoption of Eucalyptus Woodlot in Wogera District, North Gondar Zone, Amhara Regional State of Ethiopia. *International Journal of Scientific Research and Management*, *8*(07), 567–574. https://doi.org/10.18535/ijsrm/v6i7.em07
DFID. (2001). *Sustainable livelihoods guidance sheets.* 1–150.
Dibekulu, D. (2020). *An Overview of Data Analysis and Interpretations in*. *8*(March), 1–27. https://doi.org/10.14662/IJARER2020.015
Ermias, N. ., Sakata, G., Argaw, T., Berta, A., Gunta, S., Beyene, G., Shiferaw, G., & Abebe, A. (2021). The current status, challenges and prospects of using biomass energy in Ethiopia. *Biotechnology for Biofuels*, *14*(1), 1–24. https://doi.org/10.1186/s13068-021-02060-3
FAO. (2006). Food security Food security. Pollicy Brief. *Nature*, *2*, 1–2. http://dx.doi.org/10.1038/544S5a
FAO. (2008a). An Introduction to the Basic Concepts of Food Security Food Security Information for Action. *EC - FAO Food Security Programme*, 1–3. http://www.fao.org/docrep/013/al936e/al936e00.pdf
FAO. (2008b). *Baseline Food Security Assessments. Introduction to Baseline and Action-oriented Assessments-Learner s ' Notes*.
FAO. (2008c). *Baseline Food Security Assessments. Selecting a Baseline Assessment Method-Learner s ' Notes*.
FAO. (2009). World Summit on Food Security. *World Food Summit, November 2009*, 16–18.
FAO. (2017). *Watershed management in action – lessons learned from FAO field projects. Rome*.
Fikre, L. O., Gezahegn, B. Y., Fikadu, M. A., & Adugna, E. B. (2017). Why does food insecurity persist in Ethiopia? Trends, challenges and prospects of food security in Ethiopia. *Journal of Development and Agricultural Economics*, *9*(12), 341–354. https://doi.org/10.5897/jdae2017.0846
Foster, A. N. and M. (2001). Working Paper 148 The Potential of Using Sustainable Livelihoods Approaches in Poverty Reduction Strategy Papers Andy Norton and Mick Foster Centre for Aid and Public Expenditure July 2001 Overseas Development Institute 111 Westminster Bridge Road London. *Development*, *July*.
Frankenberger, T., Langworthy, M., Spangler, T., & Nelson, S. (2012). Enhancing Resilience to Food Security Shocks. *TANGO International Inc.*, *May*, 57.
Gbetnkom, D. (2009). Forest depletion and food security of poor rural populations in Africa: Evidence from Cameroon. *Journal of African Economies*, *18*(2), 261–286. https://doi.org/10.1093/jae/ejn012
Gebreegziabher, Z., Mekonnen, a, Kassie, M., & Köhlin, G. (2010). Household Tree Planting in Tigrai, Northern Ethiopia: Tree Species, Purposes, and Determinants. *Working Papers in Economics*, *2473*(432), 31.
Gershon, I., Corneli, s G., & Ihle., R. (2019). *Resilience and household food security : a review of concepts , methodological approaches and empirical evidence*. 1187–1203.
Gizachew, K. (2017). Expansion of Eucalypt Woodlot and Its Factors in Cheha District, Southern Ethiopia. *World Scientific News*, *66*, 163–180. www.worldscientificnews.com
GJANRO. (2022). Grar Jarso Woreda Agriculture and Natural Resource Office
Holden, S. T., & Tilahun, M. (2020). Farm size and gender distribution of land: Evidence from

Ethiopian land registry data. In *World Development* (Vol. 130, Issue 02). https://doi.org/10.1016/j.worlddev.2020.104926

Israel, G. D. (1992). *Determining Sample Size. University of Florida Cooperative Extension Service, Institute of Food and Agriculture Sciences, EDIS, Florida*.

Jagger, P., & Pender, J. (2000). the Role of Trees for Sustainable Management of Less-Favored Lands: the Case of Eucalyptus in Ethiopia. *International Food Policy Research Institute 2033 K Street, N.W. Washington, D.C. 20006 U.S.A.*, *65*.

Jaleta, D., Mbilinyi, B., Mahoo, H., & Lemenih, M. (2016). Evaluation of Land Use/Land Cover Changes and Eucalyptus Expansion in Meja Watershed, Ethiopia. *Journal of Geography, Environment and Earth Science International*, *7*(3), 1–12. https://doi.org/10.9734/jgeesi/2016/26606

Jember, M., & Asmamaw, T. (2014). *Understanding Food Security*. 113pp. https://www.dppc.gov.et/downloadable/Documentation/DRM MANUALS/Understanding Food Security.pdf

Kaur, A., & Monga, R. (2021). Eucalyptus Trees Plantation: A Review on Suitability and their Beneficial Role. *International Journal of Bio-Resource and Stress Management*, *12*(1), 016–025. https://doi.org/10.23910/1.2021.2174

Kelemu, K., & Tadesse, and W. (2010). Analysis of Eucalyptus Role in the Livelihoods of Rural Households. In: Gil L, Tadesse W, Tolosana E, López, R, (eds.) Eucalyptus species management, history, status and trends in Ethiopia. Proceedings of the Congress. Ethiopian Institute for Agricultural. In *Proceeding of the conference on Eucalyptus species management, history, status and trends in Ethiopia*.

Kollmair, M., & Gamper, S. (2002). *THE SUSTAINABLE LIVELIHOODS APPROACH*. *September*.

KOTHARI, C. R. (2004). *Research Mmethodology: Methods and Techniques* (2nd ed.).

Lirenso, A. (2009). Food Security and Vulnerability in Ethiopia: A development perspective. *International Conference on Contemporary Development Issues in Ethiopia*, *September*.

M.Mulugeta. (2012). Resettlement and Food Security Nexus in Ethiopia : A Case from Nonno Resettlement Sites , Central Ethiopia. *Ejossah*, *7*(2).

Mamo, H., & Haile, D. (2016). Analysis of Household Food Insecurity and its Covariates in Girar Jarso Woreda, Oromia Regional State, Ethiopia. In *Journal of Economics and Sustainable Development www.iiste.org ISSN* (Vol. 7, Issue 3). Online. www.iiste.org

Maxwell, D., & Smith, M. (1992). *Household food security: a conceptual review. In: Maxwell, S., Frankenberger, T.R. (Eds.), Household Food Security: Concepts, Indicators, Measurements: A Technical Review. UNICEF and IFAD, New York and Rome.*

Maxwell, S. (1994). *FOOD SECURITY: A POST-MODERN PERSPECTIVE*.

Mekonnen, Z. (2006). Eucalyptus as an Alternative Sources for Energy and Food security. *Researchgate*, *March*. https://doi.org/10.13140/RG.2.1.3197.0962

Mekonnen, Z., Kassa, H., Lemenh, M., & Morgan, B. C. (2007). The role and management of eucalyptus in lode hetosa district, central ethiopia. *Forests Trees and Livelihoods*, *17*(4), 309–323. https://doi.org/10.1080/14728028.2007.9752606

Mohamed, A. A. (2017). Food Security Situation in Ethiopia: A Review Study. *International Journal of Health Economics and Policy*, *2*(311), 86–96. https://doi.org/10.11648/j.hep.20170203.11

Mulugeta, M. (2009). *Journal of Sustainable Development in Africa (Volume 11, No.4, 2009)*. *11*(4), 286–304.

Mulugeta, M. (2010). *Food Security Attainment Role of Urban Agriculture : A Case Study from Adama City By 1 . Introduction : Physical and Socio-economic Profile of Adama City 1 . 1The*

Study Area Adama is one of the largest and most populated towns in Oromiya. *1*.
Mulugeta, M., & Legese, T. (2013). Spatiotemporal Environmental Dynamics and its Implications on Rural Livelihoods in Wasarbi-Garba Guracha Watershed, Central Ethiopia. *Journal of Sustainable Development in Africa*, *15*(8), 155–181.
NET, F. (2022). *ETHIOPIA Food Security Outlook June 2021 to January 2022 Conflict likely to drive extreme food insecurity in Tigray through at least January 2022*. *June 2021*.
Nkonde, C., Audain, K., Marinda, P., & Kiwanuka-, R. N. (2021). *Effect of agricultural diversification on dietary diversity in rural households with children under 5 years of age in Zambia*. *August*, 6274–6285. https://doi.org/10.1002/fsn3.2587
Odi. (1974). *Humanitarian Exchange - famine*. *44*(0).
OXFAM. (2017). *The sustainable livelihoods approach Toolkit for Wales*.
Patino, C. M., & Ferreira, J. C. (2018). Inclusion and exclusion criteria in research studies: Definitions and why they matter. *Jornal Brasileiro de Pneumologia*, *44*(2), 84. https://doi.org/10.1590/s1806-37562018000000088
Samuel, O. O., & Sylvia, T. S. (2019). Analysis of rural livelihood diversification strategies among maize farmers in north west province of South Africa. *International Journal of Entrepreneurship*, *23*(2), 1–11.
Satgé, R. de., Ailsa, H., Dan, M., Leah, N., & Penny, W. (2002). *About Livelihoods Insights from Southern Africa*.
Swindale, A., & Bilinsky, P. (2010). Months of Adequate Household Food Provisioning (MAHFP) for Measurement of Household Food Access : Indicator Guide VERSION 4. *Fhi 360*. https://www.fantaproject.org/sites/default/files/resources/MAHFP_June_2010_ENGLISH_v4.pdf
Takada, J., Workneh, W. A., & Matsushita, S. (2022). Statistical analysis on egalitarian land redistribution in Ethiopia: policy evaluation using repeated cross-sectional data. *Discover Sustainability*, *3*(1). https://doi.org/10.1007/s43621-022-00075-w
Tefera, N., Demeke, M., & Kayitakire, F. (2017). *Building sustainable resilience for food security and livelihood dynamics : The case of rural farming households in Ethiopia*. https://doi.org/10.2760/973096
Tesfaw, A., Senbeta, F., & Alemu, D. (2021). *Value Chain Analysis of Eucalyptus Wood Products in the Blue Nile Highlands of Northwestern Ethiopia*. 1–25.
UFLC. (2018). *Food Security & Socio-Economic Trend Analysis - Eastern Ukraine*.
UN. (1948). United Nations Universal Declaration of Human Rights 1948. *Applied Ethics: A Multicultural Approach: Sixth Edition*, 54–57. https://doi.org/10.4324/9781315097176
Yadeta, D. (2021). Economic Contribution of Eucalyptus globulus to the Livelihoods of Local Communities in Chelia District, Oromia, Ethiopia. *European Business & Management*, *7*(6), 159. https://doi.org/10.11648/j.ebm.20210706.11
Zerga, B., & Berta, A. (2016). Preference, Purpose, and Pattern of Eucalyptus tree Farming in Eza Wereda, Ethiopia. In *International Journal of Research and Innovations in Earth Science* (Vol. 3, Issue 2).
Zerga, B., Warkineh, B., Teketay, D., & Woldetsadik, M. (2021). *Environmental Impacts of Eucalypt Plantations in the Western Gurage*. 1–31.
Zerga, B., & Woldetsadik, M. (2016). *Contribution Of Eucalyptus Tree Farming For Rural Livelihood In Eza Wereda, Ethiopia*. http://www.palgojournals.org/PJA/Index.htm
Zhang, Y., & Wang, X. (2021). Geographical spatial distribution and productivity dynamic change of eucalyptus plantations in China. *Scientific Reports*, *0123456789*, 1–15. https://doi.org/10.1038/s41598-021-97089-7

Appendices

Appendix 1: Consent for household questionnaire to eucalyptus growers and non-growers

My name is [name of the enumerator] and I am collecting this data on behalf of Lemessa Negeri, a MSc in Food Security and Development student at College of Development Studies of the Addis Ababa University. The purpose of this research is to assess the household livelihoods and food security benefits of eucalyptus plantation at Hariro microwatershed, in Torban Ashe Kebele of Girar Jarso Woreda.

This survey will be conducted for selected eucalyptus grower and non-grower households in Hariro microwatershed and I am going to ask you few questions regarding your livelihood and food security in relation with eucalyptus farming and other agricultural products and incomes. Your answers are completely confidential and will not be shared to third party and you will not be identified by name in any way. If you do not have to answer any questions that you do not want to answer, you may end this interview at any time you want to, you are free to do so. Your honest answers to these questions will help us better understand the existing situation. We would greatly appreciate your help in responding to this survey. The survey will take about 30 minutes to an hour.

Would you be willing to participate knowing that you were doing so voluntarily and there will not be any monetary returns?

_____

dd/mm/yyyy

(Signature of interviewer certifying that informed consent has been given verbally by therespondent)

Appendix 2: Household survey questionnaires

No.	Questions	Coding categories	Skip Options
1	General information		
1.1	Enumerator name	Name_____Signature_ _____	
1.2	Date of interview	Date:_____Month:_____ Year:_____	
1.3	Household identification number	[_____]	
2	Household characterstics		
2.1	Age of the household head	[____]	
2.2	Household family Size	Total:_____	
2.3	What is the total size of your land in Ha?	[____]	
2.4	What is the size of your land as per your land use system in ha	Annual crop [____] Grazing land [____] Land covered with euclayptus [____] Land covered with other [____] Perennial crops [____] Others(specify)……..	
2.5	Why do you plant eucalyptus? (multiple answers are possible)	For commercial/income 1 generation 2 To replace declining crop yield 3 For land demarcation and fencing 4 For soil and water conservation 5 Has social value For other (specify)……..	
2.6	If yes to Q 2.6 and your answers for Q2.12 are choices, do you have eucalyptus farming of more than 40 trees?	Yes 1 No 0	If no, skip to 3.12
3	Eucalyptus grwors only		
3.1	What is the size of your land covered with eucalyptus in ha?	2011 | 2012 | 2013 | 2014	
3.2	Number of eucalyptus planted on the land by year? Year in E.C.	2011 | 2012 | 2013 | 2014	
3.3	For what purpose do you mostly use eucalyptus incomes at home in crop/livestock production or off-farm?	For farm equipments 1 For purchase of improved crop 2 inputs 3 For purchase of grains for food 4 For purchase of livestock/oxen/feed 5 For engaging in off-farm.	

3.4	On what types of land have you planted your eucalyptus? (circle all the possibles)	Degraded land 1 Land normally used for crops 2	
3.5	What are the estimated annual income from sale of eucalyptus products in the last four years in ETB? Year in E.C.	2011 | 2012 | 2013 | 2014 | | | |	
3.6	Of the total annual income (in ETB) obtained from eucalyptus products, how much have you invested ……..?	For livestock production/oxen purchase [_____] For crop production [_____] For eucalyptus expansion [_____] For purchase of in house consumption [_____] For taxes, school fees,etc [_____] For medical and emergency [_____] For Savings [_____] For schools [_____] Others (specify)…… [_____]	
3.7	In what conditions do you mostly sale your eucalyptus products (multiple answers are possible)	When sale of livestock is cheap 1 When sale of grain is cheap 2 when farm inputs are highly needed 3 When emergency money is needed 4 When in need to start new job 5 During low income from off-farm 6	
3.8	What are the main factors affecting income from eucalyptus? (Multiple answers are possible)'	Price decrease 1 Lack of market information 2 Distance from the market 3 Lack of road access 4 5	
	Eucalyptus growers + non-growers		
3.13	Do you have savings at bank or at local fincance institutions?	Yes 1 No 0	
3.9	If yes to Q 3.13 above, what is the main income sources for the amount saved?	Income from sale of livestock 1 Income from sale of crop yield 2 Income from sale of eucalyptus 3 products 4 Income from off-farm activities 5 Others (specify)……	
3.10	Amount of annual average income from the various livelihoods	Income sources ETB Livestock and livestock products sale [_] Grain/Fruit sale [_] Eucalyptus product sale [_] Charcoal of other trees and kubet [_] sale Local drink sale [_]	

		Local trade [ ] Labor wage [_] House rental [_] Others, specify [_]	
3.11	What are the three most income sources for purchase of agricultural inputs (e.g. fertilizer, improved seeds, etc)?	Sale of livestock 1 Sale of crop yields/grains 2 Sale of eucalyptus products 3 Income from off-farm activities 4	
3.12	What are the major income sources for covering expenses of your in -house food and non-food items?e.g. cooking oil, euipments, berbere, etc.	Sale of livestock 1 Sale of crop yields/grains 2 Sale of eucalyptus products 3 Income from off-farm activities 4	
3.13	Does the crop yield from your farmland increasing or decreasing?	Increasing 1 Decreasing 0	
3.14	Do you have access to credit?	Yes 1 No 0	
3.15	Number of household members working directly or indirectly on eucalyptus farming/products for family or employed to get income as daily laborer?	Male [__] Female [__]	
3.16	Do you face food gap in any months of the year, during the last year?	Yes 1 No 0	
3.17	If yes to Q 3.23 above, what are the number of months in the year?	Of months_____	
3.18	On Q 3.24, what are the main sources of food for your family consumption during this food gap? (multiple answers are possible)	From loan 1 With income from livestock 2 With income from eucalyptus 3 products 4 With income from off-farm 5 From Rental (e.g.land, house, etc) 6 Others (Specify if any)……	
3.19	What are the number of livestock holding size?	Cattle [__] Shoat [__] Horse [__] Donkey [__] Beehives with bee colonies [__] Poultry [__]	

3.20	What are the most frequent shocks in your area? (multiple answers are possible)	Abnormal rain 1 Crop failure from drought 2 Poor soil fertility 3 Crop pest and disease 4 Livestock disease 5 Others (specify)…… 6	
3.21	Which income sources do you mostly use during shocks? (multiple answers are possible)	Sale of livestock 1 Sale of crop yields/grains 2 Sale of eucalyptus products 3 Income from off-farm activities 4 Others (Specify)…… 5	

HFIAS QUESTIONNAIRE

The following nine questionnaires are used to assess the food security status of the sample household.

NO	QUESTION	RESPONSE OPTIONS	CODE
1.	In the past four weeks, did you worry that your household would not have enough food?	0= No (skip to Q2)1=Yes	….|____|
1.a	If yes, how often did this happen?	1= Rarely (once or twice in the past four weeks) 2= Sometimes (three to ten times in the past four weeks) 3= Often (more than ten times in the past four weeks)	….|___|
2.	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of lack of resources?	0= No (skip to Q3)1=Yes	….|___|
2.a	If yes, how often did this happen?	1= Rarely (once or twice in the past fourweeks) 2= Sometimes (three to ten times in the pastf our weeks) 3= Often (more than ten times in the past four weeks)	….|___|
3.	In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	0= No (skip to Q4)1= Yes	….|___|
3.a	If yes, how often did this happen?	1= Rarely (once or twice in the past fourweeks) 2= Sometimes (three to ten times in the pastfour weeks)	….|___|

		3= Often (more than ten times in the past four weeks)	
4.	In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain othertypes of food?	0= No (skip to Q5)1= Yes	….|___|
4.a	If yes, how often did this happen?	1= Rarely (once or twice in the past fourweeks) 2= Sometimes (three to ten times in the pastfour weeks) 3= Often (more than ten times in the past four weeks)	….|___|
5.	In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	0= No (skip to Q6)1= Yes	….|___|
5.a	If yes, how often did this happen?	1= Rarely (once or twice in the past fourweeks) 2= Sometimes (three to ten times in the pastfour weeks) 3= Often (more than ten times in the past four weeks)	….|___|
6.	In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	0= No (skip to Q7)1= Yes	….|___|
6.a	If yes, how often did this happen?	1= Rarely (once or twice in the past fourweeks) 2= Sometimes (three to ten times in the pastfour weeks) 3= Often (more than ten times in the past four weeks)	….|___|
7.	In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	0= No (skip to Q8)1= Yes	….|___|
7.a	If yes, how often did this happen?	1= Rarely (once or twice in the past fourweeks) 2= Sometimes (three to ten times in the pastfour weeks) 3= Often (more than ten times in the past four weeks)	….|___|
8.	In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	0= No (skip to Q9)1= Yes	….|___|

8.a	If yes, how often did this happen?	1= Rarely (once or twice in the past fourweeks) 2= Sometimes (three to ten times in the pastfour weeks) 3= Often (more than ten times in the past four weeks)	….|___|
9.	In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	0= No (questionnaire is finished)1= Yes	….|___|
9.a	If yes, how often did this happen?	1= Rarely (once or twice in the past fourweeks) 2= Sometimes (three to ten times in the past four weeks) 3= Often (more than ten times in the past four weeks)	….|___|

Household CSI Table with contextualized questions, to be contextualized with FGD on the field

In the past 7 days, if there have been times when you did not have enough food or money to buy food, how often has your household had to:	Frequency	Severity Weight	Weighted Score = Frequency X weight
a. Sell eucalyptus before its maturity period			
b. Rely on less preferred food			
c. Borrow food or rely on relatives			
d. Purchase food on credit			
e. Consume seed stock			
f. Send children to eat with neighbors			
g. Limit portion size at meal			
h. Restrict consumption by adults for small children to eat			
i. Feed working members in the expense of non-workers			
j. Reduce number of meals eaten a day			
Skip entire day without food			
TOTAL HOUSEHOLD SCORE	Sum down the totals for each		

Appendix 3: Qualitative interview guide and checklist

(a) Key Informant Interview (KII) guide

Dear Respondent,

My name is Lemessa Negeri, a MSc in Food Security and Development student at College of Development Studies of the Addis Ababa University. The purpose of this research is to assess the household livelihoods and food security benefits of eucalyptus plantation at Hariro microwatershed of Girar Jarso Woreda. The overall research consists of survey of selected eucalyptus grower and non-grower households, focus group discussions and key informant interviews to collect primary data while secondary data review will be conducted in order to understand the research subject in depth.

The main objective of this key informant interview is to collect primary data from individuals who have in-depth understanding of the eucalyptus benefits to livelihoods and food security of households and to see comparatively about the food security and livelihood coping strategies of eucalyptus growers and non-growers at the study area. Therefore, as a key informant interview, I believe that you will provide relevant information that will contribute to the success of this research which will be used by academic community for further study. In addition, the research findings will be used to inform government and non-governmental organizations for strategies and program development. Your answers will be held completely confidential and will not be shared to third party and you will not be identified by name in any way. If you do not have to answer any questions that you do not want to answer, and you may end this interview at any time youwant to, you are free to do so. However, your responses to my questions are valuable, andwill help us better understand the existing situation. We would greatly appreciate your help in responding to this interview which will take about 30 minutes.

Would you be willing to participate knowing that you are doing so voluntarily and there will not be any monetary returns?

Thank you in advance and please "tick" one of the boxes below

☐ Consent given
☐ Consent declined

1. Why some households plant eucalyptus, and others not in your area?
2. How do you see farmland productivity, decreasing or increasing in the last five years? Why and

what should be done?

3. With regard to eucalyptus plantation, what do you recommend? What balances more to the HH socio-economic condition, its advantage or side effects?
4. What are the current challenges of getting income from eucalyptus products? What should be done to improve it?
5. What is the contribution of government sectoral offices in eucalyptus plantation?
6. Do you think eucalyptus plantation increasing to crop land? If yes, what is your suggestion?
7. How should HHs try to manage to improve the income from eucalyptus, crops and livestock? What will happen if there is no eucalyptus?
8. Is there a time when there is crop yield decrease or failure due to abnormal rain, drought, crop pest and disease in the last five years? What were the contributions of eucalyptus during these times?
9. Is there times when there are decreasing yield or number of animals due to livestock disease or lack of animal feed from consequences of drought/abnormal rain? What were the contributions of eucalyptus during these times?

(b) Focus Group Discussion (FGD) checklist

Dear Respondents,

The main objective of this research is to assess the household livelihoods and food security benefits of eucalyptus plantation at Torban Ashe Kebele of Girar Jarso Woreda.

Therefore, as an FGD participants, I believe that you will provide relevant information that will contribute to the success of this research which was used for further academic investigation. In addition, theresearch findings will be used to inform government and non-governmental organizations strategies and program development.

Your answers was held completely confidential and will not be shared to third party. You will not be identified by name in any way. If you do not have to answer any questions that you do not want to answer, and you may end this interview at any time you want to, you are free to do so. However, your responses to my questions are valuable, and will help us better understand the existing situation under study. We would greatly appreciate your participation in the focus group discussion which will take about 30 minutes to an hour.

Would you be willing to participate knowing that you are doing so voluntarily and there will not be any monetary returns?

Thank you and please "tick" one of the boxes below (to be filled by the FGD facilitator whois either the researcher or the research assistant)

☐ Consent given

☐ Consent declined

1. General information

a. Location

i. Zone: _____

ii. Woreda:_ _____

iii. Kebele: _____

b. Participants

i. Total number of participants: Male:____Female: _____

ii. Age distribution of participants_____

2. Why people in your area plant eucalyptus? Why some not planting?
3. Are farmers increasing or decreasing expansion of eucalyptus plantation to farmland? Why is this?
4.What are the benefits of eucalyptus income to livelihoods and food security?
5.What is the relationship between eucalyptus and other crops, eucalyptus and livestock towards HH livelihoods improvement? What is the importance of eucalyptus to other livelihoods?
6.To whom is eucalyptus plantation provide more benefits? To the poor or better off?
7. In what months do people face shortage of grains and at months do HH sell mostly of their eucalyptus?
8. Why people face food shortage? Are these increasing or decreasing in the last three years? How people fill their food gaps?
9. What do HHs do when there is shortage of money or grain at home?
10. Do people prefer to sell eucalyptus or crops or livestock during food shortage?
11. Have you ever observed shocks related with livestock in the last five years? What are these? How many times did you observe livestock shocks in the last five years? What actions have you taken during these shocks?
12. For what livelihood activity do you mostly use your time/labor? Crop, livestock, off-farm or eucalyptus?

Thank you very much for your time and cooperation to contribute to the study!

Lemessa Negeri, M.Sc. in Food Security and Development, College of Development Studies, Addis Ababa University, Email address: lemessaneg@yahoo.com; Mobile number: +251-910612355

Appendix 4: Qualitative data reporting formats

(a) KII reporting template.

Woreda Name: _____
Kebele: _____
Sex: _____
Community represented: _____
Name of facilitator: _____
Date: _____

Summary of the KII in word format (1.5 to 3 pages) in single spacing

(b) Focus Group Discussion (FGD) reporting template.

Zone: _____Woreda:_____

Kebele: _____

Male:_____Female:_____

Community represented: _____

Name of facilitator: _____

Date: _____

Summary of the case study in word format (2 to 3 pages) in single spacing

Appendix 5: Odds of the dependent variables (food insecurity status on the HFIAS scale)

Variables	Eucalyptus growers						Non-Euc growers					
	Log likelihood = -31.8248				Number of observations	100	Log likelihood = -22.849136				Number of observations	65
					LR chi2 (12)	125.32					LR chi2 (9)	118.72
					Prob > chi2	0.0000					Prob > chi2	0.0000
					Pseudo R2	0.5455					Pseudo R2	0.7221
	Coef.	SE	z	P>|z|	(95% confidence interval)		Coef.	Std.	z	P>|z|	(95% confidence interval)	
AHH	0.0738	0.0363	2.03	0.042*	0.0026	0.1450	0.3377	0.0930	3.63	0.000**	0.1556	0.5199
FS	0.6387	0.1705	3.75	0.000**	0.3045	0.9729	0.6964	0.3368	2.07	0.039*	0.0362	1.3566
Land size	0.1202	0.3863	0.31	0.756	-0.6368	0.8773	-2.3040	0.8775	-2.63	0.009**	-4.0240	-0.5841
Land size for eucalyptus	-0.3229	2.2439	-0.14	0.886	-4.7208	4.0750						
# of eucalyptus planted	0.0000	0.0002	0.18	0.855	-0.0003	0.0004						
Av .annual HH income from eucalyptus	-0.0004	0.0002	-1.97	0.049	-0.0007	-1.0700						
Av. annual HH income from livestock	-1.8000	0.0001	-0.02	0.981	-0.0001	0.0002	0.0005	0.0002	1.96	0.050	-4.7000	0.0009
Av .annual HH income from crop	0.0002	0.0003	0.51	0.609	-0.0004	0.0008	-0.0014	0.0010	-1.45	0.146	-0.0032	0.0005
Av. annual HH income from labor	-0.0001	0.0001	-1.01	0.310	-0.0003	0.0001	-0.0001	0.0001	-1.14	0.255	-0.0004	0.0001
TLU oxen	-0.6894	0.4041	-1.71	0.088	-1.4815	0.1027	-0.2253	0.5833	-0.39	0.699	-1.3686	0.9178
TLU	-0.0505	0.1259	-0.40	0.688	-0.2974	0.1963	-0.2849	0.2830	-1.01	0.314	-0.8396	0.2698
CSI Score	0.0834	0.0270	3.09	0.002**	0.0305	0.1364	0.1032	0.0407	2.53	0.011*	0.0234	0.1830
Cut1	3.7752	1.7602			0.3254	7.22510	13.4976	5.0218			3.6550	23.3402
Cut2	9.9387	2.5769			4.8879	14.9894	23.4108	6.9119			9.8637	36.9578
Cut3	16.9521	3.5523			9.9897	23.9145	29.8984	7.6503			14.9041	44.8927

*Where Coef. = coefficients of the ordered logistics regression of the predictors, SE = standard error, z = z-score for the statistics and p = probability. * = statistically significant variables at 95% confidence interval and ** = statistically significant variables at 99% confidence interval*

Appendix 6: Odds ratio of the ordered logit for the dependent variable (food insecurity status on the HFIAS scale)

Variables	Eucalyptus growers						Non-Euc growers					
	Log likelihood = --52.2127				Number of observations	100	Log likelihood = -19.3238				Number of observations	65
					LR chi2 (12)	125.32					LR chi2 (9)	118.72
					Prob > chi2	0.0000					Prob > chi2	0.0000
					Pseudo R2	0.5455					Pseudo R2	0.7221
	Coef.	SE	z	P>|z|	(95% confidence interval)		Coef.	Std.	z	P>|z|	(95% confidence interval)	
AHH	1.0766	0.0392	2.03	0.042*	0.0026	0.1450	1.4018	0.1303	3.63	1.4018	1.1683	1.6819
FS	1.8940	0.3229	3.75	0.000**	0.3045	0.9729	2.0065	0.6759	2.07	2.0065	1.0368	3.8829
LSH	1.1278	0.4356	0.31	0.756	-0.6368	0.8773	0.0999	0.0876	-2.63	0.0999	0.0179	0.5576
LUTE	0.7240	1.6247	-0.14	0.886	-4.7208	4.0750						
# of eucalyptus planted	1.0000	0.0002	0.18	0.855	-0.0003	0.0004						
Av. annual HH income from eucalyptus	0.9996	0.0002	-1.97	0.049	-0.0007	-1.0700						
Av. annual HH income from livestock	1.0000	0.0001	-0.02	0.981	-0.0005	0.0002	1.0004	0.0002	1.96	1.0004	1.0000	1.0009
Av .annual HH income from crop	1.0002	.0003	0.51	0.609	-0.0005	0.0008	0.9986	0.0010	-1.45	0.9986	0.9967	1.0005
Av. annual HH income from labor	1.0000	0.0001	-1.01	0.310	-0.0003	0.0001	1.0000	0.0001	-1.14	1.0000	0.9996	1.0001
TLU oxen	0.5019	0.2028	-1.71	0.088	-1.4815	0.1027	0.7982	0.4656	-0.39	0.7982	0.2545	2.5038
TLU	0.9507	0.1197	-0.40	0.688	-0.2974	0.1963	0.7521	0.2128	-1.01	0.7521	0.4319	1.3096
CSI Score	1.0870	0.0294	3.09	0.002**	0.0305	0.1364	1.1087	0.0451	2.53	1.1087	1.0236	1.2008
Cut1	3.7752	1.7602			0.3254	7.2251	13.4976	5.0218			3.6550	23.3402
Cut2	9.9387	2.5769			4.8879	14.9894	23.4108	6.9119			9.8637	36.9578
Cut3	16.9521	3.5523			9.9897	23.9145	29.8983	7.6503			14.9041	44.8927

*Where Coef. = coefficients of the ordered logistics regression of the predictors, SE = standard error, z = z-score for the statistics and p = probability. * = statistically significant variables at 95% confidence interval and ** = statistically significant variables at 99% confidence interval*