THE CONTRIBUTION OF FARM PLOT LEVEL TRADITIONAL HOME-GARDEN AGROFORESTRY TO INCOME GENERATION IN LIGHT OF CLIMATE CHANGE IN HAWASSA ZURIA DISTRICT OF SIDAMA REGIONAL STATE, ETHIOPIA

MSc THESIS

BY

BIZUNEH ABERA

HAWASSA UNIVERSITY

COLLEGE OF AGRICULTURE

HAWASSA, ETHIOPIA

DECEMBER, 2021

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A THESIS SUBMITTED TO FACULTY OF ENVIRONMENT, GENDER AND DEVELOPMENT STUDIES

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE

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SCHOOL OF GRADUATE STUDIES

HAWASSA UNIVERSITY ADVISORS’ APPROVAL SHEET

(Submission Sheet-1)

This is to certify that the thesis entitled the contribution of farm plot level traditional home-garden agroforestry to income generation in light of climate change in Hawassa Zuria district of Sidama regional state, Ethiopia. Submitted in partial fulfillment of the degree of Master with specialization in climate change and sustainable agriculture the graduate program of the department of development, gender and environment studies and has been carried out by Bizuneh Abera under my/our supervision. Therefore I/we recommend that the student has fulfilled the requirements and hence hereby can submit the theses to the school.

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As members of the board of examiners of the final open defense by Bizuneh Abera have read and evaluated his thesis the contribution of farm plot level traditional home-garden agroforestry to income generation in light of climate change in Hawassa Zuria district of Sidama regional state, Ethiopia and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the Degree of Master of Science in Climate Change and Sustainable Agriculture.

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Dedication

I dedicated this thesis to my lord Jesus Christ, my mother Dararo Hamito and my father Abera Arusa as well as my brother Adane Abera and Tsegaye Abera for their support and encouragement.

Declaration

The author hereby declare, that this thesis entitled ‘‘the contribution of farm plot level traditional home-garden agroforestry to income generation in light of climate change in Hawassa Zuria district of Sidama regional state, Ethiopia’’ submitted for the partial fulfillment of the requirements for the Masters of Science in Climate Change and Sustainable Agriculture, is the original work done by him under the supervision of Teramage Tesfaye (PhD). To the best of my knowledge and belief, this thesis has not been published or submitted elsewhere for the requirement of a degree program. Materials or ideas of other authors used in this thesis have been duly acknowledged and references are listed at the end of the main text.

Name Bizuneh Abera

Signature………………………

Date: ……………………………

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Abbreviation and Acronyms

AF	Agroforestry
CC	Climate change
FAO	Food and Agriculture Organization
FGD	Focused Group Discussion
GAF	Global Assessment Function
GHG	Greenhouse Gas
GDP	Gross Domestic Product
THAF	Traditional Home-Garden Agroforestry
HZDOA	Hawassa Zuria District office of Agriculture
IFAD	International Fund for Agricultural Development
IPCC	International Panel on Climate Change
KAs	Kebele Administrations
KII	Key Informant Interview
MoA	Ministry of Agriculture
NAPA	National Adaptation Programme of Action
NAF	Non Agroforestry
NHAF	Non-home-Garden Agroforestry
NMMSA	National Meteorological Service Agency
NGOs	Non-Governmental Organizations
GOs	Governmental Organizations
SNNPR	Southern Nation Nationalities and People Region
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change

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THE CONTRIBUTION OF FARM PLOT LEVEL TRADITIONAL HOME-GARDEN AGROFORESTRY TO INCOME GENERATION INLIGHT OF CLIMATE CHANGE IN HAWASSA ZURIA DISTRICT OF SIDAMA REGIONAL STATE, ETHIOPIA

BY: BIZUNEH ABERA

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ABSTRACT

The climate of Ethiopia is characterized by high variability in annual, seasonal and spatial distributions. This study assessed the contribution of farm plot level traditional home-garden agroforestry to income generation for the local community in Hawassa Zuria district under the existing climate condition. Both simple random sampling and purposive sampling have been used to get 134 households from traditional home-garden agroforestry beneficiary and 134 households from non-home-garden agroforestry beneficiary totally 268 sample respondents were interviewed. Data were collected from both primary and secondary sources. The primary data were collected by interviewing 268 smallholder male and female household heads, focus group discussions and key informants. Secondary data were collected from documents reviews, journals, published and unpublished materials. These data were presented and analyzed using descriptive and inferential statistics such as table, crosstabs, Chi-square test, independent t-test by using SPSS version 20. Information from the surrounding weather station indicated that the maximum temperature of Hawassa Zuria district for the past 30 years has increased by about 0.028^{O}C annually, while average minimum temperature has increased by 0.063 ^{O}C. The coefficient of variation of rainfall in the study area were 15.84%, 21.19%, and 29.63% for annual, kiremit and belg rainfall respectively, which indicate that there was high inter-annual variability of rainfall between 1991-2020. In agreement, a climate change perception survey indicated that about 89.6% of households (practicing traditional home-garden agroforestry) and 81.3% (practicing non-home-garden agroforestry households heard and believed that there is climate change in the study area. The comparative analysis of income level between traditional home-garden agroforestry and non-traditional home-garden agroforestry households was 4,677.71±1985.04 and 2,627.79±1095.02 Birr, respectively. The independent t-test showed that there was a statistically significant difference in the income between traditional home-garden agroforestry and non-traditional home-garden agroforestry in the study area ($p<0.05$), implying traditional home-garden agroforestry is better than non-traditional agroforestry to minimize the effects of climate change related shocks at household levels. This is associated with high diversity in agroforestry that leads to increased production throughout the year, provides immediate fresh food for sale and household consumption, reduces cost of purchasing fertilizer, use of fruits to reduce frequency requests for meals and avoid hunger especially for children. traditional home-garden agroforestry beneficiary households with more income, have a higher ability to cope in case of climate shock than non-tradititional home-garden agroforestry beneficiary households. The great role of traditional home-garden agroforestry is sensitivity reduction and increasing resilience of farmers to effects of climate variability is through increasing fuel-woodstock on a farm, reducing erosion intensity, increasing income and assets such as trees, livestock, and crop production. Therefore traditional home-garden agroforestry participant households have more assets and annual income, less sensitivity and have better resilience to climate variability compared to the non-home-garden agroforestry participant households. Distribute and plant suitable multipurpose tree species including fruit tree seedlings to the farmers in order to increase income and resist the effect of climate change risk. Households who are not involved in home-garden agroforestry activities and those who lack knowledge on the benefits of home-garden agroforestry should be given special consideration in raising awareness (*mini-workshop and agricultural extension methods)*

Key words: Climate change, Agroforestry, Traditional Home-garden

CHAPTER ONE

INTRODUCTION

1.1. Background and justification

The impact of global climate change, particularly increasing temperatures, rainfall variability, frequency and severity of extreme events, and increasing incidence of pests and diseases will likely to affect the agriculture sector (IPCC, 2012; Howden et al., 2007). Smallholder farmers in developing countries, in general Sub-Saharan Africa and particular in Ethiopia practice rain-fed agriculture and forestry, therefore they depend on complex interactions of monsoon systems and local heat and hydrological feedbacks which dictate the temporality and spatiality of rainfall (Turpie and Visser, 2013; Polcher et al., 2011).

Ethiopia is highly vulnerable to climate change impacts because it is predominantly an agrarian country and agriculture is severely impacted by the changing climate. The country's geographical location and topography is also reported as a potential reason leading to high vulnerability to the impacts of climate change (World Bank, 2010). Many smallholder farmers in Sub-Saharan Africa practice agroforestry. These systems have prevailed despite persistent attempts to introduce monoculture production of annual crops, which have been much less successful in Africa than elsewhere. Agroforestry has been shown to provide a number of benefits to farmers. For instance, it can enhance soil fertility in many situations and improve farm household resilience through provision of additional products for sale or home consumption.

The insight that trees on farms provide livelihood benefits is not new, and diversity-based approaches to agricultural adaptation to climate variability have been adopted by many farmers. In light of recurring food shortages, projected climate change, and rising prices of fossil fuel-based agricultural inputs, agroforestry has recently experienced a surge in interest from the research and development communities, as a cost-effective means to enhance food security, while at the same time contributing to climate change adaptation and mitigation. It has also experienced a recent increase in adoption by farmers in many parts of Africa (Garrity et al., 2010).

Agroforestry systems are often very productive and have been practiced in different parts of the country like Gedio and Sidama. The system has been developed during subsequent millennia into a number of indigenous agroforestry systems providing multi-benefits to the local communities (Mesele and Starr, 2015) Abebe, (2013) stated that the home-gardens of the highlands of Southern Ethiopia have coffee as a dominant crop, like many of their counterparts in other eastern African countries. What makes them different is the unique association of coffee with the co-dominant native crop enset (*Enset ventricosum* (Welw.) Cheesman). Its contribution, however, has been recently acknowledged as a potential land-use system and technologies to mitigate climate change derived problems, including its household income generation potential.

Enhancing the smallholder farmer's agroforestry system is a basic response to climate change, increasing crop production and food insecurity (McCarthy et al., 2011). And also as the key economic sector of most low income countries, improving the resilience of the agroforestry system is essential for climate change adaptation (Conant, 2009; Adger et al., 2003). This can be achieved by promoting agroforestry (AF) especially home-garden agroforestry which is considered as a sustainable land use in multi-functional landscapes and enhances farmers' ability to adapt to climate change, since the multiple benefits it delivers including food provision, supplementary income and environmental services (Schoenerger et al., 2012; Lusco et al., 2011). Home-gardens agroforestry increase the improvement in farm productivity and profitability; through diversifying income and food sources; increasing incomes; spreading income risks and stabilizing/enhancing livelihoods (Rodel et al., 2013).

1.2. Statement of the problem

The climate of Ethiopia is characterized by high variability in annual, seasonal and spatial distributions. Especially the amount and seasonal trends of precipitation are varying annually and difficult to predict, while the temporal distribution of rainfall during the growing season is an important factor influencing crop yield (Evangelista et al., 201). Such erratic climatic conditions made the country vulnerable, especially to the changing climate.

Climate change affects all aspects of economic growth especially in least developing countries. To reduce the impact of climate change and enhance food security, adaptation measures are urgently required. The process of adaptation options are needed to be location, integrated and flexible. This climate change effects to all agricultural sectors in a multitude of ways. For example, changing weather patterns such as heavy floods and storms makes agricultural production low and leads to extreme events of poverty and slow down economic development.

Hawassa Zuria district is a lowland area which is where the major agricultural production areas in Sidama region have been experiencing crop yield reduction by climate change impacts. However, historical, social and economic impacts of all natural hazards are not systematically well documented as well as quantitative climate change impact assessments are not properly conducted.

Among such areas, Hawassa Zuria district is the one that has promoted home-garden agroforestry over the last few years to improve soil fertility, crop productivity and enhance household income level in the farming communities continues farmers' capacity building in the form of conservation farming by Rift Valley Project, Safety Net Projects and government organization (HZDOA, 2020). There is high demand for sustainable crop production for a rapidly increasing population, enhancing the income generation capacity and enhancing the adaptation to the climate change impacts for systems. This needs the introduction of climate resilient technologies that meet these requirements. (Rodel et al., 2013).

Therefore, the aim of this study was to investigate the contribution of farm plot level of traditional home garden agroforestry to income generation by smallholder farmers in Hawassa Zuria District of Sidama Regional State, Ethiopia under the existing climate change scenario.

1.3. Objectives of the study

1.3.1. General Objective

The general objective of this study was to assess the contribution of traditional home-garden agroforestry to income generation at farm plot level in Hawassa Zuria district under existing changing climatic conditions.

1.3.2. Specific objectives

1) To assess the contribution of traditional home-garden agroforestry system to household's income generation under changing climatic condition,
2) To investigate the farmers' perception on home-garden agroforestry in reducing the effects of climate change in the study area.

1.4. Research questions

1) What is the contribution of traditional home-garden agroforestry systems in a household's income generation under changing climatic conditions?
2) What are farmers' perceptions on home-garden agroforestry in reducing the effects of climate change in the study area?

1.5. Significance of the study

The outputs of this study could be used as an input for development or modification of agroforestry promotion strategies in Ethiopia. More specifically, the information from this study on contribution of traditional home-garden agroforestry at farm plot level to improve household's income in the face of climate change can be used to:

1. Provide feedback from farmers that are helpful in refining the technology generation effort.
2. Improve the link and flow of information between research and extension services.
3. Document the role of home-garden agroforestry practices and extension.

1.6. Scope and limitations of the study

This study basically focused on assessing the contribution of traditional home-garden agroforestry to income generation and perception of households climate change and its contribution of the practice in reducing the climate derived shocks, specifically to Hawassa Zuria district of Sidama regional state, Ethiopia. Although carrying out this research task in all Sidama region districts would be impractical because of the limitation of resources and time, the study was limited only to four Kebeles of the district.

The comprehensiveness of this study was also limited by different challenges. Especially while to collecting data from some sample households, focus group discussion (FGD), key informants (KI), development agents (DAs) and some officials were not ready to provide well-organized and necessary data that the research question desires. Another challenge was shortage of money, time, and willingness of respondents to give data. Data on some issues were in a way inconvenient to access immediately from the record office. Despite all these challenges the researcher tried to critically organize the available data.

1.7. Organization of the study

This study was organized into five chapters. The first chapter focuses on the introductory part which deals with background of the study, statement of the problem, objectives of the study, significance of the study, scope and limitation of the study. The second chapter discusses the literature review part of the study. The third chapter briefly outlines the research methodology. Chapter four presents the analysis, interpretation and discussion of the study results. Chapter five is devoted to presenting the summary, conclusion, and recommendation of the study. At the end of the study paper, reference and/ or bibliography is attached followed by appendices.

CHAPTER TWO

LITERATURE REVIEW

2. Definition, Theoretical overview and Empirical studies

2.1. Definition

2.1.1. Climate change (CC): The most universal definition of climate change is a change in the statistical properties of the climate system over periods of decades or longer, regardless of cause (IPCC, 2014). The term sometimes is used to refer specifically to climate change caused by human activity. For example, the United Nations Framework Convention on Climate Change (UNFCCC, 2014), defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.

2.1.2. Agroforestry (AF); is the collective term for land-use systems and technologies in which woody perennials (e.g. trees, shrubs, palms or bamboos) and agricultural crops or animals are used deliberately on the same parcel of land in some form of spatial and temporal arrangement.

2.1.3. Non-agroforestry (NAF); Refers to land-use systems and practices in which without trees based agriculture which are crops and/or animals on the same land-management unit. The integration can be either in a spatial mixture or in a temporal sequence.

2.1.4. Traditional Home-gardens Agroforestry (THGAFs): Traditional home-garden agroforestry is a special category of agroforestry that deals with the traditional cultivation of multipurpose and multi-storied trees and crops combined with animal husbandry around a homestead (Kabir. 2008)

2.1.5. Non-traditional Home-garden Agroforestry (NTHGAF); is category of traditional agriculture that deals without trees-based cultivation of crops combined with animal husbandry around a homestead.

2.1.6. Home-gardens agroforestry (HGAF); have been variously defined by different authors. Fernandez and Nair (1986) have defined home-gardens as "land use practices involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably, livestock, within the compounds of individual houses, the whole crop-tree-animal unit being managed by the family labour.

2.1.7. Non-home-garden agroforestry NHGAF); Non-home-garden agroforestry refers to extended farm fields (far/ around from houses) intimate association with annual and perennial agricultural crops and invariably, livestock within the compounds of individual houses.

2.2. Theoretical overview

2.2.1. Climate change in the global context

Climate Change is one of the biggest global problems posing challenges to sustainable livelihoods, food security and economic development, particularly for developing countries (Kibassa, 2013). Climate change, whether driven by natural or human forcing, can lead to changes in the likelihood of the occurrence or strength of extreme weather and climate events or both (Cubasch et al., 2013). Human influence on the climate system is clear and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have widespread impacts on human and natural systems (IPCC, 2014a).

Increase in population size, economic activity, lifestyle, energy use, land use patterns, technology and climate policy had been the main drivers of anthropogenic emissions of greenhouse gases. Since 1950 extreme weather and climate change events have been observed, whereby more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in GHG concentrations and other anthropogenic forcing. Heat waves, droughts, floods, cyclones and wildfires are recent climate related extreme impacts that reveal significant vulnerability and exposure of some ecosystems and many human systems to current climate change and climate variability. Moreover, future climate will depend on committed warming caused by past anthropogenic emissions as well as future anthropogenic emissions and natural climate variability (IPCC, 2014b).

2.2.2. Climate change in the Africa context

It is widely held that developing countries in Africa will be particularly susceptible to climate change in part, because of the extraordinary growth of its human population, fragility of national and regional economies, food and water insecurity and rapid loss of natural resources (IPCC, 2007; World Bank, 2010). Furthermore, the majority of subsistence food produced in Africa comes from rain-fed agricultural systems that are dominated by small-scale subsistence farming; practices have changed little over the last few centuries.

The scarcity of water and lack of irrigation systems throughout most of Africa substantially increases the dependency people have on climate for food production. Fluctuating climatic cycles (e.g., El Nino) have led to extensive drought, famine, and loss of life throughout sub-Saharan Africa (Beltrando and Chamberlin, 1993) and altered rainfall patterns and the subsequent loss in agricultural productivity can have direct influences on national economies (World Bank, 2010), war, conflict and political stability

(Raleigh and Kniveton, 2012). Climate change is often seen as the “death knell” for many communities and countries unless farming policies can change in advance of the climate (Dinar, 2007).

2.2.3. Climate change in the Ethiopian context

Ethiopia is one of those countries that are extremely vulnerable to climate change. Its geographical location and topography coupled with low adaptive capacity due to low level of development and dependence on agriculture, explain its vulnerability to the impacts of climate change. Agriculture is the mainstay of its economy contributing 42 % of its GDP and employing close to 80% of its population. The majority of farmers are smallholders that depend on rain-fed agriculture for subsistence production, which makes them highly exposed to climate variability and consequently to both transient and chronic food insecurity (Conway and Hopper, 2011).

Ethiopia has a wider range of climatic zones that vary in altitude and location. Altitudinal variation induces temperature changes and is a factor for the formation of three main climatic zones; cool (Dega), temperate (Weyna Dega) and hot (Kola). The mean annual rainfall distribution in the country ranges from a maximum of more than 2000 mm over the South Western highlands to a minimum of less than 300 mm over the South-Eastern and North Western lowlands.

Similarly, mean annual temperature varies considerably from lower than 15 ^{0}C over the highlands to over 25 ^{0}C in the lowlands. This climate variability is used to classify the three seasons in the country mainly based on rainfall regimes. These are the dry season (Bega) from October to January; the short rainy season (Belg) from February to May and the long rainy season (Kiremet) from June to September (FDRE, 2015; Livelihoods Integration Unit (LIU), 2011).

In Ethiopia, climate variability is common and has caused several droughts and floods, undermining food security and even causing famine for decades. Drought and floods are the major climatic hazards in

Ethiopia and occur every 3 to 5 years. Since the early 1980s the country has suffered five major droughts that caused famines. (World Bank, 2009). Over the last two decades, the frequency and severity of droughts has increased in many parts of the country and are likely to continue with increasing trends in global warming. These droughts have caused livelihood breakdowns, aggravated poverty and triggered major catastrophes such as the 1972/73 and 1984 Wello famines. Likewise, flooding caused considerable damage to lives and livelihoods by destroying crops and infrastructure in different parts of the country in 1988, 1993, 1994, 1995, 1996, and 2006 (ICPAC, 2007).

2.2.4. Farmers' perception the role of agroforestry in reducing the effects of climate change

Historically Ethiopia has been prone to extreme weather variability. Most farmers in Africa perceive the increased temperature and declined precipitation. In line with this, the majorities of the farmers who have been contacted in Ethiopia are aware of climate change and perceive an increase in temperature and decrease in precipitation. However, the perception of climate change is shaped by varying cognitive structures caused by socioeconomic and cultural differences that expose people to differing attitudes, values and interests. Therefore, farmers' perceptions of climate change, variability and its effects are influenced by psychological and socioeconomic differences which will limit their response to climate change (Hausken, 2004).

Agroforestry has been proposed as a potential strategy for helping subsistence farmers to reduce their vulnerability to climate change. Farmers perception agroforestry systems comprise a long list of land management practices including agroforestry diversification, long rotation systems for soil conservation, home-gardens, boundary plantings, perennial crops, hedgerow intercropping, live fences, improved fallows or mixed strata agroforestry these reduce during climate shock happens. If well managed, agroforestry can play a crucial role in improving resilience to uncertain climates through microclimate buffering and regulation of water flow (Mbow, 2014).

The farmer's perception of agroforestry practice stands out as strategies for reducing the impact of climate variability, especially for ensuring fuel-wood sustainability and income. Agroforestry system has a major role for the reduction of climate change impacts, particularly total agroforestry production failure and reduction of carbon concentration in the atmosphere. In this research finding agroforestry systems can reduce the effect of climate change. Farmers perceive that agroforestry reduces soil erosion, balances microclimate, adjusted rainfall and sinks of greenhouse gas (GHG). These climate change reduction indicators are enhanced through diversified agroforestry systems and planting agroforestry fruits/trees on farm land.

Farmers' perception about the home-garden agroforestry's ability to reduce climate change compared to another type of land use. Farmers' perception also planting agroforestry fruits/trees to save the world from climate change, it's clear that planting trees is a useful tool that we can use to reduce the effects of climate change.

2.2.5. Impact of climate change on agroforestry

The major and almost the exclusive livelihood activities of rural Ethiopia are crop production, agroforestry systems, livestock rearing, natural resource extraction, and only less than a small percentage engaged in off-farm activities. Hence, given the inherent link of these livelihood activities to natural resources, they are largely at the mercy of uncertainties driven by climate change, including extreme events such as flooding and drought.

Over the last decade or so, climate change (in terms of long-term changes in mean temperature or precipitation, as well as an increased frequency of extreme climate effects) has gradually been recognized as an additional factor which, with other conventional pressures, will have a significant weight on the form, scale, spatial and temporal impact on rural livelihood activities. In other cases, impacts will be unexpected, and appropriate responses may not easily be known or implemented in advance (Seyoum, 2015).

Climate change not only affects the growth of agroforestry fruit/ trees but also their quality, production, harvest time and storage. Climate change affects agroforestry production, land and resource degradation are the most vulnerable to livelihood of households. Trees have important roles in reducing such vulnerability, increasing resilience of farming systems and buffering households against climate related risks. Climate change impacts changes in precipitation patterns, amount and changes in temperature will influence agroforestry crop growth and yields through changes in soil water content, runoff and erosion, nutrient recycles and salinization, biodiversity, and soil organic matter.

Climate change will affect agroforestry systems by pest and disease incidence and virulence in ways that are poorly understood at present. Diseases and insect populations are strongly dependent upon temperature and humidity and changes could alter their distributions and virulence. Generally climate change impacts are on agroforestry crop production**,** livelihood income**,** livestock production, water and on forest resources.

2.2.6. The roles of traditional home-garden agroforestry to income generation

In agroforestry, year round production increase income, food and a wide range of other products such as fuel wood, fodder, spices, medicinal plants and ornamentals (Marten and Abdullah, 1988; Gliessman, 1990). The role of home-garden agroforestry decreased risks of production failure, increased income productivity over time, expansion of the amount and quality of labor applied in the farm, and provision of output flexibility and alternative production should unfavorable circumstances develop (Wojtkowski, 1993).

Agroforestry has the potential to serve as repositories of genetic diversity, besides acting as insurance against pests and disease outbreaks, which may be very severe in mono-cultural stands (Michon, 1983). Avoidance of environmental deterioration commonly associated with mono-cultural production systems largely due to effective nutrient cycling and relatively small hazard for leaching and soil erosion (Jensen, 1993). Provision of materials for breeding of useful new crop varieties. Wider ecological services such as landscape protection, soil protection and health, water cycle and quality and air quality (Cromwell, 1999). These overall roles of home-garden agroforestry systems offer a major pathway for sustainable incomes.

Home-garden agroforestry plays an important role and unique land management system because of the potential role in addressing biophysical, economical and socio-ecological components. Such diversity and interaction leads to high income, greater functional and structural complexity as compared to non-tree based gardens. This research finding from study area home-garden agroforestry systems increase income than non-agroforestry participants. Surveyed households also admire home-garden agroforestry importance especially income generation and climate change reduction. Agroforestry systems play a critical role increase income, moderating the microclimate, highly effective in soil and water conservation through provision of permanent cover, to provide economically viable and environmentally friendly means to improve soil fertility and potential to limit carbon emissions and sequester carbon as compared to non-agroforestry systems.

Agroforestry high species diversity provides an important role in ecological services such as nutrient recycling, soil and water conservation, and reduces environmental deterioration hence, ecological sustainability (Hughes, 2007). The role of agroforestry systems helps as a means of ecological sustainability (stability and resilience) for sustainable agroforestry production, control of soil and water loss (erosion), enhanced fuel-wood production and managing hazards through timber and fruit sales for sustainable income generation for smallholder farmers. Agroforestry beneficiary households with more income, have a higher ability to cope in case of climate shock and decrease sensitivity farm households than non-agroforestry beneficiary households (Krishnal et al., 2012).

2.2.7. Categorization of home-garden agroforestry

According to Abebe (2005), two types of home-gardens can be recognized on the basis of their contribution to the welfare of households. He mentioned the first one as the small-scale supplementary food production systems found around houses in areas where livelihood of the owners is usually from other activities (farming or non-farming). This category includes a wide range of rural, semi-urban and urban gardens and are said to be common in much of the tropics. Examples of this type include; the home-gardens of Java that supplement monoculture rice production and most home-gardens from Latin America (Mendéz et al., 2001).

Urban gardens used to produce vegetables and ornamentals to supplement non-agricultural income of owners also fall in this category. The home-garden in Burkina Faso is mainly for subsistence purposes (Ouédraogo, 2010; Kristensen and Balsle, 2003) and is thus expected to belong to this category. The second category of home-gardens refers to extended farm fields around houses that form the main source of livelihood for farming households. Most of the home-gardens in the highlands of Eastern Africa belong to this category (Rugalema et al., 1994). Farmers under this category either have no additional land, or they have smaller lands which are supplementary to the home-gardens. Home-gardens may also be categorized based on the size of land occupied and different researchers have provided different categories based on this criterion. In this research study area also home-garden agroforestry belongs to this category.

Mohan (2004) identified four categories; small, medium, large and commercial. Another way of categorizing home-gardens is based on the quantity of products sold at the end of each production season. For example, (Abdullah et al., 2006) have described two categories of home-gardens called commercial and non-commercial based on this criterion. They explained that if a household consumed more than half of their home-garden products, then the home-garden is considered as non-commercial while a commercial home-garden is one in which more than half of the products are sold out.

Three categories of home-garden agroforestry are small, medium and commercial. These could also be classified as subsistence, intermediate and commercial home-gardens based on the quantity of products sold. Subsistence home-gardens are those in which all the products are solely for household consumption with very little or no sales at all. Intermediate home-gardens refer to those in which appreciable quantities up to 50 % of the products are sold out while some good quantities up to 50 % are still used for household consumption.

Commercial home-gardens are those in which the quantity of products sold is by far larger than the quantity that is used for household consumption. Possible classification of home-gardens was identified based on composition and arrangement of crops.

i. Single crop home-gardens

This refers to those home-gardens in which only one type of arable crop is planted during the entire season and may include some vegetables. Some home-gardens cultivated in this manner are usually made of staple food crops such as maize, or millet.

ii. Mixed crop home-gardens

This refers to those home-gardens in which two or more arable crops are cultivated on the same piece of land. Integrated mixed home-gardens in the different types of crops are all cultivated on the same unit of land within the entire garden. This implies that you can find more than one crop planted at the same time in the entire garden.

iii. Segregated mixed home-gardens

These are home-gardens in which the entire garden area is seen as mixed cropping but the area is divided into units and each unit has a different single crop on it. The vegetables may be grown within any of the units.

2.2.8. Composition of home-gardens agroforestry

Home-gardens are typically composed of crops (both annual and perennial), woody plants (trees and shrubs), as well as animals. Arrangement of home-gardens components is affected by space and time. Trees and crops are arranged such that the most compatible ones are together while the time for growth of each is also taken into consideration. The crops are usually for household consumption but also sometimes for commercial purposes.

The woody plants may serve to provide; fruits, fuel wood, fodder, shade, and medicine. Woody plants may also be used to show boundaries, for soil conservation or for provision of timber. Usually however, the trees and shrubs found in home-gardens are multipurpose thus providing more than one benefit to the household all year round. The home-gardens in Southern Burkina Faso typically compose of maize, millet, sweet potato, cowpea, black-eyed peas as well as vegetables such as okra, tomatoes and pepper. The trees include; mango, shea, and orange. The livestock include; chicken, sheep, goats, cattle and donkeys (Kristensen and Balslev, 2003). The composition of home-gardens is dependent on the needs and interests of the owner.

The decision of what to include in the home-garden is affected by several factors including social, religious and cultural values of the people who manage it. Tree, livestock and crops are the most commonly known as three stable ecosystems of home-garden agroforestry, which is related to three scientific disciplines of forestry, animal rearing and agronomy, respectively (Abebe, 2000). As a result, it can improve the livelihoods of the farmer through providing multiple services like food/fruit, timber, firewood and fodder (Kumar and Nair, 2004).

However, home-garden agroforestry land use practice has varied from place to place depending on its goal and types of tree species, farmer's interest and management system. For example, diversity home-garden agroforestry in the south nation nationality people region state (SNNPRS) was recognized by a unique combination of two native major perennials coffee (*Coffea arabica* L.) and Enset (*Enset ventricosum* Welw), which increase income for agroforestry beneficiary.

2.2.8.1. Plant component – crops, shrubs and trees

Home-garden agroforestry is important to the mainly subsistence level existence of farmers in the tropics (Mendez et al., 2001). Many of the benefits provided to farmers by these gardens are unknown for lack of quantification of the products used by the household (Mohan, 2004). The crops in home-gardens agroforestry provide a variety of benefits including; food/nutrition, medicine, ornamentals, and cash while the trees provide fruits, fuel wood, fodder for livestock, medicine, building materials, shade and timber for construction of other household needs including carvings for sale. For example, farmers in Burkina Faso employ traditional agroforestry practices such as live hedges to protect their vegetable gardens from animals (Ayuk, 1997).

These live hedges also provide additional sources of income such as fuel wood and timber. The crops and trees planted in a home-garden are carefully arranged to provide for specific functions and benefits, which are primarily economic in nature (Mohan, 2004). Personal preferences, socio-economic status and culture seem to be the main determinants of the appearance, function, and structure of home-gardens. Kumar and Nair (2004) also observed that the structures of home-gardens vary from place to place according to the local physical environment, ecological characteristics, and socioeconomic and cultural factors.

2.2.8.2. Animal component

Livestock's are a very important component of almost all home-gardens. Since most people keep animals on an extensive basis, it is not too difficult or expensive to practice. Livestock contribute significantly to the household income of small-scale how to contribute significantly to the household income of small-scale home-gardens in many developing countries, while fulfilling several social and cultural needs (Wilson, 1995).

Devandra and Thomas (2002) reported that small-scale, resource-poor farmers own about 95% of the livestock in home-gardens. They further observed that in some of the very small gardens, where land is a constraint to production, livestock are sometimes the main income generators, serving as cash buffers and capital reserves. Livestock serve as a constant source of income all year round particularly in arid areas such as Burkina Faso where there is only a single cultivation season each year. As described by Devandra and Thomas (2002), the most important "cash crop" in small-scale mixed farming systems is known to contribute to food security and alleviate seasonal food variability and availability.

Similarly livestock is a store of wealth that serves as an important insurance mechanism in the sense that these assets are saleable in poor years to provide purchasing power for grain consumption. Animals provide the farmer with a greater ability to deal with seasonal crop failure and other natural disasters. Livestock also provide draught power for land preparation, transport, and manure to enhance soil fertility. Agriculture is a major contributor to the gross domestic product (GDP) in many countries, with livestock contributing up to 20% of the agricultural GDP (Devandra and Thomas, 2002) for example, in

India, incomes from livestock production account for 15–40% of total farm household earnings (World Bank, 1996).

Livestock also offer opportunities for milk and meat-processing ventures, thus increasing employment especially in rural areas (Mohan, 2004). Animals can be used to control weeds in perennial tree crop systems, and to control insect pests. Integration of animals with cropping systems provides means to sustainably intensify agricultural production and contribute to the nutrient cycling in the system. In a study of banana-based home-gardens kibanja in Bukoba district in Tanzania, nutrient balances were negative for home-gardens without cattle. They further observed that the relatively good banana production in those gardens without cattle, and owned by resource-poor farmers might be explained by the fact that some farmers find other nutrient-saving solutions by keeping small ruminants like goats and sheep, while others make compost heaps and recycle crop residues. Livestock also promote the adoption of adaptive management techniques.

2.2.9. Importance of home-garden agroforestry

Home-garden agroforestry is widespread throughout the tropics including Burkina Faso and is of immense importance in the socioeconomic structure of the rural communities. They provide income and are also used to generate non-market benefits such as aesthetics, ornamentation, improved food quality and nutritional security to the farmer (Drescher, 1996). They provide both economic and social benefits that are essential to the nutritional welfare and security of the household (Mohan, 2004).

Crops planted in home-gardens have been found to provide a major component of household food intake. For example, home-gardens have been reported to provide 18-40 % of household calories in Java (Christianity, 1981) and 50–58 % of the recommended daily allowance for calories in the Philippines

(Christianity, 1990). They make a significant contribution to the nutrient requirements (proteins, carbohydrates and vitamins) of rural dwellers especially children and hence help to prevent several health problems (Abdullah, 1986).

They may also be of cultural value to households and are said to enhance social status of households (FAO, 2004). These gardens, with their diversified agroforestry crops and trees fulfill the basic needs of the local population (Mohan, 2004) and are also of vital importance to the subsistence economy of many areas in the tropics. In addition, the multi-storied arrangements of plants and relatively high species diversities prevent the environmental degradation that is commonly associated with monocultures (Nair, 1993). Potential environmental benefits of home-gardens may be important not only for home-gardening households, but for the broader society as well (FAO, 2004). Thus, they provide economic benefits while remaining ecologically sound and biologically sustainable (Mohan, 2004).

2.2.10. Contribution of home-gardens to household incomes

Home-gardens, although primarily used for subsistence purposes of the household, are increasingly being used to generate cash income (Mendez et al., 2001). It is a common misconception that home-gardens are exclusively subsistence oriented, whereas in fact home-gardens provide households with cash crops as well as food crops. Returns to land and labour are often higher for home-gardens than for field agriculture (Marsh, 1998).

The quantity of home-garden production that actually gets sold is highly variable differing from one household to another. In a study of home-gardens (Hoogerbrugge and Fresco, 1993) reported that between 9 % and 51 % of production is sold while (Okigbo, 1990) reported that sale of livestock and tree crops produced on home-gardens in south eastern Nigeria accounted for over 60% of family cash income. A study of urban and rural households in three Russian provinces found that two-thirds of all households obtained some income from home-gardens (FAO, 2004).

In the Helen Keller International (HKI) pilot home-garden project in Bangladesh, 54 % of households reported selling home-garden products and earning the cash equivalent of 14.8 % of total average monthly income. In addition to direct earnings from sale of home-garden agroforestry products, production consumed by the household frees up household earnings for other purchases. In the Bangladesh HKI home-garden project, the income value of home-garden production increased from 14 % of average monthly income to 25 % after taking into account purchased fruits and vegetables (Marsh, 1998). A study of urban home-gardens in the Philippines revealed that home-gardening families spend less on food than non-gardening families, while home-gardening families who plant a larger number of varieties of fruits and vegetables spend even less on (Miura, 2003).

2.3. Empirical studies

2.3.1. Income role of agroforestry

According to the (Hoogerbuugge, 1993), traditional home-gardens agroforestry can increase to household income in several ways, primarily used for subsistence purposes by people's livelihood; as they are increasingly being used to generate income, importance especially during climate related shock happen and improves family financial status can be used to buy food, cloth etc. Agroforestry species composition, diversity and interaction leads to greater functional and structural complexity as compared to non- traditional home- garden agroforestry.

Research findings from South Africa agroforestry fruit trees show, fruits play an important role especially during times of famine and other stress as food, nutrition and cash income (Akinnifesi et al.

2008). All other components of home-garden in the study area help the same as what a fruit tree does in one way or another. According to Scherr (1995), rural households' survival strategies encompass multiple objectives in maximization of utility, like provision of food, and subsistence goods, cash for purchase of goods, services and saving for future needs, while environmental or other shock happens; in which HGAF can do. A study in Zambia showed that some products from home-gardens agroforestry, particularly fruit and cabbage are important buffers during drought years (Alfred 2009) and consistent with this study.

Agroforestry practices have great roles to play in the livelihood of the farming community because of its multiple benefits. Some of the benefits are income generation, food, fuel, construction material, fodder and shading from shade loving crops like coffee, and amenity value. These multiple benefits of the system make it more desirable than other land use and maximize the income generating. Home garden agroforestry plays a vital role in contributing to people's livelihoods. Maroyi (2009) reported that home garden agroforestry improves the family's nutritional status, health, and food security. Agroforestry home-gardens therefore, is part of a people's livelihood strategy and has gained prominence as a natural asset through which sustainable use of resources, particularly for the livelihoods of the poor, may be achieved.

2.3.2. Farmer's perception on climate change and variability

Climate change is the primary environmental issue today and will continue so in the future at a global level. Climate variability will certainly have an effect on sustainable development of biodiversity, water, forests, land and oceans as well as in relation to various sectoral activities (WMO, 2010). The high vulnerability of people in developing countries particularly in Africa to climate variability and or change is ascribed largely to their low adaptive capacity, which results from deteriorating ecological resources, unequal land distribution, extensive poverty and high reliance on the natural resource base (Elisha et al., 2010).

Farmers' perceptions about climate change strongly affect how they deal with climate induced risks and uncertainties, and undertake specific measures by coping strategies to mitigate the adverse impact of climate change on agriculture. Most farmers in Africa perceive the increased temperature and declined precipitation. In line with this, the majorities of the farmers in Ethiopia is aware of climate change and perceive an increase in temperature and decrease in precipitation. However, the perception of climate change is shaped by varying cognitive structures caused by socioeconomic and cultural differences that expose people to differing attitudes, values and interests (Hausken, 2004).

In most parts of Ethiopia, people perceive a decline in rainfall and an increase in the frequency of drought but this is not confirmed from the weather station. Lack of congruence could be due to the fact that farmers' assess rainfall in relation to the needs of particular crops at particular times; small changes in quality, onset, and cessation of rain over days or even hours can make a big difference, whereas meteorological data is more likely to measure totals and larger events. Maddison (2006) also argued that this lack of congruence between farmers' perception and meteorological records could emanate from the analysis of short term climate data and/or due to averaging of record from wider areas.

Perception level towards climate change is differ by sex, education level, age and farming experience, agro ecology and many other factors. According to Norris, 1987 educated persons are assumed to be more perceived than uneducated because education is associated with access to information on climate change, improved technologies and consequences on productivity. Admassie (2004) also argued that female-headed households are often considered to be less likely to get information about new technologies and take risky businesses than male-headed households. More experience farmers have, the more likely they are to claim that temperatures have increased and the less likely they are to claim there has been no change. Deressa et al. (2010) indicated that farmers living in lowland areas are hypothesized to be more likely to have perceived climate change than the midlands and highlands. Because lowland areas are already hotter and a marginal change in temperature can be perceived more easily.

2.4. Conceptual framework

Climate change has a direct effect on the household livelihood components such as agroforestry systems, livestock, crops and human well-being through increasing farm sensitivity and reducing farm resilience. Introducing agroforestry as an adaptation strategy to the effects of climate change is expected to improve human and environmental to reduce household vulnerability to the impacts of climate change in parallel to increasing sustained agroforestry production, reducing and controlling soil loss, improving soil moisture content, enhance addition of important soil minerals and diversifying the income. The framework, therefore, emphasizes sensitivity and resilience components as the main variable for analysis in this research and it relates them to two main areas of interest notably climate change and agroforestry. In analyzing climate change, the framework focused on two climate components which are temperature and rainfall.

Agroforestry is defined by agroforestry components which include tree characteristics (size, species, stocking, and arrangement), livestock and crops. To analyse the sensitivity of households to climate change, natural and physical capital components were used. Variables for analysis included soil erosion intensity, tree and land resources for natural capital components and fuel-wood energy for physical capital components. The resilience of households will be analysed using agroforestry assets (crop yield per hectare, soil condition, trees, and livestock) and diversification of income.

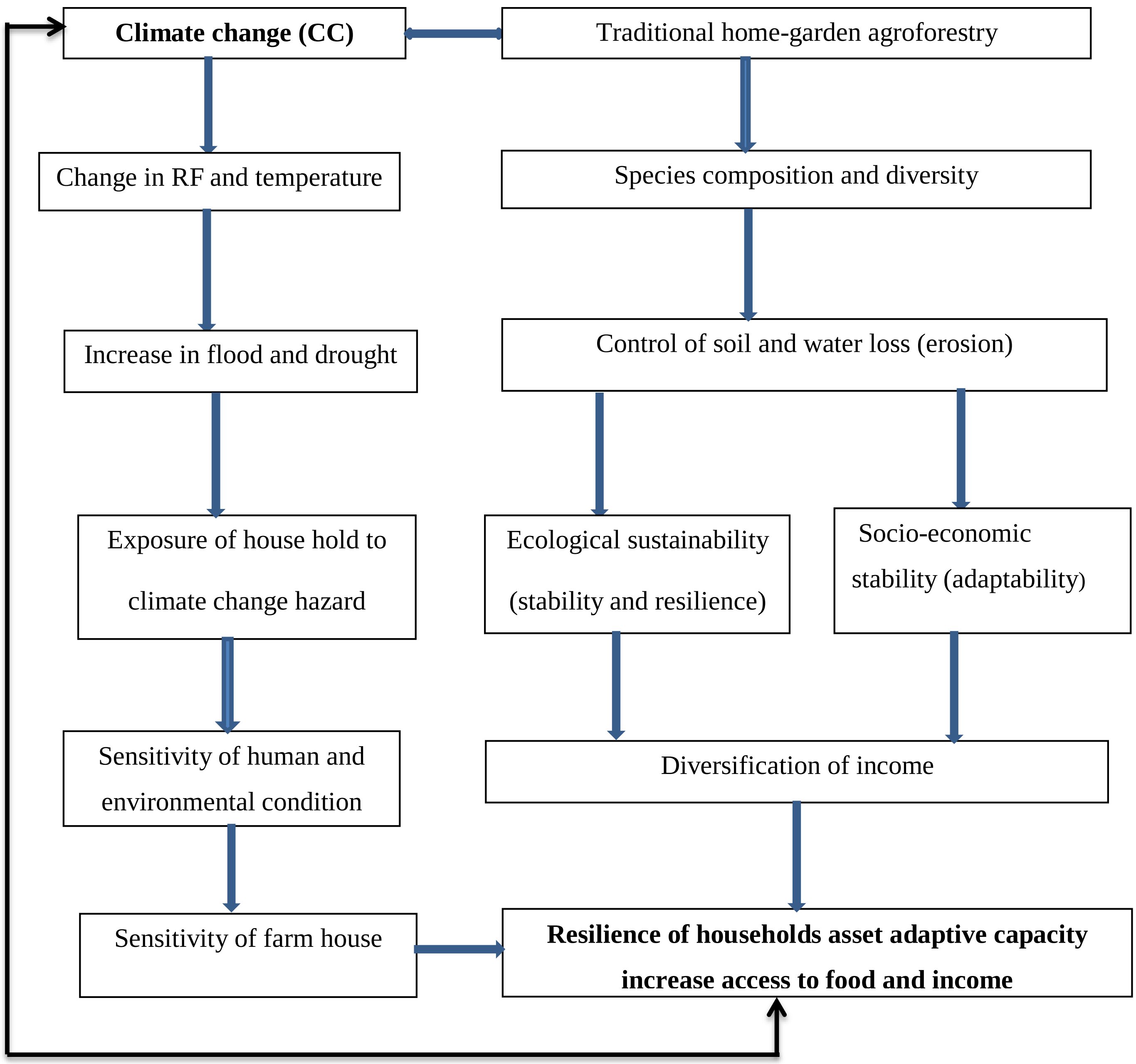

Figure3. Conceptual Framework of the Study (Turner et al., 2003)

CHAPTER THREE

RESEARCH METHODOLOGY

3.1. Description of the study area

This study was conducted at Hawassa Zuria district in Sidama Regional State of Ethiopia. It is one of the 36 districts of Sidama regional state. Its located at an altitude ranging from 1700 to 1850 m above sea level and roughly lies between 6^0 83 'to $7^0$17'N and $38^0$24'to $38^0$72 E. The Hawassa Zuria district shares boundaries with the Oromia region to the North and West, Lake Hawassa to the East and Boricha district to the South. Hawassa Zuria district is located 290 Km south of Addis Ababa. The District town, Dore-Bafano is located approximately 20 km west of Hawassa, the capital of Sidama National Regional State. Hawassa Zuria district has 23 Kebele administrations (KAs).

The district has a total population of 124,472, composed of which 62,774 are male and 61,698 female. The annual mean maximum and minimum temperatures are 27 °C and 12 °C respectively, and the mean annual rainfall is 1015 mm. In terms of traditional agro-ecology classification, categorized under Dry Woina - Dega (Sub-humid weather) and the area is characterized by bimodal rainfall pattern, i.e. belg (small rainy season that extends from March to May) and kiremt (main rainy season, extends from June to the end of September).

The size of the district is 22,643 ha. Lake Hawassa is the main water resource for fishing and vegetable production. Agriculture in the study area largely depends on rain-fed and crop-livestock mixed farming systems are commonly practiced. Maize, Haricot bean and Enset are the main staple crops mainly grown for multipurpose uses such as for food, animal feed, to construct traditional houses (HZDOA, 2020).

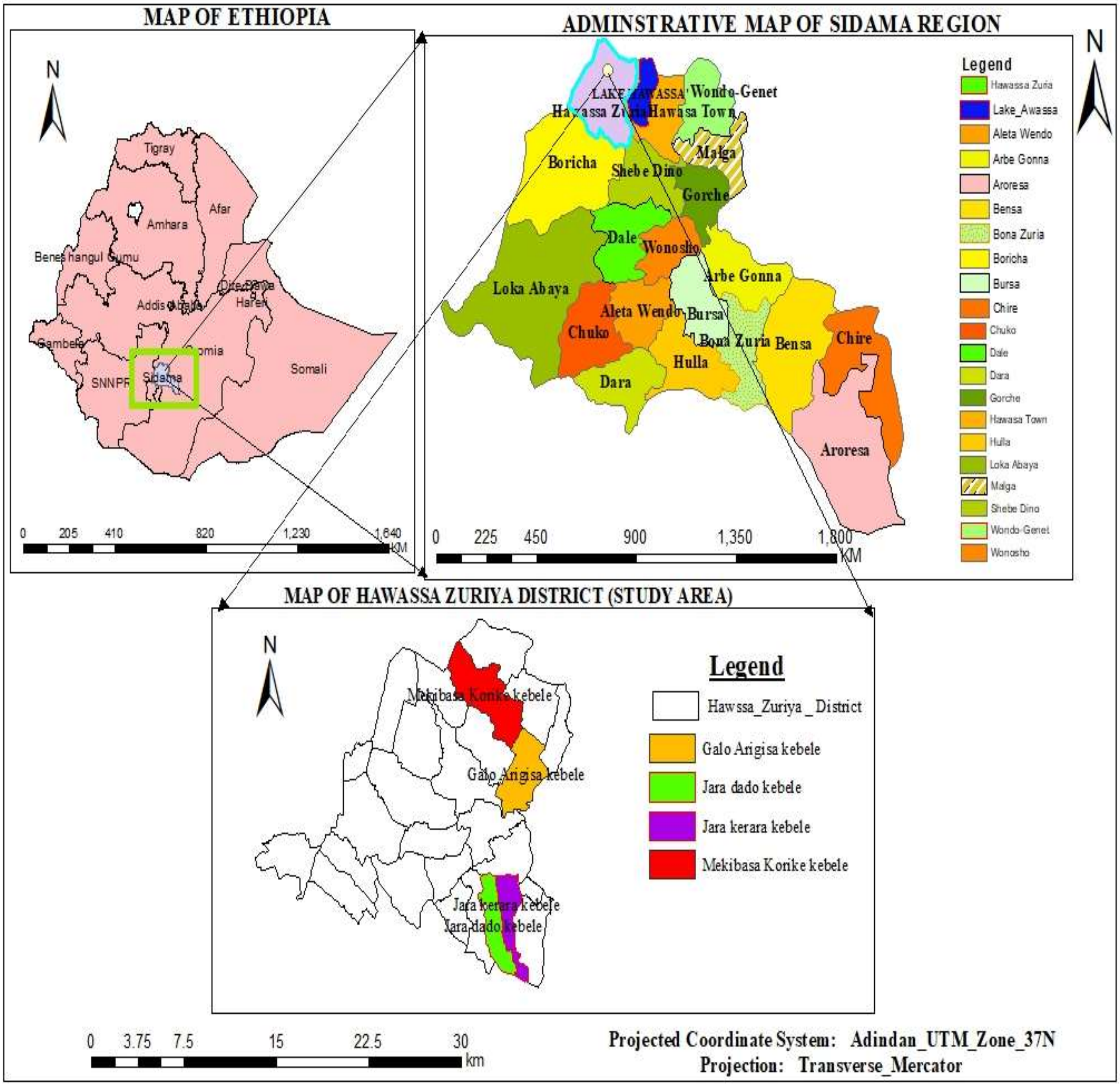

Figure4. Map of the study area (Source: Ethio-map-shape file 2020)

3.2. Research design and approaches

The study used a cross-sectional survey research design as its framework to guide the process of data collection. Because it involves collection of data mainly using questionnaires or structured interviews to capture quantitative or qualitative data at a single point in time. In this cross-sectional survey research design, interviewing individual farm households and selected key informants (KII) as well as conducting a form of focus group discussion (FGD) were employed.

This research was designed in a mixed approach (i.e. both quantitative and qualitative research approaches). Quantitative research approaches involved collection of quantitative data at the same time, presenting a visual picture of the procedure in the study area. While qualitative research approaches involved the collection of qualitative data. Qualitative data focused on collection of qualitative data from feelings and expression of focused group discussion (FGD) and key informants interview (KII) about the importance of traditional home-garden agroforestry to income generation in light of climate change in Hawassa Zuria district. Qualitative data aims at quantifying the data obtained from primary household survey and secondary data from the income of the respondents.

3.3. Sampling and sample size selection methods

3.3.1. Sampling methods

A multistage sampling method was used. First purposive samplings were used to select Hawassa Zuria district because the district is highly susceptible to climate change and agroforestry has been implemented to overcome the primary and also the proximity of the district for the researcher. Purposive sampling techniques were also adopted to select four Kebeles from traditional home-garden agroforestry area and non- traditional home-garden agroforestry area. Second, the stratified sampling techniques were used to identify the traditional home-garden agroforestry from non-traditional home-garden agroforestry areas. Finally, simple random sampling techniques were used to identify study samples.

3.3.2. Sample size selection

The sample size was determined by using a simplified formula, suggested by Yamane (1967), with 6 % level of precision. By using this formula, the study used 134 traditional home-garden agroforestry beneficiaries and 134 non-traditional home-garden agroforestry beneficiaries. In total, 268 sample households were interviewed.

$$n = \frac{N}{1+N\,(e^2)} \qquad n = \frac{7590}{1+7590\,(0.06^2)} = 268$$

Where n = sample size

N= total households

e = level of precision 6 %

Table 1. Distribution of sample to each rural Kebele administration (RKA's)

Name of sample Kebeles	Total population Male	Female	Total	Total HHs	Total sample
1. Jara-Karara	4212	4150	8362	2140	76
2. Jara-Dado	4890	5094	9984	2210	78
3. Galo-Argisa	2450	2503	4953	1540	54
4. Makibasa-Korke	3120	3522	6642	1700	60
Total	**14672**	**15269**	**29,941**	**7590**	**268**

Source: own survey (2021) HHs = Households

3.4. Data types and sources

In this study, both primary and secondary data were used. The primary data sources were male and female respondents, Key informants interview (KII), focus group discussion (FGD) and also data on the income of households from both traditional home-garden agroforestry and non-traditional home-garden agroforestry sampling units. Secondary data was collected from documents reviews, websites and internets, journals, published and unpublished materials.

3.5. Data collection methods

3.5.1. Household survey

Two professional (Diploma level) enumerators and one researcher total 3 people were recruited and trained on the contents of the questionnaire and interviewing techniques. The questionnaires were pre-tested to make changes on the questionnaire before the enumerators started the actual interviewing at each sample household level. Then, the primary quantitative data were collected under close supervision of the researcher and his assistant. Secondary quantitative data on population and households of Kebeles, traditional home-garden agroforestry (THAF) beneficiaries and non-traditional home-garden agroforestry (NTNAF) beneficiaries' lists were obtained from Hawassa Zuria district office of agriculture and natural resources management.

3.5.2. Focus group discussion (FGD)

For this study a total of four focus group discussions (FGDs) were selected purposely. One FGD was conducted in each Kebeles having 8 household head community leaders in each group. The FGD is mainly focused on collecting information in relation to traditional home-garden agroforestry against non-traditional home-garden agroforestry systems to household's income generation and farmers' perception on the role of home-garden agroforestry in reducing the effects of climate change.

3.5.3. Key informants interview (KII)

The researcher has selected 32 key informants, which included 8 DAs, 8 officials from the district office of agriculture and natural resources management and 16 elders (4 elders from each Kebeles) from community members. The discussion was proposed at evaluating the contribution of traditional home-garden agroforestry to income generation as well as their perception on the understanding of climate change in Hawassa Zuria district.

3.6. Method of data analysis

Data from the field was edited, coded and checked to ensure consistency, uniformity and accuracy. Qualitative and quantitative data sets were entered into computer software analysis. Then, it was analysed using appropriate statistical analysis procedures. Statistical Package for Social Science (SPSS, 2002) version 20 was used for the analysis. Descriptive statistics such as mean, standard deviation, percentage, frequencies, crosstabs and tables were used. Chi–square test and independent t-test were used to compare mean differences between categorical variables.

3.7. Dependent and independent variables

3.7.1. Dependent variables

Income generation (Incom Gen): Traditional home-garden agroforestry and non-traditional home-garden agroforestry income generated from the sale of timber, firewood, poles, fruits, vegetables, livestock, and crops. This was measured in the form of Ethiopian Birr ($). This is a continuous variable and expected to be a positive sign for the farmers. In this study farm income is expected to positively affect the probability of using improved agroforestry species composition and diversity.

3.7.2. Independent variables

Age of household head (Age): is a continuous variable and reflects the stage of life of the household head. Age of the household can also be used to capture farming experience. Age of the household increases, the person is expected to acquire more experience in weather forecasting and that helps increase the likelihood of practicing different adaptation strategies to combat climate change (Workneh, 2007).

Sex of the household head (Sex): it is a dummy variable, which takes a value of 1 if the household is male and 0 if female. Men dominate agroforestry management activities more than women due to their bigger responsibility to earn a living for their families (Sunward, 2010)

Educational level of the household heads (Edu): is a continuous variable which reveals the level of formal schooling completed by a household. Higher levels of education are believed to be associated with access to climate change and agroforestry information on improved technologies (Yohannes, 2009).

Total family size (TFS): It is a continuous variable that refers to the number of family members of a given household. Large number of family members can adopt the effect of climate change easily. Therefore, it was expected that household size has a positive sign for the farmers' who are using adaptation methods to climate change (Yirga, 2007).

Farming experience (FE): it is a continuous variable; a household with longer farming experience is expected to have better competence in assessing the potential benefits of new agroforestry technology than households with shorter farming experience (Basamba et al., 2016).

Farm size (FS): Land shortage is among the hindering factors in production to rural communities. This refers to the total arable farmland that a household owns measured in hectares (Getahun, 2012).

Frequency of extension contact (FAEC): This variable measures the number of contacts per year that the respondent makes with the development agent. The higher the linkage between households and development agents, the more the information flows on agroforestry technological transfer and have better knowledge on the effect of climate change, and thereby accelerate resilience to the impact of climate change. Households with access to formal agroforestry extension are better adapted to climate change (Deressa et al., 2010).

Access to climate information (ACI): It is a dummy variable. This variable measures whether farmers have access to climate information or not. Farmers getting information about seasonal forecasts and climate change, the probability of using different adaptation measures.

Access to credit service (ACS): It is a dummy variable. Availability and accessible credit facilities to farmers enhance agroforestry production improvement by easily accessing the required inputs at right times. Credit can be used for the farmers to introduce new agroforestry technology to buy suitable agroforestry trees and fruit seedlings and other inputs. The availability of credit is important for the farmers in order to make adaptation strategies (Nabikolo et al., 2012)

Table 2. Expected signs on how the explanatory variables will influence on traditional home-garden agroforestry and adaptation to climate change

Explanatory Variables	Definition	Measure	Expected Sign
SEX	Sex	Dummy, takes the value of 1 if male and 0 otherwise	±
AGE	Age	Continuous	±
FAMSIZE	Family size	Continuous	±
LEDUC	Educational level of respondent	Continuous	+
FREXP	Farm experience of respondent	Continuous	+
FLDSIZE	Farm land size(ha)	Continuous	+
ANNUALLINC	Annual income	Continuous	+
EXTSERV	Access to Extension services	Dummy	+
ACCRSRV	Access to credit service	Dummy	+
LVTKOWSHP	Livestock ownership	Continuous	+

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1. Demographic Characteristics of Respondents

Sex of Respondents

The majority 86.2% of the total sample householders were male, while the remaining 13.8% were female. From the respondents, 88.1% of the beneficiaries from traditional home-garden agroforestry and 84.3% from non-traditional home-garden agroforestry were male headed households, while the reimaging 11.9% and 15.7% of the respondents were female headed households (Table 4). The survey result indicated that the relation of sex of household head and household's decision on beneficiary of traditional home-garden agroforestry was not significantly different, showing that being male or female has not influence on for the adoption of traditional home-garden agroforestry in the study area.

The study also revealed that men dominate the agroforestry management activities more than women. This was in line with the results reported by (Sunward, 2010) who studied gender analysis in agroforestry management activities about household income in which men have a greater outpouring of work time than women in agroforestry management activities due to their bigger responsibility to earn a living for their families.

Level of education

The survey results of the sample households indicated that the majority of traditional home-garden agroforestry beneficiary households were relatively well educated compared to non-traditional home-garden agroforestry beneficiaries. About 67.2% and 18.7% of the households who are practicing the traditional home-garden agroforestry attended primary and secondary schools respectively, and the remaining 14.1% of the traditional home-garden agroforestry have college Diploma (Table 3). On the other hand half (50%) of the non- home-garden agroforestry household attend primary education while the other half cannot even read and write. These results suggest that education could be considered as a factor that determines the rate of adoption of traditional home-garden agroforestry in the study area. From these results one can understand that beneficiaries of traditional home-garden agroforestry were better educated compared to non-traditional home-garden agroforestry because of low awareness of the importance of home-garden agroforestry.

The chi-square analysis also indicated that levels of education had significant ($p< 0.05$) association with adoption of traditional home-garden agroforestry (Table 4). This result is similar to a finding reported by (Yohannes, 2009) stating that households who were well educated adopt agroforestry more quickly than those who were less educated and that knowledge related to agroforestry management and hence, they adopted the technology better than less educated households. The higher the education levels of the head of a household the greater the chance of positive decision-making about agroforestry adoption.

Table 3. Demographic Characteristics of Respondents

Variables		THGAF (N=134)		NTHGAF (N=134)		Total (N=268)		Chi-square	p-Value
		N	%	N	%	N	%		
Sex	Male	118	88.1	113	84.3	231	86.2	0.784	0.054 *NS
	Female	16	11.9	21	15.7	37	13.8		
Level of education	Can’t read and write	0	0	67	50	67	25	195.17	0.000* Sig
	Primary	90.25	67.2	67	50	92	34.3		
	Secondary	25	18.5	0	0.0	90	33.6		
	College diploma	19	14.2	0	0.0	19	7.1		

*Sig (significant $\alpha = 0.05$)

Age of Respondents

The average age of the household for both traditional home-garden agroforestry and non-traditional home-garden agroforestry beneficiaries was 38.72±1.12 years with the range between 22 to 81 years. The mean age of traditional home-garden agroforestry and non-traditional home-garden agroforestry own respondent was 35.53 ±1.029 and 41.91± 1.211 years, respectively. The statistical analysis showed that there was a significant difference between the mean age of traditional home-garden agroforestry and non-traditional home-garden agroforestry (Table 4). These results indicated that when the age of households increased, the level of adoption for new technology decreased. In agreement, similar results have been reported by (Workneh, 2007) who showed that as the age of respondents increase, the adoption of improved technologies decreases. This is because young peoples are fast and near in acquiring more knowledge for technology than elders.

Aging farmers were more likely to increase production based on traditional agroforestry practices for reasons related to knowledge and experience and young farmers were more likely to use the new technology to gain more profit. On the other hand the age of the household head increases, the person is expected to acquire more experience in weather forecasting and that helps increase in likelihood of practicing different adaptation strategies to combat climate change. This might be attributed to the experience of older farmers perceiving changes in climatic attributes.

Family size of the household

The survey results showed that the average family size of traditional home-garden agroforestry beneficiary and non- traditional home-garden agroforestry households were 3 and 5, respectively. The average family size of the non-home-garden agroforestry own a household was statistically greater than the average family size of home-garden agroforestry owned by two persons (Table 4).

The minimum family members of a household were one person while the maximum members of a household were eleven persons. Household labor measured by total household size positively and statistically influenced adoption of agroforestry (P= 0.000). In one hand, it is argued that a larger household size enables the adoption of technologies by availing the necessary labour force (Croppenstedt et al., 2003) and on the other hand, enabling the generation of additional income from extra labor invested in off-farm activities (Yirga, 2007). It is expected that farmers with larger household size are further likely to increase income and adopt agroforestry practices than farmers with smaller household size.

Farming experiences

The average farming experience of a household was 19.11± 7.6 years (ranging from 1 to 41 years). The majority of respondents in the study area were already identified as they belong in the productive age category (Table 4). This results revealed that the mean traditional home-garden agroforestry own households were 19.83 years, which is relatively more experienced in farming than non-traditional home-garden agroforestry own households 19.21 years, despite the two groups was significantly ($p<0.05$) differ (Table 4). More farming experience increases awareness of climate change impacts because farming experience is more likely to respond to climate change events by using various adaptation measures.

Similar to farming experience, experience of agroforestry was also found higher in traditional home-garden agroforestry farmers as compared to non-home-garden agroforestry farmers. Similar results have been reported by Basamba et al., (2016) hence, it shows that the total experience of the farmers in terms of agroforestry matters in its adoption. No experience acts like a barrier in agroforestry and farmers with almost no agroforestry experience do not prefer to adopt agroforestry as they find it more risky to invest or adopt such practice in which they are not experienced. Therefore, farmers with high experience are more likely to perceive climate change.

Table4. Demographic Characteristics of Respondents by different variables

Variables	Garden type	N	Mean	Min	Max	SD	t-value	P-value
Age	THGAF	134	35.53	21	90	1.029	4.008	0.000*Sig
	NTHGAF	134	41.91	23	72	1.211		
Family size	THGAF	134	3.0	1	10	1.605	5.199	0.000*Sig
	NTHGAF	134	5.0	1	11	1.949		
Farming experience	THGAF	134	19.83	1	41	9.1460	8.01	0.000*Sig
	NTHGAF	134	19.21	1	34	6.1032		

* Sig (significant $p<0.05$) and *NS (non-significant $p>0.05$)

4.2. Socio-economic status of the respondents

Access to Credit service

The availability of credit is important for the farmers' in order to practice adaptation strategies. Credit can be used for the farmers to introduce new agroforestry technology to buy improved crop seeds, agroforestry trees and fruit seedlings, fertilizers and oxen. Therefore, this was expected to be a positive sign for the farmers' who are using adaptation methods to climate change.

Regarding the presence of credit access for the farmers 71.6% of traditional home-garden agroforestry and 21.6% non- traditional home-garden agroforestry households said that there was access for credit services in the study area. Whereas, the remaining 28.4 % of traditional home-garden agroforestry and 78.4 % of non-traditional home-garden agroforestry said that there was no access for credit services in the study area. About, 27.1% of home-garden agroforestry and 62.1 % of non-agroforestry households received the credit from Omo micro-finance institutions and the remaining 34.7% of traditional home-garden agroforestry household and 37.9% of non-traditional home-garden agroforestry household had received credit from Sidama micro-finance institution in the study area (Table 5).

The district is affected by climate change impact, flooding and irregularity of rainfall during major rainy seasons. For this reason, different financial institutions in the study area provided incentives in one way or another in order to encourage the farmers to adopt the home-garden agroforestry technologies. The percentage of farmers who received credit was (46.6%) far less than the percentage of farmers (53.4%) who did not receive credit. This shows that from 268 respondent's 125 households receive credit service and remaining 143 respondents do not receive credit services. For this reason, the majority of farmers find it difficult to buy new adaptation agroforestry technologies and other important inputs.

The statistical analysis showed that there was no significant and no positive relationship between access to credit and affected adoption of home-garden agroforestry practices in the study area. Adaptation methods to climate change need money to purchase improved inputs such as fertilizer and improved seeds. The result of similar findings reported by (Deressa, 2009; Di Falco., 2011) the absence of sufficient credit, it might be difficult for farmers to adopt any adaptation strategy, even when informed on climate change, as they might not be able to purchase the requisite inputs.

Land size and land ownership

Land is an important economic resource for the development of rural livelihoods. Regarding land ownership, all (100%) of both traditional home-garden agroforestry and non-home-garden agroforestry practices had land. As we can see from (Table 5), 72.4% of the respondents owned less than 0.4 hectares of land and only 27.6% of the respondents had a farm size of more than 0.4 hectares. Farm size may also be associated with greater wealth and it is hypothesized to increase adaptation to climate change. Whereas, some literature on adoption of agroforestry technologies indicate that farm size has both negative and positive effect on the adoption of technology.

The shortage of land is basic problem in the study area to maximize agroforestry production through intensification and which is in line with the study by (Getahun, 2012) who revealed that the average land holding in the area was 0.431 hectare and he suggested that land shortage is a basic problem that resulted in small scale production on fragmented and degraded land. Farmers with more land tend to have a lot of fallow lands that they can easily allocate to tree planting and therefore will show more interest than those with low land holding.

Extension service

Extension service in the study area offers a multitude agroforestry activities such as training, advisory and techniques of input supply etc. These activities have a direct impact on the attitudes and decisions of farm households. Agroforestry extension service is statistically significant at less than 1% significance level and consistent with the prior expectation it is positively associated with the income from agroforestry practice. Based on the survey result (Table 5), the farmers who have access to agroforestry extension services were 76.1% and 23.9% who have no access to extension service for both farmers groups.

As it is to be, extension services are not only important to expand the knowledge and skills of farmers to increase income, but also it is a means to deliver the message that comes from research centers and development agencies that enables the implementation of the technology. Information communication technologies (ICTs) such as mobile phones, texting, conference calls, computer, internet, email, etc., are increasingly being used in extension services. The ICTs are effective in reaching a large number of users in a short time (Aker, 2011).

An extension worker should acquire knowledge and spread these technologies and the knowledge to use them among local people. This result is also similar with the finding by (Deressa et al., 2010) lack of agroforestry extension services to farmers lead to poor knowledge of agroforestry farming practices that leads to low yields hence, food insecurity. Moreover, the majority of rural people depend on the surplus farm produce that they sell to get income for other needs. Therefore, failure of farm produce may lead to low income earnings for agroforestry beneficiaries.

Table 5. Socio-economic status of the respondents

Variables	Response	THGAF (n=134)		NTHGAF (n=134)		Total (n=268)		Ch.-square	p-Value
		N	%	N	%	N	%		
Farm size owned by respondents	0.1-0.4 ha	92	68.7	102	86.2	194	72.4	27.51	0.000
	0.4-0.6 ha	35	26.1	27	20.3	62	23.1		
	0.8-1.0 ha	7	5.2	5	3.7	12	4.5		
Credit access	Yes	96	71.6	29	21.6	125	46.6	32.59	0.000
	No	38	28.4	105	78.4	143	53.4		
Source of credit service	Omo-m-finance	62	27.1	18	62.1	80	64	16.13	0.000
	Sidama m-finance	34	34.7	11	37.9	45	36		
Availability of extension services for AF practices	Yes	124	92.5	80	59.7	204	76.1	39.74	0.000
	No	10	7.5	54	40.3	64	23.9		
Types of extension services delivered	Advisory	43	32.1	23	17.2	66	24.6	23.42	0.000
	Training	24	17.9	35	26.1	59	22		
	Input supply	67	50.0	76	56.7	143	53.4		
	Total	134	100	134	100	268	100		

Highly significant (P-value=0.01), Significant (P-Value < 0.05), Not significant (P-Value>0.05).

4.3. The role of traditional home-garden agroforestry against non-agroforestry systems to household's income generation.

4.3.1. Income role

In this section comparing income level between traditional home-garden agroforestry against non-agroforestry beneficiary at study area. Based on the survey results, the average income of households who own traditional home-garden agroforestry and non-traditional agroforestry beneficiary, mainly originated from selling of different agroforestry products were 4,677.71±1985.04 and 2,627.79± 1095.02 Birr, respectively. The independent t-test analysis indicated that there was significant difference between the traditional home-garden agroforestry and non-agroforestry households' income level at 5% probability level with t-value 13.837.(Table 6). This result shows that traditional home-garden agroforestry was better and made a big difference on average (2,049.92 Birr) than non-agroforestry beneficiaries.

Comparative analysis between study area traditional home-garden agroforestry earned an average extra income than non-agroforestry participants. Agroforestry improves farmers' income in a number of different ways. These differences in incomes between farmers from different study areas can be contributed to factors such as, agroforestry practices adopted, number or type of trees species and crops established and sold, markets price of agroforestry products, land size, age of the trees and bargain power of farmers (Garrity, 2006).

The study also revealed that different species grown in the home-garden give different functional roles for the household. This is associated with high diversity in agroforestry that leads increase production throughout the year, reduce exposure of household to climate change hazard, requires relatively low labor input which can be covered by the members of the household, provide immediate fresh food for sale and household consumption, reduces cost of purchasing fertilizer, use of fruits to reduce frequency request for meals and avoid hunger especially for children. Agroforestry beneficiary households with more income, have a higher ability to cope in case of climate shock and decrease sensitivity farm households than non-agroforestry beneficiary households (Krishnal, 2012).

According to the (Hoogerbuugge and Fresco, 1993), traditional home-gardens agroforestry can increase to household income in several ways, primarily used for subsistence purposes by people's livelihood; as they are increasingly being used to generate income, importance especially during climate related shock happen and improves family financial status can be used to buy food, cloth etc. Agroforestry species composition, diversity and interaction leads to greater functional and structural complexity as compared to non-tree based gardens. Surveyed households admired home-garden agroforestry to reduce exposure and sensitivity of farm households to climate change hazards in the study area. Home-garden agroforestry provides fuel wood source which leads to less farm crop residual biomass removal, less dependence on animal dung for fuel and minimum investment of money for organic fertilizer than non-tree based agroforestry.

Agroforestry systems play a critical role increase income by moderating the microclimate, highly effective in soil and water conservation through provision of permanent cover, to provide economically viable and environmentally friendly means to improve soil fertility and potential to limit carbon emissions and sequester carbon as compared to non-agroforestry systems (Hughes, 2007).

In contrast, comparative analysis between study area non-agroforestry participants earned lower income (2,627.79±1095.02 Birr) than agroforestry participants (4,677.71±1985.04 Birr). Non-agroforestry garden covered by cereal/cash crop, those species are maize, sweet potato, hair coat bean and chat. This indicates the frequency of cereal crops recorded out of the 134 interview respondents in each village.

Comparing from home-garden agroforestry, non-agroforestry system is increase sensitivity human and environmental condition, exposure more households to climate change hazard, increase flood and drought, less diverse species, production is once, rarely 2 times (irrigation), households wait until the food is cook, time wasted, less labor cost, use chemical fertilizers (Incurs cost), involvement in coffee ceremony is limited to relatively well-off households, and relatively higher frequency of request for meals 3 to 5 times/day (Krishnal, 2012).

Non-traditional home-garden agroforestry majority of the respondent harvests crop residuals for livestock feed and fuel wood, which reduce soil fertility. Therefore, the overall soil fertility maintenance, soil moisture conservation help the crops to be grown, not to wilt when rainfall variability happens for one/two weeks. In fact, returns to land labour are often higher for home-gardens than non-agroforestry households (Marsh, 1998).

Hence, traditional home-garden agroforestry is among the best solutions for people's livelihoods, socio-economic stability (adaptability), ecological sustainability (resilience), control of soil and water loss (erosion), food security and income generation to smallholder farmers due to their diversity. The higher the income a household has the more resilient it is, then more household's asset adaptive capacity increases access to food and income.

Table 6. Comparing home-garden agroforestry against non-agroforestry systems to household's income generation in study area

Garden type	N	Sum (Birr)	Average (Birr)	Standard deviation	Mean difference	T-value	Sig(2-taild)
Home-garden Agroforestry	134	626,81	4,677.71	1985.03	2049.9	10.467	0.000 *Sig
Non-home-garden Agroforestry	134	352,12	2627.798	1095.02			

Source: Own field survey (2021)

Comparing income level between in each Kebele

Households in the study area at kebele level generate income from different home garden products. Income between the garden types in Jara-Dado kebele was significantly higher because of the high agroforestry potential in traditional home-garden agroforestry households (5,162.49 Birr) than non-home-garden agroforestry (2,194 Birr) annually (Fig 3). On the other hand, the remaining three kebeles Galo-Arigisa, Jara-Karara and Mekibassa-Korke 4,636.29, 4,415.41 and 4,396.50 Birr for home-garden agroforestry average income level, respectively, and Mkibasa-Korke, Glo-Argisa, Jara-karara and Jara-Dado 2,907, 2,609, 2,507.8 and 2,194 Birr for non-home-garden agroforestry, respectively (Fig 3),

In each kebeles different income level from one to another for example, Jara-Dado, Galo-Argisa, Jara-Karara and Mekibasa-Korke by ascending order better income by agroforestry potential and Mekibasa-Korke, Galo-Argisa, Jara-Karara and Jara-Dado by ascending order better for crop production for non-agroforestry beneficiary (Fig 3), this indicate that home-garden agroforestry plays a great role in generating additional income and contributes to the livelihood of smallholder farmers in the study area than non-agroforestry because of traditional home-garden agroforestry supporting people's livelihood in many diverse ways, including provision of food, fuel wood, building materials, and fodder for livestock and income.

The quantity of agroforestry home-gardens production that actually gets sold is highly variable, differing from income one household to another, home-gardens agroforestry also can solve the problem of land scarcity by using a small land the households have by integrating various components in the same piece of land hence, food security and income generation (Devandra and Thomas, 2002).

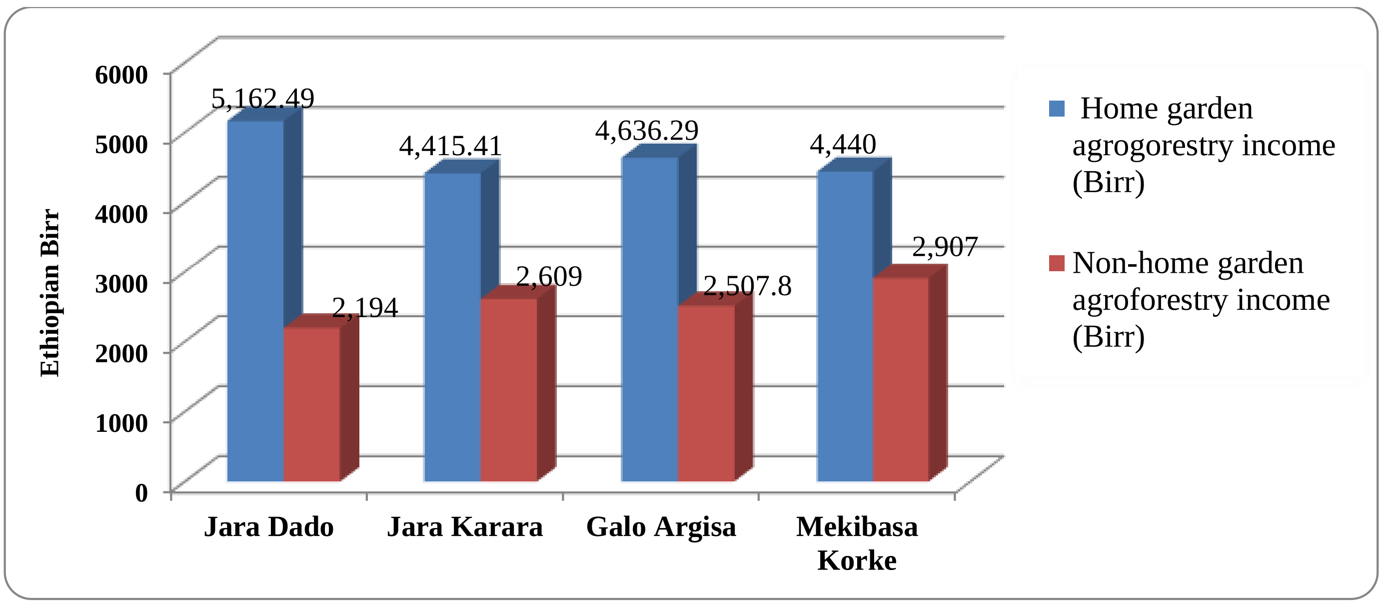

Figure 3. Average annual income at kebele level traditional home-garden agroforestry and non-traditional home-garden agroforestry in Ethiopia Birr.

4.3.2. Agro-ecological role of agroforestry as a means of sustainable income

Focus group discussion (FGD) and key informant interview (KI) in the study area agree that agro-ecological role of agroforestry systems helps as a means of ecological sustainability (stability and resilience), control of soil and water loss (erosion), enhance fuel-wood production and managing hazards through timber and fruit sales for sustainable income generation for smallholder farmers.

Focus group discussion (FGD) and key informant interview (KI) also agreed agroforestry plays a role not only in erosion control in the garden, but also gives three or four year soil fertility maintenance out of the garden/other farm field and saves soil moisture through composting. Compost not only gives soil fertility and moisture conservation, but also reduces the farmer’s fertilizer cost (could be invested in other economic activity like renting land to produce another crop), livestock manure, litter fall and compost was found rich in nitrogen and became a good fertilizer to maintain soil fertility, this increase agroforestry crop production and income (Alfred, 2009).

The multi-layered, forest-like vegetation structure of the studied home-garden in the area contributes substantially to the agro-ecological sustainability through reducing sensitivity of farm households and soil erosion. Research findings from the home-garden of Meghalaya, North-east India also confirms that multi-layered vegetation structure prevents soil erosion, provides habitat to soil microorganisms and promotes a favorable microclimate for the households (Tynsong, 2010). Fernandes and Nair (1986) also reported that the presence of a multi-layered structure of a home-garden is an indicator of ecological function through environmental protection and efficient use of resources (like sunlight).

The contribution of agroforestry to environmental sustainability is very significant through its environmental, socio-economic and social functions. Not creating a negative impact to the environment, while improving the production capacity of the soil. It is known for its ability to conserve natural resources at the same time as maintaining human activities. Traditional home-garden agroforestry households generally possess a better chance to cope with climate-related hazards such as drought and floods than non-agroforestry households.

4.3.3. Role of agroforestry in economic sustainability

In this section, agree and believe with focus group discussion (FGD) and key informant interview (KI) soil erosion is the main long term serious environmental problem that has adverse effects on the economy and hinder income in the study district. This has several environmental and economic impacts, especially in study areas where the resilience ability of soil is limited and obstacles in economic sustainability for both agroforestry and non-agroforestry farmers. Agroforestry systems provide economically viable and environmentally friendly means to improve soil fertility; hence, an agroforestry practice through the incorporation of woody perennial has the potential of mitigating the impact of soil erosion, through the incorporation of both the above and below tree biomass. Agroforestry is properly enhanced and placed in the right perspectives by all environmental stakeholders, this will help in addressing some issues of economic instability in the area.

Trees in agroforestry systems in the study area are known to provide fuel wood, food, shelter, drugs, income, raw materials and improvement of soil fertility for crop growth. As well as a wide range of environmental protection, the products and services forest products provide are essential to every aspect of life by Asinwa, (2012), who conducted a survey on the economics of some forest fruit trees playing an important role in socio-economic stability (adaptation), food security, employment and income generation.

This study was in line with the findings by Hoogerbuugge and Fresco (1993) that stated home-gardens can contribute to the household with cash crops as well as food crops. They are regarded as a source of income diversification and also play crucial, cultural and social roles in rural communities, and such contributions are in line with earlier studies by Fernandes and Nair (1986). Economically, complex agroforestry provides farmers with marketable and sustainable high value products such as fire wood, fruits, animal fodder, medicines, and high-grade timber. All of these products give economically sustainable income to the farmer (directly) and sustainable benefit to the country (indirectly). Through complex agroforestry the farmers will have the option which offers the potential to diversify their businesses. This is achieved through the integration of agroforestry production systems which can offer a number of advantages when compared to non-home-garden agroforestry.

4.3.4. Diversification of home-garden agroforestry as a means of high income

The survey result showed that annual average income from diversified agroforestry products was 4,677.71 Birr for traditional home-garden agroforestry households and 2,627.79 Birr for non-traditional home-garden agroforestry households (Table 7). Most diversified income was generated from selling crops which accounted for 32%, while the least income from selling vegetables accounted for 8.35% for both farmer groups. This result shows that the study area generated more agroforestry product crops, animals, trees, fruits and vegetables 32 %, 22 %, 19.25 %, 18.40 % and 8.35 % respectively (Table 7 and Fig 4). Diversified agroforestry product income was generated from the sale of tree/timber/poles, fruits, vegetables, livestock, and crops. On the other hand non-tree based agriculture products include crops, animals and vegetables.

The dominant income for a family in the study area comes from agroforestry fruits like mango, avocado and papaya trees 6,154 Birr and livestock products 4,926.22 Birr an average annually. A single avocado tree may provide thousands of Birr for a household when market value is high and fruits of the tree are better in production and buy market products daily to weekly basis from the avocado fruits. Diversification of agroforestry product income is a very important means for livelihood not only income generation but also for household consumption. This means a higher share for household consumption and remaining for income purposes. Agroforestry product income for each household was a summation of annual income from all agroforestry products and non-tree based agriculture products from a farm.

Dairy products and cattle are key for the livelihood of the farmers in the study area because they buy products from market income they get from livestock. Coffee is not significant to income but it serves for home consumption for those who have coffee trees. On the other hand non-tree based agriculture annual cereals like maize, hair-coat bean, animals and few trees as common agricultural products for mainstay of the livelihoods of the farmers in the study area that means 11,581 Birr earning income average annually (Table 6). Agroforestry product diversification of income is highly recognized by the farmers to satisfy growing demand of the family and some family members especially for home-garden agroforestry beneficiaries.

The household may sell products in the home-garden including fruits, vegetables, animal products and other valuable materials. The few households may use the home-garden site to conduct cottage industries to produce crafts or small manufactures that can be sold (Marsh, 1998). In addition to direct earning from sale of home-garden, products consumed by the household frees up household earning for other purchases. Urban home-gardeners in Papua New Guinea sell various fruits at local markets and obtain cash that allows them to purchase rice that produces several times the food energy of the sold fruits (Vase, 1985).

Thus, home-garden agroforestry products diversification provides households with a number of options by which they can satisfy their livelihood objectives and each household can determine for itself what combination of consumption, trade and sale of home-garden production best fits its livelihood strategy. The richer households tend to be more diversified and consider diversification as a means of increasing overall income. The high diversity of species in home-garden agroforestry, have a wide socio-economic and ecological roles including production of food and a wide range of other products such as firewood, fodder, spices, medicinal plants and ornamentals (Marten and Abdullah, 1988; Gliessman, 1990).

Agroforestry beneficiary households with more income, less sensitivity of farm households and have a higher ability to cope in case of climate shock than non-agroforestry beneficiary households. Therefore, traditional home-garden agroforestry is more resilient in terms of diversification of income sources than non-agroforestry beneficiaries.

Table7. Diversification of average income different agroforestry products in study area

Agroforestry product	agroforestry income	Non-agroforestry income	Sum of agroforestry and non-agroforestry	Percentage(%) from total income
Crops	5623.00	6098.00	11721.00	32
Animals	4926.22	2999.00	7925.22	22
Trees	4549.18	2484.00	7033.18	19.25
Fruits	6154.00	643.99	6797.99	18.40
Vegetables	2136.15	914.00	3050.15	8.35
Sum	23,388.55	13,138.99	36,527.54	100
Total average income	4,677.71	2627.79		

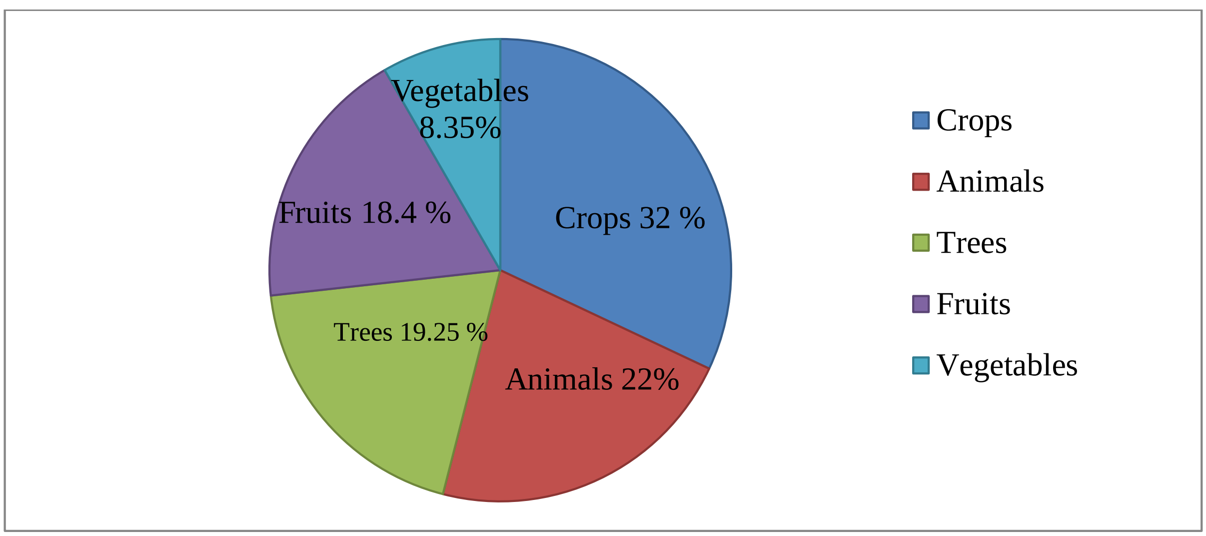

Figure 4. Comparison of agroforestry product in percentage at study area (2021)

4.3.5. Agroforestry components in study area

4.3.5.1. Tree component

All farmers in the study area had at-least three woody species on their farm which included coffee perennials, woodlots and farm trees. The average stocking of farm trees is six trees/ha with a minimum of 5-50 trees. In study areas trees provide timber, shade, fuel wood, building poles, fodder, improve soil fertility, conserve soil moisture and improve the microclimate of the area. Eleven woody species were registered in the study area (detailed list in Table 8), these included fruit trees, timber trees and multipurpose trees and shrubs. The largest farm tree recorded in the study area was *Podocarpus falcatus*, while the smallest tree was a citrus species with a *Mangifera mango.*

The tallest tree recorded on the other hand was *Eucalyptus camaldulensis* with a height of 20 m. The most frequent timber tree species registered was *Cordia africana*, which was registered in over 21 % of all households. It was planted all over the farm because of its functions for example poles for timber, leaves for manure and branches for firewood. It was also found in the household compound for shade. Other frequent timber tree species included *Grevillea robusta* 12%, which were mainly randomly planted in coffee plantations and on the farm boundary.

Certain species were more common in home-garden agroforestry households than in the non-home-garden agroforestry households. These were the tree species given by the home-garden agroforestry land such as *Cordia africana*, *Grevillea robusta* and *Acacia abyssinica* species. On the other hand non-home-garden agroforestry tree species include *Croton macrostachyus*, *Acacia abyssinica, Eucalyptus camaldulensis* and *Podocarpus falcatus* (Figure 8). Dominant tree species in the study area had a variety of functions ranging from provision for products such as fruits, firewood, fodder and services such as shade, nitrogen fixation, among others and fruit species like avocado, mango, papaya and enset on agroforestry farm land (Table 8).

On the other hand, traditional home-garden agroforestry farmers have a significantly higher number of trees and fruits per hectare than non-tree based agroforestry farmers, this increases income for agroforestry beneficiaries. Therefore, agroforestry households who had more trees on their land essentially had more income and natural capital than non-agroforestry households and hence, were less sensitive to climate variability.

Table8. List of tree and fruit species with the highest frequencies in study area

Species name	Botanical name	Uses	Species registered	Coverage (%)
Cordia	*Cordia Africana*	timber, fuel wood, shade	2102	21
Grevillea	*Grevillea robusta*	timber, fuel wood, shade	1210	12
Acacia	*Acacia abyssinica*	agroforestry, shade, fuel wood	603	6
Acacia	*Acacia albida*	agroforestry, shade, fuel wood	815	8
Croton	*Croton macrostachyus*	fuel wood, construction, shade	707	7
Eucalyptus	*Eucalyptus camaldulensis*	timber, fuel wood, construction	1000	10
podocarpus	*Podocarpus falcatus*	timber, fuel wood, construction	716	7
Enset	*Ensete ventricosum*	food, medicine and shade	1012	10
Avocado	*Persea Americana*	food, shade, fuel wood	811	8
Mango	*Mangifera mango*	food, shade,	600	6
Papaya	*Carica papaya*	food, shade,	507	5
Total			10,083	100

4.3.5.2. Livestock component

Of all households interviewed, both traditional home-garden agroforestry and non-traditional home-garden agroforestry households 56.3% and 43.7% had livestock. Six different types of livestock were identified in the study area and these included cattle, goats, sheep, chicken, and donkey. The most dominant livestock type in the study area is cattle, chicken and donkey 66.5%, 28% and 5.5% of all households respectively. The least common livestock types in the area are donkey 5.5% and ox 7.5% (Table 9 and Figure 5). Traditional home-garden agroforestry households had more livestock than non-traditional home-garden agroforestry because home-garden agroforestry has more fodder farm land and occupied perennial agroforestry farmers use cut and carry systems to feed their cattle.

Agroforestry also contributes significantly to savings on feed costs, higher survival and milk production (Nair, 1993). The presence of fodder trees has also a crucial role in increasing the number of livestock which are important assets during the time of crisis. Trees on farms provide shade to livestock which reduces the energy needed for regulating body temperatures and so results in higher feed conversion and weight gain. On the other hand non-home-garden agroforestry occupied an annual crop that is harvested on time and fed their livestock.

Devandra and Thomas (2002) reported that small-scale, resource-poor farmers own about 95% of the livestock in home-gardens. This implies that farmers with more livestock are richer and can respond to the adverse impact of climate change through adaptation methods. This is a continuous variable and expected to be a positive sign for the farmers' who were used to adaptation to climate change. Livestock is the most important asset for rural farmers in the study area. Farmers use livestock for different purposes including as a source of meat production, source of cash income in case of emergency, source of dairy production, means of transportation, and source of manures. Animals provide the farmer with a greater ability to deal with seasonal crop failure and other natural disasters.

Table9. Livestock type and number in study area

Animal species		Number	Home-garden agroforestry	Non-home-garden agroforestry	Percentage (%)
Livestock owners	Yes	134	134	134	100
	No	134	-	-	-
Cow		717	446	271	28.1
Calf and heifer		234	111	123	9.2
Ox		192	112	80	7.5
Sheep		230	105	125	9
Goat		326	156	170	12.7
Donkey		140	98	45	5.5
Chickens		716	411	301	28
Sum		2555	1439	1116	100
Percent (%)			56.3 %	43.7 %	

Source; own field survey (2021)

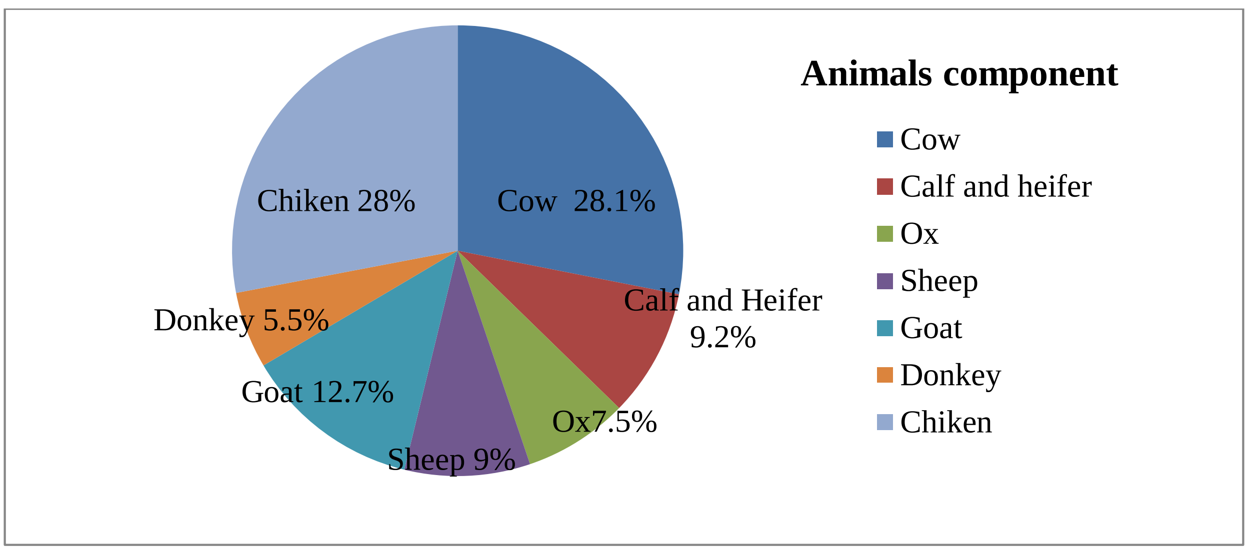

Figure 5. Livestock component share in percentage (%) in both traditional home-gardens agroforestry and non-traditional home-garden agroforestry system

4.3.5.3. Crop component

Both cash crops and food crops are grown in the study area. All respondent households cultivated at-least 6 types of crops mainly for subsistence and income use. Maize, haricot bean, enset, sweet potato, potato and chat comprised a list of major food and cash crops in the area. Farmers usually intercropped two food crops at a time like maize and haricot bean or enset with maize but in some cases, certain food crops such as sweet potatoes are cultivated as mono-crops particularly during the growing season. Other food crops included vegetables such as carrot, kale, tomato, and tuber crops. Diversification of crops in agroforestry systems was among the coping strategies used by farmers to support them during drought. Therefore, non-agroforestry households had significantly higher crop production than agroforestry households.

4.4. Contribution of traditional home-garden agroforestry to household’s income generation

In this section the researcher assessed the contribution of traditional home-garden agroforestry to a household’s income generation. To this end the researcher included different variables such as whether traditional home-garden agroforestry increased household income or not, importance of traditional home-garden agroforestry compared to other types of land use in enhancing income.

Regarding the increase of household income under traditional home-garden agroforestry, 94.8% and non-home-garden agroforestry beneficiary was 56% stated that traditional home-garden agroforestry increased their income compared to another type of land use, Whereas, 5.2% and of traditional home-garden agroforestry and 44% non-traditional home-garden agroforestry said that traditional home garden agroforestry practices did not increased their income (Table 10). From this result we can understand that traditional home-garden agroforestry has a greater role in increasing a household's income compared to another type of land use system in the study area. The existence of the traditional home-garden agroforestry and the increase of household income had positive and statistically significant association at 5% level (Table 10).

The study also conducted the comparative analysis between traditional home-garden agroforestry and another type of land use system. Accordingly, 87.3% of the traditional home-garden agroforestry and 17.8% of non-traditional home-garden agroforestry area respondents stated that traditional home-garden agroforestry was more important than another types of land use system at the study area (Table 10). Whereas, the remaining 12.75% of respondents from traditional home-garden agroforestry area and 82.2% of respondents from non-traditional home-garden agroforestry area stated that traditional home-garden agroforestry was less important compared to other types of land use system in study area (Table 10).

This result showed that the majority of respondents at the study area said traditional home-garden agroforestry was more important in increasing their farm income compared to other types of land use system and this was statistically significant at 5% significance level. Concerning the status of farm income of the farmer, almost all (100%) of the farmers from traditional home-garden agroforestry and 67.9% non-traditional home-garden agroforestry area stated that they had obtained income from their farmland 2020/2021G.C (Table 10). From this result one can understand that traditional home-garden agroforestry was important in generating year round income for households who were practicing it. Similar results were reported by (Akinnifesi, 2008) who stated that in South Africa agroforestry fruit trees show, fruits play an important role especially during times of famine and other stress as food, nutrition and cash income.

All other components of the home garden in the study area help the same as what a fruit tree does in one way or another. According to Scherr (1995), rural households' survival strategies encompass multiple objectives in maximization of utility, like provision of food, and subsistence goods, cash for purchase of goods, services and saving for future needs, while environmental or other shock happens in which home-garden agroforestry can do. Home-garden agroforestry also plays a vital role in contributing to people's livelihoods. Maroyi (2009) reported that home-garden agroforestry improves the family's nutritional status, health and food security. Agroforestry home-gardens therefore, are part of a people's livelihood strategy and have gained prominence as a natural asset through which sustainable use of resources, particularly for the livelihoods of the poor may be achieved.

Table10. Contribution of traditional home garden agroforestry to household's income generation

Variables	Response	THGAF (N= 134)		NTHGAF (N= 134)		TOTAL (N= 268)		Chi-square test	P-value
		N	%	N	%	N	%		
THGAF increase income	Yes	127	94.8	75	56.0	202	75.4	54.365	0.000
	No	7	5.2	59	44.0	66	24.6		
Compare THGAF with other types of land use systems,	THAF	117	87.3	23	17.8	140	52.2	132.14	0.000
	NHAF	17	12.7	111	82.8	128	47.8		
Income from farm in 2020/2021?		134	100	91	67.9	225	84.0		
		0	0	43	32.1	43	16.0		
	Total	134	100	134	100	268	100		

THGAF= traditional home-garden agroforestry, NTHGAF= non-home-garden agroforestry

4.5. Challenges faced by households practicing home-garden agroforestry at study area

The challenges of agroforestry home-gardens to people's livelihood food security and income generation in study area has been affected by different factors including the home-gardens productivity decrease because shortage of irrigation water, incidence of pests and diseases, lack of provision agroforestry fruit/tree seedlings, accessibility of market, land degradation and erosion, destroying the environment, fertilizer use, population increase, lack of credit service and such challenges are in line with earlier studies as reported by (Karlen, 2004).

Home-gardens productivity is an essential aspect to be viewed out of home-gardens fertility, shortage of irrigation water is a basic natural resource required to sustain life and provide various social needs as well as for economic development, lack of agroforestry extension services to farmers lead to poor knowledge of farming practices that leads to low yields hence, food insecurity (Nair, 1993). Moreover, the majority of rural people depend on the surplus farm produce that they sell to get income for other needs. Therefore, failure of farm produce may lead to low income earnings. Availability and accessible credit facilities to farmers enhance production improvement by easily accessing the required inputs at right times (Yirbecho, 2013).

Majority of smallholder farmers depend on farm products to get their food and incomes. Empowerment of farmers through credit provision will improve their production status as well as their well-being as reported by (Smale, 2009) that empowered farmers through provision of agroforestry inputs, upgraded the staple food production, also by (Doward, 2008) also reported that provision of subsidy fertilizers improves the production quantities of farmers and hence, livelihood sustainability.

4.6. Observing the existences of climate change in the study Area

In this section results to observe the existences of climate change at the study area was obtained through by climate data (rainfall and temperature) from national Meteorology center of Ethiopia by using trend analysis, this was analyzed using Crosstabs of descriptive statistics and conducting farmers perception with focus group discussion (FGD) and key informants (KI) such as elder from each Kebeles and development agent.

4.6.1. Extent of temperature and rainfall (1991-2020) at study area

Climate change is expected to create a serious risk on the environment, agroforestry production and food security of most developing countries including Ethiopia. The Ethiopian climate is characterized by great variation in different parts of the country and a history of climate extremes such as drought, flood, and increasing temperature and decreasing precipitation is common in Ethiopia *(*Leutze et al., 2003). Increasing temperature along with decreasing precipitation may enhance the water scarcity resulting from drought, which in turn, may affect both traditional home-garden agroforestry and non-home-garden agroforestry production. In study areas climate change impacts such as degradation of natural resources, decreasing major agroforestry products, low income activities and food security challenges.

4.6.1.1. Extent of temperature in the study area (1991-2020)

Information from the surrounding weather station indicated that the average yearly maximum temperature of the Hawassa Zuria district was 27 ºC, while the maximum temperature of the study area for the past 30 years has increased annually by about 0.028 ºC (Figure 6 and Table 9). Average yearly minimum temperature in the study area was 12 ºC, while average minimum temperature for the past 30 years has increased annually by about 0.063 ºC, (Figure 6).

According to the study by HDR (2007), the yearly time series of minimum temperature for 40 stations averaged over Ethiopia indicated that the average yearly minimum temperature is increasing much faster than the average annual maximum temperature. The value of coefficient of determination (R^2) minimum and maximum temperature shows that the past three decades have increased 0.7061 and 0.3081 respectively annually. The trend line equations showed positive slope value, which indicated a general increasing trend (Figure 6).

Table 11. Average annual and seasonal temperature trend (1991-2020)

Temperature (oC)		Mean	Tempe increase past 30 years	Stdv (oC)	CV (%)	Slope (R^2)
Annual	maximum	27.002	0.0282	0.72	5.45	0.3081
	minimum	12.085	0.0628	0.48	1.63	0.7061

Source: National Meteorological Agency (NMA, 2021)

The mean monthly temperature shows that there is a general increase in temperature at study areas in the last 30 years. This result shows that temperature increase affects income generation and exposure of households to climate change hazards to both traditional home-garden agroforestry and non-traditional home- garden agroforestry beneficiaries in the study area.

This was similar finding reported by (Bradshaw, 2004) that climate-related hazards like increase temperature exacerbate other stressors, often with negative outcomes for livelihoods, especially for people living in poverty, low income, reductions in crop yields or the destruction of homes, and indirectly through, for example, occurrence of diseases, increased food prices and food insecurity.
The present result was in line with by (Kassie et al., 2013), where the climate of Central Rift Valley of Ethiopia will get warmer in the coming decades and the increasing rate in minimum temperature will be higher than the maximum temperature, particularly under the current emission scenarios.

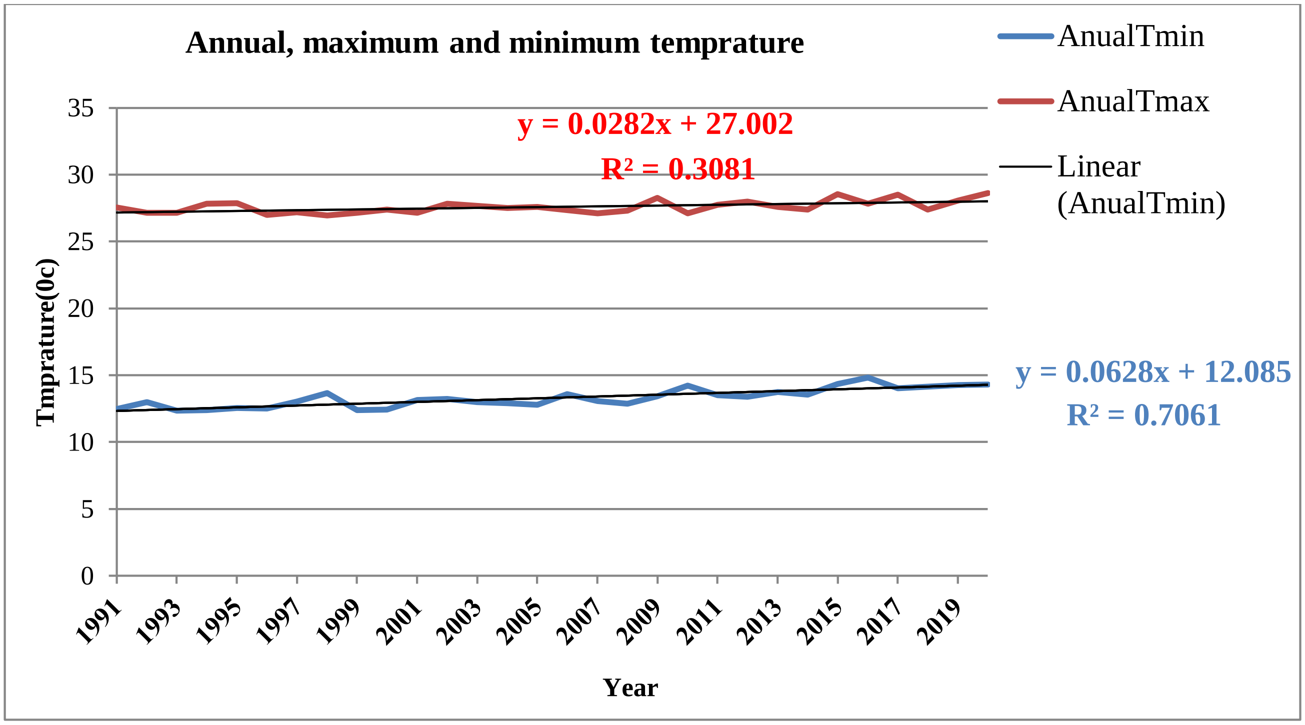

Figure6. Trends of minimum and maximum temperature in study area.

4.6.1.2. Extent of rainfall variability in the study area (1991-2020)

The data obtained from Ethiopia Meteorological Agency revealed that the coefficient of variation of study area were 15.84%, 21.19% and 29.63% for annual, summer (Kiremt) and spring (Belg) respectively, which indicates that there was less variable annual rainfall, while moderate variability of rainfall especially during the kiremt and belg rainfall between 1991-2020 (Table 11). A study made by Abate, (2009) in which CV is used to classify the degree of rainfall variability indicated that, CV< 20 it is less variable, CV < 30 moderate and high CV > 30. Various studies indicated that the trends in inter-annual and inter-seasonal rainfall variability were decline in amount and increase in intensity which would aggravate the rate of erosion, and consequently reflecting negative implication on crop productivity. The value of coefficient of determination (R^2) annual, kiremit and belg rainfall has relatively increased over the past three decades 0.0338 mm, 0.009 mm and 0.1486 mm respectively annually.

Table12. Extent of rainfall variability in the study area (1991-2020)

Rainfall (mm)	Minimum (mm)	Maximum (mm)	Mean (mm)	Stdv (mm)	CV (%)
Annual	850	1383	1035.02	164.51	15.84
Kiremt	232	504.9	344.25	72.95	21.19
Belg	123.2	532.9	305.81	90.64	29.63

Source: National Meteorology Agency of Ethiopia (2021)

According to National Meteorological Agency of Ethiopia (NMA), in the Hawassa Zuria district, the seasonal rainfall shows lower inter-annual variability than the summer main rain season (June-September) and small rainy season (March -May) rainfall. The summer (kremit) and spring-(belg) rainfalls have shown relatively an increasing trend per year in the period noted. The summer rain in this study has shown an increasing trend with 0.8281 mm, while belg rain increasing 4.151 mm per year in the period noted. Summer is the main rainy season in the study area in which farmers are engaged to produce their crop.

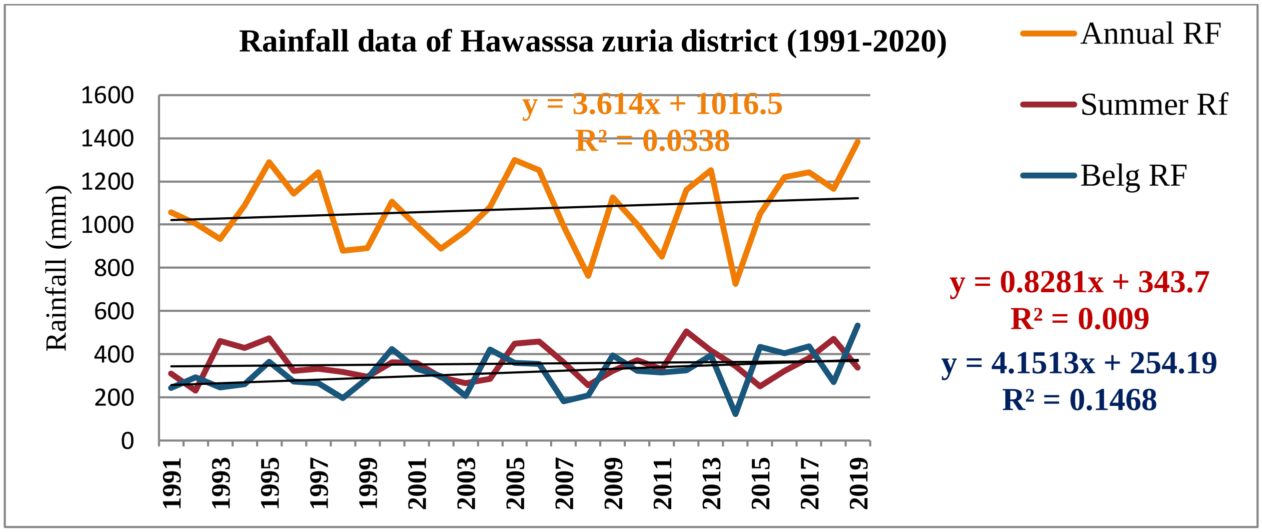

Figure7. Average annual, kiremit and Belg rainfall of the study area

(National Meteorological Agency, Ethiopia 2021)

4.6.1.3. Annual standard precipitation index (SPI)

According to NMA data, the seasonal total amount of rainfall during the summer (June to end of September) showed higher variability especially during the years 1991,1993, 1994, 1999, 2000, 2002, 2003, 2004, 2008, 2009, 2011, 2012 and 2015 which were below the average rainfall in the study area. On the other hand, the rest of the year is relatively wetter; this has to be shown by SPI values (Figure 8).

The standardized anomaly of total annual rainfall revealed that above average rainfall in the area was recorded for 17 years and below average rainfall for 13 years. Based on standard precipitation index procedure, the rainfall period of study area approximately categorized into three decades. First decade (1991-2000) was 1991-1994 years relatively drier and 1995-1999 years wet, the second decade (2001-2010) except 2005, 2006 and 2007 years relatively drier, while third decades (2010-2020) were relatively wet, confirming the slightly increasing trend already observed in the trend analysis of this study area (Figure 8)

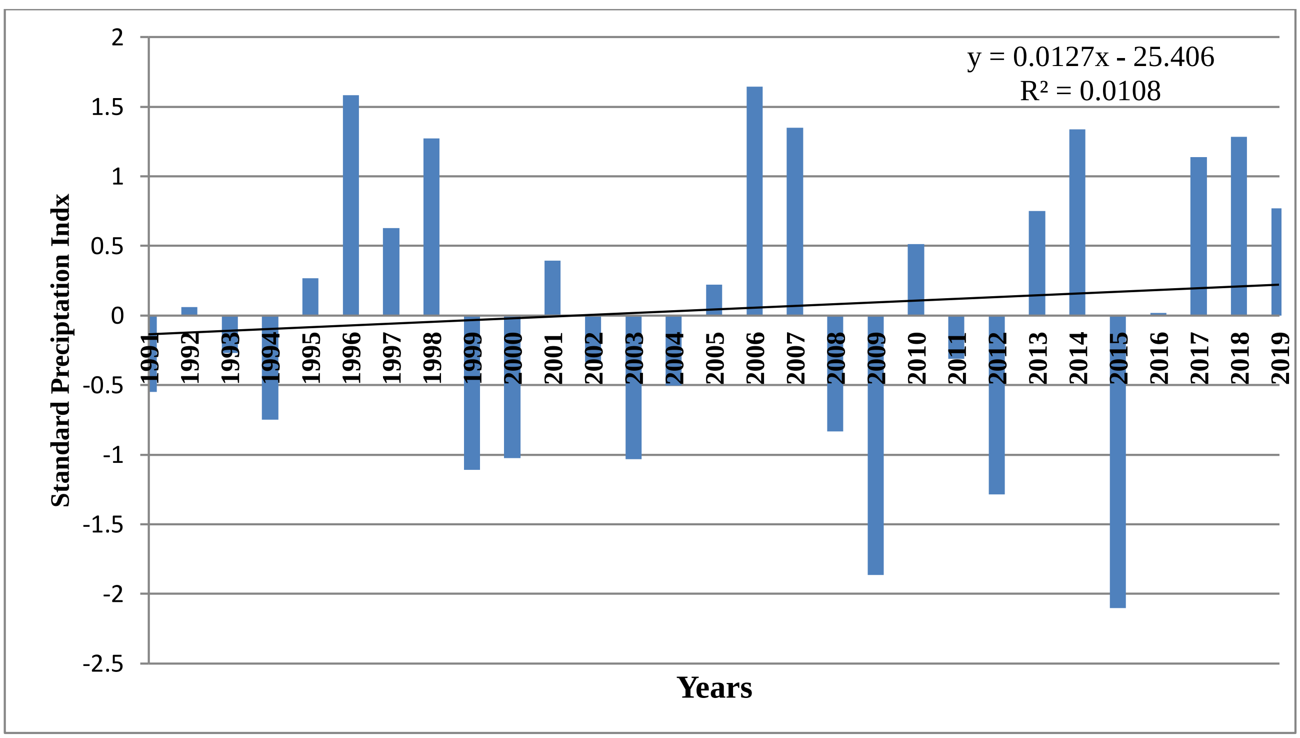

Figure 8. Annual SPI of Hawassa Zuria district (1991-2020)

4.6.2. Household's perception on climate change and variability

According to the results obtained from the survey, 89.6% of home-garden agroforestry owned households and 81.3% from non-home-garden agroforestry owned households said that they heard about the word climate change in the study area, whereas, only 10.4% of home-garden agroforestry owned households and 18.7% of non-home-garden agroforestry owned households answered that they did not hear about the word climate change and variability in the study area. The result revealed that most of the respondents have perceived as there was long-term variability in temperature in the study district over the past three decades.

Reporting on the perception of farmers' experiences on the increasing trend of the climatic change affects both home-garden agroforestry and non-agroforestry owned households in the study areas. Concerning the farmer's perception of the trend of temperature for the past 30 years fluctuating, constant, increasing and decreasing 29.9%, 3%, 67.2% and 0% of home-garden agroforestry owned households and 14.2%, 18.6%. 67.2% and 0% of non-home-garden agroforestry owned households, respectively, in such that they perceived and believed that the temperature of the study area is increasing from the past 30 years up to now.

Based on the meteorological data, similar findings were obtained in our study areas, indicating that the average temperature has increased by 0.0455 ºC; this means average temperature shows an increasing trend. Regarding the experiences of households for the existences of climate change and variability indicators such as drought, flood, frost/coolness and all indicators at the study area respondents perceived as 10.4%, 3%, 0% and 86.6% traditional home-garden agroforestry beneficiary and 27.65%, 11.2%, 3.7% and 57.5% of the non-home-garden agroforestry households, respectively. This result shows that the majority farmer's perception of all indicators (drought, flood and frost/coldness) causes climate change and variability that affect income of agroforestry and non-agroforestry beneficiaries in the study area.

Concerning the farmers perception trends of rainfall for the past three decades up to now (fluctuating, increasing and decreasing) respondents of traditional home-garden agroforestry owners agreed and believed that 53.7% (fluctuating), 0% (increasing) and 46.3% (decreasing), and non-home-garden agroforestry beneficiary agreed that 32.1% (fluctuating), 17.9% (increasing) and 50% (decreasing) (Table 13). This result shows that the majority of farmers perceived and agreed over the past three decades that rainfall fluctuated and decreased in the study area.

In this research, findings similar to that of the meteorological data in the study area claimed that rainfall has fluctuated and relatively increased by about 3.614 mm average annually. The perceived impacts of such fluctuating rainfall include emergence of pests and disease, interruption in crop calendar, wilting crops. Overall impacts are to reduce income and increase exposure of households to climate change hazard in both farmer groups. Therefore, agroforestry productivity can be highly influenced by fluctuating rainfall patterns. Key informant interviews (KI) and focus group discussions (FGDs) have recognized and perceived as there was variability in rainfall amount, its timing and distribution in the study area over the past 30 years.

Table13. Household's perception on climate change and variability in study area

Variables	Response	THGAF (N=134)		NTHGAF (N=134)		Total (N=268)		Chi-square	p-Value
		N	%	N	%	N	%		
Level of awareness of climate change for the past 30 yrs.	Yes	120	89.6	109	81.3	229	85.5	1.760	0.185
	No	14	10.4	25	18.7	39	14.5		
Climate change and variability indicators	Drought	14	10.4	37	27.6	51	19.0	29.62	0.000
	Flood	4	3.0	15	11.2	19	7.1		
	Frost	0	0	5	3.7	5	1.9		
	All	116	86.6	77	57.5	193	72.0		
Extent of temperature for the past 30 years	Fluctuating	40	29.9	19	14.2	59	22.0	22.68	0.000
	Constant	4	3.0	25	18.6	29	10.8		
	Increasing	90	67.2	90	67.2	180	67.2		
	Decreasing	0	0	0	0	0	0		
Extent of rainfall for the past 30 years	Fluctuating	72	53.7	43	32.1	115	42.9	31.50	0.000
	Increasing	0	0.0	24	17.9	24	9.0		
	Decreasing	62	46.3	67	50.0	129	48.1		

4.6.3. Farmers' perception the role of agroforestry in reducing the effects of climate change

In this section, the researchers tried to assess the farmer perception on home-garden agroforestry in reducing the effect of climate change. The researcher considered the following variables including whether farmers plant traditional home-garden agroforestry fruit and others trees or not, the reason why they plant home-garden agroforestry trees in home-garden agroforestry whether to reduce the effect of climate change, if yes, how it reduce climate change and how it enhance soil moisture holding capacity than another type of land use or not.

The survey result showed that all of respondents (100%) from home-garden agroforestry beneficiary believed that they plant home-garden agroforestry fruit/ trees on their land, and none of the farmers from non-agroforestry beneficiary no planted agroforestry trees on their land except natural regeneration trees (Table 14). According to the survey result, about 73.9% of the farmers from the agroforestry and 17.2 % non-agroforestry beneficiary perceive and agree that the reason they plant agroforestry trees for prevent soil loss by flooding and erosion, to create shade, for sale (income), balance temperature and to plant trees for all reasons. The remaining 26.1% agroforestry households and 82.8% non-agroforestry beneficiaries do not agree to such reasons (Table 14). These results were similar finding reported by (Verchot, 2007) who stated that agroforestry systems in the home-garden associated with other organisms contribute to the formation and maintenance of soil structure, to prevent soil loss and erosion, balance micro climate, retention of moisture and nutrient levels and promote the recycling of nutrients; which reduces ecosystem vulnerability to climate change.

The study stated that 100% respondents from agroforestry households and 29.3% respondents from non-agroforestry households perceived that agroforestry systems can reduce climate change. Remaining 71.7% from non-agroforestry household's perceived that agroforestry system not reducing climate change. Agroforestry can reduce climate change both groups respondent perceived as 31.7% reduce erosion, 8.2%, enhance microclimate, 13.8%, adjusted rainfall, 13.5% sink for greenhouse gas (GHG) and 32.8% reduced by all indicators. These climate change reduction indicators which are perceived by respondents are achieved through diversified agroforestry systems and planting agroforestry fruits/trees on farm land. This finding was a similar report by (Huston, 1995) who indicated that high diversity of species in these agroforestry systems contributes to acting as genetic conservation of native species, efficient resource use and biological pest control.

Also, the perennial nature of the systems together with the high species diversity provides important ecological services such as nutrient recycling, soil and water conservation, and reduces environmental deterioration hence, ecological sustainability. The maintenance of high species diversity in these agroforestry systems enables year round production of different crops and other products, reduces and spreads risks and expands the amount and quality of labor applied in the farm which increases socio-economic sustainability.

In recent years, tree-planting has become a cornerstone of many environmental campaigns. The call to plant trees is everywhere, seen as a simple and effective way to help in reducing the impact of carbon emissions, fight against climate change and restore natural ecosystems. Planting agroforestry fruits/trees to save the world from climate change, it's clear that planting trees is a useful tool that we can use to help mitigate the effects of climate change and protect the planet. Agroforestry fruits/trees are the ultimate carbon capture and storage biological-machines by sinking for greenhouse gases which in turn offset the emitted gases in the atmosphere. This finding was similar to the reported by IPCC (2019) in which agroforestry trees reduce or remove significant amounts of greenhouse gases through increased carbon storage in biomass above-ground and below ground and in soil organic carbon.

Integrating agroforestry into cropping and livestock keeping systems can enhance carbon sequestration by significant amounts. Home-gardening, boundary planting, fruit orchards, reverie hedgerows, woodlots and firewood lots are major agroforestry practices that sequester CO_2. Agroforestry stores more carbon than pastures and fields with annual crops, but less than forested areas. This result was in line with the report by (Nair, 2010) who stated that from the agroforestry point of view, carbon sequestration primarily involves the uptake of atmospheric CO_2 during photosynthesis and the transfer of fixed carbon into vegetation, detritus, and soil pools for “secure” (i.e. long-term). As such the carbon sequestration potential (CSP) in agroforestry system (AGFs) was estimated about 0.29 - 15.21 Mg ha^{-1} yr^{-1} in aboveground and 30 - 300 Mg ha^{-1} up to 1m depth in the soil (Nair, 2010).

Our study also compared the perception of respondents about the home garden agroforestry’s ability in enhancing the soil moisture holding capacity compared to other type of land uses. Accordingly, all (100%) of agroforestry households and 7.5% of non-agroforestry households owners said that traditional home-garden agroforestry was more important in enhancing soil moisture holding capacity compared to other type of land use system in the study area. This increases income and ecological sustainability (stability and resilience) more in home-garden agroforestry beneficiaries than non-agroforestry households. The remaining 92.5% of farmers from non-agroforestry areas stated that traditional home-garden agroforestry was less important to enhance soil moisture holding capacity compared to other types of land use system (Table 14).

In agreement (Verchot, 2007) reported that agroforestry systems maintain soil structure, to prevent soil loss and erosion, retention of moisture holding capacity and nutrient levels and promote the recycling of nutrients; which reduces ecosystem disturbance during climate shock. Farmers generally agree and believe that agroforestry practices to reduce sensitivity of human, environmental as well as farm households and avoid the risk of total loss in the event of a drought or flood in home garden agroforestry households.

Table14. Farmers Perception home garden agroforestry in reducing the effect of climate change

Variables		THGAF (N= 134)		NTHGAF (N= 134)		TOTAL (n=268)		Chi-square test	P-value
		N	%	N	%	N	%		
Agroforestry trees on your land	Yes	134	100	0	0.0	134	50.0	268.00	0.000
	No	0	0.0	134	100	134	50.0		
The reason plant agroforestry trees	To prevent soil loss	5	3.8	2	1.5	7	1.8	134.60	0.000
	To create shade	15	11.3	31	23.1	46	5.6		
	for sells (income)	3	2.3	0	0.0	3	1.2		
	Balance temp.	12	9	16	12	16	11.9		
	All	99	73.9	23	17.2	122	41.4		
AF reduces climate change	Yes	134	100	53	28.3	187	69.8	116.08	0.000
	No	0	0.0	81	71.7	81	30.2		
Climate change indicators	Reduce erosion	50	37.3	35	26.1	85	31.7	149.11	0.000
	Enhance m-climate	7	5.3	15	11.2	22	8.2		
	Adjust rain fall	9	6.7	28	20.9	37	13.8		
	Sink for GHG	25	18.7	12	9.0	37	13.8		
	All	43	32.1	44	32.8	87	32.5		
AF enhances soil moisture holding capacity than others	Yes	134	100	10	7.5	144	53.7	230.77	0.000
	No	0	0.0	124	92.5	124	46.3		

4.6.4. Causes of climate variability in study area

The causes of climate variability by the interviewed household's key informant (KI) and focus group discussion (FGD) were land degradation and deforestation. Other causes of climate variability reported included destroying the environment, use of chemical fertilizer and population increase. Increasing population growth in drought-prone areas increases unsustainable land and resource use which increases drought sensitivity. Human activities are also responsible for the increase in drought vulnerability in rural areas (Shiferaw, 2014).

Although extreme rainfall events such as flood and landslide cause adverse and sudden impact in the places they occur, at the same times the overall increase in rainfall occurrence has been beneficial for crops and pastoral conditions and is but often ignored (OCHA, 2013).The major disadvantage of the shortage of rainy season that farmers in Hawassa Zuria district experienced is wilting of crops. Climate variability hazards are events or occurrences that have the potential for causing injury to life, or damage to property or the environment on which the community depends for its social and economic existence.

In addition to distinct events that occur at specific points in time and space, the definition of hazards has been extended to include embedded features of the physical, social, political and economic environment with effects that gradually cause disastrous outcomes. Hazards can be sudden events (such as epidemic dysentery, landslide, gully and flood) or things that accumulate gradually (for example, soil erosion and population growth) (IPCC, 2007). In the study area pests and disease, variability of rainfall and temperature are recurring problems affecting agricultural activities and human wellbeing.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The study evaluated the climate (rainfall and temperature) parameters to check the existence of climate change, and investigated the farmer's perception on the climate change and variability. The study also assessed the contribution of traditional home-garden agroforestry to income generation at farm plot level in Hawassa Zuria district under the existing climatic condition.

According to the results, information from the surrounding weather station indicated that the maximum temperature of Hawassa Zuria district for the past 30 years has increased by about 0.025 °C annually, while average minimum temperature has increased by 0.065 °C. Mean annual rainfall variability in the past 3 decades in study area (1991-2020) were 1035.02 mm, 344.25 mm and 305.81 mm annual, kiremit and belg rainfall respectively. The coefficient of variation of rainfall in the study area was 21.19%, 29.63%, and 15.85% for kiremt, belg and annual rainfall respectively, which indicates that the presence or occurrence of high inter-annual variability of rainfall between (1991-2020) in study area. Concerning the key informant interviews and focus group discussions also recognized the presence of variability in rainfall amount, its timing and distribution in the study area over the past 30 years.

The findings related to the farmers' perception on climate change in the study area revealed that the majority (89.6%) of households (practicing home-garden agroforestry) and 81.3% (practicing non-agroforestry) households heard and believed that there is climate change in the study area, whereas, only 11.4% from practicing home-garden agroforestry and 19.7% from non-practicing agroforestry households did not heard and believed climate change. The study also assessed the farmers' perception on the role of home-garden agroforestry in reducing the effect of climate change and variability. Most of the farmers in the study area understood that traditional home-garden agroforestry can reduce the effect of climate change, 100% respondents who are practicing agroforestry households and 29.3 % from non-agroforestry households perceived and believed that agroforestry systems can reduce the effect of climate change.

According to farmers' perception, the ability of agroforestry systems in reducing climate change was through preventing soil loss and erosion, balancing micro climate, retention of moisture and nutrient levels and promoting the recycling of nutrients; which reduces ecosystem vulnerability to climate change. These benefits can be enhanced through diversified agroforestry systems and planting agroforestry fruits/trees on their farmland.

The comparative analysis of income levels between traditional home-garden agroforestry against non-traditional home-garden agroforestry households were 4,677.71 and 2,627.79 Birr, respectively. The independent t-test showed that there was a statistically significant difference in the income between traditional home-garden agroforestry against non-traditional home-garden agroforestry in the study area ($p< 0.05$), implying traditional home-garden agroforestry its year round production is better than non-home-garden agroforestry and to minimize the effects of climate change related shocks at household level.

Traditional home-garden agroforestry beneficiary households with more income, have a higher ability to cope in case of climate shock than non-traditional home-garden agroforestry beneficiary households. The higher the income a household has the more resilient it is. Diversification of agroforestry in the study area increases income and reduces climate variability highly recognized by agroforestry farmers to satisfy growing demand of the family and some family members. However, the socio-economic analysis of our assessment revealed that lack of agroforestry extension and credit services for farmers lead to poor knowledge of farming practices, low yield and income, hence, food insecurity.

Diversity of traditional home-garden agroforestry in the study area enhances the livelihood of the farming households by providing socio-economic, agro-ecological and sustainable income than non-traditional home-garden agroforestry; important to adapt to climate change or climate related stress (drought). The great role of the traditional home-garden agroforestry system to reduce sensitivity and increasing resilience of farmers to effects of climate variability is through increasing fuel-wood stock on a farm, reducing erosion intensity, increasing income and assets such as trees, livestock, and crop production.

Therefore, a traditional home-garden agroforestry participant's household shows more income, less sensitivity and higher resilience to climate variability compared to the non-traditional home-garden agroforestry participant households. Traditional home-garden agroforestry is believed to be more diverse species and provide multiple services for households than non-traditional home-garden agroforestry systems; this is due to the combination of crops, trees and livestock. Hence, traditional home-garden agroforestry is among the best solutions for people's livelihoods, to adopt climate change, food security and income generation to smallholder farmers due to their diversity.

5.2. Recommendation

Based on the findings of the following recommendation points were drawn:

1. Increasing farmers' perception about climate change awareness can be enhanced by policies aimed at strengthening weather and climate information systems as well as knowledge dissemination.
2. Governmental organizations (GOs), (Agriculture and Natural resource office), planners and research institutes, who are working in promotion of different agroforestry technologies, training

and demonstration to farmers which would help their ability in knowledge acquisition and quick understanding of agroforestry technology components.

3. To provide incentive in terms of agroforestry inputs to improve motivation of the farmers and reduce their fear of risk of technology failure. Dissemination of information for non-agroforestry beneficiaries about the importance of different traditional home-garden agroforestry technology.
4. Promoting agroforestry through improved crops, trees and live-stocks and provision of agroforestry fruit/tree seedlings to diversify livelihood of the farmers in order to resist climate change risk. Facilitate access of credit and extension services to provide adequate information for farmers to implement agroforestry systems rather than non-tree based agroforestry.
5. The government should work jointly with the agroforestry local farmers in changing the non-trees land use system to a diversified agroforestry system for climate change adaptation.
6. Households who are not involved in home garden agroforestry activities and those who lack knowledge on the benefits of home garden agroforestry should be given special consideration in raising awareness. (Example, mini-workshop and agricultural extension methods).
7. To motivate tree planting in home-gardens on the farm for agroforestry practice to stand out as strategies for reducing the impact of climate variability especially for ensuring sustainable income.
8. Introducing new agroforestry technologies (Alley cropping, strip cropping and wind breaks) for improved income and to reduce the impact of climate shock that goes in line with the changing climate patterns should be the prior agenda for researcher and development planners in study areas.

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7. Appendices

Hawassa University

School of Graduate Studies

Faculty of Environment, Gender and Development Studies. Household-level survey questionnaire for the research on contribution of traditional home- garden agroforestry on income generation in light of climate change in Hawassa Zuria district of Sidama regional state, Ethiopia

Basic Information

Name of Region: ------------------------- Name of district: -----------------------------

Name of Village (Kebele): _______________

Name of Interviewer: _________________ Name of the Respondent: _______________

Instruction: Dear enumerator, please circle the number representing respondent's answer from given alternatives for each part and or write their answer for the rest of questions requiring quantitative and other responses

Part 1: Demographic Background

1. Age of the respondent **(**in years) _________

2. Sex of respondent: (1) Male ☐ (2) Female ☐

3. Marital status of the household (1) Single ☐ (2) Married ☐ (3) Divorced ☐ Widowed ☐

4. Household structure. 1). Male headed _____ 2). Female headed_______

5. Family size/Household size: Male _______ Female _______Total_________

6. Education level of the household head (in number of schooling years) _____

7. Farming experience of the household head (in years) _______

8. Religion: 1). Christian ______ 2) Muslim_______ 3) others.__________

Socio-economic Characteristics

Landholding

9. Do you have your own land? 1) Yes___ 2) No _____

10. Land Size in (ha) --------------

Institutional and infrastructural aspects

11. Are there any credit facilities for the rural community? 1. Yes, 2. No.

12. If yes, mention the name of credit facilities______________________

13. Are there any extension services in agroforestry practices? 1) Yes, 2). No.

14. If yes, mention the types of extension services? 1) Advisory 2) training 3) Input supply 4) all

Livestock ownership

15. Do you have livestock (Livestock own)? 1) Yes_____ 2) No ______

16. If yes, mention the numbers of domestic animals owned by the households during the survey time?

Types of domestic animals	Unit	Total no. of domestic animals	Local	Improved	Remark
Cow	No.				
Ox	No.				
Calf	No.				
Heifer	No.				
Sheep	No.				
Donkey	No.				
Goat	No.				
Chicken	No.				
Horse	No.				
Total	No				

Part II: Observing Climate change and perception

17. Have you ever heard the word climate change before past 30 yrs.? 1) Yes 2) No

18. What are climate change and variability indicators that you have ever experienced?

1. Drought 2. Flood 3. Frost 4. Too little rain 5. Intensive rainfall 6. all

19. What has been the trend of temperature for the past 30 years to date?

    1. Fluctuating 2. Constant 3. Decreasing 4. Increasing

20. What were the trends of rainfall looks like for the past 30 years up to now?

1. Fluctuating 2. Increasing 3. Decreasing

21. Does the rainfall come on time? 1. on time 2. Too early 3. Too late

22. Is there enough rain on your fields at the beginning of the rainy seasons?

    1. Enough 2. Too little 3. Too much

23. Is there enough rain on your fields during the growing seasons?

1. Enough 2. Too little 3. Too much

24. Does the rain stop on time on your fields? 1) On time 2) Too early 3) Too late

25. Is it raining during harvest time? 1) Yes 2) No

Part III: Economic importance and income of Agroforestry

26. Do you think that traditional home gardens AF increase your income? 1. Yes 2. No

27. If you compare Traditional home garden AF with other types of land use system, which one is more important?

1/. Traditional home garden agroforestry 2/ Non-Traditional home garden agroforestry 3/ Both

28. Have you ever got income from your farm in 2020/2021? 1. Yes 2. No

29. What are your general sources of income (rank)

Source	Total Income	1.Very importa	2.Quite importa	3.Import ant	4.A bit importa	5.Less importa
Sale from home garden						
1.crops						
2.animals						
3.Trees						
4.Medicinal plants						
5.Sales from farm						
6.Regular job						
7.Others						

30. What is your annual income 2020/2021? -------------------------

Part IV: Roles of agroforestry on reducing the climate change

31. Do you plant home garden agroforestry trees on your land? 1) Yes 2) No

32. If Yes for Q#31, why plant trees? 1. To prevent soil loss by flooding and erosion

2. To create shade on my farm 3.for sells (income) 4. Balance temperature 5) All

33. Do you think that agroforestry reduces climate changes? 1. Yes 2. No

34. If yes, how?

1). by enhancing microclimate 2) adjust rain fall coming time 3) act as a sink for GHGs 4) all

35. Does Home garden enhance soil moisture holding capacity more than another type of land use?

1) Yes 2) No

Questionnaires' for Focus Group Discussion and key informant interview

1. What do you know about home garden Agroforestry?

2. What are the dominant plants or crops in your home garden? List accordingly.

3. Are there crops in your home garden that grow throughout the year?
4. Which plants or crops in your garden are more important? Rank accordingly.
5. List names of plants in your home garden used Vegetables, multi-purpose tree species, live fence and shade tree species, crops, spices, aromatic plants, ornamentals and edible fruit
6. What are the aims and advantages of growing plants in your home gardens?
7. Do you use the home garden crops/ plants product for household consumption or for the market purpose?
8. Which plants/ crops products are more common in the market?
9. Do you think that home garden agroforestry can contribute income for your families?
10. What affects the decision of keeping both a home garden and a farm?

Questionnaires for Key Informants Interview

1. Do you hold any meetings with farmers about tree planting?
2. Have you ever assisted some farmers to establish an Agroforestry farming system?
3. If yes, how successful was it?
4. Does the Forestry department provide seedlings to farmers?
5. What are the tree species which are mostly planted in the area?
6. What are the tree species which naturally grow in the home gardens?
7. Is it common for farmers to sell home garden products?
8. Which home garden products are commonly sold?
9. Mention the task to be performed in home gardens each month of the year by men and women – working calendar...
10. How do farmers decide whether to keep a big home garden or a small one as compared to a farm?

8. APPENDICES

Appendix-1. Monthly maximum temperature from (1991-2020) in the study area

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave.maxT
1991	30.3	28.9	28.7	29.3	28.0	26.0	23.2	25.0	25.8	27.8	29.2	28.1	27.5
1992	28.5	28.4	30.5	29.5	27.5	26.3	24.4	23.7	24.9	25.8	27.1	28.5	27.09
1993	27.6	26.9	30.6	27.8	26.9	24.9	24.3	24.8	25.7	26.9	29.0	29.9	27.10
1994	30.5	31.6	30.8	29.4	26.6	24.7	23.4	24.5	26.1	28.3	28.3	29.2	27.783
1995	30.3	30.7	29.8	27.3	27.9	27.0	24.3	24.5	25.8	27.6	27.3	29.1	27.63
1996	28.2	30.8	29.5	27.6	26.7	23.7	23.8	24.3	25.0	27.0	28.1	28.6	26.94
1997	28.9	30.2	30.7	26.8	27.5	25.7	23.8	25.5	26.7	26.4	26,5	27.2	27.21
1998	27.4	28.8	28.9	29.6	27.2	26.2	24.3	23.9	25.4	25.3	27.5	28.1	26.88
1999	29.0	31.4	28.1	29.3	27.2	26.1	23.6	24.9	25.6	24.7	27.2	28.6	27.14
2000	29.4	30.7	31.8	28.9	26.1	25.6	24.8	24.8	25.1	25.7	27.2	28.1	27.35
2001	28.6	30.2	28.3	28.4	26.7	24.7	24.3	24.7	25.9	26.7	28.2	28.8	27.12
2002	28.2	30.8	28.8	28.6	27.5	25.7	26.2	25.3	26.0	28.3	29.8	28.2	27.78
2003	28.4	31.2	30.5	28.0	28.2	25.5	24.1	24.9	26.0	28.2	29.3	27.2	27.62
2004	28.9	28.7	30.1	27.2	28.5	25.8	25.3	25.5	25.4	26.7	28.6	28.5	27.43
2005	28.8	31.5	29.9	29.3	25.8	25.5	24.5	25.6	25.9	27.3	28.0	28.4	27.54
2006	30.1	31.2	29.3	27.3	27.7	26.2	24.4	24.7	25.2	26.6	27.6	27.5	27.31
2007	28.5	29.2	30.0	28.2	27.7	25.3	24.6	24.2	25.1	26.7	27.8	27.8	27.09
2008	29.4	29.4	31.5	29.3	26.2	25.5	24.3	24.7	25.6	26.5	26.6	27.7	27.22
2009	28.4	30.0	31.2	29.2	28.9	27.6	25.9	26.0	26.3	27.5	29.5	28.1	28.216
2010	28.4	28.4	27.7	27.9	26.8	26.2	24.4	25.3	25.2	27.7	28.7	28.1	27.06
2011	28.7	30.6	30.2	30.7	27.5	26.1	25.6	24.5	25.2	28.2	27.8	27.5	27.71
2012	29.7	30.7	31.7	27.9	28.2	26.5	24.8	24.9	25.1	27.7	29.1	29.0	27.94
2013	29.9	31.3	30.3	28.7	26.6	26.0	24.3	24.7	26.2	26.8	28.0	27.9	27.53
2014	29.9	29.6	29.5	28.7	27.1	26.6	25.1	25.1	25.2	26.3	27.4	27.5	27.33
2015	28.7	31.0	31.4	30.8	28.5	26.1	26.1	26.7	27.1	28.5	29.0	28.4	28.52
2016	28.8	30.6	32.2	28.6	26.7	25.9	25.3	25.3	26.6	27.4	28.1	27.7	27.76
2017	29.4	29.9	31.5	31.6	28.4	27.7	26.1	26.6	26.3	27.9	28.5	28.3	28.51
2018	29.4	30.2	28.1	27.1	27.7	25.0	24.8	25.7	26.6	27.9	27.5	28.3	27.35
2019	29.7	31.2	31.6	29.6	29.0	26.4	25.2	25.2	25.9	26.6	27.8	27.8	28.32
2020	28.6	30.0	29.8	28.9	27.9	26.1	24.3	24.7	26.0	27.3	27.2	28.2	27.41

Source: National Meteorology Agency of Ethiopia (2021)

Appendix-2. Monthly average minimum Temperature from (1991-2020) in the study area

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave .MIN Temp
1991	11.9	12.3	13.4	12.7	14.1	15.4	14.3	13.7	13.0	9.5	9.4	9.6	12.5
1992	12.4	13.6	12.8	14.1	13.5	14.0	13.9	14.4	12.7	13.1	10.5	11.0	13.0
1993	12.1	12.3	9.6	14.1	14.1	14.2	14.3	13.7	12.8	12.8	9.3	9.1	12.4
1994	9.7	11.6	13.0	13.8	14.3	14.5	14.2	14.7	14.0	10.1	10.0	8.9	12.4
1995	9.5	12.7	13.7	14.9	13.1	13.6	14.2	14.5	13.0	12.3	8.4	10.6	12.5
1996	12.2	10.5	13.0	14.0	14.1	14.3	14.5	14.4	13.6	10.9	8.8	9.6	12.5
1997	12.4	10.0	13.3	13.9	13.1	13.6	14.1	14.2	13.2	13.6	13.8	11.3	13.0
1998	13.3	14.3	14.0	14.4	15.7	14.7	15.7	15.9	14.5	14.4	8.9	8.1	13.7
1999	10.2	9.9	13.8	12.5	13.6	14.0	14.3	13.7	13.8	14.0	9.3	9.3	12.4
2000	9.6	10.6	11.1	14.1	14.0	13.7	14.3	14.0	13.4	14.0	10.5	9.7	12.4
2001	11.6	11.1	14.0	14.4	14.2	14.6	14.8	15.0	13.1	13.7	10.3	10.9	13.1
2002	12.4	11.8	14.0	13.5	14.8	14.5	14.3	14.2	13.4	12.8	9.8	13.2	13.2
2003	11.8	11.6	13.2	14.3	14.2	14.3	14.6	14.7	14.0	11.9	11.2	10.4	13.0
2004	12.9	11.6	12.2	14.7	13.2	13.9	14.0	14.3	13.6	11.5	11.6	11.4	12.9
2005	11.3	11.4	13.8	14.0	15.0	14.6	14.2	14.7	14.4	13.1	9.5	7.8	12.8
2006	11.8	12.4	13.8	14.6	13.9	14.3	15.0	14.7	14.5	14.2	11.4	12.4	13.6
2007	12.7	12.9	12.4	14.2	14.8	15.0	14.8	14.6	14.3	11.1	10.9	9.0	13.1
2008	10.5	11.7	11.4	14.1	14.6	14.4	14.9	14.5	14.2	13.0	11.1	10.3	12.9
2009	11.8	12.4	12.9	14.3	14.4	13.9	14.2	14.7	14.8	13.2	10.7	13.6	13.4
2010	13.0	15.3	14.7	15.6	16.3	15.1	15.2	15.3	14.4	13.5	11.1	10.9	14.2
2011	12.6	11.8	13.4	14.3	15.1	15.3	14.7	14.9	14.7	12.3	13.0	10.0	13.5
2012	10.2	11.7	13.5	15.1	14.4	15.1	15.3	15.0	14.4	12.2	12.3	11.3	13.4
2013	12.2	12.2	15.6	15.1	15.1	15.4	15.1	14.9	14.2	13.5	12.0	9.4	13.7
2014	12.2	13.5	13.4	13.1	14.1	14.0	15.3	14.9	14.7	14.2	12.3	10.7	13.5
2015	11.2	13.0	14.5	14.8	15.4	15.8	14.8	15.3	15.3	14.7	13.9	13.5	14.3
2016	15.3	14.7	15.4	16.7	16.1	14.7	15.8	15.4	15.3	14.9	12.1	11.2	14.8
2017	9.7	14.5	14.5	14.8	15.8	15.5	16.0	15.5	15.6	15.1	11.7	9.4	14.0
2018	11.3	13.3	13.9	15.6	15.6	15.4	15.0	11.3	13.3	13.9	15.6	15.6	14.2
2019	10.5	12.9	15.2	14.5	13.9	16.2	11.6	15.1	14.9	13.3	13.3	12.6	13.7
2020	13.1	13.7	15.6	15.3	15.5	15.3	15.2	15.4	15.0	13.9	11.4	10.4	14.2

Source: National Meteorology Agency of Ethiopia (2021)

Appendix-3. Monthly average Rainfall from (1991-2020) in study area.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual RF	Summer RF	Belg RF
1991	12.3	90.6	86.4	48.0	146.7	116.7	109.2	90.6	110.0	21.6	12.2	44.8	1056.5	311.1	243.3
1992	23.4	83.2	73.8	109.0	60.5	83.0	104.5	123.6	74.5	142.3	80.1	17.4	1005.7	232.2	292.5
1993	101.6	109.1	22.3	104.9	165.3	46.7	54.7	130.8	47.8	130.8	10.5	3.9	932.96	460.8	247
1994	0.0	3.7	56.8	108.7	81.5	146.2	195.7	118.9	68.9	58.8	19.1	2.9	1088.1	429.1	261.5
1995	0.8	21.4	61.8	156.1	43.6	118.7	175.7	134.7	166.8	22.3	18.3	84.2	1288.3	473.2	365
1996	78.4	36.9	89.6	113.9	161.5	243.3	121.2	108.7	145.0	69.6	19.7	1.4	1142.5	323.9	272.9
1997	23.4	1.7	75.1	125.0	72.8	111.2	98.8	113.9	119.1	157.5	132.2	24.0	1241.2	333.2	266.3
1998	92.0	140.0	90.8	86.6	88.9	52.0	172.9	108.3	109.6	193.3	10.6	0.8	877.71	318.7	196.6
1999	19.8	0.4	105.5	26.4	64.7	99.8	135.1	83.8	117.4	120.4	20.1	16.8	890.82	295.6	288.1
2000	1.1	0.0	11.0	132.0	145.1	36.8	80.0	178.8	86.5	110.7	29.0	11.3	1107.1	362.9	423.6
2001	1.8	39.9	122.7	67.2	233.7	137.8	93.4	131.7	89.7	80.2	2.6	21.3	996.12	358.7	333.9
2002	52.5	2.4	129.1	119.6	85.2	91.7	76.6	190.4	83.2	37.3	0.0	51.5	889.85	294.4	297.7
2003	30.4	2.0	78.2	179.1	40.4	110.5	107.8	76.1	85.5	53.4	6.2	51.8	970.23	266.1	206.6
2004	46.2	94.2	42.0	83.1	81.5	75.7	75.4	114.9	116.0	57.1	94.2	15.3	1080.7	285.4	421.4
2005	81.1	7.7	120.9	156.0	144.5	73.2	150.9	61.3	117.2	28.4	46.0	10.4	1297.7	448.4	359.5
2006	1.7	9.0	139.2	145.9	74.4	108.0	171.1	169.3	194.9	56.9	79.2	48.3	1252.8	458.8	354.5
2007	18.0	55.0	76.4	112.0	166.1	225.4	129.1	104.3	233.8	32.7	3.7	0.0	991.68	362.2	182.2
2008	33.7	8.3	3.4	57.8	121.0	118.2	120.5	123.5	160.0	66.1	97.1	5.8	762.99	256.2	209
2009	32.8	9.0	60.3	45.6	103.1	51.6	92.6	112.0	81.7	41.6	4.1	69.9	1125.3	322.2	394.4
2010	26.6	58.4	124.8	96.1	173.5	53.1	132.5	136.6	96.1	53.1	32.0	56.0	999.7	371.2	322.8
2011	2.3	7.1	55.5	73.7	193.6	65.5	150.5	155.2	125.5	5.5	88.2	0.2	850.85	329.9	314.8
2012	0.0	2.4	13.0	210.5	91.3	89.8	152.9	87.2	86.8	15.2	23.2	13.1	1161.6	504.9	325.8
2013	23.4	1.0	104.0	78.8	143.0	132.4	209.4	163.1	117.7	77.5	22.0	0.0	1250.8	416	394.7
2014	23.4	26.3	91.5	104.5	198.7	98.4	104.6	213.0	164.0	105.3	19.1	5.8	726.80	345.6	123.2
2015	0.0	2.5	38.2	28.9	56.1	147.2	113.1	85.3	103.6	34.1	23.3	38.6	1049.9	251.7	432.9
2016	54.4	4.7	33.5	173.3	226.1	101.0	70.9	79.8	71.7	100.7	53.1	0.0	1220.3	323.4	405.1
2017	0.0	88.4	91.0	88.5	225.6	54.7	153.6	115.1	174.4	128.8	6.4	0.0	1242.9	381.5	437.1
2018	4.2	59.0	132.1	198.6	106.4	188.2	41.7	151.6	63.7	50.4	144.7	6.7	1164.6	472	271.9
2019	0.0	13.3	17.6	128.6	125.7	81.7	207.2	183.1	167.3	88.3	62.1	0.2	1383.9	338.2	532.9
2020	24.3	61.2	118.2	215.3	199.4	104.0	104.2	130.0	133.7	169.9	17.3	0.0	1234.4	405	355

Source: National Meteorology Agency of Ethiopia (2021)

Appendix-4. Household's perception on climate change and variability in study area

Variables	Response	THGAF (N=134)		NTHGAF (N=134)		Total (N=268)		Chi-square	p-Value
		N	%	N	%	N	%		
Level of awareness of climate change for the past 30 yrs.	Yes	120	89.6	109	81.3	229	85.5	1.760	0.185
	No	14	10.4	25	18.7	39	14.5		
Climate change and variability indicators	Drought	14	10.4	37	27.6	51	19.0	29.62	0.000
	Flood	4	3.0	15	11.2	19	7.1		
	Frost	0	0	5	3.7	5	1.9		
	All	116	86.6	77	57.5	193	72.0		
Extent of temperature for the last 30 years	Fluctuating	40	29.9	19	14.2	59	22.0	22.68	0.000
	Constant	4	3.0	25	18.6	29	10.8		
	Increasing	90	67.2	90	67.2	180	67.2		
	Decreasing	0	0	0	0	0	0		
Extent of rainfall for the past 30 years	Fluctuating	72	53.7	43	32.1	115	42.9	31.50	0.000
	Increasing	0	0.0	24	17.9	24	9.0		
	Decreasing	62	46.3	67	50.0	129	48.1		

Source: field survey 2021)

Appendix .5. Descriptive statics of compare mean home-garden agroforestry and non-tree base garden (Independent Samples Test)

Group Statistics							
	Group of Respondents		Statistic	Bootstrap[a]			
				Bias	Std. Error	95% Confidence Interval	
						Lower	Upper
What is your annual income 2020/2021?	HGAF	N	134				
		Mean	4677.7090	-3.0458	167.1127	4351.2370	5011.2765
		Std. Deviation	1985.0383	-31.3137	266.02023	1453.50712	2496.00666
	NHGAF	N	134				
		Mean	2627.7985	8713	94.1851	2440.5194	2799.6817
		Std. Deviation	1095.0210	-4.76172	77.85878	943.04138	1248.64496

Independent Samples Test									
		Levene's Test for Equality of Variances	t-test for Equality of Means						
		F-value	t-value	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
What is your annual income 2020/2021?	Equal variances assumed	13.837	10.467	266	.000	2049.91	195.842	1664.312	2435.508
	Equal variances not assumed		10.467	207.08	.000	2049.91	195.842	1663.810	2436.010

Source: Descriptive statics of SPSS version 20 (2021)

BIOGRAPHY

Bizuneh Abera, the author, was born in Bensa district, former Sidama zone Ethiopia on June 25, 1978 G.C. He attended his primary education at Dalecha primary schools. He completed his high school education at Aleta Wondo secondary school in July 1995 and obtained his B.Sc degree in Rural Development and Family Science in July 2009 G.C. After graduation he worked in the former Sidama zone Wondo genet district vice head agriculture and natural resource office for 7 years and former sidama zone Environment and Forestry office as forest utilization officer for 5 years. He pursued his graduate studies in Climate Change and Sustainable Agriculture at Hawassa University College of Agriculture.