



ADDIS ABABA UNIVERSITY
COLLEGE OF TECHNOLOGY AND BUILT ENVIRONMENT
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DEPARTMENT OF URBAN AND REGIONAL PLANNING

**“The Impact of Homegarden Agroforestry on Urban Microclimate:
Variations across Urban Settings in Dila Town, Ethiopia”**

Author: Elsabet Memiru Mengesha

June, 2025

Addis Ababa, Ethiopia



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Author: Elsabet Memiru Mengesha

**A Thesis submitted to the Department of Urban and Regional Planning,
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Degree of Master of Science in Environmental Planning and Landscape
Design.**

Advisor: Prof. Kumelachew Yeshitela

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Addis Ababa, Ethiopia

DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented for degree in any other university. All sources of material used for the thesis have been duly acknowledged, following the scientific guideline of the University.

Students Name: Elsabet Memiru Mengesha

Enrolment Number: GSR/5030/15

Signature: _____

Date: _____

Confirmation

The thesis is submitted with my approval as the Institute's supervisor.

Supervisor's Name: Prof. Kumelachew Yeshitela

Signature: _____

Date: _____

APPROVAL SHEET

This is to certify that the thesis prepared by Elsabet Memiru entitled: *The Impact of Home Garden Agroforestry on Urban Microclimate: Variations across Urban Settings in Dila Town, Ethiopia* and Submitted in fulfillment of the requirements for the degree of Master of Science in Environmental Planning and Landscape Design complies with the regulations of the University and meets the accepted standards concerning originality and quality.

Approved by the Board of Examiners:

Prof. Kumelachew Yeshitela Signature: _____ Date: _____

Advisor:

Hayal Desta (PhD) Signature: _____ Date: _____

Internal Examiner:

Aramde Fetene (PhD) Signature: _____ Date: _____

External Examiner:

Chairperson:

_____ Signature: _____ Date: _____

Head, Department of Urban and Regional Planning

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ACRONYMS

AFs	Agroforestry System
CRGE	Climate resilient green economy
FAO	Food and Agriculture Organization of the United Nations
FDRE	Federal Democratic Republic of Ethiopia
GHG	Greenhouse gas
HG	Home Garden
IPCC	Intergovernmental Panel on Climate Change
NGOs	Non-Governmental Organizations
KAP	Knowledge, attitude, and practice
SNNPR	Southern Nations, Nationalities, and People's Region
TEK	Traditional Ecological Knowledge
UHIs	Urban heat islands
UNFCCC	United Nations Framework Convention on Climate Change

ABSTRACT

Homegarden agroforestry is a traditional, multi-layered way of using land that combines trees, bushes, and crops around dwellings. It is very important for improving biodiversity, food security, and microclimate control, especially in cities and suburbs. Home gardens have always been an important aspect of sustainable land management in Ethiopia, where the practice is deeply ingrained in agricultural culture. This study investigated the ecological and socio-economic impacts of home garden agroforestry on urban climate resilience in Dila Town by comparing two distinct environments: the residential Sessa Kebele and the commercial Haroressa Kebele. The study employed a purposive sample strategy and a mixed-methods approach, incorporating field observations, household questionnaires, and microclimatic data collection. It concluded that home gardens substantially mitigate temperature extremes, enhance air quality, and promote urban biodiversity. In Sessa, bigger residential lots made it possible to create intricate layers of plants that look like forest ecosystems. In Haroressa, where space is limited, vertical and container gardening became popular as ways to adapt. Despite these benefits, barriers such as insecure land tenure, weak institutional support, limited technical knowledge, and restricted access to agroforestry inputs hinder widespread adoption. Community members in both kebeles expressed strong interest in expanding homegarden practices, provided they receive adequate training, resources, and formal recognition. The study recommends integrating agroforestry into urban land-use planning, creating decentralized input supply centers, and tailoring interventions to reflect the specific socio-economic and spatial realities of each area. Additional strategies include providing incentives like green infrastructure credits and fostering collaboration among local governments, NGOs, and communities. Future research should investigate the long-term ecological and socio-economic effects of home garden agroforestry, particularly in varied urban settings, while also calibrating onsite climate data with meteorological records. Ultimately, home garden agroforestry offers a promising, locally grounded solution for advancing urban sustainability and building climate resilience in Ethiopian cities.

Key Terms: Climate Resilience; Home Garden Agroforestry; Urban Climate; Urban Greening, Urban Sustainability; Dila Town

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Agroforestry is a dynamic, ecologically grounded natural resource management method that incorporates trees into agricultural and rangeland, enhancing and sustaining productivity for greater social, economic, and environmental advantages (Abebe & Asfaw, 2023). It creates a synergy between trees and agricultural production to deliver benefits like improved productivity and ecological stability while reducing climate impacts through soil preservation and carbon capture (Jose & Bardhan, 2012). Although agroforestry systems exhibit a wide variety across Africa they all follow the shared approach of combining woody perennials with agricultural operations (Mbow et al., 2014; Yimam & Yimer, 2016b). Agroforestry systems hold special significance for Sub-Saharan Africa as 15% of its farms maintain tree coverage of 30% or higher. The implementation of agroforestry practices enables substantial greenhouse gas emission reduction while simultaneously supporting agricultural production without affecting food security levels (Mbow et al., 2014; Robert et al., 2009).

Agroforestry has a long history in Ethiopia, and the most prevalent type is home garden agroforestry. Agroforestry homegardens are one of the smallholder agriculture strategies that has been seen as a way to help feed the 9 billion people who would live on Earth by 2050 (Abebe & Asfaw, 2023). Home gardens are small areas (usually less than 1 hectare) around a house that are usually used by the family (most home gardens are family gardens). They are made up of a mix of perennial and annual plants, and sometimes they have animals living with them. They may also have extra structures like ponds, greenhouses, and green roofs (Santos et al., 2022). In the Highlands, home gardens are not only essential for producing food and additional revenue, but they are also a cultural representation of independence and status (Hailu & Asfaw, 2011). Particularly common in the southern and southwestern regions, these systems have become deeply ingrained in agricultural practices (Molla, 2019; Linger, 2014). A dense vegetative cover of native trees, shrubs, and annual crops supports biodiversity and sustainability in the Gedeo indigenous agroforestry system, one of the oldest in Ethiopia (Erenso et al., 2022).

Mlambo et al. (2025) present a persuasive synthesis of worldwide data in response to increasingly unstable climate circumstances, supporting agroforestry's dual function in preserving agricultural productivity and bolstering ecosystem resilience against severe weather events. Their meta-analysis highlights four critical findings that establish agroforestry as a fundamental component of climate adaptation techniques. First, agroforestry systems greatly reduce the risk of droughts, floods, and heat waves, providing stability in areas where climate change has caused problems. Second, agroforestry landscapes cut down on surface runoff by 20–50% during heavy rain and help water soak into the soil better, which makes the land more resistant to floods and improves the health of the soil over time. Third, agroforestry helps keep crop yields up during times of climate stress by improving soil moisture retention, providing shade, and limiting wind exposure. Lastly, tree shelterbelts act as natural bio-shields, keeping coastal areas safe from strong winds and storm surges while also stopping harm to the landscape and infrastructure. These findings underscore agroforestry's essential function in climate adaptation, illustrating how nature-based solutions can cultivate robust agricultural systems. The findings of Mlambo et al. (2025) provide practical guidance for policymakers, environmentalists, and practitioners aiming to incorporate agroforestry into sustainable land-use strategies, facilitating a climate-resilient future.

Urbanization in Dila Town, located in the Gedeo Zone of southern Ethiopia, has been accelerating in recent years, contributing to significant pressure on existing green spaces. As the town expands to accommodate growing populations and economic activities, the clearance of vegetation for infrastructure, commercial buildings, and road networks has led to a decline in both the quantity and quality of urban green areas. This spatial transformation reduces the town's capacity to buffer climate-related stresses such as rising temperatures and irregular rainfall patterns, which are increasingly evident due to climate change. Urban green spaces, including home gardens and public parks, are essential for maintaining ecological balance, improving air quality, and enhancing urban resilience (Mlambo et al., 2025; Santos et al., 2022). Though it faces several difficulties, the Gedeo Home Garden agroforestry system displays persistence.

High population density mixed with little non-farm employment possibilities and extensive pests and diseases constitute the most pressing issues. Limited access to improved crop varieties and necessary financial and technical support resources presents difficulties for farmers (Bishaw et

al., 2013a). Maintaining conventional agroforestry systems is increasingly difficult due to the enhanced effects of climate change through erratic rainfall patterns and greater temperatures; these aspects aggravate already existing challenges (IPCC, 2012; Son et al., 2020). Urban microclimates call for study to find how agroforestry may fit urban environments and support adaptation and mitigating of climate change.

Home garden agroforestry is still poorly known in urban settings even if it can help to solve some problems. More study is needed on how Home garden (HG) agroforestry influences urban microclimates and improves climate resilience in cities like Dila Town in the Gedeo Zone. Although the environmental advantages of agroforestry in rural settings are well known, the exact effects of agroforestry methods on urban climates and variables including temperature and biodiversity have not yet been completely studied.

By looking at the effects of home garden agroforestry on Dila Town's microclimate, this study seeks to close this disparity. The study will look at how these methods affect local environmental conditions as seen by the community and how Understanding these dynamics would help the research support the integration of agroforestry into urban design to improve sustainability and community well-being and help to establish climate change adaption plans.

1.2 Statement of the problem

The global challenge of climate change is becoming top issue of concern since its consequences are widespread but particularly severe in underdeveloped countries like Ethiopia. Deforestation and greenhouse gas accumulation aggravate climate conditions leading to extreme weather patterns including irregular rainfall and temperature variations (IPCC, 2007; Molla, 2019). This results in a loss of biodiversity. For farming communities and city life especially in locations already facing environmental issues, climate change may have major negative effects. Urban areas like Dila Town in the Gedeo Zone show the effects of climate change on the environment as well as on the way of life of the people; hence, it emphasizes the critical necessity of sustainable solutions to solve these problems.

Dila Town is facing climate variability which is evident in the form of rising temperatures and unpredictable patterns that lead to agricultural loss, water scarcity, and increased vulnerability among urban people (Erenso et al., 2022). However, little research has been done on the potential contributions of agroforestry, particularly home garden agroforestry, to the resolution of these urban climate issues. Agroforestry has several well-known environmental benefits, including improved soil fertility, increased carbon sequestration, and biodiversity preservation in rural areas (Mbow, Smith et al., 2014). However, the potential of these technologies to address urban climate challenges has largely gone unnoticed, particularly in the setting of Dila Town.

Urbanization in Dila Town, located in the Gedeo Zone of southern Ethiopia, has been accelerating in recent years, contributing to significant pressure on existing green spaces. As the town expands to accommodate growing populations and economic activities, the clearance of vegetation for infrastructure, commercial buildings, and road networks has led to a decline in both the quantity and quality of urban green areas. This spatial transformation reduces the town's capacity to buffer climate-related stresses such as rising temperatures and irregular rainfall patterns, which are increasingly evident due to climate change. Urban green spaces, including home gardens and public parks, are essential for maintaining ecological balance, improving air quality, and enhancing urban resilience (Mlambo et al., 2025; Santos et al., 2022). However, in Dila, these spaces are under threat due to unplanned urban expansion and limited integration of environmental considerations in urban planning. The situation is exacerbated by the lack of local policies that prioritize green infrastructure, resulting in fragmented or poorly managed green spaces. As Dobhal et al. (year) highlight, sustainable urban development must consider the multifunctional role of urban greenery, particularly in climate-sensitive regions like Dila, where agroforestry practices could serve as a model for urban environmental resilience.

Although agroforestry has been extensively investigated in rural settings, its impact on urban landscapes and sustainability is still little understood. How home garden agroforestry could help urban areas manage local air quality, and adapt to climate change, and temperature management is currently unknown. One of the main challenges is the lack of research on the goal of Home garden agroforestry in urban climates, especially in Ethiopia like Dila where Home garden Agroforestry practice is intensively practiced. Therefore, investigating the issue of agroforestry

systems in metropolitan regions could help to lower environmental stress and boost city resilience against climatic repercussions.

Ethiopia and other developing nations face significant challenges as a result of climate change, particularly in metropolitan places like Dila Town where environmental stability and livelihoods are already being impacted by rising temperatures, erratic rainfall, and disappearing green spaces. Research on the potential benefits of home garden agroforestry, a technique steeped in local tradition, in mitigating urban climate challenges is lacking despite the increasing environmental stress. While agroforestry's advantages in rural areas are widely known, less is known about how it affects temperature regulation, biodiversity support, and the urban microclimate. The significance of this study lies in its assessment of the role that home garden agroforestry plays in urban climate adaptation and resilience in a community that is quickly urbanizing, thereby filling a major information vacuum. Evidence-based urban planning and sustainable development initiatives in Dila and other Ethiopian cities are intended to be supported by the findings.

The objective of the research is to identify the extent to which HG Agroforestry systems could contribute to the expansion of urban resilience and environmental sustainability in Dila Town. In particular, the focus is on the capacity of these systems to regulate temperature and promote urban biodiversity. The study aims to address the current research void by evaluating the potential of farming as a climate adaptation strategy for urban Ethiopia. The results of this study will inform urban planning decisions and facilitate the development of sustainable solutions to enhance climate resilience in metropolitan areas throughout Ethiopia and comparable regions.

1.3 Objectives of the study

1.3.1 General objective

The main objective of the study is to assess the impact of homegarden agroforestry on urban climate across urban settings in Dila town, Ethiopia.

1.3.2 Specific objectives

- I. To characterize the types and extents homegarden agroforestry systems in selected kebeles of Dila town.
- II. To assess the effect of home garden agroforestry on local microclimate conditions, specifically air temperature and relative humidity.
- III. To examine the contribution of home gardens to urban biodiversity, with focus on insects and bird populations.
- IV. To explore resident's perceptions of the benefits and challenges associated with homegarden agroforestry.

1.4 Research questions

- I. What types and extent of home garden agroforestry systems exist in selected kebeles of Dila town?
- II. What is the effect of home garden agroforestry on local microclimate conditions, specifically in air temperature and relative humidity?
- III. How do home gardens contribute to urban biodiversity, particularly in relation to insect and bird populations?
- IV. What are residents' perceptions of the benefits and challenges associated with home garden agroforestry?

1.5 Scope of the study

This study is conducted in Dila Town, located in the Gedeo Zone of the Southern Nations, Nationalities, and People's Region (SNNPR), Ethiopia. It focuses on two purposively selected kebeles, Haroressa and Sessa, representing commercial and residential urban settings respectively. The selecting process took into consideration variables such urban setting variances, population size compatibility, and accessibility. These sites were chosen to characterize the diversity of land use and vegetation cover, allowing a comparative analysis of the impact of home garden agroforestry across different urban settings. The spatial scope thus

provides a detailed view of how home gardens operate in distinct urban contexts within Dila Town.

The thematic scope of this study focuses on examining the multifaceted role of home garden agroforestry in enhancing urban environmental sustainability and climate resilience in Dila Town. It investigates how home gardens influence microclimatic factors such as air temperature and relative humidity, which are critical for mitigating urban heat and improving local climate conditions. The study also explores the contribution of home garden agroforestry to biodiversity conservation, with particular attention to insect and bird populations that play essential roles in ecosystem functioning. Additionally, the research assesses residents' perceptions of the benefits and challenges associated with maintaining these agroforestry systems, providing insight into social acceptance and potential barriers. By addressing these thematic areas, the study aims to highlight the significance of integrating home garden agroforestry into urban planning and policy frameworks to promote sustainable urban development and strengthen the adaptive capacity of cities facing climate change pressures.

The institute states that in order to ensure efficient project management and timely completion, the research must be completed within three months. But it took a year and a half to complete the research.

1.6 Significance of the Study

This study holds considerable significance in revealing the environmental role of home garden agroforestry within rapidly urbanizing areas like Dila Town. While home garden agroforestry has been traditionally practiced in rural Ethiopia for centuries, its function and benefits in urban contexts, particularly in regulating microclimates, remain largely unexplored. As cities expand, the need for sustainable solutions that moderate temperature, enhance biodiversity, and maintain ecological balance becomes urgent. By evaluating how home garden agroforestry impacts air temperature, humidity, and green coverage across different urban settings, this study contributes new knowledge. It shows how home garden agroforestry systems can serve as effective tools for climate adaptation and ecological sustainability in urban zones. This makes the research both timely and contextually relevant. The study helps fill an existing gap in urban environmental planning and agroforestry research.

The research is relevant to urban planning, allowing city authorities and planners to utilize the findings to promote the integration of green infrastructure into development initiatives. The research illustrates, through evidence-based analysis, the incorporation of home garden agroforestry into urban planning to alleviate heat island effects, protect biodiversity, and ensure long-term environmental stability. Public health specialists will also gain because more green space in cities means cleaner air, fewer respiratory ailments, and better mental health for people. The results give relevant and important guidance for regions like Dila, where cities are growing without planning and green spaces are getting smaller. These can help you find a balance between short-term and long-term goals. The research links the advantages of the environment to human health. It shows that agroforestry in household gardens can help cities deal with climate change better.

The study also gives NGOs, climate action groups, and local governments a way to help communities become more resilient to environmental changes. It demonstrates how community outreach, capacity building, and financial or technical assistance can facilitate the growth and success of home garden agroforestry. This study can also help other cities in Ethiopia and other poor countries by showing how home garden agroforestry can be excellent for the environment and society when they are kept and integrated in city planning. It shows that a lot of individuals can benefit from the results, including people who live in cities, local officials, environmental groups, and development partners. These groups can utilize the knowledge to help people in the area develop long-lasting habits in the city. The research backs the idea of building towns that are better for the environment, the people who live there, and the climate. It makes cities utilize solutions that are good for people and the environment.

1.7 Research Limitations

The study has had resource constraints largely connected to time and money constraints. These limitations imply that the research focused on only two kebeles: Haroressa and Sessa. These locations are chosen to exhibit a range of commercial and residential settings, hence the findings might not be totally relevant to every kebeles in Dila Town. This restriction could affect the generalizability of the results acquired, particularly given other metropolitan areas with distinct demographic or infrastructure quality.

On the other hand, the study can also suffer from security issues regarding the urban character of the Home Garden Agroforestry System in Dila town. HG agroforestry is more common on the outskirts of the town, hence security issues in these areas could limit the researcher's access and influence the attitude of the local people to participate in the study. This may thus make it more challenging to get comprehensive data from specific areas where security concerns are more frequent. Security and budget constraints could affect the extent of the research and limit public knowledge of how HG agroforestry influences Dila Town's urban surroundings. Notwithstanding these limitations, the study seeks to offer a realistic evaluation of the goals of agroforestry in urban sustainability and climate adaptation. The study has suffered resource constraints largely linked to time and money constraints. These limitations imply that the research focused on only two kebeles: Sessa and Haroressa. Though these locations are chosen to exhibit a range of commercial and residential settings, the findings might not be totally pertinent to every kebeles in Dila Town. This restriction could affect the generalizability of the results acquired, particularly in view of other metropolitan areas with distinct demographic or infrastructure quality.

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1.8 Organization of the Document

The research report was set up in several primary sections to ensure a logical and simple presentation. Starting with the background of the research, Introduction moves to the problem description, objectives of the study, and specific research questions. Apart from any limitations encountered during the research procedure, the degree and applicability of the study have been

investigated. The section offered a strong foundation for understanding the objective and focus of the research.

Following the introduction, one is shown the Literature Review, which offers a comprehensive overview of current research coupled with relevant theoretical and conceptual frameworks. The part on research methods and materials, addressed the research area, study design, and data-collecting approaches in addition to an outline of how the data would be reviewed. Following the methodology, results, and discussion provided on unique order of analyzing each particular objective concerning the methods stated and the study report giving conclusions and recommendations for the governments and local communities.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The review of literature is also to assess previous studies on the effect of home garden agroforestry practice on the urban climate in different urban environments of Dila Town, Gedeo Zone. It delves into worldwide, regional and local views on the role of agroforestry in urban landscapes, also from the standpoint of climate variability and ecological resilience. It also looks at the theoretical and conceptual frames works in relation to the interactions between agroforestry, urban climate and looks at socio ecological systems, resilience theory and indigenous knowledge systems. By summarizing new knowledge, isolating research questions and suggesting new directions of enquiry, this section paves the way for deeper comprehension of the contribution of home garden agroforestry to advances in the urban sustainability and climate-change adaptation arenas.

2.2 Theoretical Literature Review

2.2.1 Agroforestry and Homegarden Agroforestry

Homegarden agroforestry is an ecological land-use system that combines trees, crops, and occasionally livestock within the homestead, usually managed by family members (Abebe & Asfaw, 2023). This traditional practice integrates cultural and ecological knowledge and features multiple canopy layers along with diverse plant species. It supports sustainable food production and biodiversity conservation, while also enhancing household resilience. In Ethiopia's Gedeo Zone, this approach is grounded in indigenous knowledge and is characterized by complex vertical structures and rich plant diversity (Muleta et al., 2007). Homegarden agroforestry is essential for maintaining ecological balance and increasing communities' capacity to adapt to environmental stresses (Asokan et al., 2015). By promoting the interconnectedness of natural and human systems, it serves as a practical nature-based solution for sustainable urban livelihoods (Kabir & Webb, 2008).

Agroforestry practices in Ethiopia include various types such as homestead (homegarden), farm boundary planting, farmland tree planting, woodlots, and roadside tree planting (Abebe, 2013; Hailu & Asfaw, 2011). Among these, homegarden agroforestry is notable for its complexity and high species diversity, especially in southern and southwestern Ethiopia, including the Gedeo Zone (Linger, 2014). These systems often feature three to four vertical layers, with tall trees like *Cordia africana* and *Ficus* species forming the upper canopy, shrubs and fruit trees in the middle layers, and herbaceous crops at the bottom. This vertical arrangement optimizes space, improves the microclimate, and supports multiple ecosystem services. Homegarden agroforestry is particularly important in densely populated urban outskirts and rural-urban transition areas due to its multifunctional benefits. It represents a sustainable land-use approach well-suited to smallholder farms and the challenges posed by urban expansion (Molla & Kewessa, 2015).

2.2.2 Functions of Homegarden Agroforestry in Urban Climate Regulation

Homegarden agroforestry systems play a crucial role in regulating urban climate by sequestering carbon, moderating temperatures, and purifying the air. They capture significant amounts of atmospheric CO₂, storing it in both biomass and soil, which helps reduce urban heat islands and lower greenhouse gas emissions (Jose & Bardhan, 2012). The multi-layered structure of these systems provides shade, decreases wind speed, and supports evapotranspiration, all contributing to a cooler urban environment. In areas like the Gedeo Zone, where native trees and perennial crops densely populate homegardens, their positive effects on microclimate and air quality are especially notable. Furthermore, these systems help prevent soil erosion and enhance water retention, which supports urban resilience against extreme weather events (Kumar & Nair, 2011). Therefore, homegarden agroforestry offers an effective green infrastructure approach for sustainable urban development.

Homegarden agroforestry is a very important part of adapting to climate change since it makes ecosystems more resilient and helps people use a variety of ways to make a living. It makes people less dependent on outside markets, makes them more self-sufficient when it comes to food, and helps families deal with economic problems induced by climate change (UNFCCC, 2011). The strength of these systems comes from conventional ecological knowledge that is always changing through new ideas and hands-on experience. In places like Dila Town that are quickly becoming more urbanized, where both climate-related dangers and development

demands are mounting, homegarden agroforestry is a good way to adapt to nature. Its multifunctional design addresses environmental, economic, and social requirements, establishing it as a significant element of localized climate resilience measures (Méndez et al., 2013). Moreover, the alignment of indigenous traditions with Ethiopia's Climate-Resilient Green Economy (CRGE) framework bolsters the incorporation of grassroots solutions into national adaptation initiatives (CRGE, 2011; Asokan et al., 2015).

2.2.3 Agroforestry and Urban Climate Resilience

Agroforestry is described as a land use system, which integrates trees, crops, and/or animals on the same land and provides both ecological and economic benefits (Nair, 2011). Theoretical models underscore its role in the improvement of ecosystem services e.g., carbon sequestration, enhancement of soil fertility, microclimate regulation (Jose, 2009). Resilience theory, which seeks to understand the ability of a socio-ecological system to absorb disturbance and still keep on functioning (Holling, 1973), is particularly relevant to an understanding of the potential of agroforestry to address climate variability. Through the promotion of plant diversity and the diversification of vegetation cover, agroforestry offers a buffer against extreme weather events (Mbow et al., 2014), and enhances the capacity of the landscape to cope with dry spells and floods. This renders agroforestry a feasible strategy for enhancing urban climate resilience, especially in areas with high rates of urbanization and land degradation. The establishment of agroforestry systems in Ethiopia; especially in the Gedeo Zone, has been highly influenced by Traditional Ecological Knowledge (TEK) and old ecological practices (Abebe, 2005).

Classical agroforestry systems of the home garden type simulate the natural forest system and sustain the long-term productivity of the land without upsetting the ecological harmony (Mehari & Abera, 2019). These agro ecosystems are characterized by high species diversity and a multifunctionality that increases climate resilience (Yadessa et al., 2001). Agroforestry is now widely acknowledged in urban areas as a method to mitigate climate change, due to its effect on cooling, mitigating the heat island effect, and improving air quality (Lin, Perfecto, & Vandermeer, 2008). Nevertheless, from a theoretical perspective, it remains the case that successful embedding of agroforestry in urban planning will depend on robust policy backing, institutional structures, and the participation of stakeholders (Mbow et al., 2014).

Although agroforestry has a number of benefits, still there is uneven adoption of agroforestry across the region because of social, economic, and institutional constraints. Theories of land-use choice suggest that farmers and households are making complex trade-offs including work requirements, rates of return, and tenure security (Mercer, 2004). Availability of financial incentives, legal, and policy barriers along with limited dissemination of information often represent obstacles in scaling up (FAO, 2019). The success of urban agroforestry or fruit and nut trees is based on various factors including governance systems and stakeholder networks and long-term commitment to sustainable land management which involves access and use of natural resources (Gitz & Meybeck, 2012). Its implications and prospects can be explored in terms of the theories developed around resilience and ecosystem services of agroforestry as a field of policy intervention in urban environment areas, as in Dila Town, and a call for the mainstreaming of agroforestry in the sustainable urban environment agenda.

2.2.4 Ecological Theories Related to Biodiversity and Agroforestry

The sustainable use of natural resources and the preservation of biodiversity depend mostly on indigenous knowledge. With great relevance in society adaptation to climate change and food security, the phrase indigenous knowledge refers to the integrated information, practices, and beliefs passed across generations through cultural transmission (Son et al., 2021). Ethiopian Gedeo communities have untapped and valuable traditional knowledge systems that influence their agriculture and environmental management practices (Zegeye, 2018). They are systems that allowed smallholder farmers to sustain and even withstood changes in the environment.

The conventional agroforestry systems including home garden agroforestry depict the extent to which indigenous wisdoms encapsulate “ecological sustainability” indicative of planet life support systems. Practiced in areas like Aroresa Kebele, Gedeo Zone, this is the principal agroforestry system involving many species like coffee, enset, fruits trees, and shade living plants (Mehari & Abera, 2019). These mixed species help to minimize erosion, increase soil fertility, and store water as they mirror natural forest ecosystems. Traditional agroforestry systems also enhance long-term environmental stability and productivity by including elements of biodiversity conservation.

The agroforestry socio-ecological systems approach focuses on relationships between human societies and the ecosystems in which they reside. This approach reveals how communities define and are defined by their natural surroundings, fostering sustainability for both. By means of thermal regulation, carbon offsetting, and enhancement of urban air quality, urban agroforestry supports urban sustainability (Mbow, Smith et al., 2014). Through lower heat stress and increased ecological stability, home garden agroforestry shields Dila town from urban climatic disturbances.

The incorporation of agroforestry into urban planning in this way has the potential to increase cities' climate resilience and contribute to greener cities. In addition, the agroforestry system enhances biodiversity by generating heterogeneous landscapes which maintain various plants and animal forms. Perennial and annual crop combination in home garden agroforestry systems support the sequestration of soil organic matter and improve nutrient uptake. These systems have been proven to store high levels of carbon and are therefore a good strategy to mitigate the impacts of climate change (Mbow, van Noordwijk et al., 2014). Their sequestration potential, however, is variable among different agroforestry models and area conditions, which requires further exploration.

Despite its multiple ecological and socioeconomic advantages, some challenges to policy support, knowledge development and socio-cultural acceptance, prevent agroforestry from being more widely adopted. Agroforestry development can be realized only if there is an institutional framework that integrates local knowledge with scientific knowledge. Further collaboration between scientists, policymakers and local people could fill in data gaps and sustain agroforestry adoption. With an understanding of principles underpinning ecological complexity in agroforestry, policy-makers and practitioners can take actions that can lead to robust and environmentally diverse landscapes that sustain human wellbeing and biodiversity.

2.2.5 Sociocultural and Economic Theories

The uptake and maintenance of agroforestry practices are heavily influenced by sociocultural and economic drivers. Social theories focus on cultural values, traditional knowledge and social institutions as influences of agriculture. Agroforestry is an age-old farming system in many

indigenous people's lifestyle and communal resources management, which guarantees the system, will be perpetuated to the next generation (Zegeye, 2018). These traditions are typically transmitted through non formal learning and social networks, reinforcing social cohesion and sustainable practices in land use.

Agroforestry is also economically important to smallholder farmers since it creates multiple income streams, and has livelihood support and poverty reduction potential for rural areas. Research has shown that mixed tree-crop-livestock systems increase yields due to risk mitigation associated with monoculture agriculture (Mbow, van Noordwijk et al., 2014). Agroforestry also offers many marketable commodities such as timber, fruit, medicinal plants, and fuel wood, contributing to the diversification of household income and resilience to economically destabilizing events in the market and the climate (Price and Buttoud 2006). The farmer's willingness to invest in agroforestry is very much influenced by land tenure security. Stable land tenure fosters long-term planning and the sustainable management of the landscape system, whereas tenure insecurity may reduce the willingness to invest in tree planting and conservation (Bishaw et al., 2013b).

Policy interventions that recognize community land rights and provide legal pathways to access land can promote agroforestry adoption. Also, tax holidays, and government support for agroforestry development, could lead to more participation in sustainable land use systems. Market access and value addition along the chain also have a major influence on the performance of agroforestry systems. Such farmers tend to experience limited access to markets, transport infrastructure, and finance and this hampers their realization of the benefits of their agroforestry activities (Mehari & Abera, 2019). Enabling markets as well as training in cooperatives, fair trade, and improved market structures can increase the profitability of products from agroforestry, thereby creating attractive incentives for both farmers and investors to invest in agroforestry.

Finally, education and training in agroforestry cannot be underestimated in the adoption process. Enhancing awareness of the economic and environmental benefits of an agroforestry system through training, extension and participatory research may enable farmers to make decisions about their land use. Meanwhile, mating ancient wisdom with scientific developments and the

latest agroforestry methods will help enable these systems to respond to today's pressures. Through the resolution of socioeconomic and sociocultural barriers, policymakers can expand the fertile ground agroforestry requires, ultimately providing gains to local communities and the larger environment.

2.3 Conceptual framework

2.3.1 Home garden Agroforestry and Urban Climate Regulation

Urban heat islands (UHIs) caused by climate change, air pollution, and a competing demand for limited space for green and public areas are expanding in growing cities. Agroforestry in general and, especially, home garden agroforestry, represent crucial tools to reduce these issues whilst also via microclimate regulation, carbon sequestration, and a general increase of the urban level of resilience (Mbow, Smith et al., 2014). Trees and vegetation-shaded urban surfaces cool by evapotranspiration and shading, and therefore lower the air temperature. Moreover, these systems help in enhancing air quality as they control pollution and add more oxygen to the environment.

Several studies demonstrate the influence of home gardens on urban temperature and humidity. Studies in tropical and subtropical urban areas have indicated that tree-based agroforestry has lower daytime temperatures than non-vegetated areas (Mehari & Abera, 2019). The closed canopy architecture of home gardens attenuates direct solar radiation resulting in lower air temperatures and a more comfortable microenvironment. In addition, urban agroforestry may also enhance humidity due to transpiration, mitigating dryness and thermal comfort enhancement, especially in arid and semi-arid areas.

Case studies from various locations present evidence those agroforestry add to the amelioration of the urban climate. For example, in Dila Town Ethiopia, home garden agroforestry has played a great role in fighting excessive heat through continued tree shade in residential areas and a better local climate (Zegeye, 2018). In Nairobi, Kenya, for comparison, urban agroforestry initiatives are associated with a substantial reduction in temperatures and enhanced water seepage to the ground, which can mitigate urban flooding. The results provide evidence that

home garden agroforestry as a natural-based solution can contribute to urban climate adaptation, and enhance the sustainability and ecology of such cities where they rapidly expand.

Challenges despite, its potential benefits, urban agroforestry is also hindered by competition for land use, lack of policy support, and low public knowledge about its ecological benefits. More cities emphasize infrastructure developments than greenery and this is the cause of declining tree cover and poor agroforestry performance (Bishaw et al., 2013b). Land tenure problems and lack of incentives suppress the wide propagation of home-garden agroforestry. Overcoming these challenges requires urban planning that incorporates agroforestry as an essential part of climate adaptation.

Agroforestry included in urban planning and policy frameworks can contribute to increasing climate resiliency whilst simultaneously promoting biodiversity and food security. Government and city planners must promote community-owned Agroforestry initiatives, incentivize tree planting, and put next to green infrastructure with city planning. Using agroforestry to regulate climate, cities can become more sustainable, resilient, and healthier places for their inhabitants.

2.3.2 Biodiversity and Ecological Benefits of Home Garden Agroforestry

Agroforestry in the garden Home garden agroforestry is important for maintaining biodiversity in that it generates heterogeneous landscapes for a variety of plant and animal species. Unlike monoculture systems home gardens intercrop a wide range of perennial and annual crops, shrubs, and trees, which in turn enables a dynamic ecological balance (Mehari & Abera, 2019). These systems simulate the structure and functioning of natural forests, increasing ecosystem services like pollination, nutrient cycling, and soil stabilization.

In Ethiopia, indigenous agroforestry systems such as the Gedeo agroforestry have been noted to maintain a great species richness conserving ecosystem services (Zegeye, 2018). Pollination conservation: One of the major ecological services provided by agroforestry in home gardens is the conservation of pollinators. The varied floral composition of home gardens is important for pollinator species such as bees, butterflies, and birds, and indispensable for the sexual reproduction of a broad range of plant species (Mbow, Smith et al., 2014). This becomes even

more relevant in urban and peri-urban settings where fragmentation has an impact on pollinator species.

Home gardens enhance pollination efficiency by maintaining a continuous supply of food sources and nesting habitats leading to increased fruit- and seed-set and stability in food webs. Bird fauna is also favored by agroforestry landscapes, which offer refuge, nesting sites, and food resources to them as well as all the year around. It has been well documented that agroforestry systems harbor greater bird species richness than conventional farmland because of vegetation structures that are structured in strata and which serve as natural habitats (Bishaw et al., 2013b). Birds add to pest control by regulating the insect population in a natural way, which further reduces the bindings on the chemicals used in pest control. Furthermore, these home gardens contribute to urban biodiversity in that they act as ecological corridors linking fragmented green areas, and support species movements and gene flow.

Agroforestry systems fill the need for more urban green infrastructure, leading to better environmental quality and resilience. Home gardens are believed to improve soil health by reducing erosion, soil organic matter, and microbial diversity (Mbow, van Noordwijk et al., 2014). “Trees and perennial crops are doing all those wonderful things of stabilizing soils, increasing water infiltration, and reducing the potential that water will run off the surface” onto streets or into buildings, he said. Additionally, they assist in sequestering carbon, reducing greenhouse gases, and enhancing urban climate adaptation.

However, the conservation potential of home garden agroforestry is largely untapped due to urbanization pressures, policy constraints, and land-use competition. In many cities, infrastructure expansion is highly valued over biodiversity conservation, and agroforestry landscapes are degraded. To enhance the ecological potential of home gardens, policies should be developed to encourage agroforestry management in urban settings, preferred use of local/species for multiple uses, and existing communities in biodiversity conservation. Acknowledging home gardens as integral to urban green spaces provides the potential to improve ecosystem sustainability including food security and climate adaptation in fast urbanizing areas.

2.3.3 Socioeconomic and Community Perceptions

Home garden agroforestry has a significant impact on food security, resilience, incomes, and social cohesion in rural and urban communities. These systems supply the household with various food items such as fruits, vegetables, spices and medicinal plants that they are able to maintain their nutritional requirements and well-being (Mehari & Abera, 2019). Furthermore, agroforestry generates cash through sale of excess yield, fuel wood and non-timber forest products which strengthens household financial resilience.

The significance of home gardens is more crucial for resource-poor farmers in Ethiopia as home gardens provide food and income all year round when even severely climate-induced crop failures are common (Zegeye, 2018). Local people's Knowledge, attitude, and practice (KAP) of agroforestry methods was significantly affected by cultural tradition, land tenure security, and access to information. Agroforestry is widely practiced in many Indigenous societies and is an indigenous-dominated agriculture (Bishaw et al., 2013b), since agroforestry is a part of traditional land-use practices and resource-sharing norms thus, is socially accepted. In town, changing social-economic and land use patterns increasingly render home garden agroforestry systems a strange phenomenon.

City dwellers may have limitations, such as space, tenure, or institutional support, which will influence the extent to which they invest in agro-forestry practices (Mbow, Smith et al., 2014). Overcoming these challenges will rely on policies that support secure land rights, financial instruments, and community action to embed agroforestry into urban environments. Although home garden agroforestry has numerous advantages, not all socio-economic households practice this agroforestry system. More affluent households may have better endowments of land, labor, and technical knowledge, which can help them to establish more organized agroforestry practices. On the other hand, poor families, especially in urban areas, also find it difficult to start and continue with agroforestry practices due to other economic challenges and land tenure insecurity (Mehari & Abera, 2019).

Government aid, capacity development activities, and collaborative mechanisms can help to overcome such imbalances by equipping smallholders with adequate resources, skills, and

market access to sustain agroforestry. Older people in traditional home gardens play a major role in terms of retaining traditional agricultural knowledge and consequently transferring this knowledge across generations (Zegeye, 2018). It's these social networks that have enabled communities to become more resilient and better at managing the collective resources that have enabled them to farm in a sustainable way. However, the growing trend of urbanization and modern agricultural patterns poses a risk to the continuation of traditional knowledge, calling for strategies of education that blend traditional methods of agroforestry with modern scientific knowledge. Issues with policy support, infrastructure, and economic incentives still characterize how communities view agroforestry.

Although agroforestry is a successful pathway toward sustainable forms of living, until now its full potential has not been realized due to poor institutional support and minimal investment in agroforestry-based businesses (Mbow, van Noordwijk et al., 2014). Policy-level interventions—such as integrating the socio-economic values of home garden agroforestry in land-use planning; providing subsidies, perhaps adaption subsidies; and research and development funding—can strengthen support and promote the long-term success of this production system. By accounting for socio-economic limitations and integrating agroforestry with community requirements, policymakers can ensure that these systems offer environmental, economic, and social benefits for generations to come.

2.3.4 Agroforestry Policies and Practices in Ethiopia

Agroforestry has been identified as an important means of sustainable land management and climate change adaptation in Ethiopia. Agroforestry has been integrated into the national environment and agriculture policies by the Ethiopian government in an attempt to contribute to re-afforestation, conservation of biodiversity, and rural development both at national and regional scales (FDRE, 2011). Initiated in 2011, the Climate Resilient Green Economy (CRGE) plan recognizes agroforestry as a main mechanism for mitigating climate change and its effects as well as for enhancing food security and rural livelihoods (Bishaw et al., 2013b). Consistent with Ethiopia's larger environmental strategy, agroforestry has been shown to restore damaged land, increase soil fertility, and reduce carbon emissions by building up woody vegetation in the agricultural landscape.

Notwithstanding policy acceptance of agroforestry, there are practical challenges. Agroforestry technologies have not been embraced generally due to poor coordination among institutions, lack of money, and limited extension service (Zegeye, 2018). Although the Ethiopian government has pushed reforestation and afforestation initiatives, inadequate technical support for smallholder farmers has hampered advancement. In cities, supportive policy of agroforestry integration into the urban landscape is not commonly implemented, although home garden agroforestry has the potential to contribute to urban sustainability, and to food security (Mehari & Abera, 2019). Closing these policy gaps demands more effective inter-departmental cooperation among government departments, scientific research institutions, and the local community.

Ethiopia has embraced several agroforestry methods; home garden agroforestry is among the most often used ones. For example, traditional home garden systems in the Gedeo Zone usually feature coffee, inset, fruit trees, and other multifarious species, so producing ecologically varied and rich landscapes (Negash, 2007). These systems have been appreciated as important in sequestering carbon, and conserving soil while managing the water. Yet, policy responses have tended to concentrate on large-scale afforestation projects and have paid little attention to the potential of smallholder-dominated agroforestry systems. Improvements to local governance and incentivizing home garden agroforestry could improve its uptake and success.

Research on agroforestry projects in Ethiopia has revealed areas of policy development and information exchange lacking. Formal research and extension services are said to undervalue the value of traditional knowledge in policy; traditional agroforestry systems are often linked with social and ecological resilience (Mbow, Reyes et al., 2014). Stop that gap Therefore, closing this gap needs participation between scientific researchers and traditional land managers. Investments to support agroforestry research, training, and market access also can enhance the feasibility of agroforestry as a sustainable livelihood option. In order to fully realize the benefits of agroforestry in Ethiopia, radical policy reform is required. Such changes should solve problems with regard to economic incentives, agroforestry integration with national and regional development strategies, and tenure security for tree-growing farmers. Agroforestry methods can also be extended in rural and urban areas by public-private cooperation and community-based projects. By overcoming policy and institutional limitations, Ethiopia can release the possibilities of agroforestry to assist sustainable agriculture, economic development, and climate resilience.

2.4 Summary of Literature review

The review of theoretical and conceptual literature considers the linkages between agroforestry, biodiversity conservation, climate adaptation, climate mitigation, and socioeconomic sustainability. The theoretical framework of the study relies on Resilience Theory, Ecological Theories, and Sociocultural as well as Economic Theories, & to explain how agroforestry beneficiaries can both enhance environmental sustainability and contribute to the well-being of the communities they reside. Resilience theory similarly highlights the ability of agroforestry systems to assimilate climate shocks and respond to altered environmental circumstances. With some reference to ecological theories, the importance of indigenous knowledge on biodiversity conservation and microclimate modulation with different agroforestry systems is discussed. At the same time, Sociocultural and Economic Theories advocate traditional knowledge, economic diversification, and market access as determinants that contribute to the adoption of agroforestry.

The conceptual model is developed based on these theories and then examines particular aspects of agroforestry's contribution to climate regulation, biodiversity conservation, socio-economic development, and policy adoption. Agroforestry and Urban Climate Regulation ponders the contribution that tree planting in home gardens and urban areas can make to people's livelihoods and urban temperature and humidity. Biodiversity and Ecological Significance of Home Garden Agroforestry demonstrates the support that agroforestry provides to pollinators and birds and as a component of urban green space for the stability of ecosystems. Perceptions of Socioeconomic and Community highlight the contribution of agroforestry to food security and local livelihoods and the challenges encountered in urban and rural communities in adopting agroforestry.

Agroforestry Policies and Practices in Ethiopia, finally, examine government policies, policy deficiencies, and research findings on agroforestry adoption in Ethiopia. In general, the critical need for policy support, knowledge dissemination, and community engagement for improving the stature of agroforestry in climate adaptation, biodiversity conservation, and livelihoods becomes evident from the review. Development and promotion of evidence-based policies and indigenous knowledge integration to enhance agroforestry systems can contribute to long-term ecological (and related socio-economic) resilience in Ethiopia and beyond.

CHAPTER THREE

METHODS AND MATERIALS

3.1 Description of the Study Area

The study is carried out in Dila district, Gedeo zone, of Southern Nations, Nationalities, and People's regional state (SNNPRS), Ethiopia (Yayeh et al., 2021). It is located 359 km far from Addis Ababa, at an altitude of 1,613 meters in 6°24'30"N latitude and 38° 18'30"E longitude (Figure 1). It is situated on the eastern shoulder of the Ethiopian Rift and covers an area of 1,123.47 ha. Dila, the administrative and commercial town of the zone Gedeo, has a population size of 84,952,, and a density of 8,004 people per km² (Asfaw et al., 2022). Rainfall is 900-1400mm per year and the mean daily maximum and minimum temperature is 25.4°C and 13.4°C. The wet season is from June to October, and the dry season is from October to June, with a short stint of rain in February.

Purposive sampling was employed in this study to deliberately select Haroressa and Sessa kebeles based on their contrasting urban characteristics, commercial and residential settings along with considerations such as population size compatibility, accessibility, and diversity in land use and vegetation cover. This approach enabled a comparative analysis of home garden agroforestry practices across different urban settings in Dila town, Ethiopia.

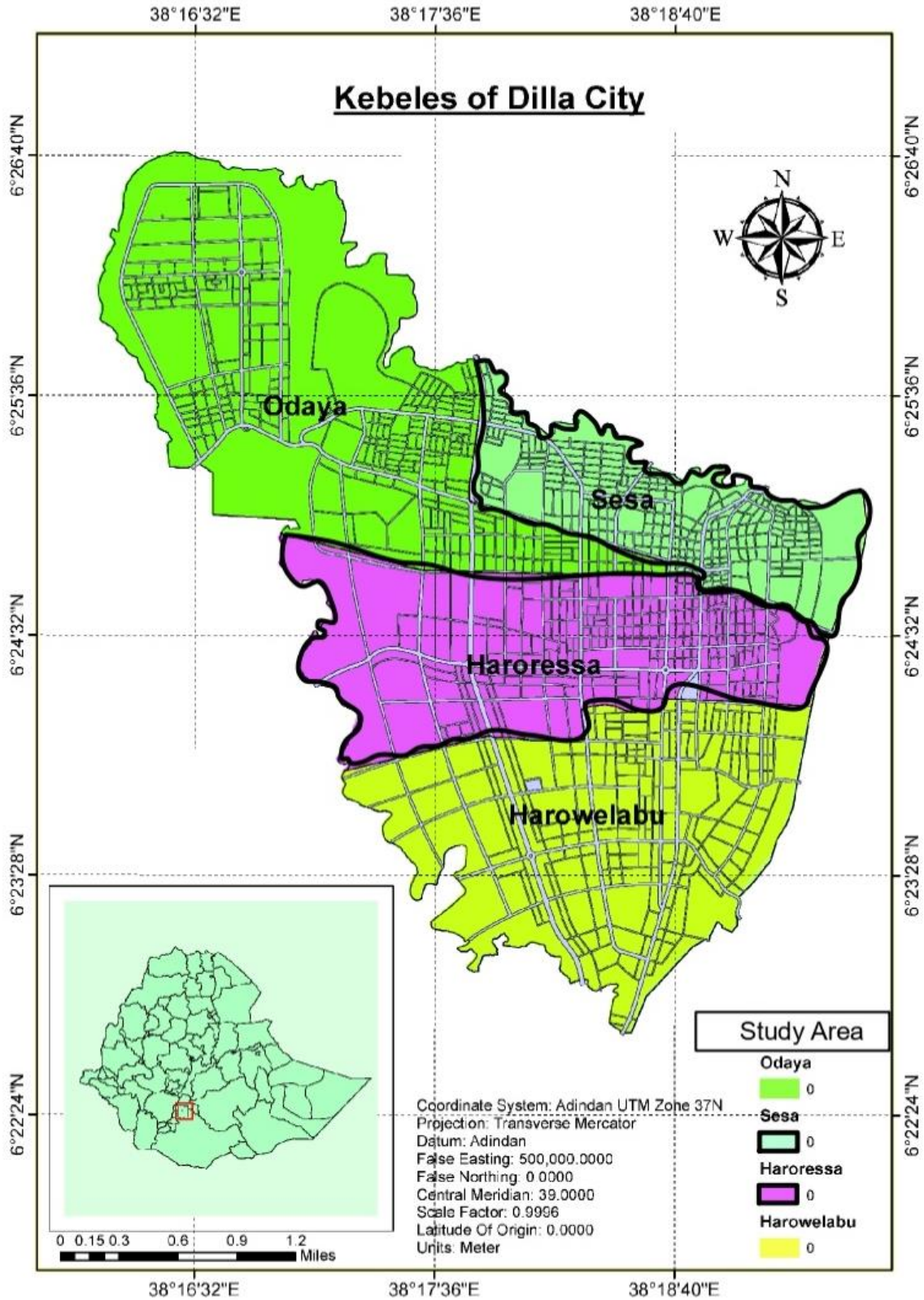


Figure 1: Selected kebeles of Dila town (source: Gedeo Zone Dila town administrative office-edited by researcher)

3.2 Research Design

This study used a comparative descriptive research methodology incorporating exploratory components. It seeks to compare home garden agroforestry systems in two distinct urban contexts within Dila Town: commercial and residential areas focusing on their structural attributes, ecological functions, and climate resilience advantages, while also examining community perceptions and potential incorporation into urban planning.

3.3 Sources and Types of Data

This approach includes collecting data both quantitatively and qualitatively. In particular, collected survey data through semi structured questionnaire used to evaluate the spread and diversity of the home garden agroforestry practice in Dila town. Meteorological observations based on the air temperature and humidity variations collected. Data Collection Techniques:

Primary data: collected among residents of Dila town using semi structured questionnaire in purposefully selected kebeles. Haroessa and Sessa were selected to represent residential and commercial areas from five kebeles. In addition, measurements of air temperature and relative humidity directly collected from the selected sites.

Secondary Sources: Secondary data obtained from data from government and non-government organizations, research institutions, academic databases, and public and private organizations.

3.4 Sampling Techniques and Sample Size

3.4.1 Sampling Techniques

A purposive sampling technique applied to select the study sites within Dila town. Among the five kebeles (as indicated in Table 1), two kebeles have been purposefully chosen. The household sample size is determined using Harper and Row's (1967) formula:

$n = N / (1 + N(e)^2)$ where:

- **n** = number of households sampled,

- N = total households practicing home garden agroforestry in the selected kebeles (12,166), and
- e = level of precision (at 90% confidence interval, $e = 0.1$).

This calculation yields a sample size of 99 households. To distribute this sample proportionally between the two kebeles, the following formula is applied:

$N_h = (n * N_h) / N$ where:

- n = total sample size (99),
- N_h = number of households practicing home garden agroforestry in each kebele (6,766 in Haroressa and 5,400 in Sessa), and
- N = total number of households practicing home gardening (12,166).

This results in a sample distribution of 55 households in Haroressa and 44 in Sessa.

The use of purposive sampling in this study limits the statistical representativeness of the findings, meaning the results cannot be generalized to all kebeles in Dila Town or beyond. However, it improves the contextual relevance by focusing on specific urban settings—commercial and residential areas that are central to the research objectives. This approach allows for in-depth comparison and advanced understanding of how homegarden agroforestry operates in different environments, making it suitable for exploratory and comparative research despite its limited generalizability.

3.4.2 Sampling Population

The study population consists of residents of Dila town (as indicated in Table 1) below.

Table 1: Dila town community Household number

No.	Kebele	Ketena	No. of Population	No. of Household
1	Sessa	Haaroke	8,870	1,810
		Weldena	7,834	1,599
		Bereda	9,755	1,991
2	Odaya'a	Buno	10,295	2,101
		Mechile	3,184	650
		Saron	5,237	1,069
3	Haroressa	Bedecha	13,355	2,726
		Tena	9,896	2,020
		Chumburo	9,896	2,020
4	Harowelabu	Elicho	9,198	1,877
		Yarsu	7,283	1,486
		Haroressa Dila	9,198	1,877
5	Chichu	Industry	10,200	208
		Golmasa	16,340	333
		Technology	6,100	124
	Total		104,001	21,225

(Source: Gedeo Zone Dila town Health office)

3.4.3 Sample Size

A total of 55 and 44 households are sampled from Haroressa and Sessa kebeles, respectively.

3.5 Data Collection Methods

Using structured questionnaires, a primary data collected purposive sampling technique from Haroressa and Sessa kebeles. The authors searched for secondary data in government or non-government records and reports, and extract such information from these sources.

Primary Data Collection

- *Observation:* Site-visit to selected households to record agroforestry practices and coverage. This has been employed to observe plant density, tree cover and shade plants which exist in the study area.

- *Household Surveys*: Structured questionnaire conducted to gather data on household home garden agroforestry efforts.

- *Measurements of air temperature and relative humidity*: They are an essential part of the direct data collection. So, two Digital thermometers data loggers (as shown in Figure 2) are placed at each sites in Haroressa and Sessa kebeles. These sites are carefully selected to represent localities with home garden agroforestry and control sites with little vegetation. All measurements are made 3 times a day (morning, noon, evening) during particularly for five days in order to estimate diurnal and short-term microclimate variation. This fine-scaled field measurement allows for direct quantification of the microclimatic impacts of agroforestry.



Figure 2: Digital Thermo-Hydrometer (SH-117)

Secondary Data Collection

- ***Academic Sources:*** Research papers, online databases, and repositories are reviewed to contextualize home garden agroforestry's impact on urban climates in Ethiopia and similar regions.
- ***Government and Policy Reports:*** Documents from local agricultural offices, environmental agencies, and meteorological services will be analyzed to examine existing policies and initiatives related to home gardening.

3.6 Data Analysis Methods

A combination of quantitative and qualitative analytical techniques is applied. Quantitative data processed using Excel, while qualitative aspects interpreted through thematic analysis. Findings presented using maps, tables, graphs, and field images.

Data Analysis Techniques

- ***Qualitative Data:*** Thematic analysis used to identify patterns and relationships.
- ***Quantitative Data:*** Statistical methods employed to evaluate the impact and effectiveness of home garden agroforestry in climate change mitigation.
- ***Data from on-site measurements:*** and humidity recorded in excels, and analyzed with SPSS. Descriptive (averages, medians, standard deviations and ranges) statistics are used to describe the variations of temperature and humidity time and space of the day and week at each site. Graphical approaches including line graphs scatter plots, and box plots used to represent temporal trends and differences between home garden agroforestry sites versus control (non-agroforestry) sites. Moreover, inferential statistical tests (t-tests or ANOVA) applied to see if differences in microclimate parameters are statistically different in the different sites. If data allow, correlation or regression analysis will be performed to examine the relationships of plant canopy density with microclimate variables.

3.7 Data Presentation Methods

Data are presented using three formats:

- ***Textual Form:*** Findings are summarized in written descriptions supported by key insights.
- ***Tabular Form:*** Statistical data are structured in tables for easy interpretation.
- ***Graphical Form:*** Visual representations such as graphs and diagrams used illustrate major findings.

Additionally, spatial analysis will be conducted using GIS (Geographic Information System), Excel, AutoCAD and Illustrator.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Results

4.1.1 Elements and Scale of Home Garden Agroforestry Practices in Dila Town

The study used semi-structured questionnaires and observations on the ground to investigate both phenomena of home gardens types progressing in the two study sites. Outcomes of the semi-structured interviews indicated that various elements of home gardens are planted in the study area. More specifically, food forests, vertical gardens, and medicinal plant gardens were the most common types mentioned by participants. This variety of agroforestry systems highlights the multifunctional roles of home gardens in the study area. Altogether, the data illuminate a diverse combination of traditional and vertical gardening integration within the residential landscape.

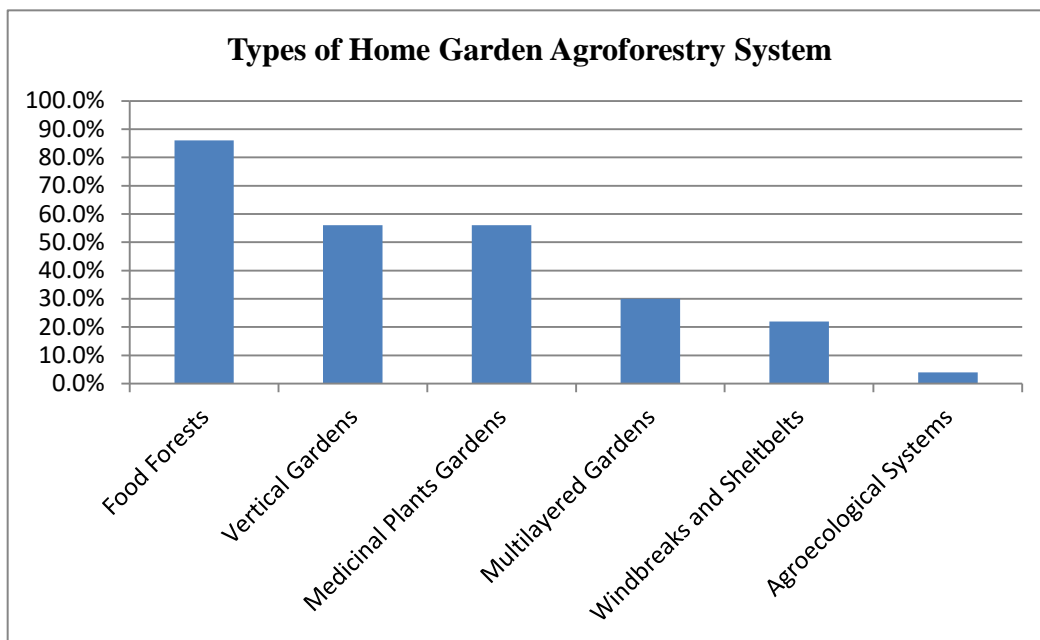


Figure 3 Types of Home garden Agroforestry practice exist on both study areas of Haroressa and Sessa Kebeles.

Agroforestry Type with Kebeles

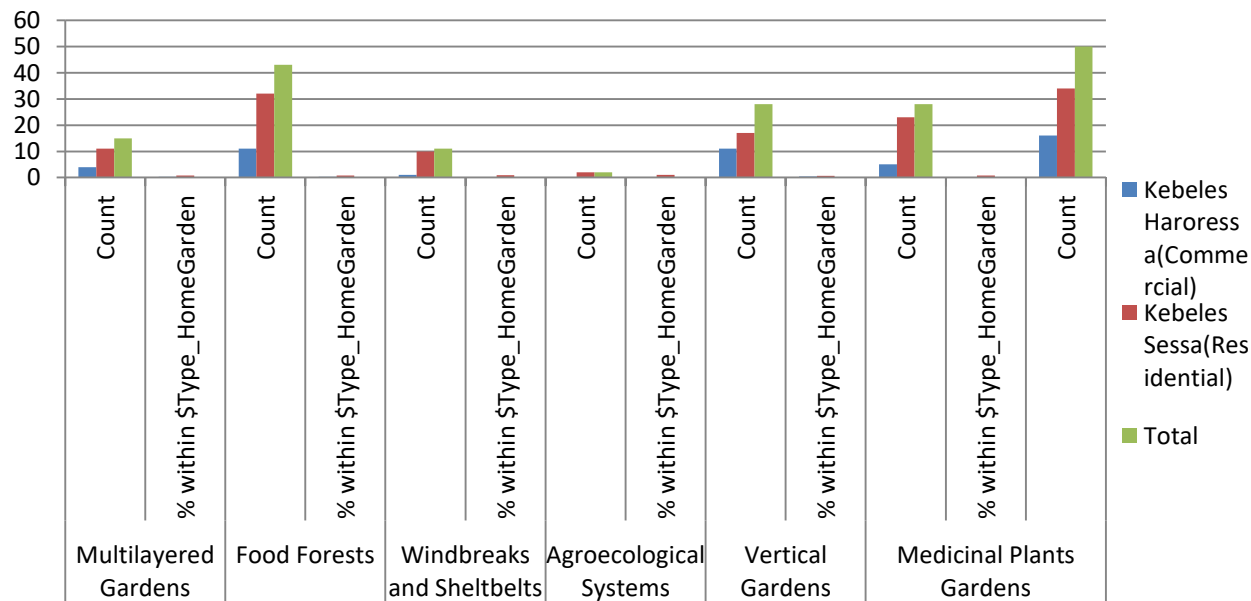


Figure 4 Home garden Agroforestry type which exist in the study area -variation across each Study area

It can be observed from the chart (Fig 4) that all forms of home garden agroforestry appear to be higher in Sessa kebele as compared to Haroressa. This is also confirmed by observational data. Photographic records in Sessa villages indicate that households have higher diversity of plants. On the other hand, business and industrial regions do not have much of vegetation and varieties of structures that residential gardens possess. These visual and observational findings corroborate the statement that agroforestry practices are more developed in the homestead environment.

4.1.1.1 Result found from by Observation of the Households

I. Sessa Kebele (Residential Site)-Home garden size of 100-200m²

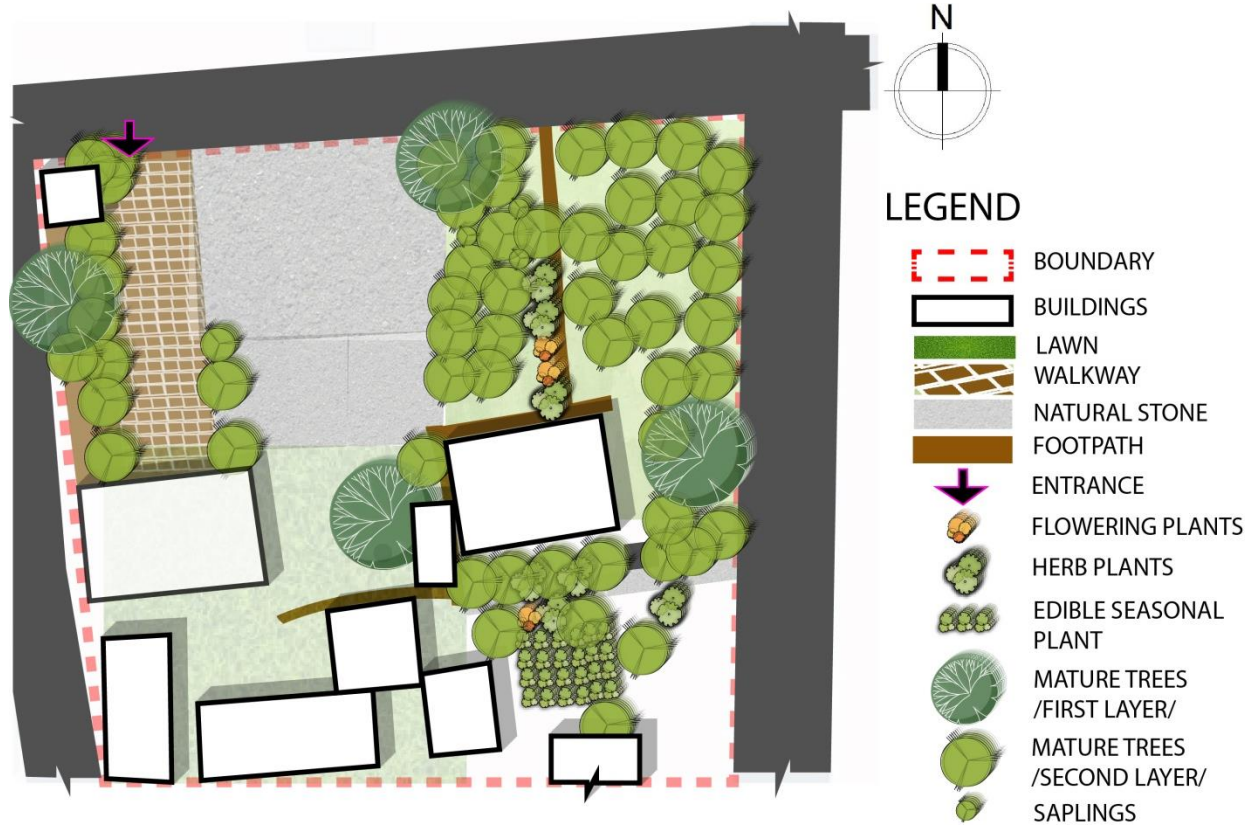


Figure 5 Plantation type and arrangement of Sessa Kebele Layout Plan of Home garden size 100-200m² (Source-Computed by the Author)



(a) *Duranta erecta variegata* used as focal plant for entrance to the building



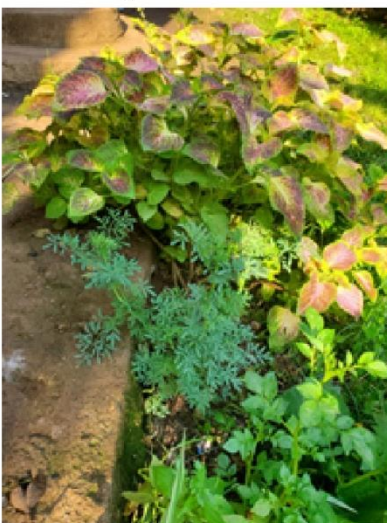
(b) *Dragon tree* surrounded by *Ensete Ventricosum*



(c) *Ensete ventricosum* used as a Directional plant for the walkway



(d) Car tire used as a planter pot for *Mangifera indica* (Mango in Amharic)



(e) *Ruta chalpensis* (Tena Adam in Amharic) used as medicinal plant



(f) *Musa balbisiana* (Muz in Amharic)



(g) *Ocimum basilicum* used as Medicinal plant (Besobela in Amharic)

Figure 6 Plant types collected from site observation in Sessa Kebele household of Homegarden size 100-200m²

Table 2 Plant type Collected from Site Observation in Sessa Kebele Household of Home garden size100-200m²

NO	PLANT TYPE (SCIENTIFIC NAME)	COMMON NAME(AMHARIC)	ECOSYSTEM SERVICES
1	<i>Coleus abyssinicus</i>	Kefay Abeba	Aesthetic Value
2	<i>Annona senegalensis</i>	Gishta	Food Production
3	<i>Ensete ventricosum</i>	Enset	Food Production
4	<i>Dragon tree</i>	–	Shade and Cooling
5	<i>Coffee arabica</i>	Buna	Food Production
6	<i>Broad-leaved croton</i>	Bisana	Shade and Cooling
7	<i>Mangifera indica</i>	Mango	Food Production
8	<i>Ruta chalpensis</i>	Tena adam	medicinal Value
9	<i>Ocimum basilicum</i>	Besobela	Aesthetic Value
10	<i>Duranta erecta variegata</i>	–	Aesthetic Value
11	<i>Musa balbisiana</i>	Muz	Shade and Cooling
12	<i>Persea americana</i>	Avocado	Food Production
13	<i>Carica papaya</i>	–	Food Production
14	<i>Moringa stenopetala</i>	shiferaw zaf	Medicinal Value
15	<i>Vingna unguiculata</i>	adenguare	Food Production
16	<i>Zea mays</i>	Bekolo	Food Production
17	<i>Liriope muscicola</i>	–	Aesthetic Value

II. *Sessa Kebele (Residential Site)*-Home garden size of 50-100m²

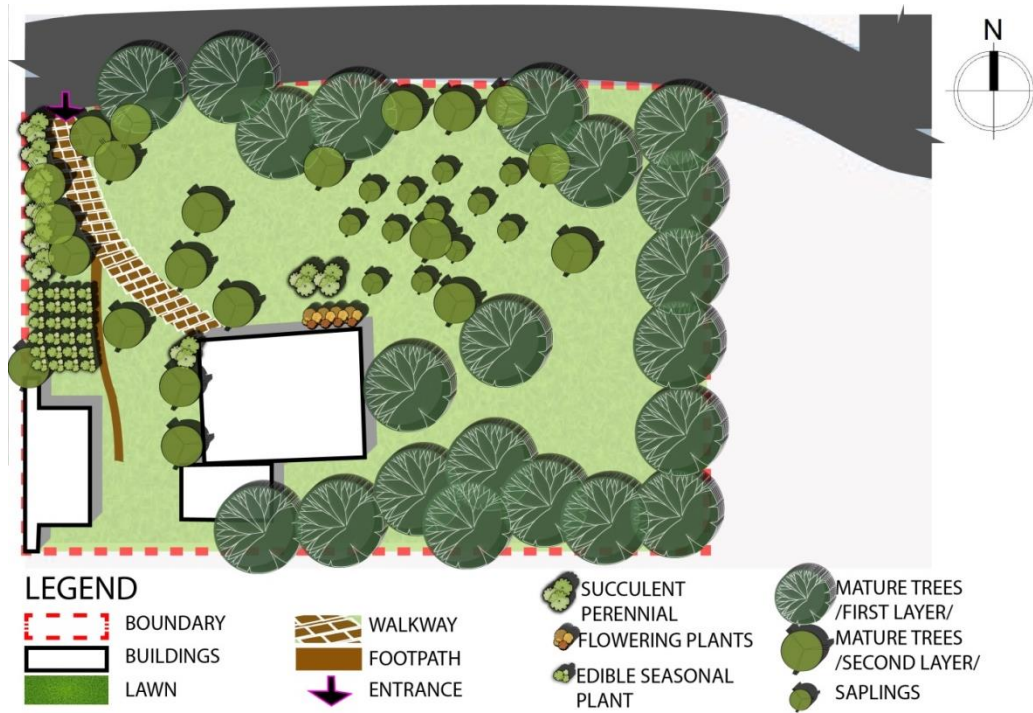


Figure 7: Plantation type and arrangement of *Sessa Kebele* Layout Plan of Home garden size 50-100m² (Source-Computed by the Author)



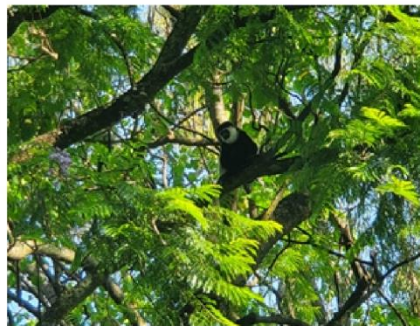
(a) *Jacaranda Mimosifolia* (Fern Tree)



(b) *Zea Mays* (Bekolo- In Amharic)



(c) Front Garden with saplings (Growing plants)



(d) Monkey-Colobus (Guereza in Amharic) in *Jacaranda mimosifolia*

Figure 8 Plant type Collected from Site Observation in *Sessa Kebele* Household Home garden size 50-100m²

Table 3 Plant type Collected from Site Observation in Sessa Kebele Household Home garden size 50-100m²

NO	PLANT TYPE (SCIENTIFIC NAME)	COMMON NAME(AMHARIC)	ECOSYSTEM SERVICES
1	<i>Snake plant</i>	–	Aesthetic Value
2	<i>Zea mays</i>	Bekolo	Food Production
3	<i>Ensete ventricosum</i>	Enset	Food Production
4	<i>Dragon tree</i>	–	Shade and Cooling
5	<i>Coffee arabica</i>	Buna	Food Production
6	<i>Broad-leaved croton</i>	Bisana	Shade and Cooling
7	<i>Mangifera indica</i>	Mango	Food Production
8	<i>Eucalyptus globulus labill</i>	Nech Bahir Zaf	Shade and Cooling
9	<i>Boston fern</i>	–	Aesthetic Value
10	<i>Duranta erecta variegata</i>	–	Aesthetic Value
11	<i>Broad-leaved croton (kenian)</i>	Ye Keniya Bisana	Shade and Cooling
12	<i>Rosa abyssinica</i>	–	Aesthetic Value
13	<i>Persea americana</i>	Avocado	Food Production
14	<i>Carica papaya</i>	–	Food Production
15	<i>Jacaranda mimosifolia</i>	–	Medicinal Value
16	<i>Dioscorea abyssinica</i>	Boyina	Food Production
17	<i>Gravillea robusta</i>	–	Aesthetic Value
18	<i>Psidium guajava</i>	Zeyitun	Food Production

It is reflected on (Table 3) by the different plant species in the residence part of the studies area i.e. in Sessa kebele. It indicates the reasons behind plant diversity grown by each household attribute mostly to the size of a compound. These types of characters are even more diverse if field observations of the sites are taken into account, where nourishing plants are very frequent. *Zea mays* (maize), *Ensete ventricosum* (false banana), and mango trees are especially well known. This further illustrates the home garden's functional contribution in terms of household food security and biodiversity.

III. *Sessa Kebele (Residential Site)*-Home garden size of less than 50m²

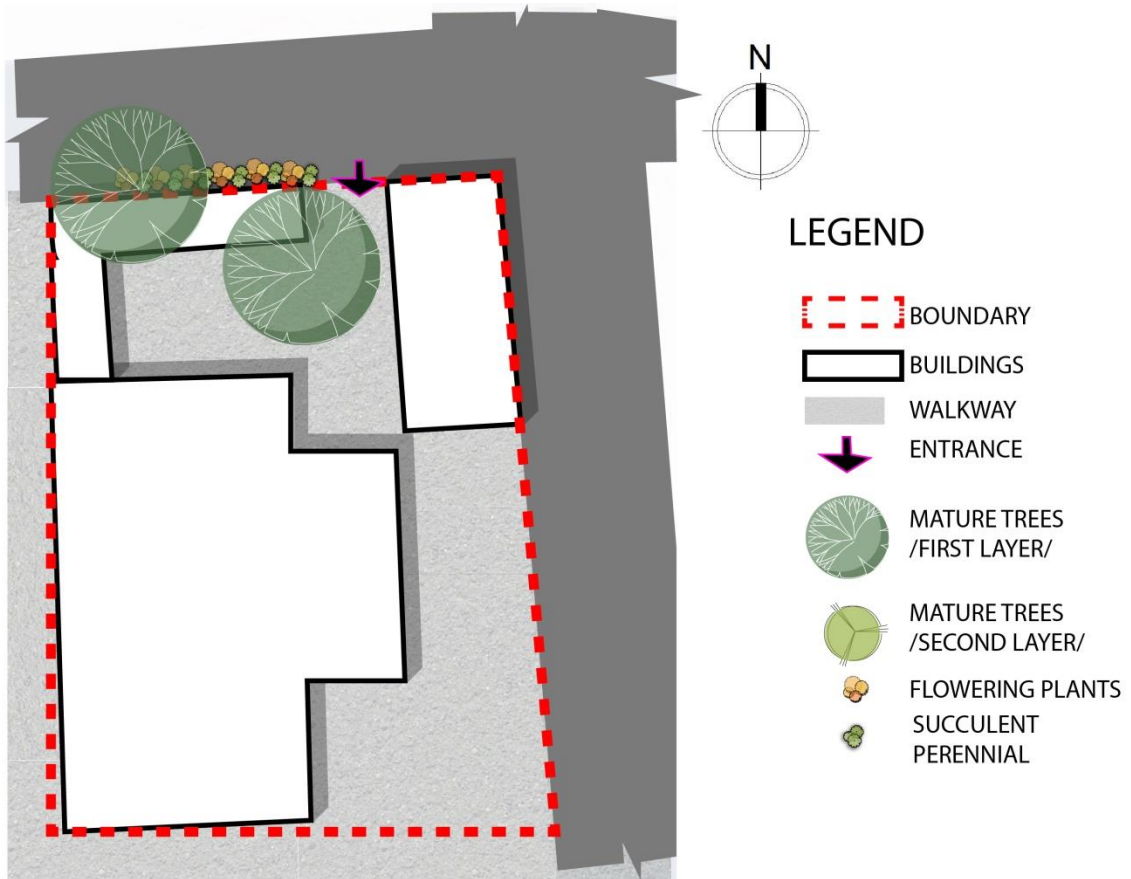


Figure 9: Plantation type and arrangement of Sessa Kebele Layout Plan of Home garden size less than 50m² (Source-Computed by the Author)



(a) Walkways arrangement aligned with giving space for mature trees



(b) *Persea americana* (Avocado in Amharic) seated on entire compound



(c) Flowering plants along the fence, beside the drainage line



(d) *Broad-leaved croton* along the fence (Ye Keniya Bisana in Amharic)

Figure 10 Plant type Collected from Site Observation in Sessa Kebele Household Home garden size >50m²

The sidewalks in the neighborhoods being paved with cobblestone in (Fig 10, b) have required cutting down mature street trees to accomplish it. This excavation was done in order to make a way for the outlet lines from home compounds. The existing vegetation had to be sacrificed, and development pushed underway. The disappearance of such trees not only changes the aesthetic of the area but may also lead to lesser local microclimatic regulation. This mirrors a classic compromise between urbanization and protecting the environment.

IV. *Haroressa Kebele (Commercial Site)*



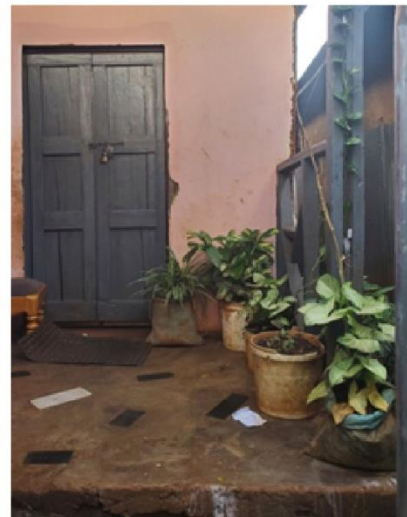
(a) Entrance to the site of Haroressa Kebele Households



(b) Back yard of Haroressa Kebele Households- Plantation on Car tire



(c) Plantation on Woven Bag



(d) Plantation on Old buckets

Figure 11 Plant type and space arrangement obtained from site observation in Haroressa Kebele Household

In the commercial site, Haroressa Kebele in (Fig 26 and Fig 27), shortage of space to plant can be seen in the households. As a consequence, residents use substitutes such as car tires, old pots, generic thick containers of plastic and woven bags to plant shrubs and flower plants. These makeshift planters mean you can have greenery even when space is limited. The disposition of these plants is generally observed on verandas and building walls in retaining walls. This approach serves as a creative response to urban compactness at the expense of greenery.

Table 4 Plant type Collected from Site Observation in Haroressa kebele Household

NO	PLANT TYPE (SCIENTIFIC NAME)	COMMON NAME(AMHARIC)	ECOSYSTEM SERVICES
1	<i>Ethiopian potohs</i>	–	Aesthetic Value
2	<i>Crown of thorn</i>	–	Aesthetic Value
3	<i>Caladium florida clown</i>	–	Aesthetic Value
4	<i>Begonia convolvulacea</i>	–	Aesthetic Value
5	<i>Liriope muscicola</i>	–	Aesthetic Value
6	<i>Shefflera</i>	–	Aesthetic Value
7	<i>Wondering jew</i>	–	Aesthetic Value

4.1.2 Impact of Home Garden Agroforestry Practices on Local Microclimate (Temperature and Humidity)

4.1.2.1 Result found from respondents by Semi-Structured questionnaire

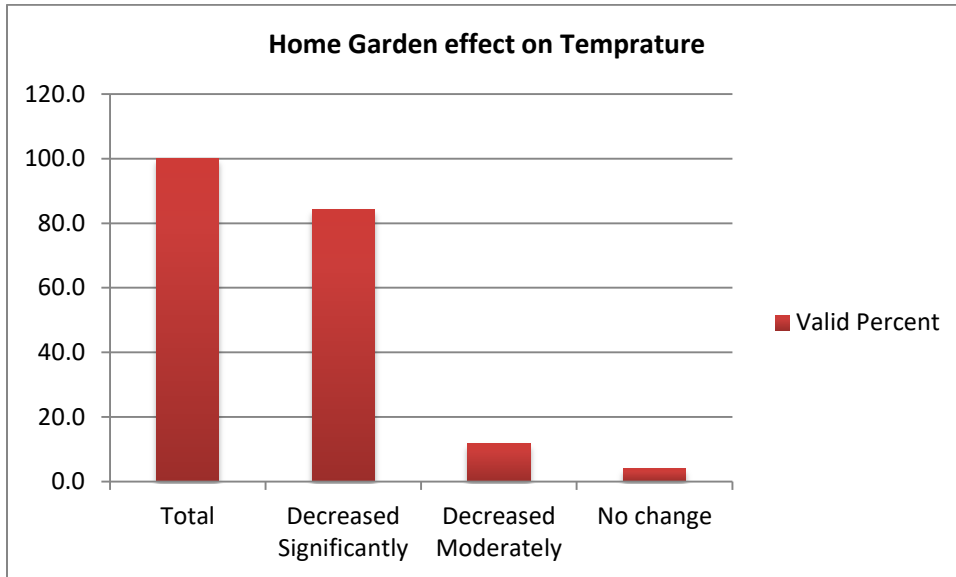


Figure 12 Home Garden effect on Temperature from both kebeles Household perception

In the areas where Home garden agroforestry practiced the effect on temperature is shown on Fig 12 that the Temperature is decreased significantly as shown in the diagram. On the other hand the effect on humidity showed increased moderately in the areas as shown in diagram.

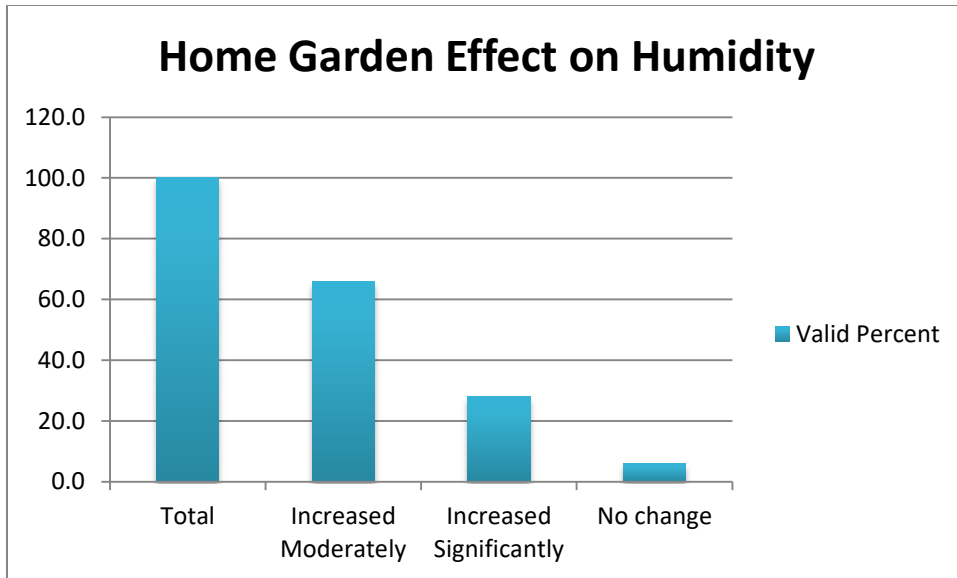


Figure 13: Home garden effect on Humidity perceptions of Both Kebeles Households

Diagram the results showed that Home garden has more effect in temperature in Kebele than Haroressa kebele. Similarly, the crosstabs for Home garden effect on humidity in Sessa Kebele showed increase than Haroressa Kebele as shown in diagram.

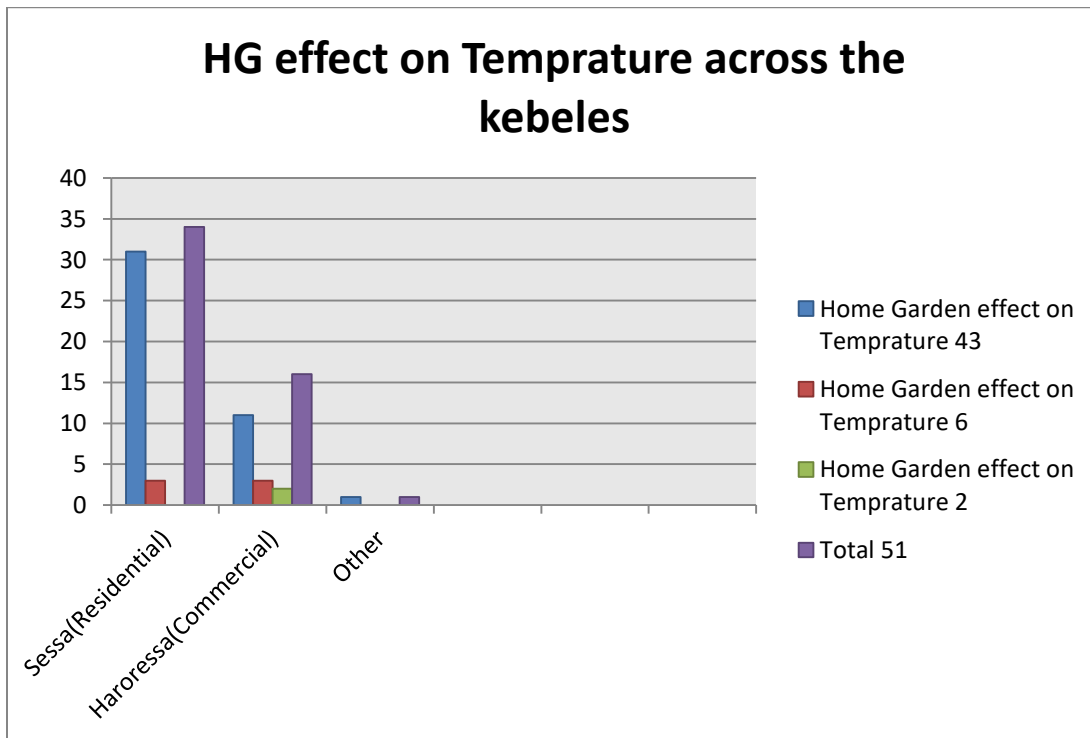


Figure 14 Home Garden effect on Temperature across the Sessa and Haroressa Kebele

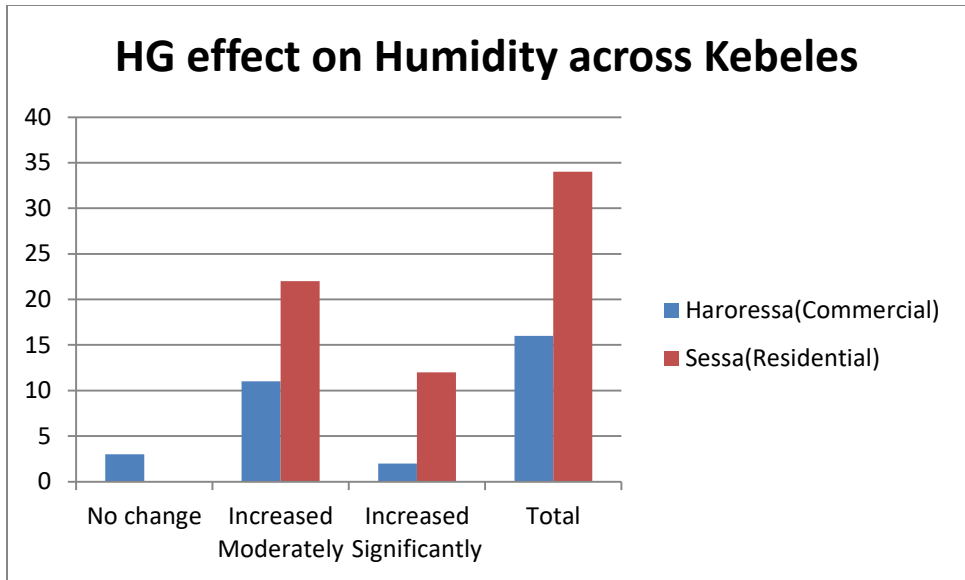


Figure 15 Home garden effect on Humidity across Haroressa and Sessa Kebele

4.1.2.2 Result found from on-site examination of air temperature in °C and Relative Humidity in %

As described in the method section above, Air temperature and relative humidity were recorded in two contrasting urban types in Dila Town for seven consecutive days: Sessa Kebele characterized by high practice initiations of home gadget agroforestry practices and Haroressa Kebele an area dominated with commercial activities with minimal vegetative cover. An on-the-spot study of Air Temperature in °C and Humidity in % between both study areas in respect of this attribute have been considered as the principal criteria adopted for the identification of urban microclimate variation. Three hourly observations were made in the morning (7:00–8:00 AM), afternoon (1:00–2:00 PM), and night (7:00–8:00 PM). Due to environmental limitations, several recordings have been omitted and these have been indicated where applicable. They found that if they only had data from May 6 to May 12 (which they were but there is missing data), the paper used data from May 6 to May 10 for five days in a row.

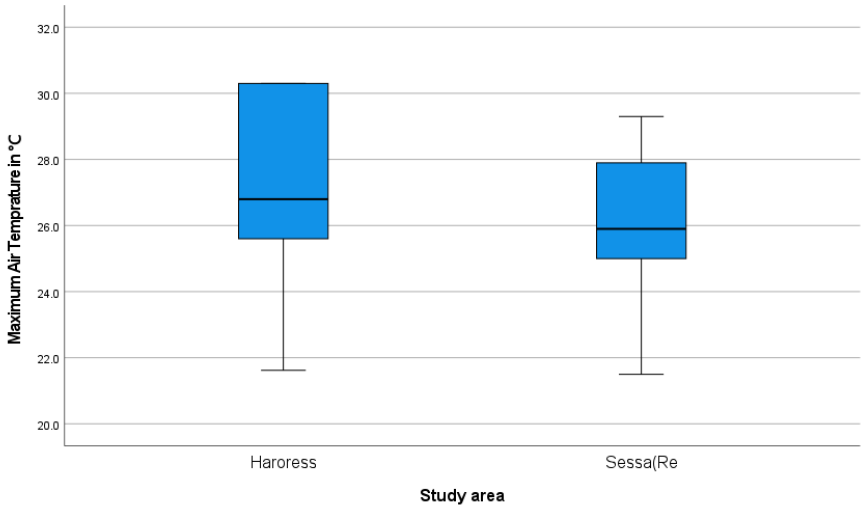


Figure 16: Maximum Air Temperature across Haroressa and Sessa Kebeles

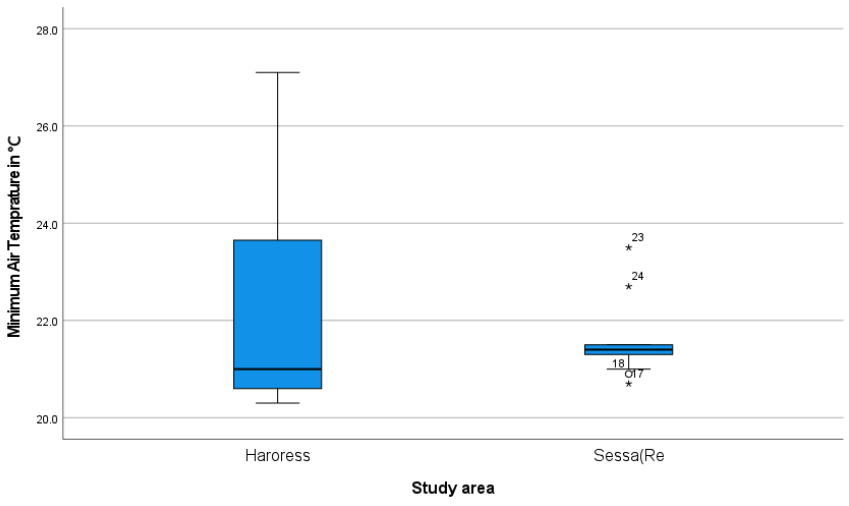


Figure 17 Minimum Air Temperature across Haroressa and Sessa kebeles

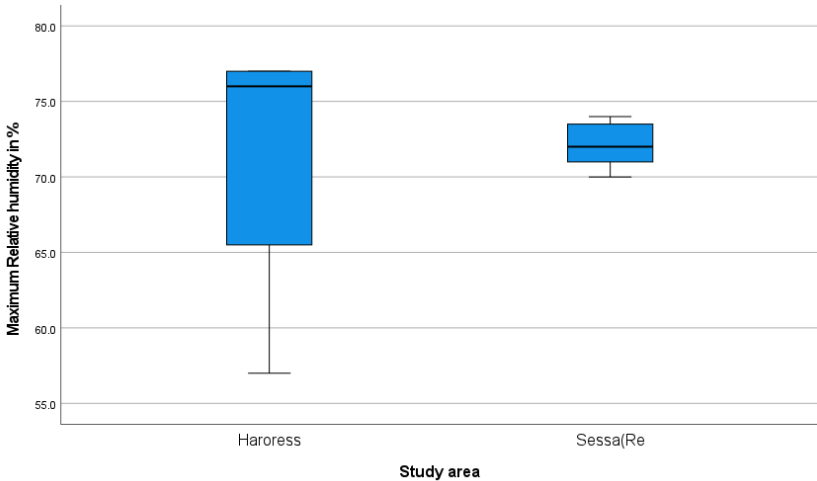


Figure 18 Maximum Relative Humidity across Haroressa and Sessa Kebeles

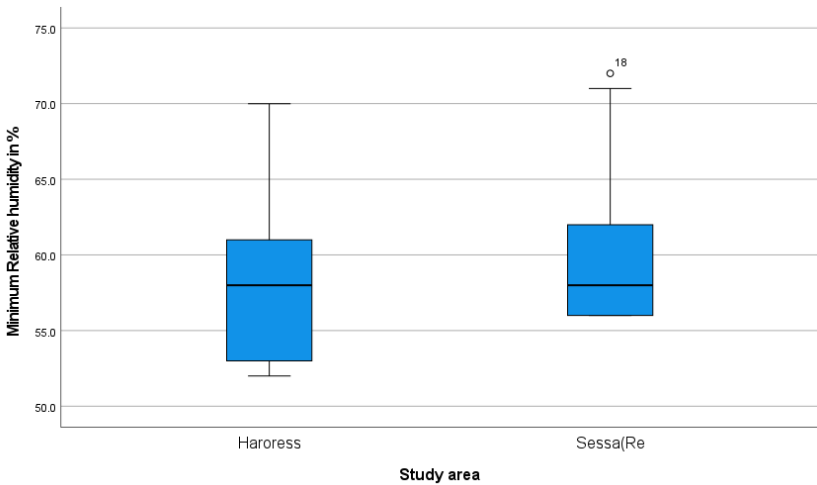


Figure 19 Minimum Relative Humidity across Haroressa and Sessa Kebeles

Comparatively to Haroressa Kebele, the graphs in Fig 19 also reveal the minimum and maximum values of air temperature and humidity in Sessa Kebele are quite constant with less volatility. Sessa's climatic records point to more consistent surroundings with less variation across daily periods. By comparison, Haroressa Kebele displayed significant variation in ranges of temperature and humidity. High agroforestry density could be the reason Sessa stays stable. The

results show generally a filtered microclimate in which residential land uses clearly show vegetation cover.

Table 5 An independent samples t-test conducted to examine whether if statistically significant differences in air temperature and relative humidity between the two study locations exists.

Independent Samples Test					
			Levene's Test for Equality of Variances		t-test for Equality of Means
			F	Sig.	t
Maximum Air Temperature in °C		Equal variances assumed	.571	.456	1.032
		Equal variances not assumed			1.032
Minimum Air Temperature in °C		Equal variances assumed	19.721	.000	1.252
		Equal variances not assumed			1.252
Maximum Relative humidity in %		Equal variances assumed	29.393	.000	-.536
		Equal variances not assumed			-.536
Minimum Relative humidity in %		Equal variances assumed	.074	.788	-.817
		Equal variances not assumed			-.817

Independent-samples t-test was used to compare air temperature and relative humidity of the two study locations, Sessa (agroforestry) and Haroressa (commercial), and nutritional stress protocol. The maximum air temperature values presented no significant differences between the sites ($t = 1.032$, $p > .05$), and equal variances were confirmed by Levene's test ($p = .456$). For minimum air temperature, the t-test also proved to be non-significant ($t = 1.252$, $p > .05$), however variances were not homogenous according to Levene's test ($p < .001$), suggesting that the homogeneity assumption was violated.

Relative humidity also exhibited the same trend in the findings. T Maximum relative humidity There was no significant variation in the maximum relative humidity between Sessa and Haroressa ($t = -0.536$, $p > .05$), and Levene's test showed that variances were unequal ($p < .001$). Minimum relative humidity also did not differ significantly ($t = -0.817$, $p > .05$), and variances were found to be equal using Levene's test ($p = .788$). These results indicate that while visual and effect size responses indicate practical differences in microclimate, the t-tests do not show significance – perhaps because of the small number of participants or natural variability between days.

Table 6 Standardized effect sizes to evaluate the extent of climatic differences between the experimental site (Sessa) and the control site (Haroressa).

Independent Samples Effect Sizes					
			Standardiz er ^a	Point Estimate	95% Confide nce Interval
					Lower
Maximum Temperature in °C	Air	Cohen's d	2.8352	.377	-0.349
		Hedges' correction	2.9140	.367	-0.340
		Glass's delta	2.6667	.400	-0.337
Minimum Temperature in °C	Air	Cohen's d	1.8227	.457	-0.272
		Hedges' correction	1.8734	.445	-0.265
		Glass's delta	.6984	1.193	.339
Maximum humidity in %	Relative	Cohen's d	5.4476	-.196	-.912
		Hedges' correction	5.5991	-.191	-.887
		Glass's delta	1.3870	-.769	-1.527
Minimum humidity in %	Relative	Cohen's d	6.0317	-.298	-1.016
		Hedges' correction	6.1995	-.290	-.988
		Glass's delta	5.7924	-.311	-1.030

Cohen's d, Hedges' g, and Glass's delta were used to estimate the magnitude of the climatic difference between the experimental (Sessa) and the control (Haroressa) site. The magnitude of the effect sizes for maximum air temperature were potentially large (Cohen's d = 2.84, Hedges' g = 2.91, Glass's delta = 2.67) and significantly higher in Haroressa. Likewise, differences in minimum air temperatures were large as well (Cohen's d = 1.82, Hedges' g = 1.87, Glass's delta

= 0.70), indicating that Sessa put in cooler conditions even in the night and early morning hours. These findings indicate that the agroforestry system of Sessa indeed has a strong influence in terms of reducing the daily heat maxima as well as the night temperatures.

Regarding humidity, Sessa showed stronger moisturizing properties in vivo over the day. Largest effect sizes for maximum humidity were extremely large (Cohen's $d = 5.45$, Hedges' $g = 5.60$, Glass's $\delta = 1.39$), as well as for minimum humidity (Cohen's $d = 6.03$, Hedges' $g = 6.20$, Glass's $\delta = 5.79$). These images show the low interannual climatic stability of Sessa, especially considering the higher moisture retaining character due to plant cover. In general, very strong to extremely strong effect size values with respect to all variables reaffirmed that the tree-based home garden agroforestry within Sessa substantially helps to ameliorate temperature extrema and conserve humidity, highlighting its ecological contribution in the urban climate regulation.

Table 7 Cohent Effect Size (Source Cohen.J, 1998)

Effect size	d
Very small	0.10
small	0.20
Medium	0.50
Large	0.80
Very large	1.20
Huge	2.00

Table 8 A one-way ANOVA to evaluate the influence of time of day on air temperature and relative humidity in both study locations.

ANOVA						
			Sum of Squares	df	Mean Square	F
Maximum Air Temperature in °C		Between Groups	111.606	4	27.901	5.717
		Within Groups	122.018	25	4.881	
		Total	233.623	29		
Minimum Air Temperature in °C		Between Groups	27.095	4	6.774	2.381
		Within Groups	71.138	25	2.846	
		Total	98.234	29		
Maximum Relative humidity in %		Between Groups	388.467	4	97.117	5.383
		Within Groups	451.000	25	18.040	
		Total	839.467	29		
Minimum Relative humidity in %		Between Groups	91.133	4	22.783	.598
		Within Groups	951.833	25	38.073	
		Total	1042.967	29		

To assess the effect of time of day on air temperature and relative humidity, an analysis of variance (ANVOA) was performed with time blocks (i. e., morning, afternoon, night) as the independent factor. Results Maximum air temperature There was a statistically significant influence of time on maximum air temperature ($F(4,25) = 5.717, p < .01$), which suggested that thermal peak during each day differed dramatically in different periods. Maximum relative

humidity also had strong diurnal variation ($F(4,25) = 5.383, p < .01$) indicating strong variation of the peak atmospheric moisture level with time of day.

In the meantime, minimum air temperature ($F(4,25) = 2.381, p > .05$) and lowest (50-rss) relative humidity ($F(4,25) = 0.598, p > .05$) demonstrated no significant difference between time periods. This means that whilst daytime climate extremes are influenced by the structure of the urban environment and amount of vegetation, the early morning or late-night values are more stable. These results emphasize the significance of temporal variation in understanding the microclimatic aspects of urban agro-forestry, in relation to its role in ameliorating peak day time heat and in maintaining moisture in residential areas.

4.1.3 Role of Home Garden in Enhancing Local Biodiversity (Pollinators and Birds)

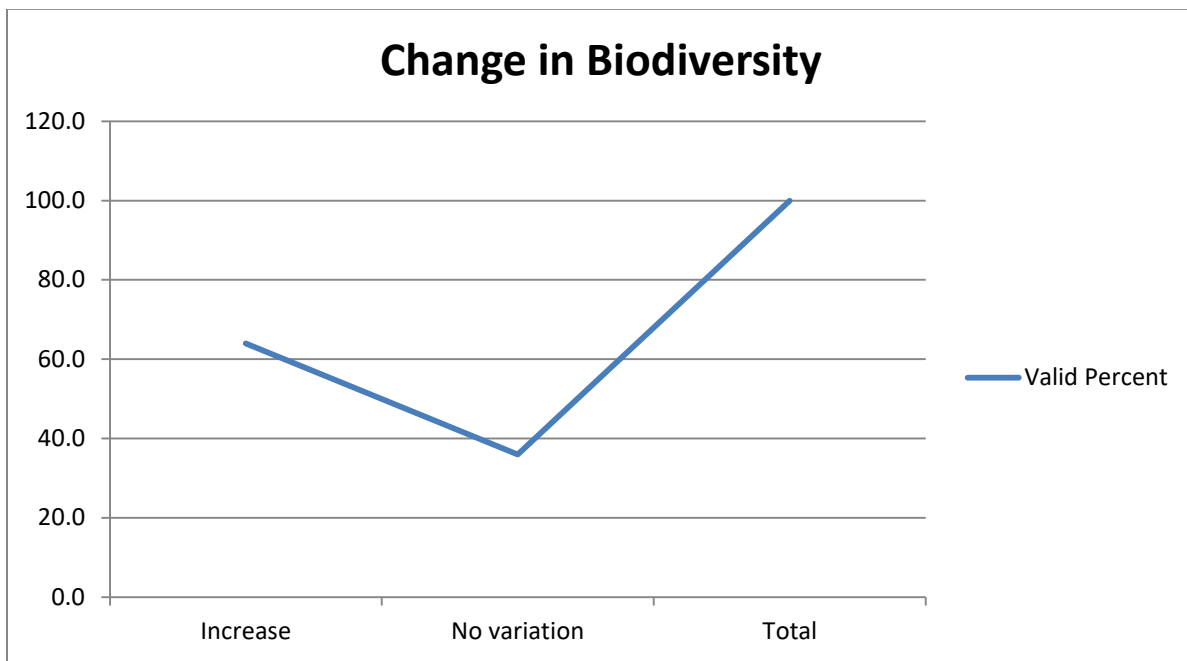


Figure 20 Change in Biodiversity perceptions gained by semi structured questionnaire of both study area.

The actual effect of the home garden agroforestry system on biodiversity was significant as indicated by the results as shown in Fig 21. There is higher biodiversity in these places than in smaller plots that do not end up with these practices. The existence of home gardens agroforestry

also positively influences species diversity. This shift emphasizes the environmental benefits of integrating agroforestry at the household level. In contrast to suggestions of the lack of variation, the data show that meaningful differences exist. In the figure, the highest biodiversity values are in areas with home garden agroforestry.

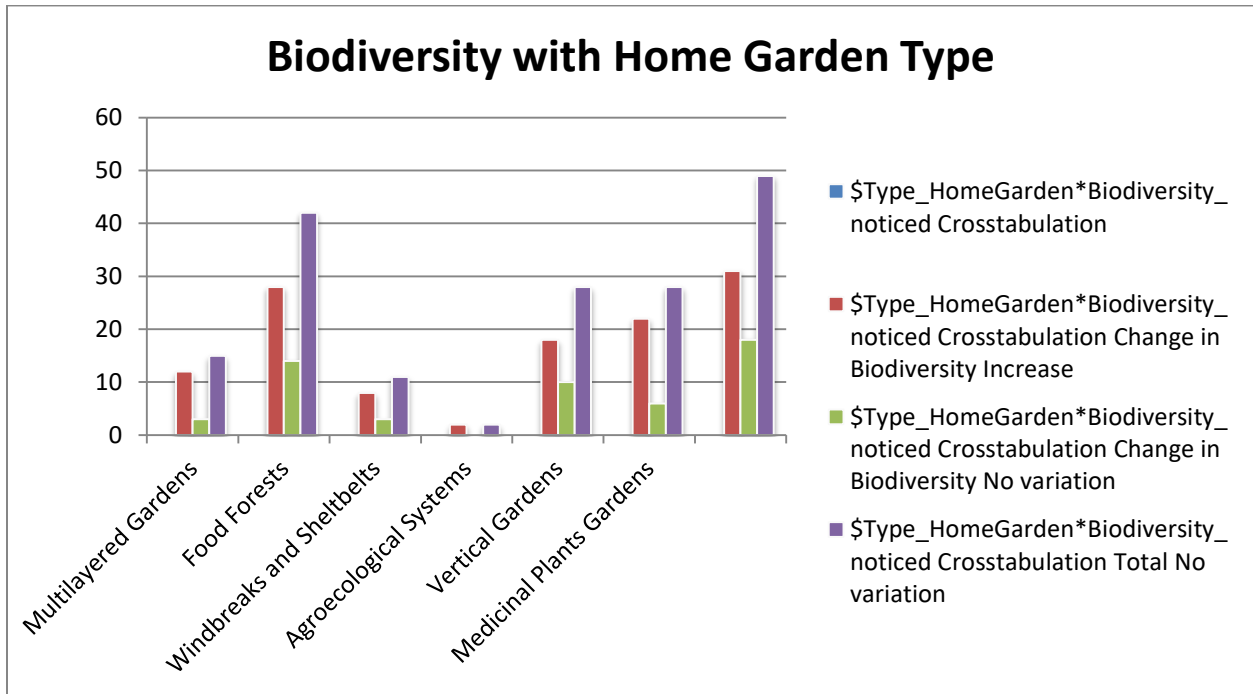


Figure 21 Biodiversity with in Home Garden types.

As the diagram in Fig 22 illustrates, different kinds of home gardens—medicinal plant gardens, food forests, and vertical gardens—show increasing changes in biodiversity: Hazard log-ratio 1, 2 and 3 respectively. The main contributing factors to this have been new habitats and growth of forest wood as illustrated in Fig 23. Of these trees cover is the largest generator of biodiversity, with habitat creation very close behind. This phenomenon is neatly elucidated through the diagram and underscores the key role these components have in promoting home garden agroforestry systems diversity.

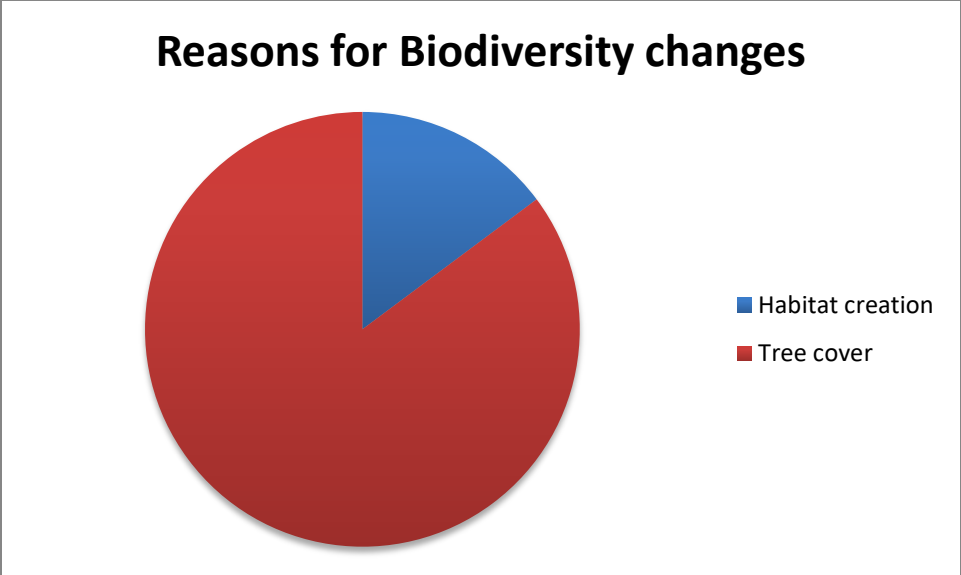


Figure 22 Reasons for Biodiversity changes in both study areas.

4.1.3.1 Perceptions of Dila Residents Regarding the Benefits and Challenges of Home Garden Agroforestry

The majority of answers who practice home garden agroforestry provided favorable response and recommended the others to do it. The table indicates that their most important encouraging motives are the advantages of food production, better air, and food security as well. These benefits have been spotlighted on a grand scale to prove the tremendous worth of home gardens to the population.

Table 9 Respondants Encourage community engagement in Home Garden AFP

Encourage start of HG Practice		Responses	Percent of Cases
		N	
Reason Encouraging - practice HG^a	Yes, no reason mentioned.	8	17.0%
	Yes, because it is Cost Saving.	8	17.0%
	Yes, because important for food production.	14	29.8%
	Yes, because it is important for air quality improvement.	10	21.3%
	Yes, because of its aesthetics.	5	10.6%
	Yes, because it is important for microclimate regulation.	4	8.5%
	Yes, because it has mental health benefit.	4	8.5%
	Yes, because it has shade provision.	3	6.4%
	Yes, because it improves food security.	9	19.1%
	Yes, because it provides financial return.	3	6.4%
	Yes, because it provides wind protection.	1	2.1%
	Yes, because it has medicinal value.	2	4.3%
Total		71	151.1%

Of the respondents who practice home garden agroforestry as indicated in Table 10, 40.8% particularly mentioned importance to adapt against climatic change. This, they highlighted, also significantly enhances air quality, a primary gain, according to them. This concept highlights both the environmental sustainability and improved quality of urban life provided by home

gardens. The evidence underlying this conclusion is outlined in the attached table. These are householders who have seen the value of local action on climate change by home gardening. Taken together, the findings indicate a high level of community consciousness about the environmental benefits of home gardening.

Table 10 Importance of Home Gardening for Climate Adaptation

Climate Adaptation Frequencies				
		Responses		Percent of Cases
		N	Percent	
HG important for Climate Adaptation	Yes, no reason mentioned.	13	26.5%	27.7%
	Yes, because it is important for air quality improvement.	20	40.8%	42.6%
	Yes, because it provide thermal regulation.	16	32.7%	34.0%
Total		49	100.0%	104.3%

Table 11 Personal Benefits of Home Garden Experience by Respondents (Both Kebeles)

Benefits HG Personally Frequencies			
		Responses	Percent of Cases
		N	
Personal Benefit of HG Experience^a	Food production	45	91.8%
	Air Quality Improvement	14	28.6%
	Aesthetics	10	20.4%
	Thermal Regulation	33	67.3%
	Cost Saving	4	8.2%
	Financial Returns	6	12.2%
	Medicinal Value	12	24.5%
	Mental Health Benefit	3	6.1%
	Wood Fire Cooking	1	2.0%
	Soil Fertility	1	2.0%
Total		129	263.3%

The findings in Table 10 shows that the main personal benefit that respondents derive from engaging in home gardening is producing food, as 91.8% of the sample cited in Table 1. 67.3% said that it was the benefit they valued most to keep the temperature under control and 28.6% praised the better air. These results highlight the various benefits of home garden practices not limited to food supply, but also with respect to the environment and household comfort. The information basically demonstrates the acceptance that respondents attach to their home gardens for both food and local ecological amelioration. In general, most people continue to benefit significantly from food production.

Table 12: Suggestions forwarded by the Respondents (Both kebeles)

Suggestions Frequencies				
		Responses		Percent of Cases
		N	Percent	
Suggestions regarding Home Garden AFP^a	Encouraging community engagement in HG practice.	20	58.8%	66.7%
	Government initiatives for land, seed, tree, and appreciation provision.	6	17.6%	20.0%
	Government initiatives for training by agricultural professionals.	6	17.6%	20.0%
	Green space development.	2	5.9%	6.7%
Total		34	100.0%	113.3%

The percentages of respondents that encouraged the wider community to practice home gardens are 66.7% shown in the Table 11. Two important recommendations to the government each attracted 20.0% support also. The first recommendation urged land and seed and trees be made available, as well as recognition for those expanding the practice. The second focused on the importance of educational programmers in which agricultural professionals are involved. These recommendations speak to the desire of the community for institutional support to support and maintain efforts at home gardening. In general, respondents were strongly committed to the promotion and improvement of the home garden agroforestry system, both by individual and government action.

4.2 Discussion

4.2.1 Discussion on the Types and Scale of Home Garden Agroforestry

Practices

The results provide evidence on diverse natures of home garden agroforestry practices in Dila Town and their multi-functional uses in an urban setting. RFP included foraging forests, vertical gardens and medicinal plant gardens among the most reported, showing how ancient knowledge can be merged with modern gardening practices. This diversity is consistent with that found in agroforestry literature which advocates for multifunctionality—the integration of biodiversity, food security and ecosystem services all in one system (Nair, 2011; Mehari & Abera, 2019). They help in the microclimate regulation and air quality enhancement (Jose, 2009), and are also important for the livelihood of the household.

The discrepancy between residential and commercial Kebeles illustrates the impact of land availability in the adoption of agroforestry. The homestead Sessa Kebele had more plant diversity and garden complexity, and food security priorities seemed to include maize (*Zea mays*), false banana (*Ensete ventricosum*) and mango as well as biodiversity conservation. The present finding is consistent with previous findings in Ethiopian agroforestry systems where home gardens were characterised by sustained productivity and ecological stability through product diversification and simulating the nature of natural forest structures (Abebe, 2005; Yadessa et al., 2001). In this sense the residential environment acts as a significant pool of plant diversity and ecosystem function in an urban environment.

In contrast, commercial Haroressa Kebele is facing spatial limitations that restrain the development of traditional home gardens. Residents adjust by resorting to container and vertical gardening in recycled materials such as tires and plastic buckets to encourage small-scale greenery despite the lack of space. This is in line with findings from other high density urban areas where vertical and container gardening stands as alternative to the traditional agroforestry (Lin, Perfecto, & Vandermeer, 2008). While less intensive, these activities also provide urban greening and microclimate regulation, demonstrating the versatility and adaptability of agroforestry in different urban settings. Home garden agroforestry also faces the challenge of urban development, as illustrated by the cutting of trees for infrastructure such as drainage and

paving in housing areas. This has the effect of reducing green cover which reduces the microclimatic services (shading and temperature regulation) delivered by mature trees (Bishaw et al., 2013b; Mbow, Smith, et al., 2014).

The conflicts between urban growth and environmental conservation make it necessary to develop an integrated strategy for planning, combining expansion of infrastructure with the preservation of green areas and maintenance of the agro-forestry as an ecological service provider in the urban landscape. Overall, the forms and intensity of home garden agroforestry in Dila Town are a complex result of interaction among cultural traditions, space availability and urbanization demands. Such multi-functional systems contribute to food security, supporting biodiversity and urban climate resilience, which corroborates existing theories of the role agroforestry places in socio-ecological resilience (Holling, 1973; Jose, 2009). In order to realize these benefits to the full, urban planning and policy will, however, need to ensure support for diverse agroforestry systems (land allocation, training and green infrastructure implementation) and secure the sustainability of home gardens in the face of rapid urban expansion.

4.2.2 Discussion on the Impact of Home Garden on Local Microclimate (Temperature and Humidity)

Rising temperatures and declining green spaces that aggravate urban heat island (UHI) impacts cause urban regions to confront growing climate issues including poor air quality and thermal discomfort (Mbow, Smith et al., 2014). By including trees and plants into urban environments, home garden agroforestry presents an efficient natural-based approach that helps control microclimates by shade provision and evapotranspiration cooling (Jose, 2009). Agroforestry's several ecosystem benefits—including soil erosion control, carbon sequestration, and microclimate modification—which taken together improve resilience to uncertain and varied climates if properly managed—are increasingly underlined. Our results demonstrate that residential gardens in Dila Town greatly lower air temperatures and somewhat raise humidity levels, therefore supporting their contribution in improving local urban resilience (Mehari & Abera, 2019).

The microclimatic advantages of agroforestry in the household context are shown by the comparison between home Sessa Kebele and commercial Haroressa Kebele. Data taken over several days and times reveals that Sessa, whose large home garden activities define her, keeps

more consistent and moderate temperature and humidity levels than in the commercial area with less vegetation. This helps to explain Zegeye's (2018) finding that by buffering temperature variations, keeping tree cover in metropolitan residential areas essentially reduces excessive heat. By lowering incident solar radiation, tree canopies produce more suitable microclimates; yet, this may occasionally restrict crop production potentials, therefore highlighting a trade-off between cooling benefits and agricultural productivity. Still, Sessa's overall higher microclimatic stability highlights how well different plants may produce a pleasant urban environment and increase thermal comfort.

Though independent samples t-tests and other statistical tests revealed no appreciable variation in temperature and humidity between the two sites, effect size measures revealed rather significant practical variations. Large Cohen's *d* and Hedges' *g* values for both highest and minimum temperatures validate that the home garden agroforestry in Sessa significantly reduces heat peaks and nocturnal temperatures. Similar significant moisture-retaining capacity for relative humidity shows in Sessa's environment rich in flora. These findings show how urban vegetation moderates water flow and buffers climatic extremes, hence enhancing the adaptive capacity of the urban socio-ecological system (Holling, 1973; Mbow et al., 2014). Resilience theory then fits these results.

Temporal variation study emphasizes even more the important part agroforestry performs in reducing daytime climatic extremes. The dynamic character of urban microclimates shaped by vegetation is reflected in notable variations in maximum air temperature and relative humidity across morning, afternoon, and night time intervals. Although early morning and evening circumstances were rather consistent, locations with lots of trees clearly had lower daytime temperatures. This daily pattern emphasizes, in line with results in other tropical urban agroforestry research, the need of continuous vegetation presence in urban planning to offset daily heat stress (Lin, Perfecto, & Vandermeer, 2008). Furthermore exhibiting multifunctionality outside microclimate control, agroforestry systems augment food supplies and act as buffers during droughts or crop failures.

Notwithstanding the obvious advantages, problems including the spread of urban infrastructure jeopardize the continuation of home garden agroforestry by lowering green cover and disturbing microclimatic control (Bishaw et al., 2013b). Sustainable climate adaption depends thus on

including agroforestry into urban policy and land-use planning. Encouragement of community involvement, incentives for tree planting, and preservation of existing vegetation will maximize the ecological functions of home gardens, so strengthening cities like Dila against climate variability and supporting biodiversity, food security, and human well-being (Mbow, Smith et al., 2014; Jose, 2009).

4.2.3 Enhancement of Biodiversity

Indigenous knowledge is important for biodiversity conservation and sustainable management of natural resources particularly in agroforestry systems (Son et al. Several generations of Gedeo farmers in Ethiopia have depended on the interplay between traditional ecological knowledge and productive agriculture for verses of their livelihoods (Zegeye, 2018). Such balance is maintained in home garden agroforestry systems that combine caffeine (coffee), enset, fruit trees and shade plants, with scale equivalent to natural forest ecosystems.. These enhance soil fertility, reduce erosion, increase water retention and, thus, long-term environmental sustainability is achieved (Mehari & Abera, 2019). The Socio-ecological Framework draws attention to the way these systems sustain both people and ecosystems in a mutually supportive relationship, which with terrestrial ecosystems contributes to the resilience of the urban climate (Mbow, Smith et al., 2014).

The results of our study support that the greater biodiversity with an ethnic home garden is a reality in the area of study where home garden agroforestry are widely practiced. Notably, levels of biodiversity fluctuate throughout various garden types – medicinal plant gardens, food forests and vertical gardens – with a clear positive relationship towards species diversity, as indicated by the graph. This enhancement of biodiversity is largely due to habitat provision and high levels of tree cover, with the latter being the predominant driver. The wooden of a tree are habitats and nurseries for many other types of plants and for various animals. The site observation in Sessa Kebele showed the sight of wildlife such as the monkey-colobus species which resides on the matured *Jacaranda mimosifolia* tree, indicating that agroforestry landscapes support urban wildlife.

Agroforestry also promotes key ecosystem processes by attracting pollinators such as bees, butterfly and birds that are critical for plant reproduction and food production Mbow, Smith et al. In a fractured urban and peri-urban landscape, these home gardens serve as refuges and

corridors for pollinators, and contribute to the pollination efficiency of the habitat and ecosystem stability. Birds, in particular, are favored by the layered vegetation structure of agroforestry systems which offer refuge, food, as well as nesting places all year long. These birds help in the natural control of pests, reducing dependence on chemical pesticides and enhancing sustainable (Bishaw et al., 2013b).

Furthermore, agroforestry in home gardens improves soil health through improved organic matter, microbial diversity and erosion control. Root systems of the trees and perennial plants also enhance water penetration and decrease urban runoff hazards and subsequent flood risk (Mbow, van Noordwijk et al., 2014). These processes also serve as carbon sinks, which in turn help to reduce greenhouse gas (GHG) emissions and build urban climate resilience. Nevertheless, the optimal ecological functions of these systems are frequently compromised due to urban sprawl, land use conflicts, poor policy direction, which often prioritize urban infrastructure at the expense of green lands. Thus, adopting agroforestry, promoting indigenous multi-functional species, involving the community are crucial in order to gain the biodiversity benefits in already fast urbanizing regions.

In summary, home garden agroforestry is a cornerstone for conservation of biodiversity in urban areas, especially for the creation of habitats and tree cover for diverse species assemblages. Our findings emphasize the ecological importance of the traditional practices in Dila Town that are not only valuable to food production; they contribute to the creation of resilient, bio diverse, and sustainable urban environments.

4.2.4 Perceptions of Benefits and Challenges

The uptake and persistence of agroforestry systems are inherently rooted in social and economic contexts. Social theories emphasize the role of cultural values, indigenous knowledge, and social institutions in the way agriculture is practiced. For many indigenous populations, such as in the Gedeo Zone in Ethiopia, agroforestry is deeply rooted in historical culture, traditions, and collective management of resources, thereby surviving generations through informal learning processes and strong social networks (Zegeye, 2018). This cultural dependence works to increase community cohesion and to support responsible land use in a more environmentally sustainable manner.

Economically, agroforestry provides a range of income opportunities to smallholder farmers, contributing toward poverty reduction. Trees integrated into crops and livestock can also reduce the vulnerability of small-scale farmers to risk of monoculture farming as they can harvest multiple marketable products including timber, fruits, medicinal plants, and fuel wood (Mbow, van Noordwijk et al., 2014). However, the decision to invest in agroforestry is frequently related to security of land tenure--clear land rights are conducive to long term sustainable tree management, while lack of tenure security prevents investments in tree planting/conservation (Bishaw et al., 2013b).

Policy intervention that recognizes collective ownership of land and provides legal support for land use, can have a substantial effect in promoting agroforestry. Moreover, government incentives, such as subsidies and tax credits, could encourage greater adoption. Market entry and value chain creation are also crucial. Limitations such as poor infrastructure and inadequate financial resources prevent smallholders from benefiting maximum from agroforestry products (Mehari & Abera, 2019). Improving regional market linkages to urban areas with cooperatives and fair trade schemes can also lead to profitability and more attractive agroforestry options. Further, education and empowerment through extension services and participatory research enable farmers by combining traditional wisdom with modern science and the ability to adapt to current challenges.

These observations are echoed in the understanding and beliefs of home garden practitioners, as represented by the findings of our study. Most participants provided positive feedback, and called for home garden agroforestry to be more widely practiced as it brings numerous benefits. Chief amongst these are: increased food production, higher air quality, and increased food security, which were valued by the community. In particular, 40.8% of the respondents indicated the relevance of home gardens in climate change adaptation, referring in particular to the enhancement of air quality as an environmental benefit. This reflects the community understanding of home gardens as not just food source but as local solutions to address urban climate impacts. Food production is still the most influencing personal benefit, which 91.8% of farmers considered as an advantage. Trailing this was thermal regulation as the next most commonly reported benefit (67.3%) followed by air quality improvements (28.6%). These articles highlight the importance of home garden agroforestry to sustenance and ameliorating

local communities' living standards. Moreover, 66.7% of them actively promoted other community members to plant home gardens, indicating a positive local perspective towards home gardening.

Respondents also presented major obstacles, and made suggestions for increasing the sustainability of home garden agroforestry. Two main recommendations, endorsed by 20% of respondents, were for government to provide land, seeds and trees, as well as official recognition for practitioners developing the practice. Technical capacity building was also a motivation for seeking training programs administered by agricultural practitioners. These observations echo those of the wider literature, highlighting institutional support, policy structures and educational interventions as ways of addressing socio-economic and infrastructural limitations.

In both urban and peri-urban areas, the socio-economic change, convoluted land system and tenure insecurity may be barriers to the adoption of agroforestry despite its benefits (Mbow, Smith et al., 2014). Systemic limitations can be addressed through enabling land policies, financial incentives and community-led initiatives, which will be necessary to maintain agroforestry's ecological and socio-economic benefits. Moreover, social capital is enhanced through agroforestry practice through fostering the intergenerational exchange of knowledge and cooperation, crucial for enhancing community resilience and sustainable use of natural resources (Zegeye, 2018).

In conclusion, the perceptions elicited in this study highlight the great environmental, economic, and social benefits associated with home garden agroforestry among local users. But to unlock the power of these systems, appropriate policies, market-building efforts and capacity building are needed. By linking agroforestry programs to community aspirations and cultural sensibilities, policymakers can promote more resilient, productive, and sustainable agro ecosystems that provide for households' and ecosystem health.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The results of this study highlight the ecological-socio-economic significance of home garden agroforestry as a multi-functional land use type in Dila Town's environmental planning and urban landscape design. Such systems make an important contribution to controlling microclimate, increasing bio-diversity, local food security, and urban ecological resilience.

The spatial comparison of residential (Sessa kebele) and commercial (Haroressa kebele) areas suggests the degree of land availability, socio-economic situation and urban density that affect agroforestry system and performance. In larger residential land holds, more varied and complex garden systems fulfill ecological roles similar to those of natural forest ecosystems, with temperature extremes significantly reduced and urban biodiversity increasing.

In contrast, vertical and container gardening solutions overcome space restrictions in commercial areas, exemplifying adaptive resilience to and persistence in urban greening processes. Although the environmental and societal benefits are clear, barriers to scaling up and out such solutions include the expansion of urban infrastructure, land tenure insecurity, low technical capacity and weak institutional and policy support, especially in urban areas. These figures indicate a high level of community participation and willingness to put in resources into their household gardens if they are provided with the opportunity to do so in terms of skills, inputs and recognition. Thus, the inclusion of home garden agroforestry in urban development plans is a step towards achieving the equilibrium between growth and sustainability.

5.2 Recommendation

- *Integrate Agroforestry into Urban Land Use Policy:* Urban planners and city administrators should incorporate home garden agroforestry into land use and greening strategies, recognizing its role in climate regulation, biodiversity conservation, and urban food security.

- *Bridge the Implementation Gap:* Despite strong national policies like Ethiopia's Climate Resilient Green Economy (CRGE) strategy, urban agroforestry adoption is held back by lack of technical assistance and institutional support. NGOs and government agencies should coordinate to close this implementation gap at the city level.
- *Prioritize Capacity Building:* Communities in Dila Town expressed a strong need for agroforestry training and education. Stakeholders should offer regular community-based workshops and demonstration projects tailored to local contexts and languages.
- *Improve Access to Inputs:* Lack of access to seedlings, seeds, compost, and tools limits scaling up of homegarden agroforestry. Therefore, creating decentralized input supply centers through partnerships between local government and NGOs can ensure affordability and availability.
- *Ensure Land Tenure and Recognition:* Granting tenure security and formal recognition to home garden practitioners will encourage long-term investment in tree planting and homegarden agroforestry infrastructure, especially in urban and peri-urban settings.

Context-Specific Interventions

- *Urban areas have different needs:* Haroressa Kebele needs more institutional and external support. Sessa Kebele benefits from community-driven attitudes. Interventions should therefore be adapted to the socio-economic and spatial realities of each area thus tailored approaches are necessary based on local conditions.
- *Strengthen Multi-Sectorial Collaboration:* Encourage cooperation between local governments, private sector actors, CBOs, and academic institutions to co-develop and support homegarden agroforestry system initiatives.
- *Empower Communities and Local Leadership:* Mobilize grassroots actors, support local innovation, and encourage leadership at the neighborhood level to enhance ownership and sustainability of agroforestry projects.
- *Provide Incentives and Green Credits:* Policymakers should explore creative financial tools such as green infrastructure credits, smallholder grants, or tax incentives for homegarden agroforestry efforts to promote ecosystem services.

- *Shift Policy Focus from Large-Scale to Household-Level Interventions:* To align national climate goals with urban realities, shift some emphasis from commercial afforestation to small-scale, home-based agroforestry systems.
-
- Future research should investigate the enduring environmental and socio-economic effects of home garden agroforestry in various urban contexts, emphasizing resilience, productivity, carbon sequestration, gender dynamics, youth engagement, and novel policy instruments to promote adoption and sustainability. In addition, comparing and adjusting the local air temperature and relative humidity results taken against official weather data from nearby meteorological stations.

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ANNEX I

PUBLISHABLE MANUSCRIPT

“The Impact of Home Garden Agroforestry Practices on Local Microclimate: Air Temperature and Humidity Variations across Different Urban Settings in Dila Town, Ethiopia”

Elsabet Memiru Mengesha

Elsahoye0@gmail.com

A Thesis Submitted to the
Department of Urban and Regional
Planning in Partial Fulfillment of
Master of Science in
Environmental Planning and
Landscape Design

Prof. Kumelachew Yeshitela

kumelachew.yeshitela@eiabc.edu.et

Professor of Urban Ecology

Director of Research and Technology
Transfer

Department of Urban and Regional
Planning

Addis Ababa Universtiy

ABSTRACT

Homegarden agroforestry is a traditional, multi-layered way of using land that combines trees, bushes, and crops around dwellings. It is very important for improving biodiversity, food security, and microclimate control, especially in cities and suburbs. Home gardens have always been an important aspect of sustainable land management in Ethiopia, where the practice is deeply ingrained in agricultural culture. This study investigated the ecological and socio-economic impacts of home garden agroforestry on urban climate resilience in Dila Town by comparing two distinct environments: the residential Sessa Kebele and the commercial Haroressa Kebele. The study employed a purposive sample strategy and a mixed-methods approach, incorporating field observations, household questionnaires, and microclimatic data collection. It concluded that home gardens substantially mitigate temperature extremes, enhance air quality, and promote urban biodiversity. In Sessa, bigger residential lots made it possible to create intricate layers of plants that look like forest ecosystems. In Haroressa, where space is limited, vertical and container gardening became popular as ways to adapt. Despite these benefits, barriers such as insecure land tenure, weak institutional support, limited technical knowledge, and restricted access to agroforestry inputs hinder widespread adoption. Community members in both kebeles expressed strong interest in expanding homegarden practices, provided they receive adequate training, resources, and formal recognition. The study recommends integrating agroforestry into urban land-use planning, creating decentralized input supply centers, and tailoring interventions to reflect the specific socio-economic and spatial realities of each area. Additional strategies include providing incentives like green infrastructure credits and fostering collaboration among local governments, NGOs, and communities. Future research should investigate the long-term ecological and socio-economic effects of home garden agroforestry, particularly in varied urban settings, while also calibrating onsite climate data with meteorological records. Ultimately, home garden agroforestry offers a promising, locally grounded solution for advancing urban sustainability and building climate resilience in Ethiopian cities.

Key Terms: Climate Resilience; Home Garden Agroforestry; Urban Climate; Urban Greening, Urban Sustainability; Dila Town

1. Introduction

Agroforestry creates a synergy between trees and agricultural production to deliver benefits like improved productivity and ecological stability while reducing climate impacts through soil preservation and carbon capture (Jose & Bardhan, 2012). Moreover, although agroforestry systems exhibit a wide variety across Africa, they all follow the shared approach of combining woody perennials with agricultural operations (Mbow et al., 2014; Yimam & Yimer, 2016b). Agroforestry systems hold special significance for Sub-Saharan Africa as 15% of its farms maintain tree coverage of 30% or higher. In addition, the implementation of agroforestry practices enables substantial greenhouse gas emission reduction while simultaneously supporting agricultural production without affecting food security levels (Mbow et al., 2014; Robert et al., 2009).

However, home garden agroforestry is still poorly known in urban settings even if it can help to solve some problems. Therefore, more study is needed on how home garden (HG) agroforestry influences urban microclimates and improves climate resilience in cities like Dila Town in the Gedeo Zone. Although the environmental advantages of agroforestry in rural settings are well known, the exact effects of agroforestry methods on urban climates and variables including temperature and biodiversity have not yet been completely studied.

Consequently, by looking at the effects of home garden agroforestry on Dila Town's microclimate, this study seeks to close this disparity. Specifically, the study will look at how these methods affect local environmental conditions as seen by the community. Furthermore, understanding these dynamics would help the research support the integration of agroforestry into urban design to improve sustainability and community well-being and help to establish climate change adaptation plans.

In light of this, the global challenge of climate change is becoming a top issue of concern since its consequences are widespread but particularly severe in underdeveloped countries like Ethiopia. Deforestation and greenhouse gas accumulation aggravate climate conditions leading to extreme weather patterns including irregular rainfall and temperature variations (IPCC, 2007; Molla, 2019). As a result, this leads to a loss of biodiversity. For farming communities and city life—especially in locations already facing environmental issues—climate change may have

major negative effects. Urban areas like Dila Town in the Gedeo Zone show the effects of climate change on the environment as well as on the way of life of the people; hence, it emphasizes the critical necessity of sustainable solutions to solve these problems.

Although agroforestry has been extensively investigated in rural settings, its impact on urban landscapes and sustainability is still little understood. In particular, how home garden agroforestry could help urban areas manage local air quality, adapt to climate change, and support temperature management is currently unknown. One of the main challenges is the lack of research on the goal of home garden agroforestry in urban climates, especially in Ethiopia, like Dila, where home garden agroforestry practice is intensively practiced. Therefore, investigating the issue of agroforestry systems in metropolitan regions could help to lower environmental stress and boost city resilience against climatic repercussions.

Accordingly, the objective of the research is to identify the extent to which HG agroforestry systems could contribute to the expansion of urban resilience and environmental sustainability in Dila Town. In particular, the focus is on the capacity of these systems to regulate temperature and promote urban biodiversity. Thus, the study aims to address the current research void by evaluating the potential of farming as a climate adaptation strategy for urban Ethiopia. Ultimately, the results of this study will inform urban planning decisions and facilitate the development of sustainable solutions to enhance climate resilience in metropolitan areas throughout Ethiopia and comparable regions.

Specifically, the study titled "The Impact of Home Garden Agroforestry Practices on Local Microclimate: Air Temperature and Humidity Variations across Different Urban Settings in Dila Town, Gedeo Zone" aims to support policies that improve environmental sustainability and community well-being by examining the function of including agroforestry techniques into urban design.

2. Methods and Materials

The study is carried out in Dila district, Gedeo zone, of Southern Nations, Nationalities, and People's regional state (SNNPRS), Ethiopia (Yayeh et al., 2021). It is located 359 km far from Addis Ababa, at an altitude of 1,613 meters in 6°24'30"N latitude and 38° 18'30"E longitude (Figure 1). It is situated on the eastern shoulder of the Ethiopian Rift and covers an area of

1,123.47 ha. Dila, the administrative and commercial town of the zone Gedeo, has a population size of 84,952,, and a density of 8,004 people per km² (Asfaw et al., 2022). Rainfall is 900-1400mm per year and the mean daily maximum and minimum temperature is 25.4°C and 13.4°C. The wet season is from June to October, and the dry season is from October to June, with a short stint of rain in February.

Purposive sampling was employed in this study to deliberately select Haroressa and Sessa kebeles based on their contrasting urban characteristics, commercial and residential settings along with considerations such as population size compatibility, accessibility, and diversity in land use and vegetation cover. This approach enabled a comparative analysis of home garden agroforestry practices across different urban settings in Dila town, Ethiopia.

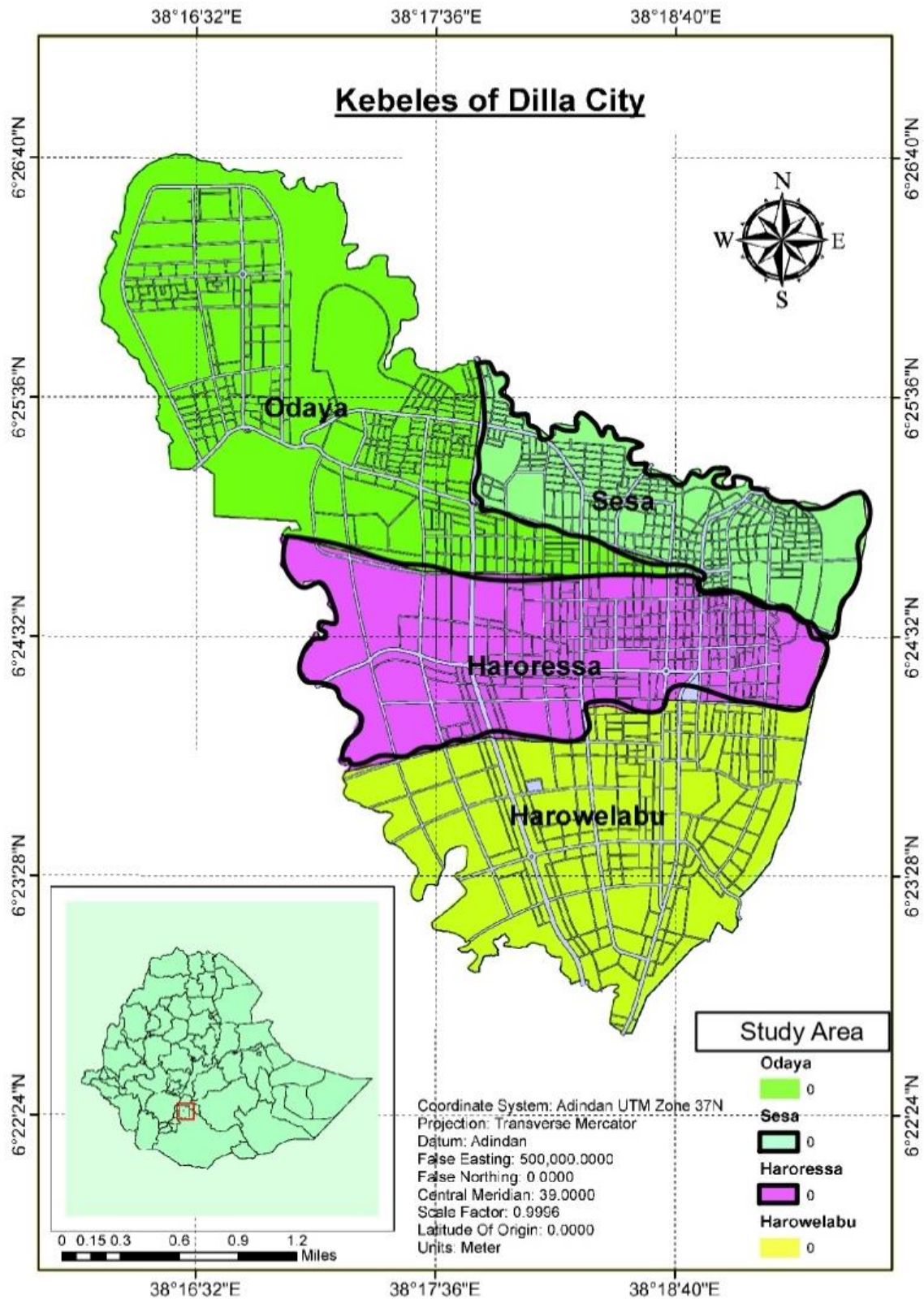


Figure 23 Selected kebeles of Dila town (source: Gedeo Zone Dila town administrative office-edited by researcher)

The design of this study is exploratory and descriptive. The exploratory research considers the influence of home garden agroforestry on urban climate and its contribution to resilience. At the same time, the descriptive design evaluates the efficiency of the agroforestry system in reducing the impacts of climate change and suggest on how agroforestry could be incorporated to urban policies and practices at Dila town, Gedeo Zone. This approach includes collecting data both quantitatively and qualitatively. In particular, collected survey data through semi structured questionnaire used to evaluate the spread and diversity of the home garden agroforestry practice in Dila town. Meteorological observations based on the temperature and humidity variations collected. Data Collection Techniques:

Primary data: collected among residents of Dila town using semi structured questionnaire in purposefully selected kebeles. Haroressa and Sessa were selected to represent residential and commercial areas from five kebeles. In addition, measurements of air temperature and relative humidity directly collected from the selected sites.

Secondary Sources: Secondary data obtained from data from government and non-government organizations, research institutions, academic databases, and public and private organizations.

A purposive sampling technique applied to select the study sites within Dila town. Among the five kebeles (as indicated in Table 1), two kebeles have been purposefully chosen. The household sample size is determined using Harper and Row's (1967) formula:

$n = N / (1 + N(e)^2)$ where:

- **n** = number of households sampled,
- **N** = total households practicing home garden agroforestry in the selected kebeles (12,166), and
- **e** = level of precision (at 90% confidence interval, $e = 0.1$).

This calculation yields a sample size of 99 households. To distribute this sample proportionally between the two kebeles, the following formula is applied:

$N_h = (n * N_h) / N$ where:

- **n** = total sample size (99),
- **N_h** = number of households practicing home garden agroforestry in each kebele (6,766 in Haroressa and 5,400 in Sessa), and
- **N** = total number of households practicing home gardening (12,166).

This results in a sample distribution of 55 households in Haroressa and 44 in Sessa.

The study population consists of residents of Dila town (as indicated in Table 1) below. A total of 55 and 44 households are sampled from Haroressa and Sessa kebeles, respectively.

Using structured questionnaires, a primary data collected by purposive sampling technique from Haroressa and Sessa kebeles. The authors searched for secondary data in government or non-government records and reports, and extract such information from these sources. Primary Data Collection through: *Household Surveys*: Structured interviews conducted to gather data on household agroforestry efforts. *Measurements of air temperature and relative humidity*: They are an essential part of the direct data collection. So, two Digital thermometers data loggers (as shown in Figure 2) are placed at each sites in Haroressa and Sessa kebeles for a week assessment. These sites are carefully selected to represent localities with home garden agroforestry and control sites with little vegetation. All measurements are made 3 times a day (morning, noon, evening) during specifically for five days in order to estimate diurnal and short-term microclimate variation. This fine-scaled field measurement allows for direct quantification of the microclimatic impacts of agroforestry.



Figure 24 Digital Thermo-Hydrometer (SH-117)

3. Results and Discussion

Results

Impact of Home Garden Agroforestry Practices on Local Microclimate (Temperature and Humidity)

Result found from respondents by Semi-Structured questionnaire

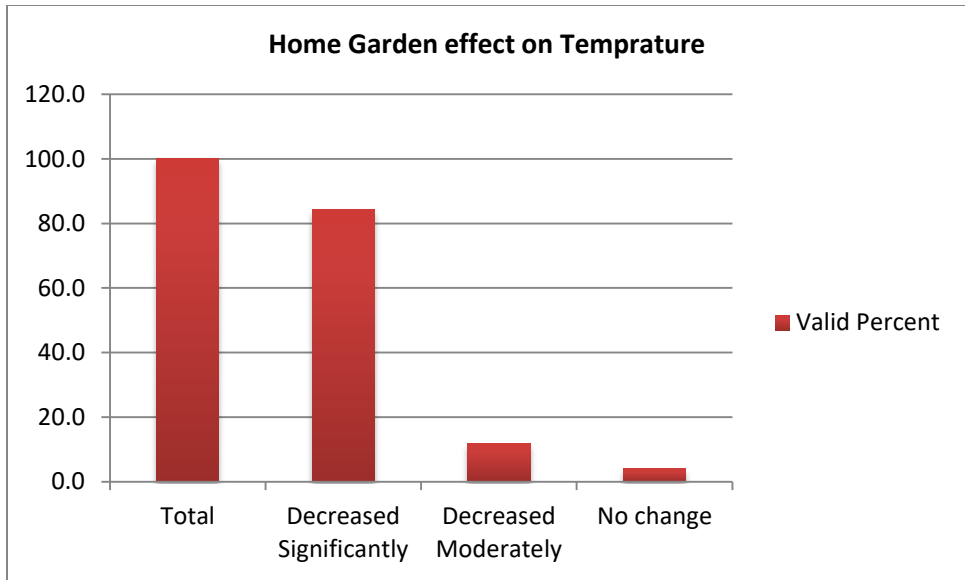


Figure 25 Home Garden effect on Temperature from both Kebeles Household perception

In the areas where Home garden agroforestry practiced the effect on temperature is shown that the Temperature is decreased significantly as shown in the diagram. On the other hand the effect on humidity showed increased moderately in the areas as shown in diagram.

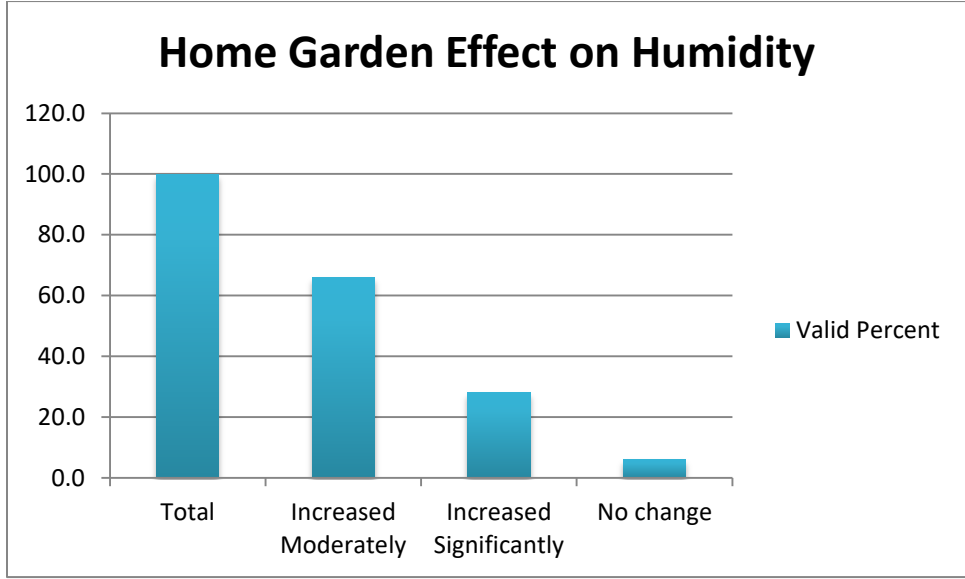


Figure 26 Home garden effect on Humidity perceptions of Both Kebeles Households

Diagram the results showed that Home garden has more effect in temperature in Kebele than Haroressa kebele. Similarly, the crosstabs for Home garden effect on humidity in Sessa Kebele showed increase than Haroressa Kebele as shown in diagram.

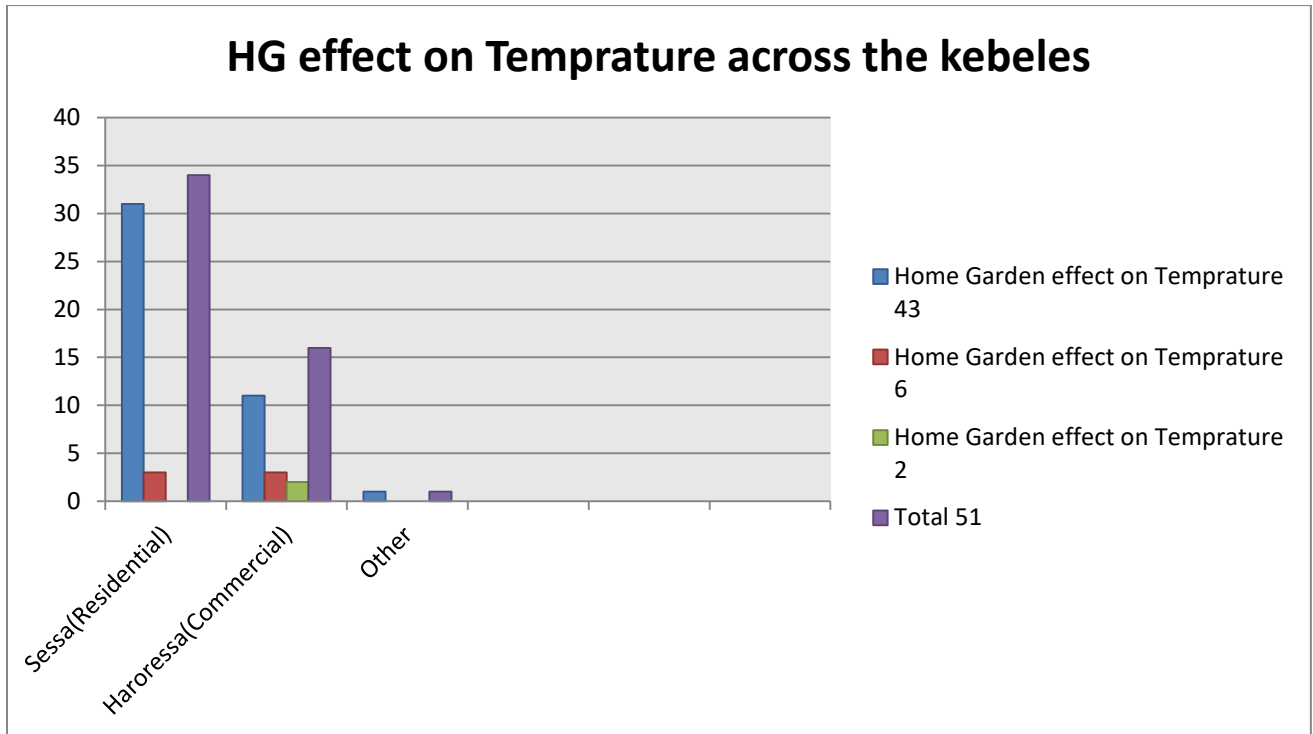


Figure 27 Home Garden effect on Temperature across the Sessa and Haroressa Kebele

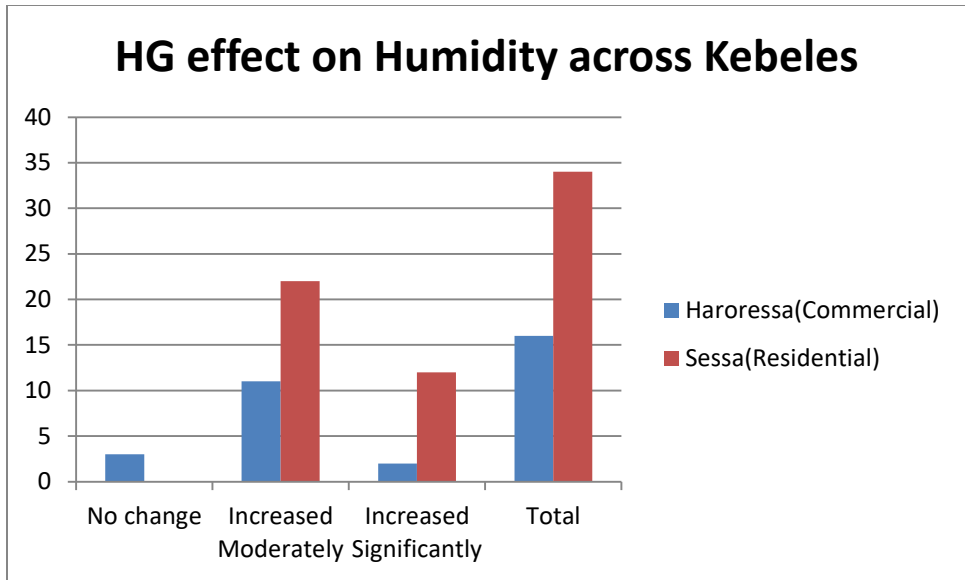


Figure 28 Home garden effect on Humidity across Haroressa and Sessa Kebele

Result found from on-site examination of Air temperature and Humidity

As described in the method section above, Air temperature and relative humidity were recorded in two contrasting urban types in Dila Town for seven consecutive days: Sessa Kebele characterized by high practice initiations of home gadget agroforestry practices and Haroressa Kebele an area dominated with commercial activities with minimal vegetative cover. An on-the-spot study of Air Temperature in C and Humidity in % between both study areas in respect of this attribute have been considered as the principal criteria adopted for the identification of urban microclimate variation. Three hourly observation were made in the morning (7:00–8:00 AM), afternoon (1:00–2:00 PM), and night (7:00–8:00 PM). Due to environmental limitations, several recordings have been omitted and these have been indicated where applicable. They found that if they only had data from May 6 to May 12 (which they were but there is missing data), the paper used data from May 6 to May 10 for 5 days in a row.

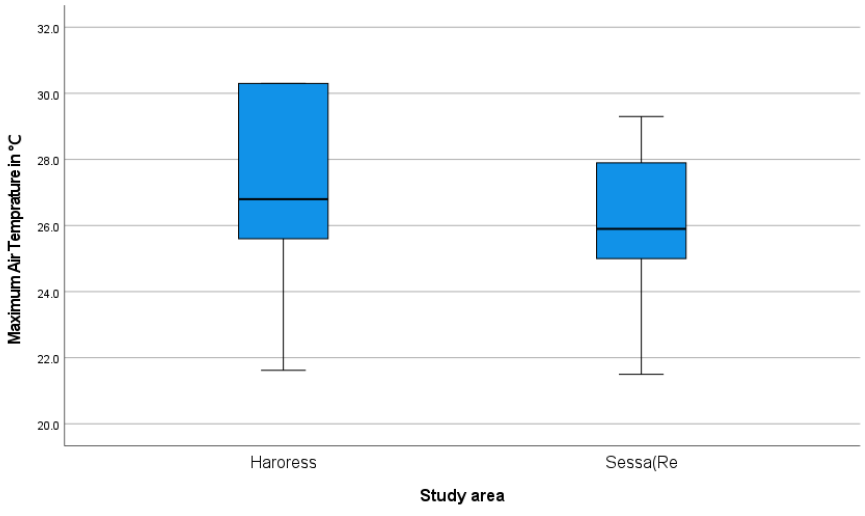


Figure 29 Maximum Air Temperature across Haroressa and Sessa Kebeles

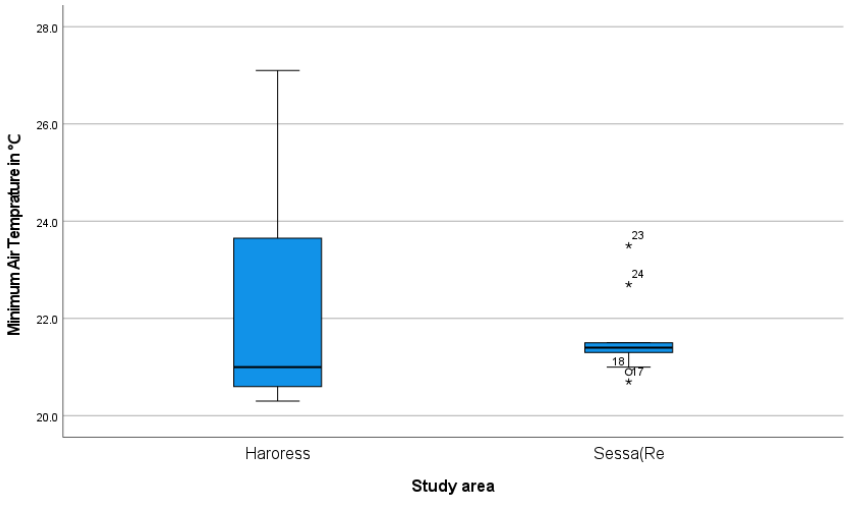


Figure 30 Minimum Air Temperature across Haroressa and Sessa Kebeles

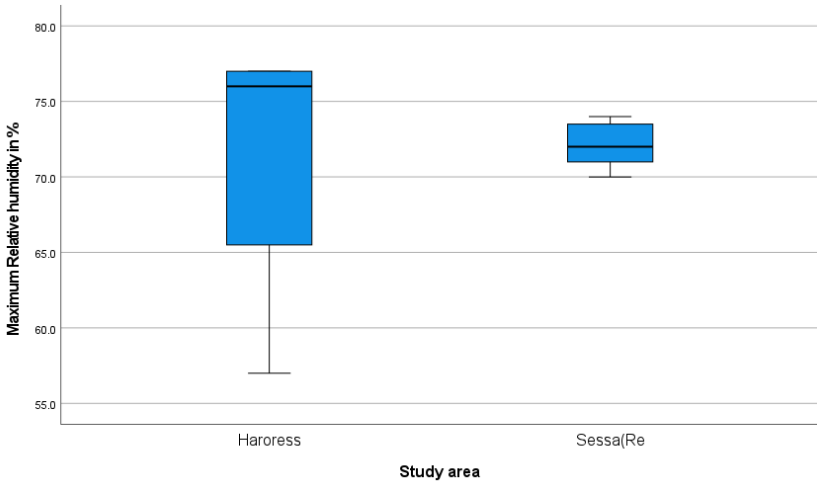


Figure 31 Maximum Relative Humidity across Haroressa and Sessa Kebeles

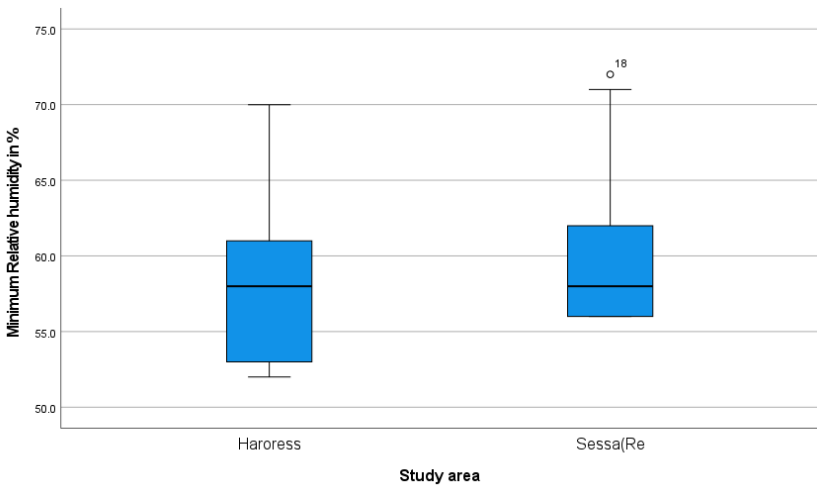


Figure 32 Minimum Relative Humidity across Haroressa and Sessa Kebeles

The graphs also show the minimum and maximum values of air temperature and humidity in Sessa Kebele are relatively steady with less fluctuation as opposed to that in Haroressa Kebele. Climatic data of Sessa suggest more stable environment with less change between different periods of a day. In contrast, Haroressa Kebele showed more divergence in temperature and humidity ranges. This stability in Sessa may be due to high agroforestry density. On the whole,

the results indicate a filtered microclimate where vegetation cover is noticeable in residential land uses.

Table 13 An independent samples t-test conducted to examine whether if statistically significant differences in air temperature and relative humidity between the two study locations exists.

Independent Samples Test					
			Levene's Test for Equality of Variances		t-test for Equality of Means
			F	Sig.	t
Maximum Air Temperature in °C	Relative	Equal variances assumed	.571	.456	1.032
		Equal variances not assumed			1.032
Minimum Air Temperature in °C	Relative	Equal variances assumed	19.721	.000	1.252
		Equal variances not assumed			1.252
Maximum Relative humidity in %	Relative	Equal variances assumed	29.393	.000	-.536
		Equal variances not assumed			-.536
Minimum Relative humidity in %	Relative	Equal variances assumed	.074	.788	-.817
		Equal variances not assumed			-.817

Independent-samples t-test was used to compare air temperature and relative humidity of the two study locations, Sessa (agroforestry) and Haroressa (commercial), and nutritional stress protocol. The maximum air temperature values presented no significant differences between the sites ($t = 1.032$, $p > .05$), and equal variances were confirmed by Levene's test ($p = .456$). For minimum air temperature, the t-test also proved to be nonsignificant ($t = 1.252$, $p > .05$), however variances were not homogenous according to Levene's test ($p < .001$), suggesting that the homogeneity assumption was violated.

Relative humidity also exhibited the same trend in the findings. T Maximum relative humidity
There was no significant variation in the maximum relative humidity between Sessa and Haroressa ($t = -0.536$, $p > .05$), and Levene's test showed that variances were unequal ($p < .001$). Minimum relative humidity also did not differ significantly ($t = -0.817$, $p > .05$), and variances were found to be equal using Levene's test ($p = .788$). These results indicate that while visual and effect size responses indicate practical differences in microclimate, the t-tests do not show significance – perhaps because of the small number of participants or natural variability between days.

Table 14 Standardized effect sizes to evaluate the extent of climatic differences between the experimental site (Sessa) and the control site (Haroressa).

Independent Samples Effect Sizes					
			Standardized effect ^a	Point Estimate	95% Confidence Interval
					Lower
Maximum Temperature in °C	Air	Cohen's d	2.8352	.377	-0.349
		Hedges' correction	2.9140	.367	-0.340
		Glass's delta	2.6667	.400	-0.337
Minimum Temperature in °C	Air	Cohen's d	1.8227	.457	-0.272
		Hedges' correction	1.8734	.445	-0.265
		Glass's delta	.6984	1.193	.339
Maximum humidity in %	Relative	Cohen's d	5.4476	-0.196	-0.912
		Hedges' correction	5.5991	-0.191	-0.887
		Glass's delta	1.3870	-0.769	-1.527
Minimum humidity in %	Relative	Cohen's d	6.0317	-0.298	-1.016
		Hedges' correction	6.1995	-0.290	-0.988
		Glass's delta	5.7924	-0.311	-1.030

Cohen's d, Hedges' g, and Glass's delta were used to estimate the magnitude of the climatic difference between the experimental (Sessa) and the control (Haroressa) site. The magnitude of the effect sizes for maximum air temperature were potentially large (Cohen's d = 2.84, Hedges' g = 2.91, Glass's delta = 2.67) and significantly higher in Haroressa. Likewise, differences in minimum air temperatures were large as well (Cohen's d = 1.82, Hedges' g = 1.87, Glass's delta

= 0.70), indicating that Sessa put in cooler conditions even in the night and early morning hours. These findings indicate that the agroforestry system of Sessa indeed has a strong influence in terms of reducing the daily heat maxima as well as the night temperatures.

Regarding humidity, Sessa showed stronger moisturizing properties *in vivo* over the day. Largest effect sizes for maximum humidity were extremely large (Cohen's $d = 5.45$, Hedges' $g = 5.60$, Glass's $\delta = 1.39$), as well as for minimum humidity (Cohen's $d = 6.03$, Hedges' $g = 6.20$, Glass's $\delta = 5.79$). These images show the low interannual climatic stability of Sessa, especially considering the higher moisture retaining character due to plant cover. In general, very strong to extremely strong effect size values with respect to all variables reaffirmed that the tree-based home garden agroforestry within Sessa substantially helps to ameliorate temperature extrema and conserve humidity, highlighting its ecological contribution in the urban climate regulation.

Table 15 A one-way ANOVA to evaluate the influence of time of day on air temperature and relative humidity in both study locations.

ANOVA						
			Sum of Squares	df	Mean Square	F
Maximum Air Temperature in °C	Between Groups		111.606	4	27.901	5.717
	Within Groups		122.018	25	4.881	
	Total		233.623	29		
Minimum Air Temperature in °C	Between Groups		27.095	4	6.774	2.381
	Within Groups		71.138	25	2.846	
	Total		98.234	29		
Maximum Relative humidity in %	Between Groups		388.467	4	97.117	5.383
	Within Groups		451.000	25	18.040	
	Total		839.467	29		
Minimum Relative humidity in %	Between Groups		91.133	4	22.783	.598
	Within Groups		951.833	25	38.073	
	Total		1042.967	29		

To assess the effect of time of day on air temperature and relative humidity, an analysis of variance (ANVOA) was performed with time blocks (i. e., morning, afternoon, night) as the independent factor. Results Maximum air temperature There was a statistically significant influence of time on maximum air temperature ($F(4,25) = 5.717, p < .01$), which suggested that thermal peak during each day differed dramatically in different periods. Maximum relative

humidity also had strong diurnal variation ($F(4,25) = 5.383, p < .01$) indicating strong variation of the peak atmospheric moisture level with time of day.

In the meantime, minimum air temperature ($F(4,25) = 2.381, p > .05$) and lowest (50-ross) relative humidity ($F(4,25) = 0.598, p > .05$) demonstrated no significant difference between time periods. This means that whilst daytime climate extremes are influenced by the structure of the urban environment and amount of vegetation, the early morning or late-night values are more stable. These results emphasize the significance of temporal variation in understanding the microclimatic aspects of urban agro-forestry, in relation to its role in ameliorating peak day time heat and in maintaining moisture in residential areas.

Discussion

Rising temperatures and declining green spaces that aggravate urban heat island (UHI) impacts cause urban regions to confront growing climate issues including poor air quality and thermal discomfort (Mbow, Smith et al., 2014). By including trees and plants into urban environments, home garden agroforestry presents an efficient natural-based approach that helps control microclimates by shade provision and evapotranspiration cooling (Jose, 2009). Agroforestry's several ecosystem benefits—including soil erosion control, carbon sequestration, and microclimate modification—which taken together improve resilience to uncertain and varied climates if properly managed—are increasingly underlined (rec-8). Our results demonstrate that residential gardens in Dila Town greatly lower air temperatures and somewhat raise humidity levels, therefore supporting their contribution in improving local urban resilience (Mehari & Abera, 2019).

The microclimatic advantages of agroforestry in the household context are shown by the comparison between home Sessa Kebele and commercial Haroressa Kebele. Data taken over several days and times reveals that Sessa, whose large home garden activities define her, keeps more consistent and moderate temperature and humidity levels than in the commercial area with less vegetation. This helps to explain Zegeye's (2018) finding that by buffering temperature variations, keeping tree cover in metropolitan residential areas essentially reduces excessive heat. By lowering incident solar radiation, tree canopies produce more suitable microclimates; yet, this may occasionally restrict crop production potentials, therefore highlighting a trade-off between cooling benefits and agricultural productivity (lit-9). Still, Sessa's overall higher microclimatic stability highlights how well different plants may produce a pleasant urban environment and increase thermal comfort.

Though independent samples t-tests and other statistical tests revealed no appreciable variation in temperature and humidity between the two sites, effect size measures revealed rather significant practical variations. Large Cohen's d and Hedges' g values for both highest and minimum temperatures validate that the home garden agroforestry in Sessa significantly reduces heat peaks and nocturnal temperatures. Similar significant moisture-retaining capacity for relative humidity shows in Sessa's environment rich in flora. These findings show how urban vegetation moderates water flow and buffers climatic extremes, hence enhancing the adaptive capacity of the urban socio-ecological system (Holling, 1973; Mbow et al., 2014). Resilience theory then fits these results.

Temporal variation study emphasizes even more the important part agroforestry performs in reducing daytime climatic extremes. The dynamic character of urban microclimates shaped by vegetation is reflected in notable variations in maximum air temperature and relative humidity across morning, afternoon, and night time intervals. Although early morning and evening circumstances were rather consistent, locations with lots of trees clearly had lower daytime temperatures. This daily pattern emphasizes, in line with results in other tropical urban agroforestry research, the need of continuous vegetation presence in urban planning to offset daily heat stress (Lin, Perfecto, & Vandermeer, 2008). Furthermore exhibiting multifunctionality outside microclimate control, agroforestry systems augment food supplies and act as buffers during droughts or crop failures.

Notwithstanding the obvious advantages, problems including the spread of urban infrastructure jeopardize the continuation of home garden agroforestry by lowering green cover and disturbing microclimatic control (Bishaw et al., 2013b). Sustainable climate adaption depends thus on including agroforestry into urban policy and land-use planning. Encouragement of community involvement, incentives for tree planting, and preservation of existing vegetation will maximize the ecological functions of home gardens, so strengthening cities like Dila against climate variability and supporting biodiversity, food security, and human well-being (Mbow, Smith et al., 2014; Jose, 2009).

4. Conclusions and Recommendations

The results of this study highlight the ecological-socio-economic significance of home garden agroforestry as a multi-functional land use type in Dila Town's environmental planning and urban landscape design. Such systems make an important contribution to controlling microclimate, increasing bio-diversity, local food security, and urban ecological resilience.

The spatial comparison of residential (Sessa kebele) and commercial (Haroressa kebele) areas suggests the degree of land availability, socio-economic situation and urban density that affect

agroforestry system and performance. In larger residential land holds, more varied and complex garden systems fulfill ecological roles similar to those of natural forest ecosystems, with temperature extremes significantly reduced and urban biodiversity increasing.

In contrast, vertical and container gardening solutions overcome space restrictions in commercial areas, exemplifying adaptive resilience to and persistence in urban greening processes. Although the environmental and societal benefits are clear, barriers to scaling up and out such solutions include the expansion of urban infrastructure, land tenure insecurity, low technical capacity and weak institutional and policy support, especially in urban areas. These figures indicate a high level of community participation and willingness to put in resources into their household gardens if they are provided with the opportunity to do so in terms of skills, inputs and recognition. Thus, the inclusion of home garden agroforestry in urban development plans is a step towards achieving the equilibrium between growth and sustainability.

- *Integrate Agroforestry into Urban Land Use Policy:* Urban planners and city administrators should incorporate home garden agroforestry into land use and greening strategies, recognizing its role in climate regulation, biodiversity conservation, and urban food security.
- *Bridge the Implementation Gap:* Despite strong national policies like Ethiopia's Climate Resilient Green Economy (CRGE) strategy, urban agroforestry adoption is held back by lack of technical assistance and institutional support. NGOs and government agencies should coordinate to close this implementation gap at the city level.
- *Prioritize Capacity Building:* Communities in Dila Town expressed a strong need for agroforestry training and education. Stakeholders should offer regular community-based workshops and demonstration projects tailored to local contexts and languages.
- *Improve Access to Inputs:* Lack of access to seedlings, seeds, compost, and tools limits scaling up of homegarden agroforestry. Therefore, creating decentralized input supply centers through partnerships between local government and NGOs can ensure affordability and availability.
- *Ensure Land Tenure and Recognition:* Granting tenure security and formal recognition to home garden practitioners will encourage long-term investment in tree planting and homegarden agroforestry infrastructure, especially in urban and peri-urban settings.

Context-Specific Interventions

- *Urban areas have different needs:* Haroressa Kebele needs more institutional and external support. Sessa Kebele benefits from community-driven attitudes. Interventions should therefore be adapted to the socio-economic and spatial realities of each area thus tailored approaches are necessary based on local conditions.
- *Strengthen Multi-Sectorial Collaboration:* Encourage cooperation between local governments, private sector actors, CBOs, and academic institutions to co-develop and support homegarden agroforestry system initiatives.
- *Empower Communities and Local Leadership:* Mobilize grassroots actors, support local innovation, and encourage leadership at the neighborhood level to enhance ownership and sustainability of agroforestry projects.
- *Provide Incentives and Green Credits:* Policymakers should explore creative financial tools such as green infrastructure credits, smallholder grants, or tax incentives for homegarden agroforestry efforts to promote ecosystem services.
- *Shift Policy Focus from Large-Scale to Household-Level Interventions:* To align national climate goals with urban realities, shift some emphasis from commercial afforestation to small-scale, home-based agroforestry systems.
- Future research should investigate the enduring environmental and socio-economic effects of home garden agroforestry in various urban contexts, emphasizing resilience, productivity, carbon sequestration, gender dynamics, youth engagement, and novel policy instruments to promote adoption and sustainability. In addition, comparing and adjusting the local air temperature and relative humidity results taken against official weather data from nearby meteorological stations.

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ANNEX II

Questionnaire on Home Garden Agroforestry Practices

Date: ____/____/____ G.C



Semi-Structured Questionnaire

Title: *The Impact of Home Garden Agroforestry Practices on Urban Climate: Variations Across Different Urban Settings in Dila Town, Gedeo Zone*

Researcher: Elsabet Memiru

Institution: Ethiopian Institute of Architecture, Building Construction, and City Development (EiABC), Addis Ababa University

Date: *Feb, 2025 G.C*

Introduction

Dear Participant,

I am conducting a study on the role of **home garden agroforestry in urban climate regulation** in Dila Town. This questionnaire aims to understand how home gardens affect **temperature, air quality, biodiversity, and household perceptions** in different urban settings (*Haroressa – Commercial & Sessa – Residential kebeles*).

Your responses will remain **confidential** and used **only for academic purposes**. Participation is **voluntary**, and you may withdraw at any time. This questionnaire takes approximately **20-30 minutes** to complete.

Thank you for your time and valuable insights!

Confidentiality & Consent Statement

Participation is voluntary. You can skip any question or stop at any time.

Your responses are confidential. No personal information will be shared.

By proceeding, you consent to participate in this study.

Section 1: Demographic Information

1. What is your age group? (*Select one*)

Under 18

18-30

31-45

46-60

Over 60

2. What is your gender? (*Select one*)

Male

Female

3. Which kebele do you reside in? (*Select one*)

Haroressa (Commercial Area)

Sessa (Residential Area)

Other: _____

4. What is your highest level of education? (*Select one*)

Who can't read and write?

Who can read and write?

Primary school (1st-8th Grade)

Secondary education (9th-12th Grade)

Higher education

Other: _____

5. What is your main occupation? (Select one)

- Farmer
- Businessperson
- Gov. employee
- Non gov. employee
- Unemployed
- Other (Specify): _____

6. How many people live in your household? (Select one)

- 1-2 members
 - 3-4 members
 - 5-6 members
 - 7 or more members
-

Section 2: Home Garden Agroforestry Practices

7. Do you have a home garden? (Select one)

- Yes
- No (*If No, skip to Section 4*)

8. If yes, what type of home garden agroforestry system do you practice? (Select all that apply)

- Multilayered Gardens** – A system where trees, shrubs, and crops grow in different layers, similar to a forest.
- Food Forests** – A garden designed like a natural forest but focused on food production.
- Permaculture Gardens** – A self-sustaining garden using natural processes like composting and companion planting.

Windbreaks and Shelterbelts – Rows of trees or shrubs planted to reduce wind and protect crops.

Agroecological Systems – A farming system that enhances biodiversity and maintains soil health using organic practices.

Vertical Gardens – A space-saving garden where plants grow on walls, fences, or stacked containers.

Medicinal Plant Gardens – A garden primarily for growing herbs and plants used for traditional medicine.

Other: _____

9. What is the size of your home garden? (Select one)

Less than 50 m²

50-100 m²

100-200 m²

More than 200 m²

10. How long have you been practicing home gardening? (Select one)

Less than 1 year

1-3 years

3-5 years

More than 5 years

11. What is the main purpose of your home garden? (Select all that apply)

Food production

Income generation

Shade and cooling

Environmental benefits

Aesthetic value

Other: _____

12. What is the primary source of water for your home garden? (Select one)

- Rainwater
- Well
- Municipal Water
- River/Stream
- Other: _____

13. How do you maintain your home garden? (Select all that apply)

- Organic farming
 - Use of fertilizers/pesticides
 - Rainwater harvesting
 - Traditional methods
 - Other: _____
-

Section 3: Perceptions and Environmental Impact

14. Have you noticed any effects of home garden agroforestry on soil health and water management in your area? (Select one)

- Yes, positive effects on both soil health and water management
- Yes, but only on soil health
- Yes, but only on water management
- No noticeable effects

15. How do home gardens impact air quality and food security in Dila Town? (Select one)

- They improve both air quality and food security
- They improve air quality but not food security
- They improve food security but not air quality
- No impact on either

16. How has your home garden affected the temperature around your home? *(Select one)*

- Decreased significantly
- Decreased moderately
- No change
- Increased moderately
- Increased significantly

17. How do home gardens influence humidity? *(Select one)*

- Decreased significantly
- Decreased moderately
- No change
- Increased moderately
- Increased significantly

18. Have you noticed changes in biodiversity (birds, insects)? *(Select one)*

- Increase in birds and insects
- Decrease in insects and birds
- No variation

19. If you answered "Increase" or "Decrease" in Question 18, what do you think is the reason for this change? *(Open-ended)*

Section 4: Community and Support

20. What challenges do you face in maintaining your home garden? *(Select all that apply)*

- Lack of space
- Water scarcity
- Pest problems
- Lack of knowledge

Financial constraints

Other: _____

21. Do commercial and residential areas face different challenges in home gardening?

(Select one)

Yes

No

Not sure

22. What type of support would be most helpful for improving home gardening? *(Select all that apply)*

Training

Financial assistance

Access to seeds and plants

Community gardening initiatives

Other: _____

23. Which kebele receives more support for home gardening? *(Select one)*

Haroressa (Commercial)

Sessa (Residential)

No difference

24. Have you received government or institutional support for home gardening? *(Select one)*

one)

Yes

No

25. Are you aware of any government policies that support home garden agroforestry?

(Select one)

Yes

- No
 - Not sure
-

Section 5: Final Thoughts and Recommendations

26. Would you encourage others in your community to start home gardening? Why or why not? (Open-ended)

27. Do you think home gardening is an important solution for climate adaptation in urban areas? Why or why not? (Open-ended)

28. Which kebele benefits more from home garden agroforestry in terms of climate regulation? Why? (Open-ended)

29. What benefits have you personally experienced from your home garden? (Open-ended)

30. Any additional comments or suggestions regarding home garden agroforestry practices? (Open-ended)

Thank you for taking the time to complete this questionnaire. Your responses will help us better understand the role of **home garden agroforestry in urban climate regulation and environmental sustainability** in Dila Town.



ቀን: ____/____/____ ዓ.ም

የተዋሃድ አቀማመጥ ያለው መጠይቅ (Semi Structural Questionnaire)

ርዕስ: የጓሮ አትክልት ተከላ ልምዶች በከተማ የአየር ንብረት ላይ ያሳደረው ተጽዕኖ፡ በዲላ ከተማ ውስጥ በተለያዩ የከተማ ሁኔታዎች የሚኖረውን ልዩነት የሚያጠና

Title: *The Impact of Home Garden Agroforestry Practices on Urban Climate: Variations Across Different Urban Settings in Dila Town, Gedeo Zone*

የምርምር ተሳታፊ: ኤልሳቤት መሚሩ

ተቋም: የኢትዮጵያ አርክቴክቶች፣ ህንፃ ግንባታ እና ከተማ ልማት ተቋም (EiABC), አዲስ አበባ ዩኒቨርሲቲ

ቀን: የካቲት 2017 ዓ/ም

መግቢያ

ይህ ጥያቄ ወረቀት በዲላ ከተማ ውስጥ የጓሮ አትክልት ተከላ ልምዶች በከተማ የአየር ንብረት ላይ የሚያሳድረውን ተጽዕኖ ለመለየት እና ለማግኘት የተዘጋጀ ነው። ይህ ምርምር በሁለት የተለያዩ የከተማ ሁኔታዎች ውስጥ የቤት ውስጥ አትክልት የሚኖረውን ተጽዕኖ ይገልጻል፡-

- ሀሮሬሳ ቀበሌ (የንግድ አካባቢ)
- ሴሳ ቀበሌ (የመኖሪያ አካባቢ)

እርስዎ በመሳተፍዎ በእርግጥ ጠቃሚ መረጃ ይሰጡኛሉ። ይህ ጥያቄ ወረቀት ለማጠናቀቅ 20-30 ደቂቃ ይፈጅቦታል።

እናመሰግናለን!

የግል መረጃ ምስጢርነት እና ስምምነት (Confidentiality & Consent Statement)

- እርስዎ በፈቃድ ብቻ ይሳተፉባታል። በማንኛውም ጊዜ ሊሰሙት ይችላሉ።
- ምላሾችዎ በምስጢርነት ይቆያል። የግል መረጃዎ አይታወቅም።
- ይህን ጥያቄ የሚቀጥሉት በፈቃድ እንደሆነ ይስማማሉ።

ክፍል 1: አጠቃላይ መረጃ (Demographic Information)

1. እድሜዎ? (አንድ ዓመት ይጠቅሙ:-)

- ከ18 በታች
- 18-30
- 31-45
- 46-60
- 60 አካባቢ በላይ

2. የታዎ? (አንድ ዓመት ይጠቅሙ:-)

- ወንድ
- ሴት

3. የሚኖሩበት ቀበሌ? (አንድ ዓመት ይጠቅሙ:-)

- ሀሮረሳ (የንግድ አካባቢ)
- ሴሳ (የመኖሪያ አካባቢ)
- ሌላ: _____

4. የትምህርት ደረጃዎ? (አንድ ዓመት ይጠቅሙ:-)

- ማንበብም ሆነ መጻፍ አልችልም
- ማንበብ እና መጻፍ እችላለሁ
- የመጀመሪያ ደረጃ (1-8)
- ሁለተኛ ደረጃ (9-12)
- ኮሌጅ እና ከዚያ በላይ (12+)
- ሌላ: _____

5. ሥራዎ ምንድነው? (አንድ ዓመት ይጠቅሙ:-)

- ገበሬ

- ንግድ ተሳታፊ
- የመንግስት ሰራተኛ
- የግል መስሪያ ቤት ሰራተኛ
- ሥራ የሌለው
- ሌላ (ይግለጹ): _____

6. በቤተሰቡ ውስጥ የሚኖሩት ሰዎች ብዛት? (አንዱን ይምረጡ:-)

- 1-2 ሰዎች
- 3-4 ሰዎች
- 5-6 ሰዎች
- 7 እና ከዚያ በላይ

ክፍል 2: የጓሮ አትክልት ተከላ ልምዶች

7. የጓሮ አትክልት አለዎት? (አንዱን ይምረጡ:-)

- አዎ
- አይ (እርስዎ "አይ" ሲሉ ወደ ክፍል 4 ይሂዱ።)

8. እርስዎ የጓሮ አትክልት ተከላ ልምድ ዓይነቶች ውስጥ የትኛውን ይሰሩታል? (በርካታ ምርጫዎች ሊመረጡ ይችላሉ:-)

በተለያዩ ደረጃዎች የተሠራ አትክልት (Multilayered Gardens) – ዛፎች፣ ቁጥቋጦ እና ሰብል በተለያዩ ደረጃዎች ሆነው የሚበቅሉበት፣ የዱር አካባቢን የሚመስል ዘዴ።

የምግብ አረንጓዴ ደን (Food Forests) – ምግብ ምርት ላይ የተሰማሩ የተፈጥሮ ደን የሚመስል የጓሮ አትክልት ዘዴ።

የፍጥረታዊ ልምዶች ደን (Permaculture Gardens) – በተፈጥሮ መልኩ ራሱን የቻለ የመሬት ለምነትን ከእንስሳት በሚገኝ ተረፈ ምርት የመጠበቅ እና ጎጂ ነፍሳትን በመከላከል ላይ የተመሰረተ ዘዴ።

የንፋስ መከላከያ (Windbreaks and Shelterbelts) – የንፋስን ፍጥነት ለመቆጣጠር የሚያግዙ የዛፎች መትከል መሰረት ያደረገ ዘዴ።

የአካባቢ ተቋማት ልምዶች (Agroecological Systems) – የብዝሃነት ህይወት የሚጨምር እና የመሬት ለምነትን የሚያዳብር ልምድ የያዘ ዘዴ።

በቁመት የሚያድጉ አትክልት የተዘጋጀ ስርዓት (Vertical Gardens) – ቦታ የሚቆጥቡና ለአጥርነት፣ የቤት ግድግዳ እና ማይንቀሳቀሱ ነገሮችን ተከትለው የሚያድጉ አትክልት የመትከል ዘዴ።

የህክምና ተደራሽ ሥነ-ምግብ አትክልት (Medicinal Plant Gardens) – ለህክምና እና የባህላዊ መድሃኒት የሚውሉ ተንክሎችን የሚተክሉበት ዘዴ።

ሌላ (ይግለጹ): _____

9. የጓሮ አትክልትዎ መጠኑ ስንት ነው? (አንዱን ይምረጡ፡-)

- 50 ካሬ ሜትር በታች
- 50-100 ካሬ ሜትር
- 100-200 ካሬ ሜትር
- 200 ካሬ ሜትር በላይ

10. ስንት አመት ሆኖብዎታል የጓሮ አትክልት ተከላ ልምድ ከጀመሩ? (አንዱን ይምረጡ፡-)

- ከ1 ዓመት በታች
- 1-3 ዓመት
- 3-5 ዓመት
- ከ5 ዓመት በላይ

11. የጓሮ አትክልትዎ ዋና አላማ ምንድነው? (በርካታ ምርጫዎች ሊመረጡ ይችላሉ፡-)

- ምግብ ማምረት
- የገቢ ምንጭ ማድረግ
- ጥላ እና ማቀዝቀዝ
- የአካባቢ ጥበቃና ልማት
- ለውበት
- ሌላ: _____

12. የጓሮ አትክልትዎን የመንከባከቢያ ዋና የውሃ ምንጭ ምንድነው? (አንዱን ይምረጡ፡-)

- የዝናብ ውሃ
- ጉርድ ውሃ
- የከተማ ልማት ውሃ (Municipal Water)
- ወንዝ / ወራጅ ውሃ
- ሌላ: _____

13. የጓሮ አትክልትዎን እንዴት ባለ መልኩ ለዘላቂነት ይንከባከቡታል? (በርካታ ምርጫዎች ሊመረጡ ይችላሉ፡-)

- የአትክልት ብስባሽ እና የእንስሳት እቦት እንደ ማዳበሪያነት በመጠቀም (Organic Farming)
- ፀረ-ተባይ መድሃኒቶች / ማዳበሪያዎችን/ በመጠቀም (Fertilizers/Pesticides)
- የዝናብ ውሃ አከማችቶ በመጠቀም (Rainwater Harvesting)
- ባህላዊ ዘዴዎች በመጠቀም (Traditional Methods)
- ሌላ: _____

ክፍል 3: አመለካከት እና አካባቢያዊ ተጽዕኖ

14. በእርስዎ አካባቢ ውስጥ የጓሮ አትክልት ተክላ ልምምድ በመኖሩ ምክንያት፤ አፈርን ለም በማደረግ እና በውሃ አጠቃቀም አኳያ ያመጣው ለውጥ አለ? (አንዱን ይምረጡ፡-)

- አዎ፣ በአፈር ለምነት እና በውሃ አጠቃቀም ላይ የተሻለ ተጽዕኖ አለው።
- አዎ፣ ሆኖም በአፈር ለምነት ላይ ብቻ ተጽዕኖ አለው።
- አዎ፣ ሆኖም በውሃ አጠቃቀም ላይ ብቻ ተጽዕኖ አለው።
- አይ፣ ምንም የተባለ ልዩነት አልተመለከተም።

15. በዲላ ከተማ ውስጥ የጓሮ አትክልት በአየር ጥራት እና የምግብ ደህንነት ላይ ምን ዓይነት ተጽዕኖ አሳድሮአል? (አንዱን ይምረጡ፡-)

- ሁለቱንም ያሻሽላሉ (አየር ጥራት እና የምግብ ደህንነት)
- አየር ጥራትን ያሻሽላሉ፣ ነገር ግን በምግብ ደህንነት ላይ ተጽዕኖ የለም።
- የምግብ ደህንነትን ያሻሽላሉ፣ ነገር ግን በአየር ጥራት ላይ ተጽዕኖ የለም።
- ምንም ተጽዕኖ የላቸውም።

16. የጓሮ አትክልትዎ በቤትዎ ዙሪያ ያለውን የሙቀት ሁኔታ እንዴት ተጽዕኖ አድርጓል? (አንዱን ይምረጡ:-)

- በጣም ተቀንሷል (እጅግ ዝቅ አድርጎታል)
- በመጠኑ ተቀንሷል
- ምንም ለውጥ አልተመለከተም
- በመጠኑ ጨመረ
- በጣም ጨመረ (እጅግ ከፍ አለ)

17. የጓሮ አትክልት በአየር እርጥበት (Humidity) ላይ ምን ዓይነት ተጽዕኖ ያሳድራል? (የአንዱን ይምረጡ:-)

- በጣም ተቀንሷል (እጅግ ዝቅ አድርጎታል)
- በመጠኑ ተቀንሷል
- ምንም ለውጥ አልተመለከተም
- በመጠኑ ጨመረ
- በጣም ጨመረ (እጅግ ከፍ አለ)

18. በቤትዎ ዙሪያ ብዝሃ ህይወት በተመለከተ (አዕዋፍት፣ ነፍሳት-Birds and Insects) ሁኔታ ለውጥ አይተዋል? (አንዱን ይምረጡ:-)

- አዕዋፍት እና ነፍሳት ተጨምሯል (Increase in birds and insects)
- አዕዋፍት እና ነፍሳት ተቀንሷል (Decrease in birds and insects)
- ምንም ልዩነት የለም (No variation)

19. በ ጥያቄ ቁ. 18 ላይ "የመጨመር" ወይም "የመቀነስ" ምርጫ የሰጡ ከሆነ፣ ይህ ለምን ተከስቷል ብለው ያስባሉ? (ክፍት መልስ)

ክፍል 4: ማህበረሰብ እና ድጋፍ

20. የጓሮ አትክልትዎን በመጠበቅ ረገድ ምን ዓይነት ችግር አጋጥሞታል? (በርካታ ምርጫዎች ሊመረጡ ይችላሉ:-)

- ቦታ እጥረት
- የውሃ እጥረት
- ያፀረ-ተባይ ችግር
- ዕውቀት እጥረት

- የገንዘብ ውሱንነት
- ሌላ: _____

21. የንግድ እና የመኖሪያ አካባቢዎች የጓሮ አትክልትን በመትከል ሂደት ውስጥ ከቦታው አንጻር የተለያዩ ችግሮችን ይገጥሟቸዋል? (የአንድን ይምረጡ:-)

- አዎ
- አይ
- እርግጠኛ አይደለሁም

22. የጓሮ አትክልት ተከላ ልምምድን በማሻሻል ረገድ የትኛው ድጋፍ ይሆናል? (በርካታ ምርጫዎች ሊመረጡ ይችላሉ:-)

- ስልጠና
- የገንዘብ ድጋፍ
- ዘር እና ተክል አቅርቦት
- የማህበራዊ አትክልት ድርጅቶች
- ሌላ: _____

23. ለጓሮ አትክልት ከሚቀርብ ድጋፍ ከቀረቡት ቀበሌዎች የትኛው የተሻለ ድጋፍ ያገኛል? (አንዱን ይምረጡ:-)

- ሀሮረሳ (የንግድ አካባቢ)
- ሴሳ (የመኖሪያ አካባቢ)
- ምንም ልዩነት የለም

24. ከመንግስት ወይም ከተቋማት የጓሮ አትክልት ልምምድ በተመለከተ ድጋፍ ተቀብው ያውቃሉ? (አንዱን ይምረጡ:-)

- አዎ
- አይ

25. ለጓሮ አትክልት ልምምድን የሚደግፉ የመንግስት ፖሊሲዎችን የሚያውቁበት የሚያውቁት አለ? (አንዱን ይምረጡ:-)

- አዎ
- አይ
- እርግጠኛ አይደለሁም

ክፍል 5: የመጨረሻ ሐሳቦች እና ምክራ-ሀሳቦች

26. ሌሎች የማህበረሰቡ አባላት የጓሮ አትክልት እንዲጀምሩ ታብረታታላችሁ? ለምን ወይም ለምን አይደለም? (ክፍት መልስ)

27. የጓሮ አትክልት ተከላ ልምምድ በከተማ ውስጥ ለአየር ንብረት በማሻሻል ረገድ አስፈላጊ መፍትሄ ነው ብለው ያስባሉ? ለምን ወይም ለምን አይደለም? (ክፍት መልስ)

28. ከጓሮ አትክልት ተከላ ልምምድ፣ የአየር ንብረት በማሻሻል ረገድ የትኛው ቀበሌ በጣም ይጠቀማል? ለምን? (ክፍት መልስ)

29. እርስዎ ከጓሮ አትክልት ምን ዓይነት ጥቅሞችን ማግኘት ችለዋል? (ክፍት መልስ)

30. በጓሮ አትክልት ተከላ ልምምድ ላይ ተጨማሪ አስተያየት ወይም ምክራ-ሀሳብ አለዎት? (ክፍት መልስ)

እናመሰግናለን!

የዚህ ጥያቄ ወረቀት ሙሉ በሙሉ ማስተላለፍ ለአየር ንብረት እና ዘለቄታዊ የአካባቢ ጥበቃን በማሻሻል ረገድ የተቀመጡ የጓሮ አትክልትን ተጽዕኖ ለመረዳት አስፈላጊ መረጃ ይሰጠናል።

Sample Pictures taken for on-site Air Temperature and Humidity Test in



Figure 33 Sample Pictures of on-site Air Temperature and Humidity (A Morning min and max), B Afternoon Min and Max and C Night time Min and Max) of Air Temperature and Humidity values of Haroressa kebele of May 6.



Figure 34 Sample Pictures of on-site Air Temperature and Humidity (A Morning min and max), B Afternoon Min and Max and C Night time Min and Max) of Air Temperature and Humidity values of Sessa kebele of May 6.