The potential of agroforestry to contribute to food security for smallholder households in Ethiopia

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Abstract

Ethiopia suffers from national food insecurity, and many Ethiopians are not able to fulfill their daily dietary and nutritional requirements. The effects of climate change, a rapidly growing population and land degradation arising from monoculture agricultural practices, further threaten the current circumstance. To address this pressing challenge, there is a growing recognition of the need for sustainable agricultural practices. Agroforestry, in particular, has emerged as a potential solution to contribute to food security, as this practice promises environmental, social and economic benefits. This research aims to fill the research gap of evaluating agroforestry as an approach to contribute toward improved food security for smallholder households in Ethiopia, and thereby taking into account the farmer´s personal beliefs and experiences, as well as socioeconomic and political circumstances for smallholder farmers. Thus, both intrinsic and extrinsic factors are evaluated which can either foster or hinder the adoption of agroforestry among smallholder farmers.

For this purpose, a case study of Ethiopia is used to identify the factors that influence the practice of agroforestry by reviewing existing case studies on national agroforestry practices and conducting semi-structured interviews with experts from the agroforestry field in Ethiopia. As a result, this research identifies both facilitating and inhibiting factors on the adoption of agroforestry and the extent to which the practice contributes to food security in Ethiopia.

Keywords: Agroforestry, agrisilviculture, food security, smallholder farmers, subsistence farming, Ethiopia

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List of Abbreviations

ADLI	Agricultural Development-Led Industrialization
Afr100	African Forest Landscape Restoration Initiative
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
GDP	Gross Domestic Product
NGO	Non-governmental Organization
UN	United Nations
WFP	World Food Programme

1. Introduction

1.1. Food insecurity in Ethiopia

The Federal Democratic Republic of Ethiopia (FDRE), an East African country, has achieved important development gains over the past decades, resulting in a significant reduction of domestic poverty. Ethiopia´s National Government has since implemented a five-year Growth and Transformation Plan which aims to elevate the country with its more than 126 million inhabitants to a lower middle-income status by 2025 (National Planning Commission, 2016; World Population Review, 2023). But despite the constant development, food insecurity remains a huge national concern to this day (World Food Programme, 2023). The Global Hunger Index (2022) ranks Ethiopia at position 104 out of 121 countries, which categorizes Ethiopia with a serious level of hunger (Global Hunger Index, 2022). The nation has been subject to serious famines and droughts and remains structurally food deficient due to the effects of climate change, progressing land degradation and rapid population growth (Caron et al., 2018; Degefa & Markos, 2022).

According to the Food and Agriculture Organization, *"a person is food insecure when they lack regular access to enough safe and nutritious food for normal growth and development and an active and healthy life. […] Food insecurity can be experienced at different levels of severity"* (FAO, 2023, para. 4). This insecurity can manifest as low food intake, variable food access, and overall vulnerability to unforeseeable shocks, such as extreme weather conditions like droughts or floods. Furthermore, food insecurity can occur chronically, cyclically and transitory (Devereux & Sussex, 2000). *Transitory* food insecurity is caused among others by droughts. *Cyclical* food insecurity is caused by seasonal crop cultivation, while *chronic* food insecurity is both cause and consequence of structural factors, such as unhelpful or inconsistent government policies and poor market structures. A growing number of Ethiopians are subject to all forms of food insecurity, as they cannot meet their food needs even under ideal weather conditions (Devereux & Sussex, 2000). Ethiopia experiences highly irregular rainfall patterns, resulting in dry seasons and a risk of annual droughts, which the country is historically prone to. As a result, seasonal hunger is prevalent among vulnerable populations, particularly in rural areas (FAO, 2016). The country´s recovery from food crises is hampered by

repeated droughts, resulting in perpetuating food insecurity (Devereux & Sussex, 2000). (Welthungerhilfe, 2023).

Ethiopia´s present situation is summarized by the economist Mekonnen Manyazewal as follows: *"Perhaps the greatest challenge that the country faces is that of ensuring food security. This is so because of the low technological base of agriculture, limited rural infrastructure and off-farm employment compounded by neglect and inappropriate policies over many years. The food security strategy, whose implementation has begun, is meant to break the complex problems to close the food gap and ensure food security"*. (Ministry of Development and Cooperation, Government of Ethiopia in Devereux & Sussex, 2000, p. 1). Manyazewal thereby refers to the national food security strategy, which aims at closing the food gap, ensuring food security, as well as improving rural livelihood, and seeks to alleviate these issues through enhanced agricultural productivity (Feed the Future, 2018).

In light of Ethiopia´s current circumstances on food security, the search for sustainable and indigenous knowledge-based agricultural practices become crucial. Such practices must provide socioeconomic benefits while mitigating the impacts of climate change and land degradation (Degefa & Markos, 2022). Agroforestry emerges as a viable sustainable production system with multiple benefits and services that could address these challenges effectively.

1.2. Statement of the main research

Agroforestry is widely recognized as a sustainable agricultural approach by providing societal, environmental and economic benefits. While individual research on agroforestry in Ethiopia has been conducted, the majority of the research has primarily focused on biophysical and environmental aspects. Consequently, there is a notable gap in empirical investigations concerning the adoption of agroforestry in diverse contexts. The neglect of policy studies at various levels and the cultural understanding of individuals and communities in relation to agroforestry adoption have been evident in previous research (Fagerholm et al., 2016; Mercer & Miller, 1998)

Given Ethiopia´s chronic food insecurity and the looming threat of worsening conditions, there is an urgent need to conduct research on the potential of sustainable agricultural practices to contribute to food security. It is found that the consideration of agroforestry as a means to enhance food production and ultimately increase food security has been frequently

overlooked or inadequately represented in existing studies. Therefore, it is considered important and appropriate to assess agroforestry as a potential solution to contribute to food security in Ethiopia.

1.2.1. Research aim and objectives

The aim of this research is to examine the potential of agroforestry to promote food security for smallholder households in Ethiopia. More specifically, the research aims to explore the potential of agroforestry in improving agricultural practices and yields within the context of smallholder farmers. The research objectives are:

- To evaluate the importance and goals of agroforestry in Ethiopian national policy on agriculture
- To analyze the perspectives of public and private stakeholders on the role and potential of agroforestry in Ethiopia
- To assess the potential contribution of agroforestry to food security for smallholder households in Ethiopia

1.2.2. Research questions

The central Research Question for this study is as follows:

"What is the potential of agroforestry to ensure food security for smallholder households in Ethiopia?"

The sub-questions are:

SQ1: What are the goals and instruments of Ethiopian national policy to promote agroforestry?

SQ2: What do stakeholders and experts think about the potential of agroforestry in Ethiopia?

SQ3: What is the potential contribution of agroforestry to improve agricultural practices and yields of smallholders in Ethiopia?

1.3. Outline

In *Chapter 2* of this research, a literature review and a conceptual framework concerning agroforestry in Ethiopia and the concept of food security are presented. The focal point of the framework revolves around smallholder farmers, with an examination of both internal and external factors that may influence their willingness and capacity to adopt/adapt agroforestry practices. The research methodology is elaborated on in *Chapter 3*. The case study of Ethiopia is based on semi-structured interviews and document analysis. The results, which aim to address the sub-questions of this research, are outlined in in *Chapter 4*. The discussion in *Chapter 5* connects the findings and main results to the framework established in Chapter 2. The limitations encountered during the research process as well as recommendations are provided in *Chapter 6*. Lastly, a conclusion is presented in *Chapter 7*, where the main research question is addressed.

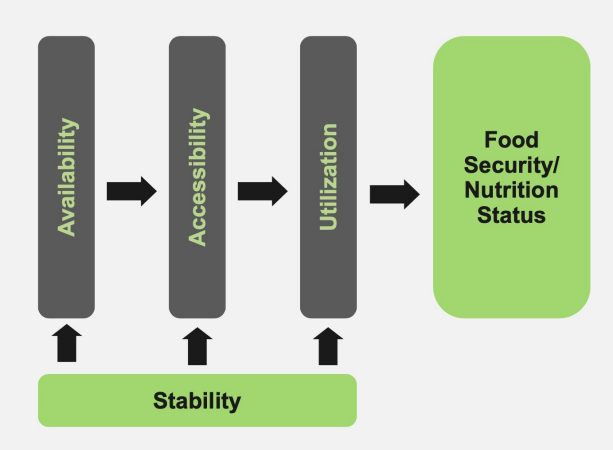
2. Literature Review and Conceptual Framework

2.1. The Theory of Food Security

In order to assess the potential of agroforestry in contributing to improved food security, it is crucial to first examine the concept of food security. Therefore, a focus is put on the Theory of Food Security, whereby the individual components and features are assessed, which, upon fulfillment, lead towards the attainment of food security. Figure 1 illustrates the categorical elements of food and nutrition security as proposed by Weingärtner and Klennert (2005), as well as Simelane and Worth (2020). As previously mentioned, *food insecurity* signifies a lack of consistent access to safe and nutritious food (FAO, 2023). Consequently, the converse definition of *food security* can be drawn. According to Simelane and Worth (2020), "*food and nutrition security can only be achieved when all people have, when needed, physical, social, and economic access to adequate, safe (free of contaminants), and nutritious food to satisfy their dietary needs and choices for an active and healthy life*" (Simelane & Worth, 2020 , p. 368). It is important to note that a household may be food secure while a region or nation may not be, and vice versa.

Figure 1

The relationship among the categorical elements of framework of food and nutrition security (Weingärtner & Klennert, 2005; Simelane & Worth, 2020)



The theory comprises four interrelated components, which are as follows:

- *Food availability:* entails the physical presence of food, obtained either through on-farm production or purchases from external sources, such as markets.
- *Food accessibility:* the ability of households and individuals to acquire sufficient means and resources to obtain the necessary food for a nutritionally adequate diet, considering both physical and financial accessibility.
- *Food utilization:* considers the human´s body to assimilate nutrients from the consumed food (e.g., through dietary habits, food preparation, variety of the diet, etc.), as well as socioeconomic factors such as knowledge and habits.
- *Stability:* refers to the temporal aspect and acknowledges the potential fluctuations in food security over time, as it can be gained or lost depending on the prevailing circumstances.

These components are interconnected, and their simultaneous presence and fulfilment contribute to improved nutrition and the attainment of food security (Weingärtner & KLENNERT, 2005).

Furthermore, food security is categorized based on socio-organizational dimensions. The macro-perspective provides a comprehensive view, encompassing global, regional and national food and nutrition statuses. The meso-perspective focuses on community-level food and nutrition statuses, such as those of provinces, cities and villages. Lastly, a micro-perspective centers on the household, family, and individual food and nutrition statuses (Simelane & Worth, 2020; Weingärtner & KLENNERT, 2005).

Within the scope of this research, a *micro-level perspective* is adopted, as the study revolves around smallholder farmers and their perspectives on adopting agroforestry. With this research, an estimation on the fulfillment of the four categories through adopting and practicing agroforestry in Ethiopia, will be provided.

2.2. Agriculture and agroforestry in Ethiopia

2.2.1. Agriculture in Ethiopia

Agriculture serves as the primary source of food provision, making the functionality and productivity of agricultural practices critical (FAO, 2023). This section provides an overview of Ethiopia´s agricultural landscape.

Agriculture remains the basis of Ethiopia´s economy. As of 2022, agriculture employs at least 80 percent of the population, contributes to nearly 40 percent of the national gross domestic product (GDP) and accounts for 90 percent of its export earnings (International Trade Administration, 2022). Crop production is the mainstay of Ethiopia´s agricultural outputs, with cereals, such as teff, wheat, maize, sorghum, and barley, occupying a substantial portion of the cultivated area (Se et al., 2011). The agricultural exports primarily comprise unprocessed commodities, with coffee as the primary export product, followed by oil seeds, cereals, cotton, sugarcane, incense, and spices (FAO, 2016).

Ethiopia´s diverse topography, as depicted in figure 2, results in a wide range of agroecological zones and arable land, which allow for a wide range of agricultural systems. The regions are broadly categorized into highland (starting at 1500 meters above sea level), midland (between 1000 and 2000 meters) and lowland (below 1000 meters) (FAO, 2016). Ethiopia is dominated by small-scale farmers who practice rainfed farming and rely on traditional technology (Gebre-Selassie & Bekele, 2012). The UN Environment Programme classifies small-scale farmers as those *"with a low asset base and operating in less than two hectares of cropland and under structural constraints such as access to sub-optimal amounts of resources, technology and markets"* (UN Environment Programme, 2023, para. 1). Consequently, these farmers operate under challenging conditions with restricted land availability. Rainfed agriculture is heavily reliant on rainfall patterns, and any changes in these patterns can lead to severe droughts during dry seasons and water logging during periods of increased rainfall (He et al., 2013).

As previously mentioned, Ethiopia is a country with various geographical and climatic variations and can be divided into three major agroclimatic zones. The first zone includes the eastern, northeastern, southeastern, southern and northern lowlands, where rainfall is scarce or non-existent, resulting in the absence of a significant crop-growing season. The second zone, in the western half of the country, experiences a single rain season from February/March until October/November, providing one growing season per year. The length of the wet season diminishes from south to north. The third zone, characterized by two rainy seasons, can be subdivided into two areas: the eastern region experiences a modest rainfall peak in April and a larger one in august, while the southern and southeastern areas have two separate rainy seasons from February to April and June to September. The peak months of rainfall are April and September, with distinct dry periods between the two seasons (FAO, 2016).

Figure 2

Map of Ethiopia (World Atlas, 2021)

As mentioned, majority of Ethiopia´s population depends on agriculture, particularly rainfed agriculture, for their livelihoods (Concern Worldwide, 2019). However, Ethiopia is particularly vulnerable to the effects of climate change, such as weather-related shocks and increasing weather extremes, like droughts and floods (Welthungerhilfe, 2023). Recurring dry seasons contribute to crop failures and livestock losses, compounded by a growing population and technology which is generally traditional and rudimentary. This results in Ethiopia´s agriculture largely being characterized as low-input and low-output subsistence farming with comparatively low yields by international standards (Sasakawa Africa Association, 2023; Se et al., 2011). Subsistence farming refers to the production of crops that satisfy the basic needs of the farmer and their household, without generating surpluses for market sale (Park & Allaby, 2007). Therefore, agroforestry is examined as an alternative practice to improve Ethiopia´s current agricultural circumstances by enhancing food productivity and thus improve food security.

2.2.2. An Introduction to Agroforestry

According to Leakey (1996), agroforestry can be described as the *"cultivation and use of trees and shrubs with crops and livestock in agricultural systems"* (Leakey, 1996). Agroforestry enables the integration of diverse products on the same farmland and can be categorized into three main forms:

1. *Agrisilvicultural System:* Involves the simultaneous cultivation of trees and crops on the same plot of land.
2. *Silvopastoral System:* combines the grazing of domesticated animals on pastures, rangelands or on-farm with the cultivation of trees and shrubs on the same land.
3. *Agrosilvopastoral System:* Incorporates all three types of plantations, including food crops, animals, and trees (FAO, 2015).

This research focuses in the following on agrisilviculture, the combination of trees and crops. Existing literature and research organizations oftentimes naturally refer to agroforestry as the integration of trees into an agricultural system. Therefore, and for the sake of simplicity, agrisilviculture is referred to as agroforestry in the context of this research.

Literature shows that the list of benefits that are obtained through agroforestry is long. The most important benefits of agroforestry are enlisted in table 1 below.

Table 1

Important benefits of agroforestry

Protection from extreme weather	Agroforestry can help prevent soil erosion, improve soil fertility, and thus counteract drought. The trees can help to bind the soil, prevent water runoff, and improve soil quality through nutrient cycling (Campbell et al., 1991; Jose, 2009)
Resilient and increased food production	Agroforestry can contribute to diversified product cultivation by mixing various components simultaneously into one piece of land (Waldron et al., 2017)
Economic benefits	Agroforestry can provide multiple income streams for farmers through the production of crops, livestock, and tree products such as timber, fruit, and nuts. This can help to diversify income sources and increase the overall resilience of farmers and communities (Franzel et al., 2001)
Biodiversity conservation	Agroforestry can enhance biodiversity by providing habitats for wildlife and promoting the growth of a variety of plants and animals (Jose, 2009) ;Soil Association, 2023)
Climate change Mitigation and adaptation	Agroforestry can help to mitigate climate change by sequestrating carbon in trees and soil. This can help to reduce greenhouse gas emissions and mitigate the effects of climate change (U.S Department of Agriculture, 2023)
Water conservation	Agroforestry can help to conserve water by increasing water infiltration. Trees can also help to regulate water flow and improve water quality (U.S Department of Agriculture, 2023)

Agroforestry represents a viable land use system that offers sustainability and multifunctionality and contributes to the resolution of various challenges facing agriculture and society at large. Despite its numerous advantages, it is crucial to acknowledge and carefully assess potential disadvantages associated with agroforestry, as outlined in table 2 below.

Table 2

Important disadvantages of agroforestry

Limited sustainability in some areas	Agroforestry may not be suitable in all areas due to factors such as climate, soil type, and topography (Chemura et al., 2021)
Initial costs	The initial investment in establishing agroforestry systems can be high, as it requires planning, investment in trees, and changes in farming practices (Slavikova, 2019)
Management challenges	Agroforestry requires more complex management due to the diverse cultivation, which can be challenging for farmers who may lack the necessary knowledge and skills (Slavikova, 2019)
Reduced crop yields	in some cases, the presence of trees in agroforestry systems can lead to reduced crop yields due to competition for sunlight, water, and nutrients (Chemura et al., 2021)
Limited market access	Some tree crops grown in agroforestry systems may have limited market access or low prices, which can make them less profitable for farmers (Slavikova, 2019)
Risks of pests, use of inappropriate tree species, etc.	The combination of different species requires in-depth knowledge about the topographic conditions needed for successful cultivation as well as risks, such as heightened probability of pests, which are not as pronounced in monoculture practices (Asfaw & Ågren, 2007)

While it is important to carefully consider the potential disadvantages of agroforestry, this research focuses on exploring the asserted benefits and analyzing them as a basis for providing the possibility of enhanced food security.

2.2.3. Agroforestry in Ethiopia

Agroforestry practices are widely observed across Ethiopia, exhibiting diverse forms and variations that are significantly influenced by the prevailing biophysical and socioeconomic characteristics of the regions. Nationwide, agroforestry is more commonly practiced in the midlands and highlands, while being less prevalent in the lowlands, owing to the varying climate conditions, with the highlands enjoying a temperate climate and the lowlands classified with a tropical and subtropical climate (Bishaw et al., 2013).

The existing literature on agroforestry benefits in Ethiopia predominantly adopts a quantitative approach and reflects on biophysical circumstances. Nevertheless, these benefits

encompass various dimensions, including environmental, economic, and societal aspects, and should be examined holistically due to their interconnectedness and potential spillover effects.

From an environmental perspective, the positive impacts of agroforestry on climate change adaptation and mitigation, as well as its role in enhancing resilience to climate variability, hold significant importance for land productivity in Ethiopia, particularly considering the country´s vulnerability to climate change-induced challenges such as droughts and erratic rainfall (Chemura et al., 2021). Research by Manaye et al. (2021) conducted in the Tigray region of Ethiopia´s lowland, midland, and highland areas showed that agroforestry effectively enhances agricultural production´s resilience to climatic fluctuations by regulating microclimatic conditions and mitigating temperature extremes through the presence of trees in the agroforestry system (Manaye et al., 2021). Moreover, trees absorb and store carbon dioxide from the atmosphere, and thus contribute to climate change mitigation efforts. In light of this, a growing number of projects focus on planting trees with the sole intent to contribute to carbon sequestration (Kim et al., 2022).
Similarly, Kim et al. (2022) found that trees in agroforestry systems not only aid in climate change mitigation by sequestering carbon but also contribute to improved soil fertility in Northwestern Ethiopia (Kim et al., 2022). They observed that an agroforestry system combining the cereal teff and the acacia tree, along with on-site charcoal production, exhibited higher levels of soil pH, phosphorus, potassium, magnesium, and calcium compared to crop monocultures. Mbow et al. (2014) found out that the improved soil fertility can be attributed to increased soil organic matter and biological nitrogen fixation facilitated by leguminous trees, leading to tighter nutrient cycling compared to monoculture system (Mbow, Smith, et al., 2014). Asfaw and Ågren (2007) also suggest that potassium accumulation and its impact on soil fertility may result from litter fall and the roots of various plant species (Asfaw & Ågren, 2007).

These findings highlight the role of locally adopted agroforestry in Ethiopia in promoting increased and/or restored nutrients, better conservation of soil moisture, and improved soil fertility. These are crucial factors in boosting food security by enhancing cultivation and growth

conditions, ultimately leading to heightened productivity which is significant for Ethiopia´s food security status (Mbow, Van Noordwijk, et al., 2014).

Furthermore, Chemura et al. (2021) demonstrated that providing ten percent shade to crops by incorporating trees in the farming system reduced maize yield losses by 6.9 percent compared to monocultures under current climate conditions in Ethiopia, while 20 percent shade reduced losses by 11.5 percent. This finding highlights agroforestry´s capacity to buffer yield losses and its potential in building climate-resilient agricultural systems (Chemura et al., 2021). Kassie et al. (2015) also revealed that farmers in Northwest Ethiopia prefer integrating tree plantations, particularly eucalyptus trees, into their farmlands due to their higher resilience to weather shocks compared to seasonal and less diversified food crop production, which is facing a higher risk of seasonal crop failures (Kassie et al., 2015). This shift towards a more continuous yearly farming system through the inclusion of multipurpose trees positively impacts farmers´ income and livelihoods, diversifying income sources and leading to improved economic security (Degefa & Markos, 2022; Kassie et al., 2015). Additionally, Mbow et al. (2014) stated that the incorporation of trees can influence on local and regional rainfall patterns and thus hold the potential of lowering the risk of drought in Ethiopia, which is vital for successful product cultivation (Mbow, Smith, et al., 2014).

One notable benefit observed in Ethiopia is the contribution of agroforestry to biodiversity conservation and protection of natural resources. Trees within agroforestry systems create habitats for various wildlife, including birds and insects, thereby promoting biodiversity within agricultural landscapes (Legesse & Negash, 2021). Legesse and Negash (2021) found a total of 40 different woody species in Tigray, distributed across various agro-ecosystems. Ethiopian farmers show a preference for multipurpose trees that can provide diverse products and services. These trees contribute to food production through fruits, construction materials, shade for crops, beehives, fuel wood and medicinal resources. The food obtained from trees serves as an alternative dietary source during crop production deficits and can also generate income. Trees also serve as fodder sources, ultimately contributing valuable plant nutrients (Legesse & Negash, 2021; Mbow, Smith, et al., 2014).

Kim et al. (2022) corroborate these findings by demonstrating that agroforestry systems combining teff and acacia trees produce not only crops but also grass and charcoal. These products

serve as food, animal feed, energy sources, and additional income streams when sold in markets, substantially improving the livelihoods of farmers (Kim et al., 2022). In a case study conducted in the Oromia region (Southeast Ethiopia), Yusuf et al. (2020) highlighted the numerous advantages of planting trees, including income generation, improved soil quality, food production, shade provision, fuelwood, construction materials, manure, fodder, and medicinal resources, all of which fostered a positive attitude toward agroforestry among farmers (Adane et al., 2019; Yusuf et al., 2020). Adane et al. (2019), who conducted a case study in Sidama in South Ethiopia, emphasized the significance of agroforestry systems with fruit trees for the livelihood improvement of smallholder farmers, as they contribute both to household income as well as providing supplementary food for smallholder farmers. Looking at the total annual income, fruit trees contribute to almost a quarter (24.75 percent) for poor Ethiopian households and 23.34 percent for medium income households, while being less important for rich households. Thus, especially for smallholder farmers who are limited in their resources, fruit trees are important due to their dietary purpose and nutritional value, as well as the income source as a result of the fruits´ high market value. Particularly in the event of famines or droughts, fruits offer an essential safety option due to their higher resistance and durability in extreme weather conditions compared to crops. The most widely distributed fruits in the Sidarma region were bananas (44.39 percent), avocados (32 percent) and mangoes (7.01 percent) (Adane et al., 2019).

The incorporation of diverse plant species in agroforestry systems enhances ecosystem resilience, reduces vulnerability to climate-related shocks, and ensures sustainable agricultural production. Additionally, the use of multipurpose trees allows for product diversification, which can significantly increase the overall profitability of agroforestry practices. Many of these benefits lead to the improvement of biophysical features, such as enhanced soil fertility, and thus to income and biodiversity diversification, as well as enhanced productivity of food and non-food sources. Directly or indirectly, this contributes to the improved food security for the farmer, which makes it important to include these aspects into the holistic perspective of factors which contribute to food security.

Alongside considering the biophysical context, understanding farmers´ behavior regarding agroforestry adoption is crucial. As mentioned earlier, the potential of agroforestry to enhance

yields also depends on the human context (Mbow, Smith, et al., 2014). A comprehensive understanding of the socioeconomic conditions is necessary to take a holistic view of agroforest adoption in Ethiopia (Gebru et al., 2019).

2.3. Conceptual Framework

The Theory of Planned Behavior (TPB) will be employed in this study to examine the factors and components that either facilitate or impede the adoption/adaptation of agroforestry systems. The study centers on smallholder farmers in Ethiopia, taking into account their experiences and expectations with agroforestry practices. The analysis does not have a specific time frame but primarily focuses on current and past experiences of farmers and ongoing or planned agroforestry projects at the time of the research. The literature considered for this analysis spans the past ten years, starting from 2013.

The scope of the analysis is at the national level, considering that the Ethiopian government formulates agricultural policies and various national and international non-governmental organizations (NGOs) and development agencies operate at the national level. Thus, an overview of the entire country is established. However, it is acknowledged that individual regions within the FDRE may have their own unique agricultural policies. Due to practical limitations, these regional policies are not accounted for in this research. Furthermore, it is essential to recognize the considerable variation in biophysical and socioeconomic features among Ethiopia´s regions. Given that the literature is limited and biophysical case studies often focus on specific regions, generalizations are made when deemed appropriate and relevant to the national level analysis.

2.3.1. The Theory of Planned Behavior

Agroforestry offers numerous benefits for farmers´ livelihoods. However, it is essential to acknowledge that various factors play a role in influencing farmers´ environmental behaviors and actions. Both internal factors and external context in which farmers operate must be carefully considered (Meijer et al., 2015). The Theory of Planned Behavior, originally established by Ajzen in 1991 as a social psychological theory, has been used in various literature to explore the contributions of agroforestry to food security. The TPB aims to explain and predict human behavior based on an individual´s attitudes, subjective norms, and perceived behavioral

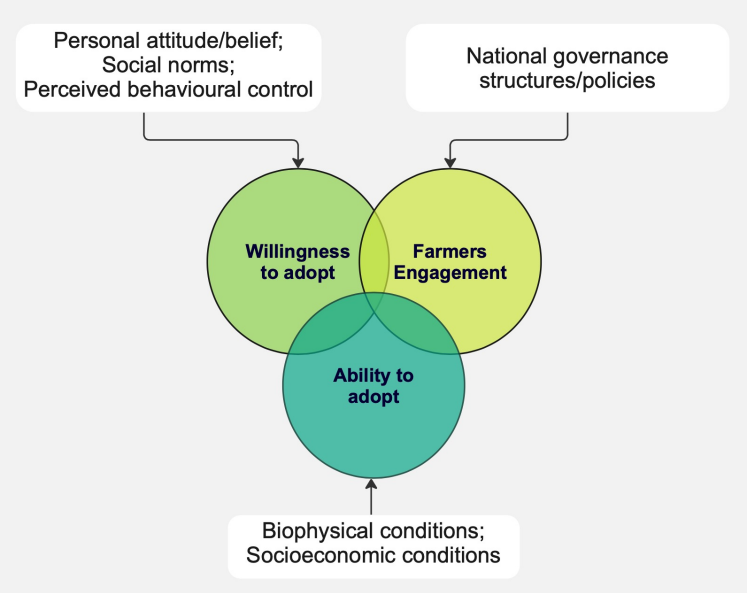
control (Ajzen, 1991)[1]. This theory proposes that these three factors collectively influence an individual´s intention to engage in a specific behavior. In agriculture and agroforestry literature, the TPB framework has been referenced to determine whether certain influencing factors either support or hinder the adoption of specific agricultural practices and to further define additional or new components (Amare & Darr, 2022; Fielding et al., 2008). Amare and Darr (2022) demonstrated a significant correlation between the TPB constructs (attitude, subjective norms, perceived behavioral control) and farmers´ intention to adopt agroforestry. However, authors continue to subject the TPB to further empirical tests to expand its scope or enhance its explanatory power, often by incorporating additional constructs (Amare & Darr, 2022; Sok et al., 2021).

For instance, in the context of agroforestry adoption in Vietnam, Nguyen et al. (2021) introduced two components, namely willingness and capacity, to emphasize the importance of social and cultural norms. Similarly, Mills et al. (2017) identified three components – farmers´ engagement, willingness to adopt, and ability to adopt – to assess farmers´ readiness and capability for environmental management (Mills et al., 2017). For this research, the combination of the three components proposed by Mills et al. (2017) is deemed suitable and applied for analysis. The following section provides a closer definition of these three components, as illustrated in figure 3.

[1] According to Fielding et al. (2008), Attitudes are positive or negative evaluations of performing the behaviour. Subjective norms are based on individuals' perception of whether others in their life would want them to perform the behaviour. Perceived behavioural control is the extent to which individuals perceive the behaviour to be under their control (Fielding et al., 2008)

Figure 3

Factors influencing farmer environmental decision-making (Mills et al., 2017)



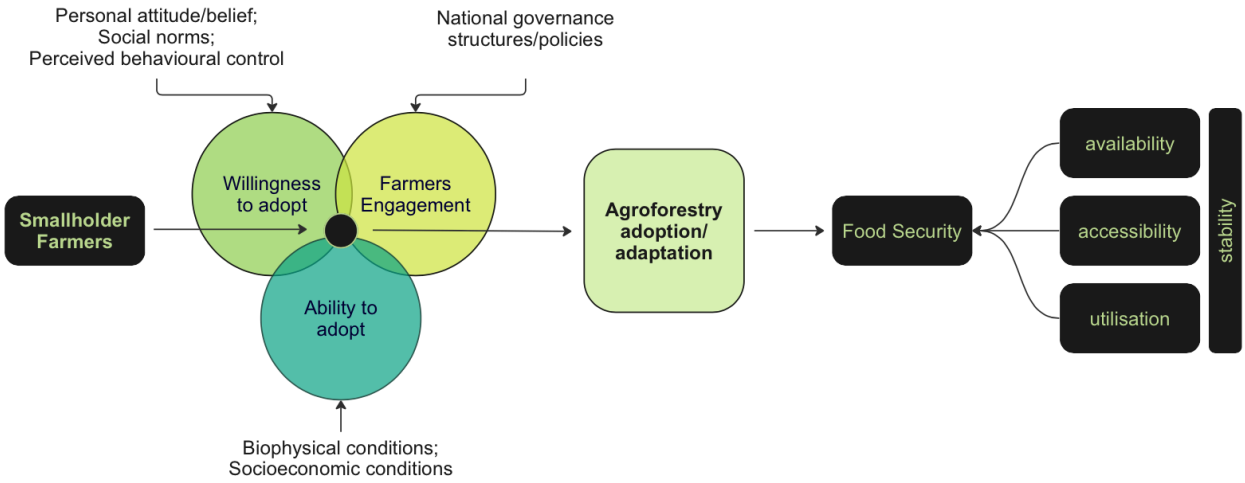
- A farmer´s ability to adopt agroforestry is determined by farm characteristics, encompassing both biophysical and socioeconomic conditions.
    - *Biophysical* conditions involve factors like soil type, soil fertility, geographical context, and farm size, which collectively influence the adoption feasibility.
    - *Socioeconomic* factors such as market incentives and household preferences play a crucial role in shaping the farmer´s capacity to adopt agroforestry.
- A farmer´s willingness to adopt agroforestry is influenced a combination of personal beliefs, attitudes, social norms, and perceived behavioral controls.
    - Farmers´ *attitudes* towards agroforestry, whether negative, positive, or neutral, are influences for instance by their access to information about its benefits and extension services.
- Farmer engagement with agroforestry entails various aspects, including sources of advice, levels of trust, and continuity of relationships.
    - *Policy* plays a significant role in fostering the adoption of agroforestry; government policies must align with farmers´ needs and specific contexts to facilitate successful integration.

Farmers´ decision-making processes are influenced not only by their perceptions of the advantages and disadvantages of agroforestry practices but also by the opinions and actions of relevant third parties in their environment, alongside the actual opportunities available for practicing agroforestry. Understanding the diverse motivations for agroforestry adoption and the preferred options and values of different farmers can aid policymakers and development projects in designing effective engagement strategies and best-fit agroforestry practices for specific contexts.

In light of these considerations, a conceptual framework, depicted in figure 4 below, is applied in this research. The framework integrates the Theory of Planned Behavior (Ajzen, 1991) along with its variation, incorporating the three components proposed by Mills et al. (2017). This conceptual framework seeks to achieve joint fulfillment of agroforestry adoption/adaptation. Additionally, the attainment of agroforestry adoption/adaptation is linked to food security through the Theory of Food Security (Simelane & Worth, 2020; Weingärtner & KLENNERT, 2005), which comprises four components contributing to food security fulfilment.

Figure 4

Author´s own conceptual framework based on the Theory of Planned Behavior and the Theory of Food Security



Agroforestry has been acknowledged as a potential contributor to improved food security, offering various benefits such as income diversification and enhanced crop production. Duffy et al. (2021) have established a direct link between agroforestry and food security, highlighting

the positive outcomes it brings, including increased income, improved food quantity and quality, positive environmental impacts, and better health outcomes (Duffy et al., 2021). These benefits can have significant effects on the accessibility, availability, utilization, and overall stability of food security, as categorized in figure 1. In the context of Ethiopia, a county facing food insecurity, the impact of agroforestry can be particularly valuable for the livelihoods of smallholder farmers. Hence, it becomes crucial to examine the factors outlined in the Theory of Planned Behavior and their influence (whether positive, negative, or neutral) on the adoption of agroforestry practices in Ethiopia. Once these factors are outlined, an evaluation for the Theory of Food Security can be made.

3. Research Methodology

The research has started with a literature review on agroforestry linked to food security in Ethiopia. Due to the limited number of case studies available, the scope of the literature review was set on a national scale. Several databases and Google Scholar were used with keywords related to agroforestry, trees, and food security in Ethiopia (e.g. heightened/ensuring food security, farmer livelihood, farmer income, nutritious food, etc.) to retrieve relevant articles. It has been found that a range of actors are involved in the field of agroforestry in Ethiopia, and it is taken into account that actors who are not involved in the literature might exist in the system. The literature highlights mainly positive societal, economic and environmental outcomes of practicing agroforestry in Ethiopia, thus a positive assumption is established toward food security.

The condition of improved food security is inherently subjective and depends on the perspective taken. A smallholder farmer in Ethiopia may perceive it differently from public authorities establishing policies and nutritional reference values. Individual knowledge and opinions are deemed valuable to determine whether agroforestry practices have an influence on food security. Hence, this research has adopted inductive reasoning with a constructivist approach, as it is assumed that individuals hold diverse approaches, beliefs and opinions which result in varied interpretations of the same subject.

By using the Theory of Planned Behavior, the researcher establishes interrelated components which indicate a position of subjective observation and interpretation. Within this approach, qualitative data was gathered via in-depth and semi-structured interviews from a systemic

perspective and the study has built on observations rather than hypothesis testing. For reaching the interviewees, the snowball/network sampling method is used to interact with key actors from the agroforestry field in Ethiopia, as well as through direct online search for suitable organizations as the starting point of contact. The sample size includes ten experts in total, as well as the analysis of five papers.

As a guideline for the interviews, the components of the Theory of Planned Behavior (willingness to adopt, ability to adopt, farmers engagement) as well as the Food Security Theory (availability, accessibility, utilization, stability) are used to identify talking points and to create a questionnaire (Appendix A). The interviews were held online due to the physical distance. After the completion of the interviews, the records of the interviews were transcribed for coding, for which the qualitative data analysis software ATLAS.ti was used. The researcher made use of open coding and axial coding to uncover similarities and differences in statements and findings which can be determined as important factors influencing the adoption/adaptation of agroforestry. The analysis followed an iterative and reflexive process. As a result of receiving a considerable number of varying responses, the counting method was used to identify the most frequently mentioned terms and concepts. The document analysis was conducted after finishing the interviews, to compare and supplement findings with the interview data. A total of 173 codes were established throughout the process of open coding, leading to 35 groups under axial coding (Appendix B). After all, the researcher aims to find answers to the opportunities and barriers of agroforestry practices in Ethiopia presented in the data collected and hence assess to what extent this can lead toward improved food security.

4. Results

4.1. Context

The results include two sources of data: the findings from the document analysis regarding the existing case studies on Ethiopia, and the findings from semi-structured interviews. The analysed papers are outlined in table 3 below, and an overview of the interviewed organizations, regarding their operations, organizational structure, values, missions, and visions, is presented in table 4. The information provided in this section is a collection of the content that

exists on the websites of these organizations as well as responses from semi-structured interviews.

Table 3

Papers for the case study of Ethiopia

Paper No.	Paper Name	Coverage
(P1)	Assessment of Traditional Agroforestry Practices, benefits and Constraints: The Case of West Hararghe Zone, Oromia National Regional State, South-eastern Ethiopia (Yusuf et al., 2020)	The study focuses on understanding various traditional agroforestry practices in South-eastern Ethiopia, to identify the reasons behind practicing and to prioritize major constraints related to agroforestry practices. The major benefits for planting tree species are identified, as well as the barriers and recommendations to overcome difficulties of practicing agroforestry.
(P2)	Socio-Ecological Niche and Factors Affecting Agroforestry Practice Adoption in Different Agroecologies of South Tigray, Ethiopia (Gebru et al., 2019)	A focus is put on the identification and characterization of traditional common agroforestry practices and to understand the existing knowledge of farm households on the management of trees under different agroforestry system in Southern Ethiopia. The most dominant fruit trees are identified, as well as the role of multi-purpose trees.
(P3)	Agroforestry and farm income diversification: synergy or trade-off? The case of Ethiopia (Kassie et al., 2015)	This study examines the relationship between agroforestry and non-farm income diversification activities in Northwest Ethiopia. The positive and negative outcomes of agroforestry and product diversification are elaborated on to examine the economic impact on the livelihood of the farmer.
(P4)	Farmers´ local knowledge and topsoil properties of agroforestry practices in Sidama, Southern Ethiopia (Asfaw & Ågren, 2007)	This paper focuses on the environmental impacts of different tree species in agroforestry systems and how they contribute to soil nutrients and thus towards soil fertility in Southern Ethiopia.
(P5)	Agroforestry solutions to address food security and climate change challenges in Africa (Mbow, Van Noordwijk, et al., 2014)	This study examines the contribution of trees to food security and the livelihood of farmers in Africa while considering the effects of climate variability and change. A further look is taken at policies concerning forestry and agriculture.

Table 4

List of interviewed organizations

Interview No.	Organization	Description
(I1)	Sasakawa Africa Association (SAA)	SAA works in collaboration with national agricultural extension services in Ethiopia and further African Countries to support smallholder farmers along the agricultural value chain. SAA aims to increase farmers´ income and food and nutrition security through promoting market-oriented, sustainable, resilient, regenerative and nutrition-sensitive agricultural innovations and building the capacity of Extension Agents and farmers. SAA is supported by the Ministry of Agriculture and promotes need-based agricultural practices and improved technologies in rural communities.
(I2)	CIFOR-ICRAF (Merger between the Centre for International Forestry Research (CIFOR) and World Agroforestry (ICRAF)); Regreening Africa	CIFOR-ICRAF is a research institution with the aim to build and apply evidence about the role of trees, forests and tree-based agriculture as pathways to solving global crises such as poverty, hunger and land degradation. Their 2020-2030 strategy includes the regeneration of degraded land, promoting the use of trees and transforming current food systems. Regreening Africa is a partner of CIFOR-ICRAF, which focuses on scaling-up green agriculture by using locally appropriate techniques including Farmer-Managed Natural Regeneration, tree planting and other forms of agroforestry and complementary sustainable land management interventions.
(I3)	Mekele University, Ethiopia; Hamburg University of Technology, Germany	The contact person works as a lecturer at Mekelle University, Ethiopia, and as a researcher at the Hamburg University of Technology, Germany at the institute for wastewater management and water protection. The research aim is to integrate rainwater harvesting and soil organic amendment with agroforestry as a restoration measure in the Tigray Region of Ethiopia.
(I4)	Orda Ethiopia	The organizational goal entails to contribute to the overall efforts of ensuring food, livelihood and environmental security that realizes sustainable development and social transformation in Ethiopia. Orda Ethiopia establishes pillar programs, such as the landscape restoration program which focuses on the inclusion of multi-purpose trees in form of cash crops and fruit trees into agricultural systems.
(I5)	An International Financial Institution[2]	The International Financial Institution administers a landscape program in Ethiopia, which seeks to reduce deforestation by improving sustainable forest management and natural resource production and thus

[2] The representative of the International Financial Institution requested full anonymity on their name and associated organization

		lowering greenhouse gas emissions from land use according to the Climate Resilient Green Economy (CRGE) and Growth and Transformation Plan (GTP), and improving communities livelihoods, shared benefits and resilience.
(I6)	Agri-Service Ethiopia	Agri-Service Ethiopia is a non-governmental indigenous development organization, which works in rural areas of Ethiopia on integrating food security and community capacity building programs. Their strategic plan and programs are in line with and in support of the Growth and Transformation Plan (GTP) of Ethiopia and the agriculture and rural development policy and strategy, the food security strategy and the National Climate Adaptation Plan of Action in particular.
(I7)	Farm Africa	Farm Africa holds the goal to reduce poverty in East Africa by improving agricultural practices and maximizing the effectiveness. The organization aims to find effective agricultural strategies which maximize yields and productivity, while protecting the environment and improving smallholder farmers connections to markets. Therefore, Farm Africa takes a holistic perspective of the production value chain.
(I8)	Sustainable Natural Resource Management Association (SUNARMA)	SUNARMA works in rural Ethiopia amongst farmers who live in areas that are food insecure and currently work on three projects with the aim to improve food production and income and creating a productive countryside, such as the Sustainable Forest and Land Management Project which aims to increase food security through improved and innovative agricultural practices.
(I9)	Environment and Coffee Forest Forum (ECFF)	The ECFF is a local Civil Society Organization, which focuses on developing strategies for sustainable use and conservation of the environment in general, and the coffee forests in particular. This is done through research on conservation planning, education, capacity building and pilot implementation of research findings, such as in a current cooperation project with the Horn of Africa Environmental Center and Network from the Addis Ababa University.
(I10)	The African Forest Landscape Restoration Initiative (AFR100)	AFR100 is a country-led effort to bring 100 million hectares of land in Africa into restoration by 2030. Ethiopia is committed to restore 15 million hectares by 2030 and planted 20 million trees by 2022 and adheres to the governments Climate Resilient Green Economy (CRGE) goal and Growth and Transformation Plan (GTP). Agroforestry plays a central role in various projects under the pillars of Agroforestry Assisted Natural Regeneration Reforestation and Agroforestry Regeneration.

4.2. SQ1 What are the goals and instruments of Ethiopian national policy to promote agroforestry?

While the Ethiopian Government's main focus are economic and commercial aspects of agricultural practices, sustainability and environmental matters are steadily growing, as the trade-offs of practicing commercial agriculture, such as monoculture, on long-term productivity capacity of the land are increasingly present. Thus, the government is committed to integrating and promoting sustainable practices into their national goals and policies (I1, I4, I5, I6, I10, P5) and aligning government development programs with environmental goals (I6). The federal government launches policies, and the regions should follow that principle and follow up with the implementation (I4, I10).

4.2.1. The allocation of responsibilities

Simultaneously, the *allocation of responsibilities* is frequently expressed as a challenge in Ethiopian agroforestry and is considered a barrier for institutions and NGOs to establish a point of contact (I2, I4, I6, I8, P1). Agroforestry is characterized as a cross-sectoral practice and can thus be suitable for sectors such as agriculture (crop production), forestry (timber and wood production) and biodiversity and environmental matters (soil fertility, carbon sequestration) (I2). Within the Ministry of Agriculture in Ethiopia, there are different departments, including Natural Resource Management, Crop Production, and Livestock, which are equally involved in agroforestry practices (I2). As agroforestry does not live up to one institution, the division of responsibilities is thus not always well-defined and clear. The research institution CIFOR-ICRAF for instance works with both the Ethiopian Forestry Development and the Ministry of Agriculture on the research and promotion of agroforestry. Nevertheless, the representative assesses the cooperation with both institutions as uncomplicated, saying that *"the structure itself is not really a problem in terms of promoting and having ownership of agroforestry. It is for the project to find the appropriate sector to work with"* (I2). The allocation of the right contact point is thus not considered difficult, as the Ministry of Agriculture and the Ethiopian Forestry Development are considered umbrella organizations for agroforestry (I2). Interview 8 voices that *"at one time, agroforestry is a forestry component under the Ministry of Agriculture. Another time, the Ministry of Agriculture is kept out and agroforestry is inserted into the Ministry of*

Environment and Climate Change. The institution is unstable, and this affects the total structure from federal to local level" (I8). According to interview 6, the government and responsible authorities are well structured, but the representative mentions as well that different agroforestry policies derive from different departments and relate to different sectors/focuses (I6). The opinions towards the functionality of governmental structures do thus differ from each other according to personal working experiences and beliefs.

4.2.2. Ethiopian National Policies to promote agroforestry

Even though discrepancies and criticism regarding the allocation of responsibilities are voiced, a number of interviews (I1, I5, I6, I7) expressed that the government is putting several policies and instruments in place regarding the promotion of agroforestry and ensuring food security. Interview 2 states that *"there is not a big challenge in terms of mainstreaming agroforestry"* (I2). According to interview 7, *"there is no problem in terms of policy in Ethiopia".* According to I1, I2, I5, I6, and I7 the government does not object to agroforestry. According to interviews I2, I5, I6, and I7 the implementation and promotion of agroforestry policies are not considered a problem.

Therefore, various plans and initiatives have been implemented by the national government to support agroforestry practices in Ethiopia. Most prominently, the government has been following the Agricultural Development-led Industrialization Policy (ADLI). Within the ADLI, the Growth and Transformation Plans (GTP1, 2010-2015/ GTP2, 2015-2020) were established, with a focus on providing food security by accelerating growth in agricultural productivity, increasing crop productivity, and improving extension services (I3, I7). Within the GTP, Ethiopia´s Climate-Resilient Green Economy (CRGE) has been laid out (I7), which links back to the government´s overall aim to develop into a middle-income country by 2025, as presented in Chapter 1. Thereby, the government recognizes that the path of conventional development and agriculture results in an unsustainable use of natural resources and increased greenhouse gas emissions. Thus, decreasing the number of livestock and increasing agroforestry programs, improving crop production practices for higher food security and farmer income, and protecting and re-establishing forests are central themes in this Ethiopian green strategy to increase overall productivity (I1, I4, I7, Economy, 2011).

The Green Legacy initiative has been mentioned throughout all interviews (I1, I2, I3, I4, I5, I6, I7, I8, I9, I10), which is a campaign developed by the current government to adopt agroforestry systems amongst small-scale farmers by letting farmers plant seedlings, such as fruit tree seeds, on their own, from which the majority (55%) are associated with agroforestry by inter-cropping trees and crops (I2, I9, I10).
The policies and plans show that agroforestry and tree planting play a significant role in Ethiopian agricultural policies, and a tendency of growth in this direction has been vocalized throughout the interviews.

The government of Ethiopia has further been localizing distinct areas with main product sources, such as avocado, coffee, papaya, and wheat. The distribution is done according to biophysical conditions and the capacity and potential of the area, and existing knowledge of where products grow best (I7, I10). According to interview 7, this method and focus on optimal growing conditions contributes to diversifying products and income and also secures the food security of the local community by specializing in products that are typically grown in agroforestry systems. Consequently, the Southwest, which is mainly the forest-covered part of Ethiopia, is categorized as a coffee-growing area, as well as a fruit-growing area. The south-east highlands are barley-, wheat-, and cereal-growing areas. The lowlands are categorized as oil-crop-growing areas (I7). Overall, the government puts emphasised focus on products such as coffee, eucalyptus, avocado, mango and oil crops, as they are the main export products of the country (I7, I8). Through this regional distinction, the government supports production through agroforestry and aims to heighten productivity by complying with scientific knowledge (I7).

4.2.3. The Ethiopian government´s investment into agroforestry

Interview 10 states that the government´s financial resource allocation is still conformed to commercial agriculture rather than agroforestry (I10). This is because commercial agriculture provides short-term benefits in agricultural production, which the government strives for in the circumstance of a fast-growing population and the aim to promptly provide nutritional value to the population (P5).
Simultaneously, the representative acknowledges that the government is currently expanding on agroforestry practices (I10, P5), and in the course of this the government has been

providing different capacity buildings for the implementers (e.g., farmers and experts at lower/field level), as well as monitoring, technical backstopping, and inputs like seedlings, water pumps, different technologies, and fertilizer in order to support communities and encourage agroforestry (I7, I10).

An example of capacity building are extension agents, whom the government introduces as an initiative to promote agroforestry. Therefore, the government assigned experts from the Natural Resource Management sector to facilitate seed planting at the community level who are mobilized to prepare the land for tree planting. Thus, communities plant trees in the areas they prepared (such as in their backyard, homegarden, or farm boundaries) during the rainy season (P1).

4.2.4. Land tenure uncertainty

An important issue mentioned is land tenure uncertainty (I1, I6, I7, I8, I9, P3). In the Ethiopian Constitution, land is only legitimized to be owned by the state. Accordingly, there is no private land ownership possible in the FDRE, and farmers are only allowed to use the land. Land ownership is thus considered a barrier at the policy level. As planting trees is a long-term investment, some farmers might be discouraged to do so as they are not the landowners but only hold usage rights over the land. They are entitled to farm, but since they are not owners, they can´t sell or manage the land according to personal wishes and preferences. As an example, in designated regenerative coffee forests, it is not allowed for the farmers to improve their own management practices and cut trees and minimize the shade level for crops as they have to abide by forest policies of protected forest areas. Thus, the forest is rather dense and little space is left for crop production, leading to significantly decreased yields (I7). This depicts a challenge and restriction in the policy to support agroforestry practices. Interview 9 sees the concept of regenerative forests as a positive way to sustainably manage protected areas, forests and biodiversity. No concerns were expressed toward the question of land management (I9). In interviews 6 and 8 it was mentioned that negotiations on land ownership in Ethiopia are ongoing and currently, a use right registration is being established which is supposed to guarantee more management rights to smallholder farmers (I6, I8).

4.3. SQ2 What do stakeholders and experts think about the potential of agroforestry in Ethiopia?

Commercial agriculture has divided opinions upon its usage and benefits. While it is proven as a way to immediately feed an emerging population by providing short-term benefits, it becomes increasingly clearer that the environmental damage it causes, bears long-term trade-offs and deteriorates the quality, capacity and productivity of farmland and the earned products (I1, I2, P2, P4). In conclusion from this, throughout all interviews agroforestry is vastly seen as a suitable and positive agricultural solution, which bears holistic benefits. Stakeholders and experts in the field of agroforestry, such as development partners and organizations, research institutions, and extension workers are thus not confronted with instances that oppose agroforestry practices, since a rather multi-domain and multi-level positive attitude is present, as the importance for food security, income at the rural level, diversification, as well as environmental benefits such as soil and water benefits, are widely acknowledged (I2, I3, I5, I7, I9, P1, P2, P5).

4.3.1. The outlook on the potential of agroforestry

The support of development partners and stakeholders, such as local NGOs, is crucial to promote and support agroforestry practices. They support the government in the development and implementation of extension services and work at a ground level, and are dedicated to their resources, time and expertise (I5).

While the government continuously provides agroforestry policies and develops regulations on (re-)extension services, it was mentioned throughout various interviews (I2, I3, I8) that the problem lies in the practical realization of such, which was stated among the interviewed experts as an important barrier to practice agroforestry. Monitoring and follow-up processes of the policies are lacking and currently absent, with interview 3 stating that *“the policies look nice from the outside but when they go to practice, there are still problems since they are not supported and followed-up on, therefore they won´t bring you anywhere”* (I3).

4.3.2. The long-term perspective on agroforestry

While stakeholders and experts generally hold a positive outlook on agroforestry and the vast benefits the practice provides, they express the concern that a number of barriers exists in the form of operational and logistical management, which hinder the adoption of agroforestry in Ethiopia.

One of the key issues which hold farmers back from adopting agroforestry, is the lack of seeing and recognizing short-term benefits, which farmers are normally used to by practicing commercial agriculture (I2, I3, I4, I5, I8, P3). As it has been stated in Chapter 2, the benefits of practicing agroforestry can especially be seen in the long run, when the products of trees, which take longer to grow than crops, can be harvested. By that time, the diversified income sources lead to an overall higher income for the smallholder farmer. This shows that an overall understanding of the benefits, as well as trade-offs of commercial agriculture is lacking amongst farmers.

Therefore, preventative education and training should be provided for smallholder farmers throughout the implementation process until the final adaptation of agroforestry. This can take the form of trainings on tree management (e.g., such as the management of vegetables, coffee and further fruits) as well as a clarification on the possible risks of agroforestry, such as presented in table 2 of Chapter 2.

This should be provided as an extension service, which has to be present at all times (I9). While this will incur additional costs for the government, it will pay off since the farmer will sustain and probably contribute long-term to the national economy. Right now, the support from extension workers provided to farmers is based on counselling them, rather than actively supporting in the field at the realization phase (I3).

4.3.3. The provision of incentives

The potential of agroforestry can therefore only be unfolded when adequate incentives are provided to farmers. This statement has been made throughout all interviews and was proposed as a key component to successfully adopt and maintain agroforestry (I1, I2, I3, I4, I5, I6, I7, I8, I9, I10, P1, P2, P5).

The government needs to facilitate incentives, in order to make the smallholder farmer feel secure and supported in the adoption of agroforestry, and thus make him/her resilient in climate change matters and thus with food security (I2, P1, P2, P5). According to interview 2,

"the key issue is really how those policies get to the farm and to the farmer and in what ways exactly supported in growing trees and how he/she is supported with incentives" (I2). Such incentives can take the form of providing improved technologies, inputs like seeds, water pumps, and fertilizers (I7). In the interviews 5 and 7 it was stated that there is a shortage of government input on supply and technical know-how, which needs to be adjusted (I5, I7). The appropriate inputs, such as seedlings, tree seeds, vegetable seeds, fruit seedlings, as well as technical skills and capacities should be in place (I5, I9) in order to support smallholders and establish a value chain system which benefits the farmers.

While agroforestry holds huge contributions to food security, further thinking, research and sharing experiences is needed (I7). The recommendation is given that research should be conducted by the government, and innovative technologies should be provided, for private actors, such as farmers and market parties, to willingly implement the planned activities. Further, planning and monitoring should happen at the local level, since agroforestry adoption is further only possible if local experiences, farmers knowledge and farmers resilience strategies are acknowledged appropriately throughout research studies, project planning and the implementation stage (I5, I8, I10).

4.4. SQ3 What is the potential contribution of agroforestry to improve agricultural practices and yields of smallholders in Ethiopia?

4.4.1. Nutritional contributions of agroforestry

Agroforestry practices can lead toward nutrition and food security in different dimensions, such as heightened productivity through improved soil fertility, usage for fuel and firewood, for food, fodder and nutrition, creating favorable microclimatic conditions and grazing (I2, I3, I5, I6, I8, I9, I10, P1, P3, P5).

Throughout all interviews, the nutritional contributions and dietary purpose of practicing agroforestry is mentioned as a key component which leads toward the heightened livelihood of the smallholder farmer (I1, I2, I3, I5, I7, I8, I10). (e.g. intercropping of fruit trees like the indigenous enset, maize, bean, etc. (I6, I7, I9)). This is an intrinsic value leading toward food security, since individuals gain benefits from directly consuming the products, such as crops (mainly mentioned: maize, haricot bean, wheat, barley, teff, sorghum (I6, I7)), fruits (mainly

mentioned: coffee, mango, avocado, enset, papaya, banana (I5, I7)), vegetables (mainly mentioned: onion, cabbage, carrot (I7)), spices (mainly mentioned: cardamom, cinnamon, black pepper, etc. (I5)), oils (mainly mentioned: sesame (I8)) and herbs. Both crop diversification (e.g. protein sources through beans (I3, I7)) and heightened food quality (i.e. through usage of natural fertilizers, optimal growth conditions, etc.) lead towards an improvement in the diet and nutritional uptake of individuals, while avoiding or reducing the need to go to the market to get additional food supply (I7). Homegardening is an essential part of this component (I1, I2).

4.4.2. Income and product diversification

In addition to direct consumption, the heightened productivity through agroforestry can lead toward heightened excess production which can be sold at national and international markets and thus contribute to improved and diversified household income (I3, I4, I5, I7, I8, I9, I10, P1, P3, P5). This economic benefit is seen as a further key component of agroforestry (I2, I3, I7, P3). Especially coffee and avocado are mentioned throughout various interviews as the main export products and best income sources, since prices vary according to the quality of the product, as well as the perceived value of the product in export countries (e.g. coffee and avocado are usually valued as more expensive than wheat or bean products in western countries) (I7). Interview 2 said that “we might not deal with key improvement in terms of health or mental health, there could be different dimensions that we can address. But the key issue is really when you have those sources in your homestead, we can understand how the dietary system, the feed system, the amount of diversity of the food they are raising at local level is really increasing. So it´s not only even fruit, there are wild edible foods, like in the form of parkland agroforestry, like bannanites, and further producing fruits” (I2). As an example, the benefits from intercropping the crop products maize and haricot bean can be gained short-term and continuously throughout the time period in which coffee and banana trees are grown. After a longer growing of approximately a couple of years, the tree products can additionally be harvested next to the crop ones. In case of a rain shortage, farmers may still access benefits from one of the sources as there is no complete destruction or loss of products. Interview 7 even called agroforestry “the best solution to contribute to food security” (I7).

Income diversification is oftentimes also attributed because of multi-purpose trees (sometimes also referred to as cash trees) (I2). An example is eucalyptus, which is growing in popularity amongst Ethiopian farmers. Eucalyptus is not a native and indigenous tree in the country, but rather started to be grown due to its fast return rate to harvesting. Eucalyptus is mainly used for its wood as construction material and as fuel wood (especially where there is no electrification in the rural areas, which leads back to direct consumption since electricity is used for cooking (I4)), and thus both used for own use and sold at markets for income purposes (I3). Timber production and fuel wood extraction are thus considered important components for the livelihood of the farmer (I5, I8). A further stable and multi-purpose product is enset, also called false banana, which is mainly popular in the southern parts of the country and is used directly as a food product, as well as for animal feed and different packaging purposes (I6, I9).

4.4.3. Heightened farmer security and resilience

Agroforestry contributes to long-term land productivity and capability, since positive influence is made on soil fertility, protection from erosion, land degradation and water conservation/improves infiltration, and reduced to no use of chemical fertilizers (see lit review, I4, I6, P1, P5). Heightened land productivity and capability are deemed crucial to guarantee long term food security (I4, I6).

A major benefit of practicing agroforestry for smallholder farmers is the increased security. The diversification of crops means that the components might react differently to varying weather conditions and extreme occurrences such as droughts. This means, that certain crops might be more resistant to these extremes, which is especially helpful in the mid- and lowland areas of the country where rainfall becomes more scares (I7). The same applies for the occurrence of pests, which is likely not to infest different crops, through which some products can still be saved. This is a fallback system for emergencies and food security (I1, I5).
Interview 3 expressed mixed opinions about the possibilities of agroforestry to contribute to food security. While the interviewee says that agroforestry might have the potential to increase food security through crop diversification, external factors such as the extreme weather conditions, which will further become more extreme due to the effects of climate change, are not to be underestimated. Thus, in the summer season, when farmers harvest,

enough food is provided in order for farmers to not be depended on external food aid. While the harvest may last for up to five months, the dry season spans multiple months. Crops are mostly failing in this season of little to no rainfall and yields are low or absent, making farmers dependent on external food aid. The question of whether diversified production of agroforestry can bridge the long dry seasons is debatable and in need of further research (I3, I7). Conversely, interview 5 mentioned with regard to spice production, that it is highly drought resistant and does not require very fertile land and is thus used as a fallback crop in drought/dry seasons (I5). Accordingly, interview 10 mentioned that intercropping can contribute toward securing food security throughout the year and especially compared to practicing monoculture, which is vulnerable to intense weather conditions and droughts (I10). Interview 7 confirmed the challenge of extreme weather conditions and long periods of drought and the unclear outcome to the extent of how it will affect agroforestry practices and whether food security can fully be guaranteed through practicing agroforestry practices. Crops such as cereals are highly affected in case of low rainfall and drought (I7). Further, shortage of water has been mentioned as an issue to practicing agroforestry (I3, I7). All interviewees agreed that agroforestry and the integration of trees into crop production heightens yields. Intercropping products with each other leads to various interconnected benefits amongst the products, such as higher trees providing shade for coffee trees (I7).

5. Discussion

In order to assess the benefits of agroforestry adoption and its impact on the livelihood of smallholder farmers, it is essential to consider various internal and external factors. Taking a holistic approach is crucial in understanding how food security can be ensured for smallholder households in Ethiopia through agroforestry practices. Throughout the research conducted, numerous factors have been identified and examined.

The findings from the interviews and analyzed papers show that national policies on agroforestry are considered highly valuable in the adoption rate and practice. The establishment of supportive agroforestry policies and plans serves as a crucial incentive for providing extension services to smallholder farmers. Accordingly, among institutions such as local NGOs or development institutions, the unclear division of responsibilities is currently voiced as an important barrier. Navigating through bureaucratic and political spheres to establish contact points and

develop extension services that effectively reach smallholder farmers poses a challenge. This aligns with the proposed conceptual framework, which proposes that farmers engagement, is influenced by national governance structures and policies for agroforestry, and thereby depicts a crucial component in the smallholder farmers decision whether to adopt agroforestry practices or not.

A functioning value chain starts at the national government level, where the establishment of effective policies facilitates the dissemination of information to farmers through extension workers. Therefore, the government should create a supportive environment and provide appropriate inputs such as seedlings, and technical skills and capacities (I5, I9). However, the interviews reveal that the practical realization of such extension services is currently still lacking, as is the generation of knowledge through research and the dissemination of experiences with smallholder farmers (I7).

As part of this value chain, farmers need to feel secure throughout the process of adopting agroforestry as a potentially new agricultural practice. Doubt and fear are present within farmers who haven´t been confronted with agroforestry yet and have concerns towards the functionality of the practice. Farmers might also not have knowledge and/or awareness about the benefits which can be experienced through agroforestry. Thus, this research highlights that the absence of a safety net, for instance in form of financial incentives and fallback options in case of unsuccessful adoption attempts, leads the farmer to feel overall less secure and convinced in changing their farming systems. Accordingly, a positive attitude and trust into agroforestry can lead farmers toward a higher willingness to adopt. Personal attitudes and beliefs thus play a role in smallholder farmers decision making. Providing farmers with incentives, such as financial or technical input, as well as education on the benefits of agroforestry can create a positive attitude amongst farmers. Similarly, the reluctance of farmers to embrace agroforestry often stems from the perceived lack of immediate outcomes. Accordingly, comprehensive education through extension workers is essential in clearing doubts and illustrating the long-term benefits, such as heightened production and diversified income streams. Furthermore, the cultural background profoundly impacts farmers´ decision-making processes. Throughout the conducted interviews, livestock has been mentioned to hold traditional value and remains an inherent part of agricultural practices. Often practiced unintentionally, free grazing of livestock poses challenges in harmonizing with agroforestry practices. Farmers are reluctant to remove livestock from their known practice, hence this depicts a

good example of where knowledge distribution and education through extension workers on agroforestry benefits is needed.

Biophysical factors play a pivotal role in influencing the adoption of agroforestry and significantly impact the farmers´ ability to adopt. As shown in the literature review in Chapter 2, the overall advantages for planting trees were found in the increased income for the farmer, improved soil quality, food supply, using the wood for construction and fuel wood purpose, providing shade, fodder, manure, and medicinal purposes (P1). Ethiopia´s various agroecologies lead to differing climatic conditions, and thereby to different patterns of adoption.

It has been found that the results and outcomes of the analysis show aspects of all three components mentioned in the conceptual framework, which define whether agroforestry is possibly adopted, proving their significance in determining the potential adoption of agroforestry by smallholder farmers in Ethiopia. Therefore, it has to been observed that the components are interconnected with each other and function in a contiguous and mutually influencing way. The farmers are depended on functioning and supportive policies in order to feel secure in their agricultural practices. However, the value chain through which these policies reach the farmers is currently underdeveloped, contributing toward a negative attitude and perception among farmers. Additionally, cultural norms and practices also play a role in shaping a negative perception towards adopting a new agricultural practice. Biophysical factors further contribute to the diversifies distribution of agroforestry practices across the country, with the highest adoption and popularity observed in the southern and southwestern highlands of Ethiopia.

Hence, there remains considerable potential for further adoption, as many farmers have not yet transitioned to agroforestry practices. Notably, and as described by Duffy et al. (2021), nearly all agroforestry systems offer direct or indirect benefits for food security compared to commercial agriculture (Duffy et al., 2021). According to the insights gained from the interviews, it was stated that the number of smallholder farmers practicing agroforestry has currently been increasing with a supportive environment. Moreover, the research showed that improved food security among smallholder farmers in Ethiopia who have adopted agroforestry practices is reported according to the components of food security. These farmers commonly exhibit a positive attitude towards agroforestry (I1, I2, I3, I4, I5, I6, I7, I8, I9, I10, P1, P2, P3, P4, P5).

In line with the findings related to food availability, positive outcomes have been noted through heightened and diversified production, as the practice of agroforestry reports positive outcomes on soil fertility. In general, the environmental benefits lead toward higher yields and simultaneous cropping, which allows the farmer to obtain a higher and diversified number of products.

Food utilization has been noted with positive outcomes throughout all interviews through improved dietary habits in form of diversified food items which lead to an improved nutritional uptake for individuals by intercropping various products simultaneously on the same piece of land. Intercropping different products, allows for the farmer to have cereal-based nutrients, such as wheat, sorghum, teff, barley and maize, spices, such as cinnamon, cardamom and black pepper, oil-crops, such as sesame, cotton, sunflower and groundnut, as well as vegetables, such as carrots, cabbage and onions. The incorporation of trees allows for fruits to be a daily part of farmers nutrition.

Food accessibility has not been mentioned extensively and directly throughout the study. The preference and popularity of practicing agroforestry in close distance to the own household in form of homegardening and boundary agroforestry is due to the simplified management and security factors for farmers. This leads to more simple and direct access to the products. Further, incentives for farmers in form of improved technologies and provision of seedlings through the government guarantees improved food accessibility. As previously mentioned, functioning incentives have been claimed frequently as a lack in the current value chain, thus an improvement in food accessibility is still needed.

Lastly, stability refers to the state of improved stability over time due to the positive environmental outcomes, such as on soil fertility, and is an umbrella term to the three previously mentioned categories of food security. This theory has been validated throughout all interviews and papers. Agroforestry is seen as a sustainable practice, which bears long-term benefits to the farmer, especially compared to commercial agriculture, which will decrease farmers yields and income over time as land degrades, and the practice does not respond well to changing climate conditions and extreme weather conditions. This is further not only guaranteed through intrinsic benefits, such as through the farmers own consumption of the products, but through extrinsic purposes. The farmer's livelihood is improved through non-farm income and diversified incomes streams. An improved income leads back to the improved food security since financial means are provided for farmers to guarantee a holistic dietary

intake. Overall, the establishment of extension services and cultural experiences and mindsets take time to evolve.

Differentiated agroforestry practices throughout the country will continue due to differing biophysical and agroecological features. This means that first and foremost agroforestry practices will continue to grow throughout the highland parts of Ethiopia, where the incorporation of crops, such as coffee, avocado, mango, are popular due to smallholder's own use of the products as well as export purposes. Adoption practices are currently increasing, which is amongst others contributed to the governments effort to establish green and sustainable agricultural practices throughout the country. Nevertheless, agroforestry is still not continuously developed throughout the country which is due to the mentioned gaps in the value chain. Extension services need to be worked on to guarantee more trust and security amongst farmers to safely adopt agroforestry practices. With a functioning value chain, the adoption rate of agroforestry will likely increase, leading towards improved food security amongst smallholder farmers.

6. Limitations and Recommendations

Due to the time and physical constraints, this research has limitations regarding the number and variety of interviewees. While asking interviewees, such as famers associations, about farmers´ perspectives and experiences, it is considered that not having interviews with smallholder farmers can possibly lead to the loss of valuable perceptions. It is unknown to what extent the actual experience of farmers is represented in organizations that work with or close to farmers. Similarly, the perspective of direct government representatives is missing in this research. Numerous attempts to contact the Ministry of Agriculture and the Ethiopian Forestry Development were made but remained unsuccessful. Further, the ministries' webpage, as well as public contact information were inaccessible throughout the time of this research. Nevertheless, it has to be mentioned that some of the interviewees formerly worked at the ministry and thus contributed their knowledge to this research. Further, a vast number of agricultural organizations work closely with the Ministry of Agriculture and were therefore able to provide insights into current procedures and policies. In total, over 40 organizations and institutions were contacted, however the response rate remained low. Therefore, including a more diverse range of actors is recommended for future research. Regarding the framework,

a focused perspective on the research is taken according to the components presented in the conceptual framework. Naturally, the Theory of Food Security and the Theory of Planned Behaviour can be used in modified ways, adding or deducting components. It is recommended to further research the linkage between agroforestry and food security through new perspectives and leverage points.

As it was discussed, Ethiopia´s areas differ vastly from each other regarding their respective topographic, cultural and socioeconomic backgrounds. If it is within the researcher´s capacity, a focus on one region can be suitable in order to gain more in-depth knowledge about the local circumstances concerning agricultural and agroforestry practices. As more time and resources are required, such as the direct contact to local interviewee partners, this could be realised in a participatory approach that involves a diverse set of actors, the direct inclusion of local farmers, as well as a focus on regional policies and the approaches taken to implement aforesaid policies in the area of interest.

Research organizations should further cooperate and include indigenous knowledge and practices in order to find best-practice methods for agroforestry and simultaneously build trust and acceptance amongst smallholder farmers who might feel less reluctant to incorporate practices they are already familiar with. In addition, research should align with the latest findings on climate change and altered weather conditions. If the research does not align with changing external circumstances, findings might become redundant in the near future.

From a nutritional perspective, future research on optimal product combinations might be reasonable, in order to provide smallholder farmers with information on optimized cultivation habits and dietary purposes.

Generally, the following recommendations are given to policymakers in Ethiopia. While a growing number of policies and plans for sustainable agricultural practices are developed, agroforestry needs to be distinctively acclaimed as a holistic approach and should be implemented and promoted as such. Therefore, long-term benefits should be emphasised in the plans. A functioning value chain needs to be established with a focus on the improvement of extension services. Monitoring mechanisms, which can be fulfilled by local NGOs and development organizations, need to be in place in order to guarantee that extension services do not only remain a theoretical policy on government level, but are able to securely reach smallholder farmers. A roundtable might be a proposal that can guarantee the equal participation of all stakeholders involved in the agricultural value chain to voice their opinions and concerns.

7. Conclusion

Ethiopia is a food insecure country and the pressure to produce more food becomes increasingly difficult in view of the effects of climate change, environmental damage such as progressing land degradation, and a rapidly growing population. The country requires innovative and sustainable agricultural practices and as such, agroforestry has emerged as a practice with substantial benefits, and potentially contributes to food security, preserving environmental resources and enhancing the livelihood of farmers. Therefore, this researched has been conducted to investigate the linkages between agroforestry and food security in Ethiopia.

A framework based on the Theory of Planned Behaviour was created to consider both intrinsic and extrinsic factors and their interactions, and further modify points of perception and criteria through which agroforestry is assessed upon. Hence, a look at the political background was taken, as well as the biophysical features which characterize Ethiopia. Further, the smallholder farmers attitudes and beliefs were defined as an important factor to assess agroforestry practices in Ethiopia. The Theory of Food Security was integrated into the framework, in order to establish components and characteristics relevant to food security.

For this purpose and based on the conceptual framework, a case study on Ethiopia was prepared, in order to find similarities and differences in propositions and opinions amongst representatives in the field of agroforestry in Ethiopia. The data is collected both from papers which discuss opportunities and barriers of agroforestry in Ethiopia, as well as semi-structured interviews. Transcriptions and coding techniques were employed to analyse the data and answer the research sub-questions.

Overall, it has been found that agroforestry holds great potential to ensure food security for smallholder households in Ethiopia and can be established through various forms. Intrinsically, agroforestry can contribute to improved nutritional values and dietary purposes of individuals, since both quality and quantity of the cultivated products rise throughout the year and further provide farmers households with diversified products. Extrinsically, the farmers livelihood increases by practicing agroforestry, since the increased and diversified income through the products can lead to a surplus of cultivated products which can be sold at national and international markets. The farmer possesses more financial means to invest into their own nutrition and well-being. Overall, agroforestry contributes to healthier and restored land

which is crucial for long-term production. The actual environmental improvements will become apparent in the future.

Nevertheless, the results of this research showed that the full potential of agroforestry adoption in Ethiopia is far from reached. Across all three components proposed in the framework, several leverage points have been identified which are currently lacking in their functionality or implementation, such as the question of land ownership and the practical realization of extension services, which oftentimes fail to reach smallholder farmers appropriately. Collectively, these factors currently result in a low, as well as slow adoption rate of agroforestry in Ethiopia.

A stronger commitment from the government to prioritize agroforestry in their plans and policies is imperative. This must be accompanied by enhanced cooperation and active participation among various stakeholders engaged in agroforestry practices. Furthermore, smallholder farmers must be actively included in decision-making processes to ensure their perspectives and needs are adequately addressed. By advancing these measures, agroforestry can emerge as a promising pathway toward fostering more resilient livelihoods among smallholder farmers in Ethiopia and thus make a substantial contribution to achieving sustained food security.

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Figure 1: World Atlas (2021). Maps of Ethiopia. Retrieved 1st June 2023. https://www.worldatlas.com/maps/ethiopia

9. Appendix

Appendix A

Interview Questionnaire

1. Are you working with/ have you ever worked with agroforestry (projects)?

2. General **agricultural practices** in Ethiopia:
    a. Which form of agroforestry is the most important one for the agricultural system in Ethiopia *(according to the general categorization of agrisilvicultural, silvopastoral and agrosilvopastoral practices)*?

    b. In which Ethiopian region is agroforestry mostly practiced?

3. How do you perceive the **popularity/distribution of agroforestry** practices throughout the country? Are there regional differences? (if yes, why?)

4. In your opinion, what are the three most important **benefits** of agroforestry?

5. In your opinion, what are the three most important **challenges** of agroforestry?

6. How do you perceive the outcomes of practicing agroforestry for farmers and for the **livelihood of farmers**?

7. How would you assess the potential of agroforestry to contribute to **food security** in Ethiopia? *(If agroforestry adds to food security, for whom would it be most beneficial):*
    a. The farmer's household

    b. The community to which the farmer belongs

    c. The region where the products are on the market

    d. The population of Ethiopia

    e. The export/international market

8. Do you know what goals and instruments the Ethiopian **government/national policy** has for agroforestry? Please explain briefly.

9. Do you know what the opinion of **different stakeholders** is about agroforestry in Ethiopia:
    a. Public actors such as the government

    b. Private actors such as farmers and market parties

c. Experts on agroforestry of public and private actors and experts about agro-forestry in Ethiopia?

10. To **promote and expand** agroforestry in Ethiopia,
    a. What should the government do?

    b. What should farmers do?

Appendix B

Overview of the code-document analysis

	Interviews 10 630	Papers 5 108	Totals
5F´s 2	2		2
Action Coalition for Re... 1	1		1
ADLI 1	1		1
agroecology 13	12	1	13
agroforestry benefits 166	145	21	166
agroforestry challenges 130	124	6	130
agroforestry classifica... 75	71	4	75
alley cropping 4	3	1	4
alternative livelihood... 2	2		2
attempt to increase ag... 27	26	1	27
avocado 14	14		14
avoiding forestation/d... 9	9		9
awareness creation 6	5	1	6
banana 15	15		15
beans 10	10		10
beekeeping 11	11		11
behavior change/farm... 66	53	13	66
biodiversity 12	12		12
biomass 6	6		6
biophysical 9	6	3	9
boundary trees 12	9	3	12
cabbage 2	2		2
Carbon Sequestration 9	6	3	9
cash trees 8	7	1	8
cereal 6	5	1	6
charcoal 5	4	1	5
Climate Change 30	21	9	30
coalition 2	2		2
coffee 70	69	1	70
combination trees and... 11	11		11
commercial farmer 13	13		13
commodities 2	2		2
community capacity d... 30	30		30

compatibility between...	35	35		35
construction material	25	22	3	25
cooling down surface	1	1		1
corn	1	1		1
crop diversification	46	37	9	46
crop extension	3	3		3
crop landscape	4	4		4
cultural background	11	9	2	11
degraded land	29	23	6	29
dietary purpose	7	7		7
distance to home	4	4		4
dominant/leguminous...	13	12	1	13
drought/crisis	20	15	5	20
dry season	8	8		8
dryland	12	11	1	12
economical factors	74	68	6	74
ecosystem services	6	1	5	6
environmental damage	16	9	7	16
environmental factors	53	41	12	53
environmental impact...	1	1		1
eucalyptus	15	12	3	15
expertise/skilled work	22	22		22
export purpose/product	20	20		20
extension system/servi...	46	41	5	46
external factors	4	4		4
false banana	8	8		8
farmer accessibility	34	31	3	34
farmer against agrofor...	16	12	4	16
farmer association	4	4		4
farmer in favor of agro...	48	36	12	48
farmer incentive	21	20	1	21
farmer knowledge abo...	48	43	5	48
farmer production clus...	2	2		2

fertilizer 8	7	1	**8**
fodder 15	9	6	**15**
Food and Land Use Co... 1	1		**1**
food security 87	76	11	**87**
forest resources 4	4		**4**
free ranging livestock 16	16		**16**
fruit 47	41	6	**47**
fuel/fire wood 26	22	4	**26**
general advantage 8	8		**8**
general disadvantage 6	6		**6**
government 90	87	3	**90**
government opposing... 12	12		**12**
government supportin... 49	47	2	**49**
government/NGO/farm... 66	63	3	**66**
green legacy 8	8		**8**
GTP 6	6		**6**
gum 2	2		**2**
health 3	3		**3**
heightened quality 9	9		**9**
herbs 1	1		**1**
highland 25	25		**25**
hillside 4	4		**4**
Holistic system 7	6	1	**7**
homegardening 37	34	3	**37**
household 12	6	6	**12**
income 74	59	15	**74**
income diversification 40	23	17	**40**
Indigenous species/pr... 24	24		**24**
innovation 6	4	2	**6**
integrating trees 43	39	4	**43**
irrigation 10	10		**10**
lack of regulation/ince... 3	3		**3**
land conservation 2	2		**2**

land rehabilitation	1	1		1
landsize	16	13	3	16
landuse	36	29	7	36
livelihood improvemen...	56	36	20	56
livestock	36	34	2	36
long-term	13	10	3	13
lowland	20	20		20
maintaining seedlings	14	12	2	14
maize	21	21		21
management challeng...	72	65	7	72
mango	6	6		6
market/production for...	36	34	2	36
medicinal purpose	5	2	3	5
microclimate	16	9	7	16
midland	7	7		7
Ministry of Agriculture	8	8		8
mixed farming	13	13		13
monitoring	10	10		10
monoculture	10	9	1	10
multipurpose trees	26	21	5	26
Natural Resource Man...	29	29		29
NGO	9	8	1	9
nitrogen fixation	5	5		5
nutrient uptake/availab...	3	3		3
nutrition	22	22		22
oil crops	2	2		2
orange	2	2		2
papaya	5	5		5
parkland	9	7	2	9
peas	1	1		1
perennial crops	5	5		5
pest	6	6		6
policies	87	79	8	87

private stakeholder	9	9		9
productivity	41	35	6	41
protection of evaporati...	4	4		4
public stakeholder	10	10		10
rainfall	21	18	3	21
REDD+	3	2	1	3
Regeneration	4	4		4
Regreening Africa	2	2		2
replication/adoption	3	2	1	3
research neglecting a...	15	8	7	15
resilience	11	8	3	11
restoration	2	2		2
safety net	9	7	2	9
seeds	21	20	1	21
shade	25	22	3	25
short-term benefits for...	15	14	1	15
small farmland	24	20	4	24
socioeconomic factors	74	62	12	74
soil conservation	25	19	6	25
soil fertility	33	23	10	33
sorghum	6	6		6
spices	11	11		11
staple food	5	4	1	5
subsistence farming/s...	43	40	3	43
sustainability	16	13	3	16
sustainable agriculture	15	12	3	15
technical issues	13	10	3	13
teff	6	6		6
temperature	9	9		9
temporal scale	22	21	1	22
tenure security/uncert...	4	1	3	4
terraces	3	3		3
trade-off	8	6	2	8

traditional		24	21	3	24
unclear division of res...		10	9	1	10
unintentional agrofore...		5	5		5
value chain		16	16		16
water availability		16	16		16
water conservation		19	18	1	19
wheat		9	9		9
yields		15	14	1	15
AF challenges	15	242	215	27	242
AF economic ben...	11	204	167	37	204
AF environmental...	23	267	216	51	267
AF societal benef...	22	301	236	65	301
Agroforestry mec...	10	133	125	8	133
Attempt to increa...	2	33	31	2	33
Avoiding environ...	4	18	18		18
Beekeping/honey...	1	11	11		11
Biophysical factors	7	66	57	9	66
Commercial farmi...	1	13	13		13
Community Capa...	2	77	71	6	77
Drought/Crisis	1	20	15	5	20
Environmental da...	5	63	52	11	63
Extension System...	5	78	72	6	78
Factors for food s...	4	103	91	12	103
Farmer Networks	3	35	35		35
Farmer wellbeing...	9	160	128	32	160
Holistic system	1	7	6	1	7
Knowledge diffus...	11	156	139	17	156
land tenure/secur...	4	50	39	11	50
Livestock	2	44	42	2	44
Monoculture	3	27	23	4	27
Natural Resource...	3	35	35		35
Operational/Logis...	15	210	185	25	210
Personal attitude/...	5	122	98	24	122

Policies	20	179	166	13	**179**
Private/Public Ad...	3	21	20	1	**21**
Smallholder Farm...	6	156	122	34	**156**
Socioeconomic fa...	2	84	67	17	**84**
Subjective/social...	1	11	9	2	**11**
Temporal/spacial...	4	74	68	6	**74**
Traditional farming	3	50	47	3	**50**
Type of crop	15	65	63	2	**65**
Type of fruit/vege...	8	118	111	7	**118**
Type of tree	6	91	82	9	**91**
Totals			**5893**	**851**	**6744**