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Analysis of factors influencing the adaptation behaviour of small-scale coffee farmers towards climate change: The case of Ethiopia

BACHELOR'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled “Analysis of factors influencing the adaptation behaviour of small-scale coffee farmers towards climate change: The case of Ethiopia” independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague

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Lucie Jiříková

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Abstract

Climate change increasingly affects agricultural practices, therefore, understanding the determinants of successful adaptation becomes imperative. Focusing specifically on coffee farming, climate change appears to be a significant challenge for coffee plant growth and distribution. However, there is only a little evidence of the adaptation of small-scale coffee farmers in Ethiopia. This literature review aims to provide a comprehensive understanding of the farmers' adaptive capacities. This thesis analyses the various factors that influence small-scale coffee farmers' adaptation towards climate change in Ethiopia. Factors such as climate change knowledge and awareness, access to financial resources and technology, age, gender, and farm size were explored in relation to their impact on small-scale coffee farmers' adaptation strategies. The findings contribute to the existing body of knowledge on climate change adaptation in the context of small-scale coffee farming in Ethiopia, offering insights for future research and policy interventions.

Keywords: global warming, *coffea arabica*, lesser extent agriculture, adjustment attitude

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List of the abbreviations used in the thesis

ECFF	Environment & Coffee Forest Forum
GDP	Gross Domestic Product
ICO	International Coffee Organization
IPCC	Intergovernmental Panel on Climate Change
MAE	Ministry of Agriculture Ethiopia
MEFCCE	Ministry of Environment, Forest and Climate Change of Ethiopia
USDA	U. S. Department of Agriculture

1. Introduction

Climate change is a global issue that influences every sector all over the world. The average worldwide temperatures have risen dramatically during the Industrial Revolution, leading to global warming. This has resulted in more hot days and fewer cold weather extremes, harming food security. Climate change has a severe influence on rain-fed agriculture, reducing agricultural production and perhaps increasing food poverty. Ethiopia is facing climate change, with diminishing rainfall and harsh weather affecting agricultural productivity. Climate change adaptation programs attempt to boost agricultural output and strengthen farmer resilience (Gemeda et al. 2023).

Coffee is one of the most traded commodities worldwide. Coffee plants are very sensitive to changes in climatic patterns. Arabica coffee (*Coffea arabica*) as the only coffee variety grown in Ethiopia is highly sensitive to high temperatures and low rainfall (Ayal et al. 2023; USDA 2023; Worku 2023). Coffee is a key economic commodity in Ethiopia, accounting for 50% of exports and foreign exchange revenues. However, the country has high domestic consumption and poor marketing infrastructure, resulting in it being the world's second-largest producer of coffee (Adane & Bewket 2021).

Climate change poses an enormous threat to smallholder farming communities, particularly in low-income nations, whose livelihoods rely primarily on climate-controlled crops and forest resources. Resilient agricultural systems are critical to Ethiopia's future, and climate-smart agriculture can help lessen the consequences and dangers (Tadesse & Ahmed 2023).

Despite that there are many articles focusing on the effect of climate change on agriculture and adaptation practices used by farmers, the number of articles focusing on this issue among coffee farmers in Ethiopia is relatively low. Moreover, there is only limited evidence from recent years (2020-2024), when Covid-19 pandemic and economic crisis occurred. It is suggested that Covid-19 pandemic influenced small-scale coffee farmers' production, farmers' income and their adaptation strategies (Kabeta & Dangia 2022; Tamru et al. 2020). To close this gap, the main goal of this thesis is to analyse the factors influencing behaviour of small-scale coffee farmers toward climate change in Ethiopia.

2. Aims of the Thesis

Climate change can pose an immediate threat to the food security and nutrition of small-scale farmers who directly depend on agriculture for their livelihood (Ayal et al. 2023). The topic of the bachelor thesis is related to an analysis of factors influencing the adaptation behaviour of small-scale coffee farmers towards climate change in Ethiopia. It also provides an overview of various strategies farmers use to adapt to climate change in various regions of Ethiopia.

Main Objective: Analysis of factors influencing the adaptation behaviour of small-scale coffee farmers towards climate change in Ethiopia.

Specific Objectives:

1. To identify key factors affecting decisions and adaptation behaviour towards climate change in Ethiopia (case of coffee).
2. To point out the most common adaptation strategies.

3. Methodology

The bachelor thesis is based on secondary data. Secondary data collection was done through available scientific sources, mainly from a scientific database such as Thomson Reuters Web of Sciences, Science Direct, EBSCO, etc.

When gathering information for studies' overview part certain criteria were put in place:

1. publications not older than 2020 (to present the recent information and reflect the effect of the Covid-19 crisis on adaptation strategies),
2. in English,
3. focused only on Ethiopia,
4. the title of articles had to be similar to the title of this thesis (same/similar aim).

Keywords used for the database research: small-holder farmers, coffee, adaptation strategies, climate change, Ethiopia.

4. Literature Review

4.1. Agriculture in Ethiopia

The agricultural sector plays a crucial role in country's economy. Ethiopian agriculture was represented by 37.64 % in GDP in 2022, followed by services which accounted for 36.56 %, and lastly by industry which made 22.72 % (O'Neill 2023). Agriculture, which makes 1/3 of the country's GDP, employs over 70 % of the population (USAID 2023). This fact makes the country dependent on the primary sector, which is becoming increasingly affected by climate change.

Ethiopia is sensitive to climate change variability due to its dependence on rainfed agriculture, the vulnerability of crops and livestock, limited adaptive capacity and fragile ecosystems (Yirga & Alemu 2016). Agriculture which is very well recognised under the primary sector is not the only part that belongs to the first sector group. Forestry and fishing play an important role in Ethiopia's economy along with agriculture.

Subsistence farming is performed by many farmers, even though the emphasis is nowadays leaning more towards commercial farming. Coffee, cereals (such as maize, wheat, and teff), pulses, oilseeds, and livestock are key agricultural products (MAE 2017; World Bank 2017).

Ethiopia has diverse forest ecosystems that provide vital ecosystem services, contribute to biodiversity conservation, and support rural livelihoods. Nevertheless, practices like deforestation and forest degradation remain as the main reasons/options for the expansion of agricultural land, population growth, and unsustainable logging practices (MEFCCE 2019).

Small-scale, artisanal fishers who use traditional fishing methods and practices have long dominated the fishing business. The country's lakes and rivers are known for their species variety, as well as recreational and commercial fishing possibilities. However, even fishing has its challenges in Ethiopia, these include post-harvest losses, poor infrastructure, overfishing, wetland degradation, climate change and fish diseases (Hebano & Wake 2020).

4.1.1. Coffee farming

Ethiopia, as for the whole African continent dominates in the coffee producing numbers and ranks as the 5th top-producing country in the world. Ethiopian coffee is well-known for its distinct scent and flavour (ICO 2015). It is grown in a wide range of production systems, including woodland, semi-forest, plantation, and garden. The coffee industry employs around 15 million Ethiopians (16 % of population) and accounts for 25% of the country's export revenues (Kew & ECFF 2017; Ayal et al. 2023). Coffee in Ethiopia is most commonly produced in the Oromia Region and in general within the South West zone (Kew & ECFF 2017).

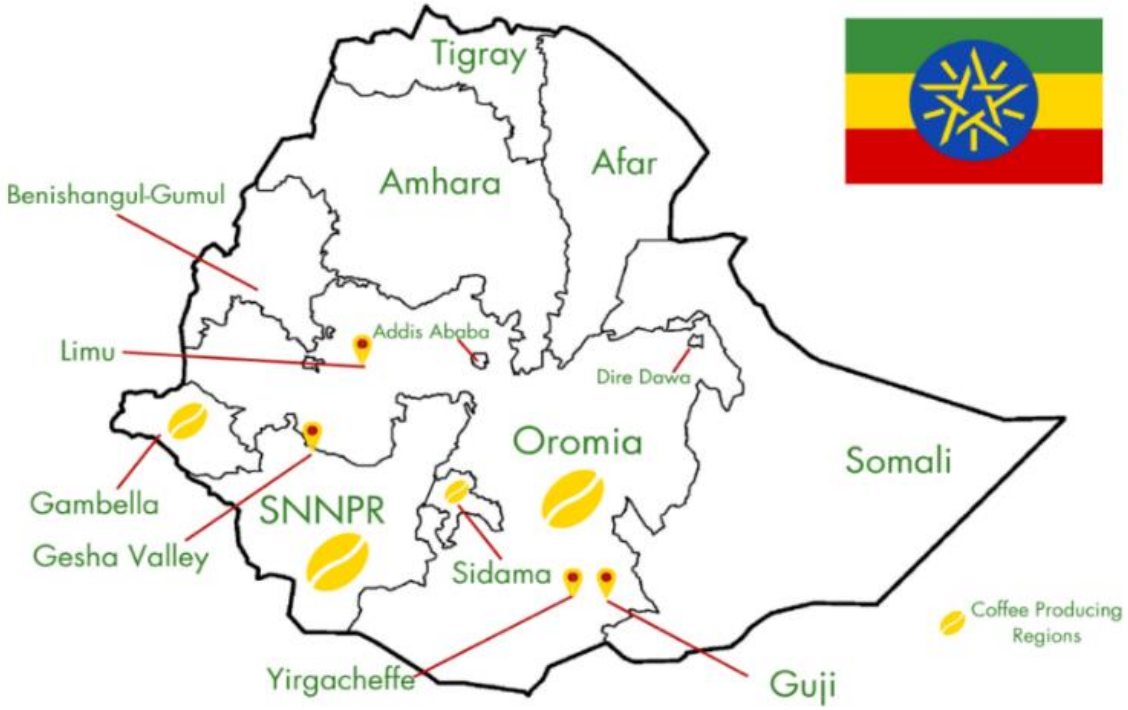

Figure 1 - Coffee producing regions in Ethiopia

Source: The Lab 2001

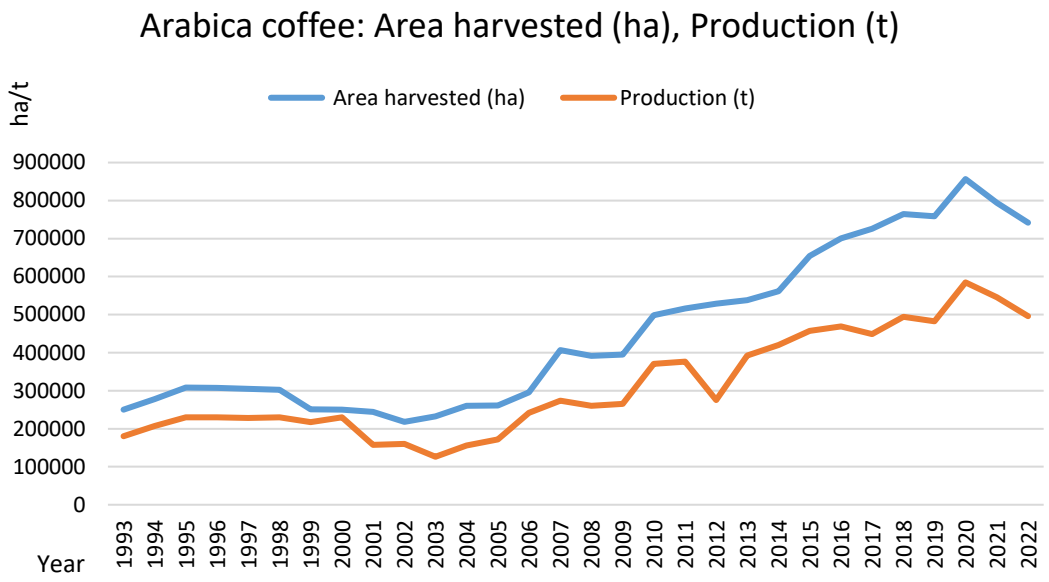

Figure 2 - Arabica green coffee in Ethiopia

Source: elaborated by author from (FAO 2024)

Two main coffee varieties are Arabica coffee *(Coffea arabica)* and Robusta coffee *(Coffea canephora)*. In the case of Ethiopia, the coffee we are talking about is arabica coffee, since based on evidence, no robusta coffee is grown in Ethiopia (USDA 2023, Worku 2023). Arabica coffee accounts for 70% of the global market, a decline in production would undoubtedly have significant socio-economic, environmental, and food insecurity consequences for coffee grower farmers, particularly in poor countries like Ethiopia due to their low adaptive capacity (Dinku et al. 2011). Farmers may be pushed to shift their livelihoods or extend their coffee farming at the expense of other land use systems such as forest, pasture, and cropland. Furthermore, the influence of climatic variability on coffee prices may have consequences throughout the whole coffee value chain structure (Zhou et al. 2022).

Ethiopia is known for the production of arabica coffee which is supposed to be native to the Southwestern highlands of the country (Kew & ECFF 2017). Most of the production (90 %) is grown on small-scale farms of less than two ha, and the rest (10 %) accounts for commercial production (Gole 2015). Study conducted by Ventocilla et al. (2020) shows that small-scale production is taking 95 % and the rest 5 % is privately owned. Since the farming is kept traditional, the use of fertilisers and pesticides is limited which along with other practices makes a lot of the coffee

production organic (USDA 2023). Nonetheless, only a few farms are certified as organic because of the high costs of certification and low revenues (Tefera & Francom 2015).

Ethiopia stands out among coffee-producing countries because approximately fifty percent of its production is consumed locally (USDA 2023). This might be due to quality standards that are not met and that is why the coffee cannot be exported (Ventocilla et al. 2020). Drinking coffee is not only an essential component of everyday life in Ethiopia, but it is also deeply integrated into Ethiopian culture. Aside from the well-known Ethiopian coffee ceremony, coffee is utilized during key occasions such as marriage and birth, regionally specific festivities, and as a means to create and encourage relationships between family, friends, and community (Kew & ECFF 2017; USDA 2023).

4.1.1.1. Sustainable practices used by small-scale coffee farmers

The country overall accounts for 95 % of small-scale coffee farmers. This means that the farmers own less than one hectare of land. In order to receive higher prices for their produce these farmers tend to join a cooperative system. This enables farmers to share their resources and mitigate some of the risks and challenges associated with farming on a small scale. More specifically, cooperatives help farmers with bulk selling (gaining bargaining power and better market prices), share resources (machinery), training and education, marketing, exporting, finance (provision of credit), etc. (Mojo et al. 2017).

The main coffee farming practice is shade growing. This practice involves the shade of trees to maintain soil fertility. In other words, this practice can be called forest coffee practice which has two categories: forest and semi-forest. These practices differ in the way, that the forest category uses the natural setting of the forest and involves minimal intervention. Meanwhile, semi-forest practices are more demanding and include some management organization (thinning of trees, weed control, planting of coffee seedlings) (Kew & ECFF 2017).

Then the opposite farming strategy is called sun coffee farming. This practice uses small volume (100 plants) at a high-density approach which is utilized in coffee gardens. It is commonly used in higher altitudes (1,700 – 2,100 m). This approach can be found within a mixed cropping system (Kew & ECFF 2017).

Agroforestry represents another commonly used approach of the integration of various crops and a native forest cover. Trees may give a variety of benefits, including shade for coffee plants, which helps control temperature and humidity, resulting in higher coffee quality. Furthermore, certain tree species can serve as windbreaks, prevent soil erosion, promote biodiversity, and provide additional revenue from items such as fruits, lumber, or medicinal plants. The symbiotic link between trees and coffee plants in agroforestry systems can help create a more sustainable and resilient farming environment (Seid & Kebebew 2022). This practice is typical for the Sidamo area, where coffee is produced solely in intensive agroforestry systems (Kew & ECFF 2017).

Another method introduced in 2012 by a non-profit organization called TechnoServe is called stumping. Stumping is the process of reducing older and less productive trees to only a stump. This promotes the creation of new sprouts, which eventually evolve into new branches. It's an effective strategy that produces a 2- to 3-fold boost in yields and a possible tripling of revenue in three years. By revitalizing existing trees, stumping lowers the need for farmers to switch to alternative crops that degrade soil nutrients and are frequently less profitable than coffee. It also results in healthier trees that are more equipped to tolerate pests, disease, and irregular weather caused by climate change. This practice may not be suitable for everyone but in the Oromia region a number of farmers (200,000) seem to be involved in education at TechnoServe's Coffee Farm College (World Bank 2021).

Nowadays, organic farming has become a trend, although some farmers have grown organically traditionally, consumer awareness has started to rise in recent decades. This farming is popular due to limited access to chemical fertilizers and pesticides which makes the farmers use organic matter which has its sign on the unique taste of the coffee. However, farmers as mentioned above can be producing organically for a long time but they might not know about it, or if they do, to be recognized as organic farms, they might need a certification. Organic certification is widely known, and it allows farmers to receive a better price per pound of coffee. The problem here might be the financing since the certification is not for free and farmers often cannot afford it. By joining a cooperative, they may have a chance to become certified with reduced costs than if they had tried to pay as individual farmers (Ayalew 2014).

4.1.2. Climate

The climate in Ethiopia is tropical, but its central area is located at a high altitude (above 1000 m), which makes the climate for coffee cooler. According to the Köppen Climate Classification (in ***Figure 3*** below), there are many different climate types in Ethiopia.

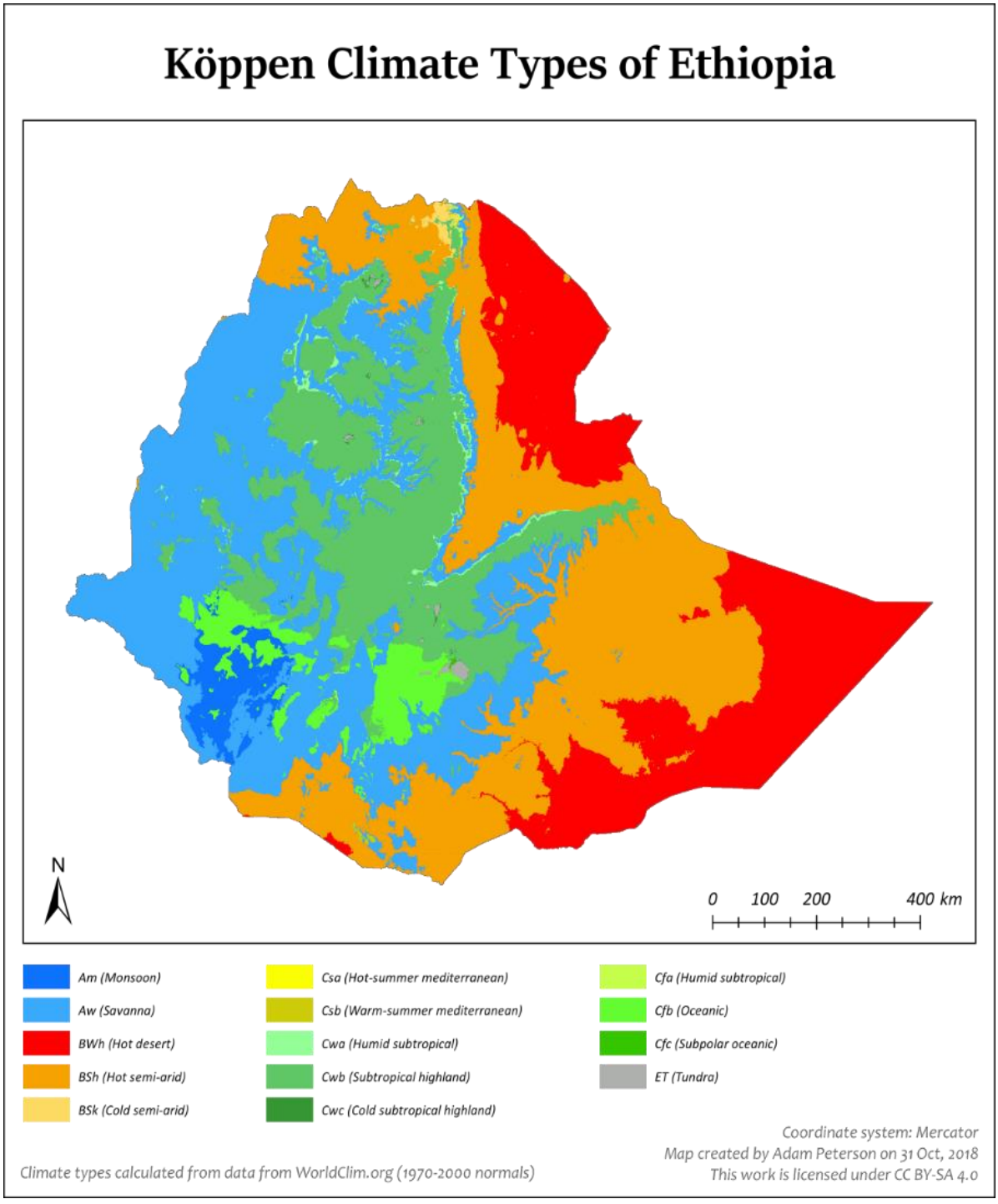

Figure 3 - Köppen Climate Types of Ethiopia

Source: Peterson 2018

There are three main seasons according to rainfall: Bega, Belg, and Kremt (Kiremt). Bega occurs from October to January/February and it is a long dry season. It is the season of coffee harvesting and processing. Belg happens from February to May which is either a pre-main rain season or a short wet season with a short dry period before the main rain season. This is the flowering season. The final season, Kremt, from June to September is the main wet season. Final coffee fruit development and ripening occur within this season (Kew & ECFF 2017).

Rainfall, as one of the most important factors affecting the coffee production, is very variable. It is distributed across Ethiopia according to season, altitude and landscape features. As introduced before, the areas of the most rainfall are the Southwestern areas where most of the coffee farming takes place. The rainfall in these areas is usually around 1,300 – 2,100 mm) (Kew & ECFF 2017; USDA 2023).

Temperatures for arabica coffee should not go below 12 – 14°C, nonetheless it can survive even temperatures below 0°C for a short time period. The ideal temperature is between 18 – 22°C with ideal maximal temperatures between 25 - 27°C. Coffee can survive temperatures around 40°C as well, but only for a short time if an adequate amount of water in the soil is present (Kew & ECFF 2017; USDA 2023).

4.2. Climate change and adaptations

Climate change poses a global threat that humanity must adapt to. Since the climate is getting warmer, the main issue, especially in already hot countries like Ethiopia, is the rise in temperature, which affects all the other natural conditions. If the temperatures are too high, severe drought can occur because there will be a lack of rainfall which is Ethiopia's coffee production driver. Consequently, the number of water bodies in the country will diminish and that does not affect just coffee farming, but the whole agricultural system and local people depending on it (Shone 2022).

According to the Intergovernmental Panel on Climate Change (IPCC), temperatures are increasing due to human activity, which is linked to higher concentrations of greenhouse gas emissions in the atmosphere (IPCC 2013). The frequency of hot days and hot nights increased in Ethiopia, especially during the wet season. IPCC data shows that the increase in mean annual temperature in years 1960 –

2006 was 1.3°C (average rate of 0.28 – 0.3°C per decade). About 10 – 20 % of rainfall has decreased since 1970 until 2000s (Jury & Funk 2012; Mekasha et al. 2013). Ethiopia's mean annual temperature is expected to rise by 1.1-3.1 degrees Celsius by the 2060s and 1.5 - 5.1 degrees Celsius by the 2090s, depending on the emission scenario (Jury & Funk 2012). Rainfall rates are highly variable, and there are many possible scenarios. According to Kew & ECFF (2017), there could be an increase in rainfall in the highlands of Ethiopia but these predictions and projections are not consistent.

4.2.1. Effects of climate change on coffee farming

Climate change threatens future coffee production by very dry and hot climate affecting the coffee-growing arable land in a way that in few years our favourite known coffee varieties may not be found ever again. Coffee is very specific to cultivate and needs just the right climate and conditions to grow. The ideal area of growing coffee is located 25 degrees north and 30 degrees south of the equator, known as the “coffee belt”. With warmer temperatures, instability, and unpredictability these regions might slowly disappear (Bianco 2020).

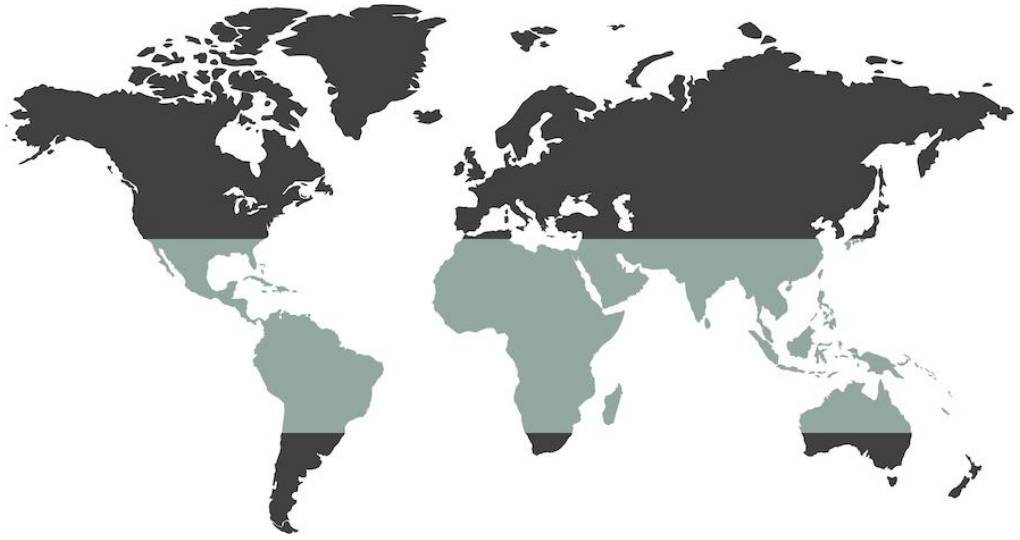

Figure 4 - Coffee belt area
Source: Sttoke Inc. 2024

"*With higher temperatures, there is less rainfall*." This is an essential issue in the industry since coffee production is heavily dependent on water. Ethiopia's coffee-growing regions have distinct wet and dry seasons, with the majority of rainfall between May and September. Adequate rainfall is vital for coffee farms during this time period. Drought conditions can result from insufficient rainfall, reducing coffee plant health,

yields, and overall quality. Some areas have additionally set up irrigation systems to supplement rainfall during dry spells (Sporchia et al. 2023).

The Kew & ECFF (2017) project discovered multiple occurrences of mild to severe plant stress and plant mortality near the finish of the dry season, with the most severe stress conditions happening in the Harar coffee zone, notably in Arsi. Numerous Harar coffee gardens lacked suitable cultivation procedures, resulting in the loss of several plants. Stress was generated by insufficient soil moisture and high temperatures.

Physiological stress, physical indications of water and heat stress, illnesses, pest infestations, and crop failure are all examples of environmental factors that might influence coffee production. Inadequate circumstances for growth can cause coffee yields to drop or fail. Prolonged drought periods can result in bean size decreases and deformities known as 'faults,' which have a direct impact on coffee costs and cup quality. Even little changes in conditions for cultivation can have an impact on produce and cup quality. Coffee quality and the environment are inseparably linked, with places labelled as unsuitable or marginal generating lower-quality coffee (Kew & ECFF 2017).

The linkage of coffee production yields, temperatures and rainfall is strongly interconnected. Coffee farming needs adequate temperature and moisture. Without it , the long-term consequences could be crucial (Shiferaw & Kefale 2021).

4.2.2. Adaptation strategies

Climate change is projected to have a severe influence on Ethiopia's coffee farming environment, but it may also make previously unsuitable locations usable as the century advances due to an upward shift in coffee growing suitability.

Ethiopia's coffee sector will be enhanced by facilitating migration to new places, notably in the South West coffee area, to replace lands lost at lower altitudes due to unfavourable climates. This shift requires careful planning and feasibility, taking into account elements such as climate, agronomy, land-use conflicts, market value, and logistics. Due to financial incentives and the possibility of expansion in previously unsuitable locations, farmers may naturally relocate to these areas (Kew & ECFF 2017).

Afforestation and reforestation are essential for coffee-growing settings because they enhance forest cover, conserve biodiversity, and boost ecosystem services. Preventing forest loss is vital, especially in the coffee zones of the South West and South

East. As part of the adaptation phase, on-the-ground monitoring is critical for tracking the impact of climate change on coffee production and agricultural communities (Kew & ECFF 2017).

Farming interventions may affect air and soil temperature and moisture, serving as protection against poor growth conditions and harsh weather occurrences. Irrigation, shade control, mulching, terracing, and pruning are some of the possible approaches. The coffee farming systems in Ethiopia have the potential for resilience, but a careful investigation is required. Improved varieties may enhance resistance to diseases (Kew & ECFF 2017). Considering improved varieties Shiferaw & Kefale (2021) recommend drought and disease-resistant varieties. Jawo et al. (2023) recommend practices like agroforestry and organic composting which enhance microclimate, soil fertility and moisture, and diversification. A study by Zerssa et al. (2021) agrees with previously mentioned studies with the focus on climate-smart agriculture and recommends conservation agriculture known in Ethiopia for over 20 years with the basis of minimal or no tillage, soil cover, diversification. According to Aboye et al. (2023) public policy ought to provide farmers with water reservoirs and irrigation equipment, as well as inexpensive livestock varieties and small ruminant animals such as goats, sheep, and poultry, to help them adapt to climate change threats. The most common adaptation strategies used in southern Ethiopia are soil and water conservation, small scale irrigation, changing planting date and improved crop and livestock variety (Dula 2018). Tessema et al. (2013) found that the major driver of climate change in eastern Ethiopia is deforestation, which is why planting trees is the most popular adaptation technique. A study done in Oromia region shows that most common adaptation strategies are improved crop and livestock variety, change of planting dates, and soil and water conservation (Shiferaw 2014).

4.2.3. Challenges of adaptation

Farmers in Ethiopia face various challenges in adapting to climate change, such as lack of information, agriculture inputs, land, money, water, labor, insecure land tenure, and market access. These hurdles are caused by a variety of social, economic, and institutional factors, emphasizing the need for increased support and mainstreaming of climate change concerns (Tessema et al. 2013). Some other barriers which stand

in the way of farmers´ adaptation to climate change were pointed out in research by Jawo et al. (2023) in South-Eastern Ethiopia which includes poor soil fertility, land shortage, lack of weather information, water and credit. There are some more challenges to add when it comes to the adaptation of climate-smart agriculture such as land size, land tenure, lack of knowledge and information, slow financial return, etc. (Zerssa et al. 2021). A study by Ventocilla et al. (2020) informs that sustainable practices are in place, but low profits, advisory tools, and lack of important information are the "next stage" issues that need to be targeted. Gemeda et al. (2023) highlight the lack of irrigation facilities, high cost of farm input, infertile soil, and poor institutional support as the largest barriers for adaptation of southwestern farmers in Ethiopia. Aboye et al. (2023) emphasize the issues encountered by farmers in Woliata's lowlands owing to labor shortages, droughts, and big investments for larger farms, emphasizing the importance of legislation to support irrigation projects and climate change information. The farm location based on elevation divided into lowlands, midlands and highlands can lead to adoption of different adaptation strategies (Aboye et al. 2023). Shiferaw (2014) mentions that the most frequent barriers in adaptation are lack of knowledge, land, capital, no observation of climate change, or no governmental support.

4.3. Factors influencing adaptation behaviour

4.3.1. Socio-economic factors

Climate information has a substantial influence on smallholder farmers' decisions to apply climate change adaptations in the coffee-based agricultural system of southwest Ethiopia. Farmers' access to information from the National Meteorological Office broadens their range of adaption choices. Regular access to official weather information results in improved adaptation decisions. Providing seasonal weather forecasts and information from extension agents can assist farmers in responding to seasonal differences in rainfall, such as planting dates, crop selections, and appropriate agricultural planning (Aboye et al. 2023; Eshetu et al. 2020; Sorecha 2017; Tessema et al. 2013).

Access to formal extension services and access to credit are other examples of interventions which are considered to be important factors influencing farmers behaviour. Several studies have agreed that the boost of these services would help farmers adapt to climate change better. Access to credit represents investment into agricultural

inputs (fe., improved varities of coffee and livestock) which is especially important when it comes to adaptation to climate change (Eshetu et al. 2020; Gemeda et al. 2023; Shiferaw 2014; Sorecha 2017; Tessema et al. 2013; Ventocilla et al. 2020).

Household education level has a major effect on climate change adaptation, as educated farmers adopt new technology and planting dates. However, it has a detrimental impact on the use of animal feed as a livestock production adaptation strategy (Ayal et al. 2023; Eshetu et al. 2020; Dula 2018; Tessema et al. 2013).

The age of the head of household has a negative impact on the choice to implement climate change adaptation strategies, as older farmers have greater expertise sensing environmental changes. However, agricultural experience enhances the likelihood of adopting climate change adaptation methods, despite the non-uniform influence of age on adaptation decisions (Eshetu et al. 2020, Tessema et al. 2013).

Farm size is another factor which can affect adaptation decisions, both negatively and positively. To start positively, larger farms have greater access to resources like financial capital, labour, and technology which can make it easier when switching to other agricultural practices or other varieties (Shiferaw 2014). This is also connected with higher diversity on larger land. On the other hand, large areas of land may be hard to maintain, labour intensive, costly to run, and hard to control quality terms. But in this case we are talking about small-scale farms which are usually lacking all of the advantages of larger farms but prosper in their disadvantages (Adane & Bewket 2021; Ayal et al. 2023; Diro et al. 2022). If the farm is owned by household it positively affects the decision to use adaptation strategies towards climate change (Dula 2018).

4.3.2. Environmental factors

The most important environmental factors are in this case the change in temperature (higher) and rainfall (lower) patterns. These are the key issues that negatively affect the coffee plants and their growth cycles leading to reduced yields. To adapt to these inalterable factors farmers have to shift planting dates and irrigation practices (Dula 2018; Gemeda et al. 2023; Shiferaw 2014; Tessema et al. 2013).

Increased pests and diseases can be other factors occurring within coffee production. To be able to address this issue farmers might need to use more resistant coffee varieties or integrated pest management (Ayal et al. 2023; Tesfaye 2021).

Soil degradation or erosion and water scarcity can appear as the result of climate change. Adoption of suitable land management practices is crucial. To enhance soil conservation practices like organic farming, usage of cover crops, or terracing, agroforestry, etc. can be adopted. More efficient water use strategies should be implemented to conserve water sources, these include rainwater harvesting systems, terracing, drip irrigation etc. (Abebe 2020, Ayal et al. 2023, Jawo et al. 2023, Shiferaw 2014; Tadesse & Ahmed 2023; Tessema et al. 2013).

4.3.3. Agricultural policies

The effect of greater agricultural revenue on rural population well-being varies per country, depending on the development and application of new technology. To enhance production and alleviate poverty and food insecurity, Ethiopia's government has undertaken a variety of agricultural policies, including market liberalization, structural adjustment, and sustainable development initiatives. Some more policies and programs include the plan for accelerated and sustainable development to end poverty, the environmental policy, the agriculture and rural development policy and strategy, the Ethiopian climate-resilient green economy policy, the Ethiopian climate-smart agriculture policy (integrated soil fertility management, water harvesting, and agroforestry), and the strategic investment framework for sustainable land management (Zerssa et al. 2021). However, many emerging nations' agricultural sectors have experienced pricing distortions and low productivity. Market incentives, agricultural research and development, irrigation, financing availability, and price support policies all have a substantial influence on agricultural transformation. Domestic supply constraints of agricultural and manufactured goods are the primary sources of inflation in Ethiopia, notably high food costs, which afflict people with fixed incomes.

In imperial times, Ethiopia’s focus was more on the support of commercial farms leaving subsistence farmers behind. Together with the political insecurity and instability, it harmed rural development programmes. Concerns have shifted to increase the production of these small farms. Obstacles like population growth, environmental deterioration, climate change, and lack of innovation and capital are in the way (Welteji 2018).

Ethiopia's coffee policy focuses on commerce and the regulation of hard currency exports to maximize foreign exchange. There are no standards governing coffee

production, but certain restrictions govern marketing, such as selling export-quality coffee on the local market and requiring specific permits for domestic wholesaling, exporting, or roasting. In January 2020, the Coffee and Tea Authority and the National Bank of Ethiopia developed the "Export Coffee Contract Administration," which would allow coffee farmers, coffee unions, commercial growers, and processors to export directly to the international market without the need for middlemen (USDA 2023).

To improve the overall situation, irrigation policies may boost agricultural output, social welfare, and employment. Precision agriculture, a tool that gives information on soil nutrient conditions and utilization rates, improves production and broadens knowledge as well. Price support policies should be implemented jointly with these measures to improve farmers' market incentives and marketing efficiency. This would provide a sufficient agricultural food supply, cheaper costs, and increased consumption for rural and urban poor people (Shikur 2020).

4.4. Studies' overview

There have been several studies on similar topic to this thesis, this part is then introduced to summarize important data and information from these studies and compare what they have in common and in what parts they disband. A summary of previous findings can be found in **Table 1** and **Table 2**.

The majority, ten out of thirteen studies (via **Table 2** below) were original research articles, three articles were literature reviews. Geographically speaking, chosen studies were mostly conducted or focused on southern Ethiopia (SE, SW) where most of the coffee comes from (via ***Figure 1*** above). Research articles include surveys and questionnaires with more than a hundred respondents.

Mostly used adaptation practices

The most common approaches discovered by Aboye et al. (2023) were modifying planting dates, crop diversification, producing drought-tolerant crops, selling animals, and off-farm and nonfarm work, among others. Erekalo & Yadda (2023) and Tadesse & Ahmed (2023) advocate for climate-smart agriculture, including crop diversification, integrated soil fertility management, integrated pest management, irrigation utilization, and the adoption of better crop varieties, particularly drought-

resistant early-maturing crop types. According to research by Olana Jawo et al. (2023), most farmers use agroforestry methods, organic manure/compost, soil conservation, altering agricultural calendars, and crop diversification.

4.4.1. Consensus

These studies confirm that farmers have noticed changes in weather patterns – higher temperatures and less rainfall. Basically, all these studies promote or have observed that climate-smart (sustainable) coffee farming should be/is introduced as the basic level to secure the coffee business. These practices include shade management, irrigation, pest management, agroforestry, improved varieties, and water and soil conservation. Majority of these studies focus on factors influencing farmers' behaviour like access to information, credit, and extension services. These factors should be boosted because farmers do not have enough financial resources. The overall issue of small-scale coffee farms appears to be lack of access to credit and inssuficient plot of land to grow on. Small farms lack what the large-scale commercial farms have. As mentioned, in all of these studies, the weather patterns have changed, and to address this barrier, there is a need to find suitable sustainable farming practices to suit a specific farm.

4.4.2. Dissonance

As mentioned as a part of the consensus subchapter, the majority of these articles mention sustainable agriculture, nevertheless, some of them promoted it as a solution to fighting climate change, where some rather mentioned that it is the basic minimum to do, and some even pointed out that sustainable coffee farming is in place and that there are other areas of focus, like the profitability of farmers. Some of these articles are focused more on climate change adaptations and some on the factors influencing adaptation behaviour (SW studies). Although, these studies were chosen because they have a lot in common, there are small differences between them – their focus, especially when it comes to conclusions, and that is what the authors consider the most important. In these studies are prioritized following indicators/key findings: quality, resilience, climate, adaptation strategies, practices, factors influencing adaptation behaviour, information, and profitability. This is what divides these articles into two groups: environmental

and economic focused. Even though these focuses are very closely linked to one another, people tend to prioritize one factor over another. This tends to be because it is easier to focus on one factor than more, person's biases, life experiences, etc.

4.4.3. Factors influencing adaptation of small-scale coffee farmers

In the **Table 1** is shown a summary of the main factors influencing the adaptation of small-scale coffee farmers toward climate change in Ethiopia. The table is divided based on type of factors (e.g. farmer´ and household characteristics, farm characteristics, institutional factors and climate characteristics). These factors are either positive (+), negative (-), or can be both (+-). Additionally, the influence of these factors on farmer's adaptation and sources where this information can be found/mentioned are presented in the table.

Age, education, access to information, access to credit, gender, land size, experience, rainfall and temperature were mostly mentioned as factors influencing the adaptation behaviour of small-scale coffee farmers in Ethiopia.

Farmer´ and household characteristics

The effect of **age** on the adaptation of small-scale farmers in Ethiopia is inconsistent since it can affect the adaptation positively, as well as negatively. Older farmers tend to be more traditional and resistant to change, whereas younger farmers tend to be more open to innovation and are willing to accept change (Adane & Bewket 2021; Ayal et al. 2023; Diro et al. 2022; Eshetu et al. 2020; Gemeda et al. 2023; Tadesse & Ahmed 2023). Only one study by Tesfaye (2021) mentioned explicitly that older farmers are more experienced compared to younger ones.

Education influences adaptation positively. When farmers are educated, they tend to have more knowledge and know-how so they know where and how to find information which can overall help them with adoption of the suitable farming practices for their farm (Adane & Bewket 2021; Ayal et al. 2023; Diro et al. 2022; Erekalo & Yadda 2023; Eshetu et al. 2020; Gemeda et al. 2023; Tesfaye 2021).

The **experience** of farmers influences adaptation positively. Experience in farming is an advantage because farmers know how to take care of their land, how to perceive risks and eliminate threats, what is important to pay attention to, or what to invest in and when (Adane & Bewket 2021; Ayal et al. 2023; Erekalo & Yadda 2023; Tesfaye 2021).

The effect of **gender** on the adaptation of small-scale farmers in Ethiopia is inconsistent. This is mainly because men tend to have easier access to credit, information, or even purchasing some land compared to women. If there is a situation on which can be looked at as a men vs women-headed farm, there can appear some differences in the division of labour, different knowledge, priorities etc. This factor is considered to be neutral because the following studies do not consider it positive or negative, or it does not play a crucial role when adapting to climate change. The majority of farm households are in this case headed by men (Adane & Bewket 2021; Ayal et al. 2023; Diro et al. 2022; Tadesse & Ahmed 2023; Tesfaye 2021).

Farm characteristics

The effect of **land size** on the adaptation of small-scale farmers in Ethiopia is inconsistent. This is because large farms can definitely have easier access to resources, diversification, building economies of scale, or mechanization than small farms. Large farms can have a problem when it comes to maintaining large land, it is labour and resource-intensive, and it is difficult to make it sustainable (Adane & Bewket 2021; Ayal et al. 2023; Diro et al. 2022; Erekalo & Yadda 2023; Eshetu et al. 2020; Gemeda et al. 2023; Tadesse & Ahmed 2023; Tesfaye 2021).

Institutional characteristics

Access to information plays an important role in the adaptation of small-scale farmers and positively influences farmers' adaptation. As mentioned before, education can help with access to information but that is not always the case. If the farmer has contacts or resources to access agricultural or any other information needed, this can raise farmers' awareness, improve decision-making, investing in technology or training (Adane & Bewket 2021; Ayal et al. 2023; Erekalo & Yadda 2023; Eshetu et al. 2020; Gemeda et al. 2023; Tesfaye 2021).

Access to credit influences adaptation positively. Usually, large-scale farms have relatively easy access to credit but this is not the case of small farms. These farms have to either join a cooperative or find some other way how to obtain credit. With credit, farmers can invest in innovation and technology, deal with losses, or spend some on capacity building and market diversification (Adane & Bewket 2021; Ayal et al. 2023; Diro et al. 2022; Erekalo & Yadda 2023).

Climate characteristics

When it comes to climate change lower rainfall and higher temperatures are affecting farmer's job. **Less rainfall** can result in lower yields, lower coffee bean quality, the spread of diseases and water stress (Abebe 2020; Ayal et al. 2023; Gemeda et al. 2023; Gomm et al. 2024; Olana Jawo et al. 2023; Shiferaw & Kefale 2021; Tadesse & Ahmed 2023; Tesfaye 2021). **Higher temperatures** result in plant heat stress, water scarcity, pest and disease outbreaks (Ayal et al. 2023; Gemeda et al. 2023; Gomm et al. 2024; Olana Jawo et al. 2023; Shiferaw & Kefale 2021; Tesfaye 2021). These two climatic factors are very closely connected.

Table 1 Factors influencing adaptation of small-scale coffee farmers

Factor	Effect + positive - negative	Effect on the adaptation of farmers/adaptation behaviour	Source (year)
Farmer´ and household characteristics			
Age	Younger farmers +-	Innovation, willingness to change, less experienced	Aboye et al. 2023, Adane & Bewket 2021, Ayal et al. 2023, Diro et al. 2022, Eshetu et al. 2020, Gemeda et al. 2023, Tadesse & Ahmed 2023
	Older farmers +-	Usage of traditional methods, resistance to change, more experienced	Aboye et al. 2023, Adane & Bewket 2021, Ayal et al. 2023, Eshetu et al. 2020, Tesfaye 2021, Gemeda et al. 2023
Education	+	Knowledge, access to information, better understanding of suitable practices	Aboye et al. 2023, Adane & Bewket 2021, Ayal et al. 2023, Diro et al. 2022, Erekalo & Yadda 2023, Eshetu et al. 2020, Gemeda et al. 2023, Tesfaye 2021
Gender	Male (+)	Access to resources, decision-making power, labour strength	Aboye et al. 2023, Adane & Bewket 2021, Ayal et al. 2023, Diro et al. 2022, Tadesse & Ahmed 2023, Tesfaye 2021
	Female (+)	Empowerment, autonomy, specific skills and knowledge, community development	
Experience	+	Knowledge, risk perception, coping strategies, innovation	Aboye et al. 2023, Adane & Bewket 2021, Ayal et al. 2023, Erekalo & Yadda 2023, Tesfaye 2021
Farmer´ perception of climate change	+/-	Action toward adaptation strategies	Adane & Bewket 2021
Income	+	Investment into technology, innovation	Aboye et al. 2023, Ayal et al. 2023, Eshetu et al. 2020

Household size/family	+	More labour	Aboye et al. 2023, Adane & Bewket 2021, Ayal et al. 2023, Diro et al. 2022, Tadesse & Ahmed 2023, Tesfaye 2021
Farm characteristics			
Land (Farm) size	Large (over 1 ha) +	Economies of scale, diversification, access to credit, technology, market access	Adane & Bewket 2021, Ayal et al. 2023, Diro et al. 2022, Erekalo & Yadda 2023, Eshetu et al. 2020, Gemeda et al. 2023, Tadesse & Ahmed 2023, Tesfaye 2021
	Small (less than 1 ha) +	Sustainable, community resilience, quality, specialty	Erekalo & Yadda 2023, Eshetu et al. 2020, Kudama et al. 2021, Tadesse & Ahmed 2023
Land tenure/ownership	+	Better adaptation of practices	Adane & Bewket 2021, Tadesse & Ahmed 2023
Institutional characteristics			
Membership in cooperatives/ organisations	+	Access to information and resources, collective action, market opportunities	Adane & Bewket 2021
Access to information	+	Awareness, decision-making, technology, training	Aboye et al. 2023, Adane & Bewket 2021, Ayal et al. 2023, Erekalo & Yadda 2023, Eshetu et al. 2020, Gemeda et al. 2023, Tesfaye 2021
Access to credit	+	Investment in technology, coping with losses, capacity building, market diversification	Aboye et al. 2023, Adane & Bewket 2021, Ayal et al. 2023, Diro et al. 2022, Erekalo & Yadda 2023
Climate characteristics			

Rainfall	-	Lower yield, lower coffee bean quality, more pests and diseases, water stress	Abebe 2020, Ayal et al. 2023, Gemeda et al. 2023, Gomm et al. 2024, Olana Jawo et al. 2023, Shiferaw & Kefale 2021, Tadesse & Ahmed 2023, Tesfaye 2021
Temperature	-	Heat stress, water scarcity, pest and disease outbreaks	Ayal et al. 2023, Gemeda et al. 2023, Gomm et al. 2024, Olana Jawo et al. 2023, Shiferaw & Kefale 2021, Tesfaye 2021

Table 2 Studies overview

Source	Location	Study period	Methods	Respondents	Main findings
Abebe 2020	Wensho district, Southern Ethiopia	2014 + 2015	The sustainable livelihood approach	176 households	This study underlines the importance of resilience - conserve water and soil, new varieties, shade growing, better access to prices, loans, social protection.
Adane & Bewket 2021	Yirgacheffe, Southern Ethiopia	/	The propensity score model	352 households - 232 conventional coffee farmers, 120 specialty coffee producers	This study points at quality coffee production which performs better in adaptation towards climate change.
Ayal et al. 2023	Nensebo Woreda, Ethiopia	2019	Household survey	181 coffee farmers	This study revealed increased rainfall and temperature trends, prone to floods and droughts. Coffee grower farmers use shade management, improved varieties, and conservation technologies for climate variability adaptation. Limited farmland prevents irrigation and crop diversification. Agroforestry practices could mitigate land degradation and ensure food security.
Diro et al. 2022	Oromia and SNNP	/	Multivariate probit (MVP) model	953 households	The finding of the study indicates the positive and significant effect of education, extension (access to extension services and participation on field days), and ownership of communication devices specifically radio on the adoption of climate smart agricultural practices.
Erekalo & Yadda 2023	Gamo, Gofa, Conso zones of Southern Ethiopia	2021	Multi-stage sampling procedure, focus group discussion, survey	271 small-scale farmers	This study affirms the adoption of climate smart agriculture.

Eshetu et al. 2020	Jimma zone, SW Ethiopia	/	Survey	240 smallholder farmers	In this study following adaptation strategies were the most common ones observed in the reasearch: adjustment of planting date, change of the crop type and variety, tree plantation, and mixed farming. The decision of adaptation strategy is affected by multiple factors (age, farm size, income, education). There is a need of boost from government to enhance life of farmers.
Gemeda et al. 2023	SW Ethiopia	/	Multi-stage sampling technique	442 individuals	The study found that factors such as household age, dependency ratio, literacy status, education level, climate change perceptions, rainfall patterns, crop loss, land, access to agricultural extension services, climate information, drought events, and delayed rainfall significantly impact households' adaptation to climate change.
Gomm et al. 2024	Gomma and Gera districts, SW Ethiopia	2020	Interview	56 farmers	Farmers' adaptation practices showed associations with local temperature, but not with farmers' perceptions of climate change.
Kudama et al.,2021	Jimma Zone, Oromia National regional state in SW Ethiopia	2020	The Multivariate Probit (MVP) model	153 households	The study results showed that the farmers' adoption of different SFEPs depended on farm and management characteristics (total size of coffee holdings, multiple plots, remoteness of coffee farm, hired labor, and farming experience), socio-economic variables (literacy, household size, and training), and Fairtrade coffee certification.
Olana Jawo et al. 2023	Sidama region, Ethiopia	2020	Household survey	351 coffee farmers	This study shows that farmers noticed rising temperatures (over last 30 years) and reduction of rainfall. Practices like agroforestry, organic manure, soil conservation, change of farming calendar, and crop diversification were introduced.

Shiferaw & Kefale 2021	Dara Woreda, South Ethiopia	/	Logit model, linear regression, Pearson's correlation	145 households	In this study, reduced rainfall, higher temperatures over last 20 years were found, decreasing coffee production.
Tadesse & Ahmed 2023	Ethiopia	2023	Review - secondary data	/	This study promotes climate smart agricultural practices which include agronomic practices, integrated soil fertility management, conservation agriculture, agroforestry, irrigation which positively affect coffee production.
Tesfaye 2021	Mana district, SWE	2020	Multi-stage sampling technique (questionnaire + interviews)	377 households	In this study was mentioned about higher temperatures, less rainfall, outbreaks of coffee diseases due to climate change variability.
Ventocilla et al. 2020	Ethiopia	2020	Review - secondary data	/	This publication considers low profitability and climate change variability as the main issues to coffee production in the country. Better advisories (My Coffee Farm) and interventions are in need.
Zerssa et al. 2021	Ethiopia	/	Review - secondary data	/	This study reveals the potential for climate smart agriculture.

Note: SW = Southwestern Ethiopia

5. Conclusions

The aim of this thesis was to analyse the factors influencing the adaptation behaviour of small-scale coffee farmers towards climate change in Ethiopia. The most common adaptation strategies used are shade/sun growing, agroforestry, organic farming, irrigation, mulching, terracing, pruning, use of improved resistant varieties, climate smart agriculture, soil and water conservation.

This research revealed that factors influencing the adaptation behaviour of small-scale coffee farmers in Ethiopia are of socio-economic and environmental origin. The key factors which influenced the adaptation of small-scale farmers in recent years were mostly age of farmer, education, access to information, access to credit, gender, land size, and experience (socio-economic factors). These factors affect coffee farming mostly positively because, usually, more owned resources are related to better possibilities for adaptation. The main climatic factors are lower rainfall and higher temperatures (environmental factors). These affect coffee farming negatively because coffee plants need specific ideal conditions to grow.

Furthermore, these practices should be used and improved based on what is the most suitable for the specific location and coffee plants. Since the majority of Ethiopian coffee growers are small-scale, more attention should be paid to them and to their needs to be able to overcome and adapt to the climate change. Small coffee farms need to be accessed (by extension services) individually based on location, coffee plant variety, weather pattern, etc. More governmental action is needed. A higher number of governmental policy interventions are needed to create a general guideline for coffee farmers. Special coffee farming, and water management guidelines should be accessed and put in place.

Further studies should be conducted on this or similar topics in the area. There is only limited evidence to this specific but complex problem. The recommendation for futher studies would be the following: to implement new policies, government action, to promote suitable coffee farming practices for special areas (fe. lowlands, midlands and highlands).

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