Exploring the Barriers to Sustainable Small-scale Arabica Coffee Farming on Mt Elgon, Uganda

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Picture from an informal conversation with the mother of one of my translators. Insistently, she told me to pick: “only the red cherries”.

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Summary

A wide range of practical, economic, and climatic *barriers* restrict the *economic* and *environmental security* of small-scale Arabica coffee farmers in Sipi and Buginyanya on Mount Elgon, Uganda, where I carried out 6 weeks of fieldwork at the end of 2025. As shown in the thesis, these *barriers intersect* in ways that challenge farmers' *human security* and impede livelihood improvements. In the first part of the thesis, it was argued that today's global coffee market is characterised by the unequal distribution of coffee revenues. The colonialist introduction of cash crop farming and the establishment of a capitalistic coffee trade system have trapped small-scale coffee producers at the bottom of the coffee value chain. In cooperation with the Danish coffee retailer *Frellsen Kaffe*, the sustainable development project, *Agroforestry for People, Ecosystems and Climate (AfPEC)*, works to counter this system by facilitating direct sales of green coffee beans.

However, the first part of the analysis showed how several *barriers* prevent this from happening. Farmers' limited investment capacity, malfunctional farm equipment, limited knowledge of best management practices, unskilled labour and unreliable weather patterns impeded the refinement of coffee, thus challenging farmers' *economic security*. In the second part, I described how farmers develop a multisensory *skilled vision* to detect "attacks" from coffee pests and diseases (CPaDs). Farmers have limited alternatives to eradicating CPaDs, as these *antagonists* are the main *barriers* to livelihood improvements. To remedy this, insights from farmer interviews, field observations, and studies on the biological and epidemiological nature of CPaDs, as well as methods for identification and organic preventive and control measures, were compiled into a background document (Appendix 3) and four brochures (Appendix 4), which will be distributed to relevant farmers in multimodal ways. The analysis of farmers' experiences with weather changes and a comparison between previous weather data and data from 2014 to 2025 showed indications of a new weather pattern. However, most farmers were unaware of climate change as the cause of the weather changes, they observed. The section on farmers' *perceptions* of climate change indicated that most farmers rather related weather changes to changes in the local tree cover. Precipitation variability, increased rainfall, extreme weather events and, occasionally, a reduced dry season characterised the new weather pattern. Associated climatic *barriers* highlighted by farmers included landslides, soil erosion, disruption of the coffee maturation cycle, increased unpredictability, destructive hailstorms, fertiliser leaching and increased prevalence of CPaDs.

The discussion demonstrated how climate change and management decisions impacted the distribution of locally relevant CPaDs. The new weather pattern enables the proliferation of CPaDs with certain microclimatic preferences and may explain why water-borne diseases are currently thriving. Additionally, warm-climate preference pests were expected to flourish under future climate conditions.

Currently, the most harmful CPaDs locally are the White Coffee Stem Borer (WCSB), Coffee Berry Borer (CBB), Coffee Leaf Rust (CLR), and the Coffee Berry Disease (CBD). A comparison of relevant literature with the new weather patterns showed that the former three were expected to flourish, whereas studies disagreed about the future development of the CBD. Hence, the current climate's unreliability and the inconsistency of future climate predictions complicate CPaD management. As argued in the second part of the discussion, factors such as the coffee farm system, farm design, and management methods also strongly influenced the prevalence of CPaDs. Regarding the coffee farm system, a considerable share of locally impactful CPaDs was limited in agroforestry systems, according to several studies. However, a few CPaDs (WCSB and CLR) were more abundant under shaded conditions unless managed properly. The choice of organic versus inorganic management practices also affected CPaD distribution. Whereas the CBB was more widely distributed on organic coffee fields in Sipi, diseases such as the CBD and CLR were more widespread across conventional coffee gardens in Buginyanya. Moreover, the highest diversity of unique CPaDs was present in Buginyanya, which might be attributed to the use of agrochemicals. The last part of the discussion found considerable environmental, economic, and health-related side effects to chemical treatment, calling for the deliberate use of such products. Considering these risks, the transition to organic coffee farming in Buginyanya via the Integrated Pest Management approach was encouraged.

List of abbreviations

AfPEC - Agroforestry for People, Ecosystems and Climate
CBB - Coffee Berry Borer
CBD - Coffee Berry Disease
CLR - Coffee Leaf Rust
CPaDs - Coffee Pests and Diseases
FFLG - Farmer Field Learning Group
FoW - Forests of the World
IPM - Integrated Pest Management
JESE - Joint Efforts to Save the Environment
LEK - Local Ecological Knowledge
NARO - National Agricultural Research Organisation
UCDA - Uganda Coffee Development Authority
SwB - Seniors without Borders
VSLA - Village Savings and Loans Associations
WCSB - White Coffee Stem Borer

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Reading guide

When reading through the thesis, make sure to "zoom in" on pictures that do not immediately reveal what is described in the accompanying text. Coffee pests and diseases are miniature beings. The thesis is inspired by visual anthropology (Taylor & Francis Online, 2026) and aims to demonstrate that multimodal dissemination increases readers' comprehension of a given subject.

Introduction

The global climate and biodiversity crisis are two out of three of the biggest environmental challenges facing humanity (Graham et al., 2021: 1894; UNFCCC, 2022). In the annual Global Risk Report, environmental challenges were highlighted as the top three long-term, global risks (World Economic Forum, 2026). Simultaneously, both "Biodiversity loss and ecosystem collapse" and "Natural resource shortages" (ibid: 9) appeared in the top ten, being risks that relate directly to Arabica coffee production. Uganda is the second-largest coffee-exporting country in Africa after Ethiopia (Ategeka, 2024: 83), the coffee plant's country of origin (Nigussie et al., 2014: 1). Coffee is Uganda's most important export cash crop (Wedig, 2019: 131; UCDA, 2019: 3), providing a livelihood for around 1.8 million households, 99% being smallholder farmers (Namuyanja et al., 2024: 276). Arabica coffee accounts for approximately 20% of the national coffee production and is cultivated in highland areas such as Mount (Henceforth: Mt) Elgon (UCDA, 2019: 4). The export value of coffee from Uganda increased in recent years (Ategeka, 2024: 86) along with increased global demand for high-quality coffee (UCDA, 2019: 1). Simultaneously, however, coffee prices have been subject to considerable volatility (Ategeka, 2024: 86), while the area of concern has experienced a decrease in coffee crop yields (Kitunzi, 2024)[1]. The

[1] "The average yield for 1961-2006 was 6,569 hg/ha, while that of 2007-2021 was 5,809 hg/ha, indicating a slight reduction." (Ategeka, 2024: 84)

reduction in yields has been attributed to climate change. In mountainous areas such as the Mt Elgon region in Uganda, climate change-related increases in temperature are aggravated with elevation (Pepin et al., 2015: 424). Furthermore, climate change interferes with the coffee maturation cycle of planting, harvesting, and crop sales (Alinyo & Leahy, 2012) and has increased the prevalence of crop pests (Ma et al., 2025: 264). The proliferation of coffee pests has resulted in rising pesticide use, increased crop losses, and higher management costs (ibid: 278). All this is worsened by the fact that adaptation to climate change in Africa is hindered by insufficient information and comprehension of the status of the global climate (Jaramillo et al., 2011: 7), which is a fact that will also reveal itself in the analysis. Based on these considerations, the thesis will uncover the following research question:

What are the main barriers to sustainable Arabica coffee cultivation on Mount Elgon in Uganda, and, considering that, how does climate change and its derived effects influence small-scale coffee producers in the northwestern part of the region?

The thesis is divided into three main parts. In the first, an introduction provides context for Arabica coffee farming on Mt Elgon, followed by a section that outlines the conceptual framework and some theoretical considerations. The latter section of this introductory part is a methods section that expounds methodological and ethical considerations. In the second part of the thesis, the analysis, several practical, economic and climatic *barriers* to local coffee farming are presented and analysed using concepts such as *actants*, *enactment* and *skilled vision*. The third and final part is a discussion that focuses on how the recent proliferation of coffee pests and diseases, might be explained.

State of the Art

A considerable number of studies and academic literature have dealt with the topics scrutinised here. Some have even been conducted in the same area. In this short section, publications with the greatest relevance for this study will be presented. A central contribution is Liebig et al. who linked Mt Elgon farmers' perceptions and knowledge on coffee pests and diseases (CPaDs) and their management to existing, scientific and expert knowledge. Their most interesting finding, when seen through the lens of this study, is how differing levels of canopy cover affect the distribution of certain CPaDs (Liebig et al., 2016). Deepening this focus on factors impacting the prevalence of CPaDs, Koutouleas et al. described how different CPaDs had varying warm or cool climate preferences, thus opening the debate of climatic impacts on CPaD distribution (Koutouleas et al., 2025). In 2019, the Ugandan Coffee Development Authority (UCDA) provided a most applicable handbook that guides Ugandan Arabica coffee farmers from the initial steps and considerations when starting a coffee business to climate adaptation and pest management. All three are crucial contributions to this thesis and serve as some of the fundament, it has been built upon. Different from these publications, however, this piece of work is combining insights from a wealth of sources; academic literature, local field studies, six weeks of selfconducted fieldwork in Sipi and Buginyanya (Figure 1), local weather data, as well as quantitative and qualitative methods that were applied through an interdisciplinary approach that allows the great variety of knowledge to merge into a whole. In many ways this study is a follow-up of Liebig et al. (2016) and the Arabica Coffee Handbook (UCDA, 2019) that gives an update on the local distribution of CPaDs and parasitic plants, collecting various preventive and control practices and discussing what the observed alterations in the prevalence of CPaDs might result from. As an example, the presence of the "dodder weed"[2] (*Cuscuta sp.*) was not reported on Mt Elgon in any of the previous studies. In comparison to Koutouleas et al. and the handbook, the thesis has a larger local relevance, focusing on the specific local experiences with and *perceptions* of climate change.

Other useful literature includes Osbahr et al. (2011) that compared climate data from 1960 to 2008 with South-West Ugandan farmers' perceptions of climate change as well as Aturihaihi et al. (2023), who studied the experience of climate change of smallholder farmers in the same region. More locally relevant studies, focusing on climate change perceptions among Mt Elgon farmers include Aggrey et al. (2024) who focused on Sebei pastoralists in neighbouring Kween District. Tiyo, Orach-Meza & Edroma (2015) investigated small-scale farmers' perceptions and the impacts of climate change on their agricultural production, livelihoods and adaptation strategies, partly focusing on farmers in Kapchesombe which is 10 km North-East of Sipi. Finally, Bomuhangi et al. (2016) compared perceptions of climate variability to available meteorological data in the Mt. Elgon region, focusing partly on Chema subcounty, which lies a few kilometres from Sipi, and Gamogo subcounty that is located between Sipi and Buginyanya. The last-mentioned study confirmed the usefulness of comparing local weather data with coffee farmers' observations and perceptions of weather change. Given that Bomuhangi et al. (2016) analysed rainfall data from 1993 to 2013, it was obvious to take a look at the subsequent data to discover long-term tendencies. More about this in the analysis.

The Local Context of Arabica Coffee Farming: The History of Coffee Farming, Agroforestry, Environmental Degradation, and Climate Change

The Colonial Roots of Coffee Cultivation and Cooperatives

Before the British Empire's establishment of the "Protectorate of Uganda", East African economies were based upon the barter system[3], and its people relied mainly on subsistence farming. During the 68-year colonial rule in Uganda (1894-1962), European settlers introduced plantation agriculture, livestock and cash crops to the region, including, among others, coffee, tea and wheat. The introduction of

[2] The dodder weed is a parasitic plant that attaches to a variety of host plants, including *Coffea arabica*, from which it extracts nutrients and water (Mutitu et al., 2020: 1).
[3] "Two individuals negotiate to determine the relative value of their goods and services and offer them to one another in an even exchange." (Kenton, 2025).

“capitalistic production relations” (Kabwegyere, 1974: 255) altered the country’s socio-economic system. Under British rule, indigenous East Africans were forced to provide their labour in farming on appropriated lands to pay “head taxes”[4]. In this way, East African farmers went from being subsistence farmers to employees in the production of export cash crops that could be sold through the newly established global trade networks (Brown, 2003). This created the structural, economic dependency on external markets that a majority of Ugandans labour under today (Jorgensen, 2023). Coffee cultivation in Uganda has its roots in the country’s colonial past. European settlers started small-scale enterprises that expanded during the early 1900s, resulting in an increase in exports and land area cultivated (Small, 1914: 242), thereby sustaining a development in coffee trade and land use change that persists today, more than 100 years later (Ategeka, 2024: 86). The evolution of the coffee sector in Uganda has largely been driven by cooperatives. Today, cooperatives can be defined as voluntary, jointly owned, democratic and autonomous associations that exist to meet members’ common economic, social and cultural needs and aspirations (Katwesigye et al., 2022: 165). Ideally, members contribute equally to the common property of the cooperative (UCDA, 2019: 98-99), which in turn offers education, training and capacity building for its members (ibid: 99). At the time of the first cooperatives in Uganda, however, they were neither “voluntary” nor “autonomous”, and their establishment was done primarily to protect colonialist interests, rather than the local population’s (Wedig, 2019: 80). Even the post-independence government maintained close control over the “agrarian cooperatives” (ibid: 82), until neoliberalist liberalization reforms in the early 1990s, and the associated reduction in public sector support to coffee cooperatives, led to a significant reduction in their trade (ibid: 4 & 132).

Before the eventual resurrection of cooperatives in Uganda in the 2000s (ibid: 4), some critical events took place on the slopes of Mt Elgon. In the 1950s, the neighbouring Bagisu people dominated the Sebei people in an economic sense through the Bagisu-led “Bugisu Cooperative Union” that controlled coffee marketing across Mt Elgon (ibid: 130). Over time this caused an aggravation of existing ethnic conflicts between the two tribes, which ultimately led to the formation of Kapchorwa District and an independent Sebei coffee cooperative (Wedig, 2019: 130). Today, small-scale farmers sell their coffee through different local and regional cooperatives, to so-called “middlemen”[5], or to companies. Farmers utilize the opportunity to sell either through a cooperative like Sipi Organic and/or Mountain Harvest in Sipi and Budadiri Coffee Mills for the Buginyanyan farmers, I interviewed. Some farmers even sell to companies such as Kawacom, Olam, Bugisu, Nimiru and Chakalanya; or to middlemen, dependent on

[4] "British administrators compelled Africans to work by ordering imposition of a head tax on all African heads of households. Africans were then forced to work for limited wages to pay this tax" (Brown, 2003).

[5] In Buginyanya and Sipi, middlemen are intermediaries that buy coffee from the farmer and sell it to companies that refine it. Selling through middlemen is a riskier affair, and they typically buy at a lower price than cooperatives and companies. However, a few farmers enjoyed the flexibility to always sell to them, when in need of money straight away. For instance, Agnes, a 68-year-old farmer from Sipi struggling with reduced mobility, was pleased with the fact that middlemen could collect the coffee directly from her home, exactly when she wanted to sell. This was an arrangement that was not always possible to settle with local field officers, who had to cover a wider range of farmers simultaneously as representatives of one of the few local cooperatives.

who offers the best price and/or who are there “at the right time, at the right place” as a Sipi-farmer explained. Accentuating this tendency, Moses, a 70-year-old retired pastor from Sipi, told me that: “when the cooperative or company sometimes does not have money to buy coffee, then you buy from the other”. Hence, Arabica coffee is a valuable commodity that has the interest from actors spanning from young coffee thieves[6] and middlemen to regional cooperatives and international companies. Depending on their short-term needs, farmers navigate in this complex web of actors to maximize their gains and find the solution that best fits their situation.

Figure 1. *The Arabica Coffee growing zones (UCDA, 2019: 7). Black circles indicate the study sites: Sipi in Kapchorwa District and Buginyanya in Bulambuli District.*

Mt Elgon Arabica Coffee

In 2019, 80% of coffee produced in Uganda was Robusta (*Coffea canephora*), while Arabica coffee (*Coffea arabica*) only accounted for around 20% (UCDA, 2019: 4). The greater part of Ugandan Arabica coffee is cultivated on the slopes of Mt Elgon that, with its peak rising 4320 meters above sea level (masl.), is the largest freestanding volcano in the world (UCDA, n.d.; Liebig et al., 2016: 3). The Bagisu people inhabit the south and southwestern slopes, while the Sebei people occupy the north and northwestern slopes (Aggrey et al., 2024: 4). The Bagisu engage in “intensive”, primarily inorganic, “mixed” agriculture dominated by coffee and banana (ibid.), while the Sebei has traditionally been a nomadic, pastoralist tribe that have now settled (ibid: 2). In recent decades, the Sebei have been cultivating Mt Elgon’s slopes for food, fodder and cash. In Sipi - and in Kapchorwa, Kween and Bukwo District in general - most inhabitants are Sebei, while the Bagisu tribe occupies the remaining districts on the Ugandan side of the mountain, including Bulambuli, where Buginyanya is located.

Recent climatic conditions on Mt Elgon have been favourable for Arabica coffee cultivation. In 2016, Liebig et al. described the climate norm as characterised by a bimodal rainfall pattern. The rainy season

[6] With the increase in the price of coffee, farmers are no longer the only ones interested in the economic benefits. Several farmers complained about coffee theft being a major challenge during the period of harvest. As an example, both my host families’ coffee was stolen at least once, indicating how widespread the problem was.

spanned from March/April to October/November, with a period of less intense rainfall in between. This was followed by a dry season from December to February (Liebig et al., 2016: 3). In a later paper by some of the same authors, referring to a study from 2005, annual precipitation was set at 1200 to 1800 mm with an average temperature of between 18 and 23ºC (Liebig et al., 2018: 515). Under these convenient circumstances, Arabica coffee cultivation has gradually become a tradition in the mountainous area (AfPEC, 2026a). In an AfPEC[7] promotion video, Joseph[8], a 52-year-old field officer from Sipi, explained the tendency accordingly: “The growing of coffee in our family started from our grandfathers, then our fathers. So, with us, we just adopted from them.” (AfPEC, 2026b: 6:31-6:43)[9]. Apart from Arabica coffee, farmers cultivate bananas (*matooke*, see below), beans, peas, ground nuts, maize, vegetables, sweet and Irish potato, avocado, and mango among others (Liebig et al., 2016: 3). This also expresses itself when you study the largely cultivated landscape (see Figure 2 & 3).

Figure 2. *Sipi at the beginning of the dry season. Satellite image, Google Earth Pro (22/11-2025).*

[7] I did my project placement in cooperation with the sustainable development project, Agroforestry for People, Ecosystems and Climate (AfPEC). The role of AfPEC will be elaborated further below.
[8] Joseph is the family father of my host family and a central collaborator.
[9] In the quote, he refers to the local land inheritance system which is largely patrimonial.

Figure 3. *Buginyanya at the end of the dry season. Satellite image, Google Earth Pro (04/02-2026).*

Coffea arabica is the species name of the perennial (Figure 4) cash crop that sustains most small-scale farmer families on the Western slopes of Mt Elgon. Coffee production works as a kind of saving, as it can "only" be harvested twice a year; as a "main crop" in October to February and a secondary "fly crop"[10] from May to July (UIA, 2014; UCDA, 2019: 85). The income from coffee sales is used for "big things" such as paying school fees, buying farming tools, machines or inputs, paying hired labour and/or covering health expenses (Jacobsen & Kroijer, 2024: 2). The coffee plant has dark green leaves, and it produces white flowers and red berries (UCDA, 2019: 4). It can grow up to 12 meters tall in the wild; in Ethiopia and South Sudan (Koutouleas et al., 2025: 171). Here, in its original ecology, it is an under-story shrub that requires protection from direct sunlight and high temperatures (Nigussie et al., 2014: 1; Jacobsen & Kroijer, 2024: 6). Farmers cultivating coffee limit its growth through measures such as pruning, which keeps them between 2 and 3 meters in height, making management and harvesting more accessible (UCDA, 2019: 4).

Figure 4. *Coffea arabica is a perennial plant, and new shoots (called "stems") can continue sprouting for several years. One farmer reported having 60-year-old coffee roots, which he was advised to uproot.*

[10] The local name for the smaller coffee harvest.

As hinted above, studies have identified microclimatic conditions favourable for Arabica coffee. Regarding altitude, the UCDA recommends Arabica cultivation at a range of 1300 to 2500 masl. (UCDA, 2019: 4). Concerning temperature, somewhere between 15 and 24 ºC is optimal (Namuyanja et al., 2024: 277; UCDA, 2019: 9; Jacobsen & Kroijer, 2024: 6), with annual mean air temperatures somewhere in between the lower and the higher threshold (Koutouleas et al., 2025: 176). When it comes to annual precipitation, the optimal range is between 1100 and 2000 millimetres (UCDA, 2019: 9; Namuyanja et al., 2024: 277; Koutouleas et al., 2025: 177). As implied, the highland crop's health is dependent on a specific and stable climate, both in terms of temperature, precipitation, winds and elevation. These are all requirements that the original mountainous climate on Mt Elgon met. However, recent weather instability and extremes expose the plant to stress that may affect the quality of the final product or completely impede production, depending on the severity of the weather events (UCDA, 2019: 9-10; Koutouleas et al., 2025: 177). In the third analytical section, the way local Arabica coffee production is affected by climate change will be clarified.

Apart from optimal microclimatic conditions, yields of the cultivated coffee plant rely on the fertility of the soil, which is remedied by 1) the application of synthetic or organic fertilizers (UCDA, 2019: 57) and/or 2) its accompanying shade trees (Nigussie et al., 2014: 2). Firstly, cultivated Arabica coffee is dependent on the availability of certain macro- and micronutrients (UCDA, 2019: 49-57) for its development, stamina and productivity:

> "In a 'closed' environment such as a rainforest, nutrients are recycled on their own and plants are more or less self-sufficient. However, where plants are grown in a commercial environment like Arabic Coffee growing, it is necessary to replenish the nutrients that are removed from the system through the harvested crop"
> (ibid: 47).

In general, there are three ways to provide this fertility, either organically, synthetically or via shade trees. Organic fertilisers come from organic plant or animal matter (ibid: 57), while inorganic or "synthetic" fertilisers are manufactured artificially (ibid: 62). In coffee-agroforestry systems (see below), shade trees replenish soil fertility by returning large amounts of organic matter to the soil, fixing nitrogen and retaining soil moisture (Nigussie et al., 2014: 2). This explains why leguminous trees are the most popular shade tree species (ibid: 9). Shade from accompanying trees, however, can also be a limiting factor to coffee yields, as photosynthesis in coffee leaves is most optimal at medium shade levels in *Coffea arabica's* original ecology (ibid.). Considering this, shade tree canopies must be regulated through operations such as shade lopping, shade thinning and shade lifting (ibid: 2)[11]. The

[11] These "operations" are collectively referred to as "pruning", locally.

implications of these agroecological strategies for the presence of coffee pests and diseases (CPaDs) will be discussed in the latter part of the thesis.

Environmental Degradation and Agroforestry

As settled, coffee is an understory shrub in its original ecology, which explains why coffee plants have traditionally been grown under shade trees in so-called coffee-agroforestry systems (Gonthier et al., 2013: 816). However, during the last 50 years, sun-exposed plantations have been promoted and become popular in many coffee-producing countries, including in East Africa (Jonsson et al., 2015: 282). This is partly because some studies revealed higher yields from such monocultural systems (Johnson et al., 2020: 9; Rezende et al., 2021: 1; Ayalew et al., 2022: 2) and monocropping being more accessible, less costly and labour-intensive, according to the Ugandan Coffee Development Authority (UCDA, 2019: 11). Considering these tendencies, the expansion of coffee production that has taken place during the last century has resulted in significant deforestation. During the last 35 years, around 45% of Uganda's natural forest cover has been reduced (Senyonjo & Odeke, 2020: 5); a trend which can also be linked to the last half a century's significant increase in population[12] (World Data, 2025; Stapp et al., 2016; Alam et al., 2024 & Hojas-Gascon et al., 2016). As a reaction, national authorities have attempted to protect the natural forest on the mountain, and in 1993, the Mt Elgon National Park was established (Aggrey et al., 2024: 4; Figure 5).

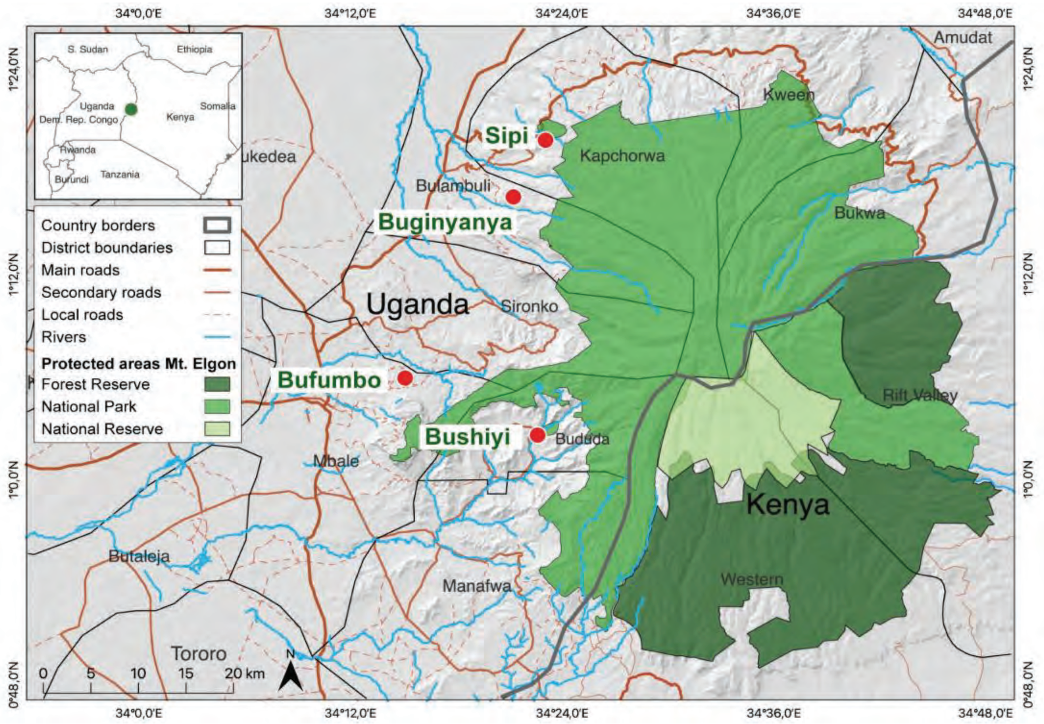

Figure 5. *Map showing the Mt Elgon National Park, Forest Reserve and National Reserve in Uganda and Kenya. AfPEC project villages are also included in the map as red dots (Willemoes, 2025: 23).*

12 According to United Nations (2025), the Ugandan national population increased from 7.6 in 1960 to 52.7 million in 2026 (United Nations, 2026).

Concurrent with the spread of monocrop coffee cultivation, a growing demand for organic coffee has led to the "revival of shade-grown coffee" (Jonsson et al., 2015: 282). This method of production is called agroforestry. Several definitions of agroforestry exist. The one that aligns the most with the system being promoted through AfPEC is the following: "the practice of deliberately integrating woody vegetation (trees or shrubs) with crops" (Pantera et al., 2021: 767). In the area of concern, the majority of cultivated Arabica coffee is already intercropped with matooke (see below) and/or a few shade trees. Underlining the latter fact, the first AfPEC-studies of local coffee production (Ellesøe, 2025; Jacobsen & Kroijer, 2024) revealed that in most "gardens", the shade tree cover was "relatively low" (Ellesøe, 2025: 28) and "below 10 %" (Jacobsen & Kroijer, 2024: 5). Adding to this, a Mt Elgon case study from 2021 (Graham et al., 2021) concluded that most farmers planted exotic species and displaced indigenous species that were already limited in numbers and species diversity (ibid: 1893 & 1908). Motivated by these insights, AfPEC aims to improve and enhance local agroforestry, being a sustainable development project that works to ensure climate resilience and amend coffee farmers' livelihoods by adapting local Arabica coffee production to climate change and supporting the refinement of coffee. The former goal is set to be achieved through the selection, promotion, and (re-)introduction of native shade tree species that provide ecosystem services and restore local biodiversity (AfPEC, 2026c). The second goal is obtained through the partnership with the Danish coffee retailer, *Frellsen Kaffe*. AfPEC specifically aims to skip middlemen in the coffee value chain by facilitating direct coffee sales through cooperatives (Jacobsen & Kroijer, 2024: 6-8).

In 2023, The Intergovernmental Panel on Climate Change (IPCC) accentuated agroforestry as a climate adaptation measure (IPCC, 2023: 8). Explaining this, Jaramillo et al. highlighted how shade trees mitigate microclimatic extremes and buffer coffee plants from microclimate variability by facilitating up to 4℃ decreases in temperature around the berries (Jaramillo et al., 2011: 6). Furthermore, Ghale et al. argued that agroforestry can be used as a climate mitigation measure because of its carbon sequestration capabilities (Ghale et al., 2022: 227). Other, more specific advantages of shade trees are erosion control, windbreaking, alternative income sources (Johnson et al., 2020: 9), and the provision of crucial ecosystem services like drought resistance, weed and pest control (Rezende et al., 2021: 1). In many ways, agroforestry mimics the natural environment for Arabica coffee by creating the microclimatic conditions that favour the development and long-term productivity of the plant. However, as will become evident through this thesis, the distance between the ideal situation and reality can be far, as the maintenance of healthy agroforestry systems requires knowledge about proper management practices that can be tedious and difficult to access. These include farm planning, id est the right spacing of shade trees/matooke/coffee shrubs, optimal species composition and shade pruning that ensures sufficient air flow and sunlight in the field (UCDA, 2019: 18). The primary constraints that make farmers desist from the agroecological system include the fact that it is a labour-intensive practice (ibid: 19), that trees are competing with coffee shrubs for nutrients and water (UCDA, 2019; Ayalew et al., 2022: 2) and the short-term income potential from selling tree products. Moreover, conceptions that intercropping with trees decrease yields (UCDA, 2019: 19) and that some tree species host pests oppose the willingness to integrate shade trees (Namuyanja et al., 2024: 284; Koutouleas et al., 2025: 190; UCDA, 2019: 18). These are some of the challenges that AfPEC must overcome, if the project is to succeed.

Matooke - the Multi-Functional Stable Crop enabling Coffee as an Investment

38 out of 40 farmers asked across Sipi and Buginyanya are intercropping coffee with “endemic banana cultivars” (Kalyebara et al., 2007: 26), a perennial banana species called “matooke” in the local languages. The plant provides limited shade to the coffee plants and is also often perceived as competing with shade trees. An observation I made in Buginyanya was that most farmers had few shade trees, and that matooke was the primary source of shade on most coffee plots. On two plots, the multifunctional plant had completely outmatched shade trees. Farmers prioritised matooke over shade trees for the short-term gains. Emphasising the advantages of matooke cultivation, Caroline[13], a hard-working 46-year-old farmer from Sipi, explained how she uses matooke for various purposes, such as wrapping goods on *Bodas*[14], animal feed, food, steaming, mulching, et cetera. As shown in the picture to the right, the banana plant prepares new seedlings that “are ready to take over once stumped”, as Caroline pointed out. Her idea was that if you plant and cut matooke throughout the year, you have a stable supply, that enhances your economic and food security year-round. Like Caroline, Chebet, a 40-year-old small-scale coffee farmer living on the slope beneath Sipi, described matooke cultivation as an economic “safety net” that safeguards them against coffee price fluctuations, as is also emphasised by UCDA (2019: 13). In this way, coffee-banana intercropping *enables*[15] Arabica coffee cultivation. Disadvantages of matooke highlighted by farmers and the UCDA included competition with shade trees for nutrients, light, water, and space, transport costs, and the alleged transfer of CPaDs to coffee plants (ibid.). In summary, matooke is both an *enabler* of coffee production in the sense that it is a short-term income source that buffers fluctuations in coffee prices and therefore makes coffee cultivation, as a long-term investment, possible. However, according to some farmers, matooke outdoes shade trees because of qualities such as immediate food provision, its multifunctionality and the fact that it, unlike shade trees, replenishes after harvest. In the most

[13] Caroline is Joseph’s wife and thus the mother of my host family. She is a central collaborator.
[14] A fuel-driven motorcycle used as the main means of short-range transport in the study area.
[15] Other *enablers* and *barriers* to Arabica coffee cultivation will be presented throughout the thesis. Their theoretical basis will be presented in the conceptual framework.

(economically and environmentally) sustainable coffee production system, matooke and shade trees are intercropped with Arabica coffee with sufficient spacing in between them and adequate management of the intercrops. However, my fieldwork made me realise that a wide range of factors and considerations influence such management decisions, the derived effects of climate being one of them.

Climate Change

Together with the land-use change and deforestation identified above, climate change is driving regional environmental degradation on Mt Elgon. On a global scale, climate change manifests as global warming, shifting precipitation patterns, and more frequent extreme weather events such as heat waves, droughts, floods, and hurricanes (Koutouleas et al., 2025: 175). A recently published, global study on the impacts of climate change on various local and indigenous communities concluded that they are already felt, experienced and widespread (Reyes-García et al., 2024: 1).

In recent years, a variety of actors have attempted to predict how these alterations will manifest in Uganda, including their effects on coffee cultivation (Jaramillo et al., 2011; Funk et al., 2012; UCDA, 2019; Johnson et al., 2020; Koutouleas et al., 2025). Funk et al. analysed weather station observations across Uganda (Funk et al., 2012: 1). Among other findings, they concluded that in the period between 1960 to 2009 mean annual temperatures increased by up to 1.5°C (ibid: 2). In just ten years, from 2001 to 2011, the Mt Elgon region experienced a 1°C increase in temperature (Bomuhangi et al., 2016: 3). As is a main point in this thesis, this will have and already have a variety of consequences for coffee farming in the region. Along with rising temperatures, weather variability and changes in *seasonality*[16] have already had serious implications for rural livelihoods in the country (Osbahr et al., 2011: 293). The UCDA emphasises the following about the national implications of climate change:

> "As a result of climate change, Uganda is witnessing ecosystem instability in the form of extreme weather conditions such as prolonged drought, floods, increased temperatures, erratic/irregular rainfall patterns, hailstorms, landslides and thunderstorms. Such changes and instability in the ecosystem has disrupted agricultural productivity" (UCDA, 2019: 107).

Among the climatic factors listed here, a study, that aligns with my ethnographic findings, emphasised droughts and precipitation variability as the primary risks towards the most important crops in Uganda: Maize and coffee (Koutouleas et al., 2025: 176). As confirmed by farmers interviewed in Buginyanya, the authors suggest that changing weather patterns would have "a direct impact up to the later parts of the value chain (i.e., processing and storage)" (ibid.). One reason is that *Coffea arabica* is particularly susceptible to heat stress and climatic variations, as stressed earlier. Along with the general surge in air

[16] In Osbahr et al. (2011), seasonality refers to "farmers' perceptions of the monthly pattern of the rains, including when they should start and end" (Osbahr et al., 2011).

temperatures in Uganda and depending on the climate scenario used, models predict that between 15-59% of areas currently fit for coffee production will be "unsuitable" by the end of the century (Koutouleas et al., 2025: 177; Johnson et al., 2020: 9; Liebig et al., 2016: 2). As a consequence, the elevation and latitude preferred by *Coffea arabica* will change (UCDA, 2019: 108; Koutouleas et al., 2025: 164). By 2050, 1600-1800 masl. will be the optimal elevation for *Coffea arabica* cultivation according to Jaramillo et al. (Jaramillo et al.: 2011: 3), whereas the UCDA indicated that Arabica coffee can currently be cultivated at a minimum of 1300 masl. (UCDA, 2019: 4). As with the risks associated with climate-change-induced pest outbreaks (Ordoñez et al., 2025: 1), such developments could provoke a situation where coffee farmers find themselves compelled to expand their land and thus offend against the forest reserve further up the mountain, potentially causing further environmental degradation and deforestation. An alternative scenario is the trapping of farmers between the forest conservation border and the lower bioclimatic threshold for coffee production. Thirdly, Jaramillo et al. suggested that the altitudinal surge, projected decreasing yields and population growth may force farmers to ultimately "replace coffee farming with the cultivation of food crops" (Jaramillo et al., 2011: 4). This risk was repeated by the young farmer, James (30) from Sipi, who equated population growth with less land for each farmer, which would lead to land fragmentation, land scarcity and associated challenges.

As a final remark, it should be noted that the dire climate predictions have nuances. A combination of the so-called "CO_2 fertilisation effect"[17] (Koutouleas et al., 2025: 178) and potential "management adjustments", such as the integration of agroforestry systems, might decelerate the negative development (ibid: 189). That said, most publications are pessimistic about the impact of climate change on Arabica coffee production in Uganda. Therefore, in the analysis, ethnographic accounts of coffee farmers' experiences with and perceptions of ongoing weather changes will be presented to improve the general understanding of the impact of climate change on local Arabica coffee farming.

Human Security Challenges to Coffee Farmers in Sipi and Buginyanya

An entire dissertation could be written to cover the wide range of insecurities experienced by local Arabica coffee farmers on Mt Elgon. During my fieldwork, I noticed challenges related to their *political*, *environmental*, *food*, *economic*, *health* and *personal security* (UNDP, 1994). In 1991, Kimberlé Crenshaw, an American civil rights advocate, introduced the term *intersectionality* to explain how social justice problems such as racism and sexism often overlap, creating multiple levels of *social injustice* (Crenshaw, 1991). In the same way, coffee farmers are experiencing a multitude of *injustices* or *insecurities* simultaneously. Underlining this claim, Osbahr et al. pointed out how climate change has

[17] The CO_2 fertilisation effect improves the coffee plant's resilience to extreme temperatures and water deficit (Koutouleas et al., 2025: 178).

indirect and direct influence on other, "existing vulnerabilities" such as "health, water availability and agricultural production" (Osbahr et al., 2011: 293). Likewise, Reyes-García et al. described how climate change impacts people who are affected by other "stressors" more severely. These *stressors* include limited access to natural resources and/or poverty (Reyes-García et al., 2023: 3) that can be derived from colonialism, racism, inequality or even environmental injustice (Reyes-García et al., 2024: 5). Among the insecurities identified above, *environmental* and *economic security* are the most significant security-related constraints reported by local coffee farmers (Figure 6), and they will be the focus of this thesis. Accordingly, this paper contributes with insight into the most important insecurities that are experienced by small-scale Arabica coffee farmers on the Western slopes of Mt Elgon. The processing of data from the so-called *AfPEC baseline data* (Kroijer et al., 2024) revealed that in top 3, farmers reported challenges that fit into the themes: "Lack of money for inputs" (economic), "Heavy rainfall and/or floods" (environmental) and "Pests and diseases" (environmental). The *intersectionality* of these insecurities will reveal itself throughout the thesis, thus underlining the interconnectedness of the seven *human security* pillars.

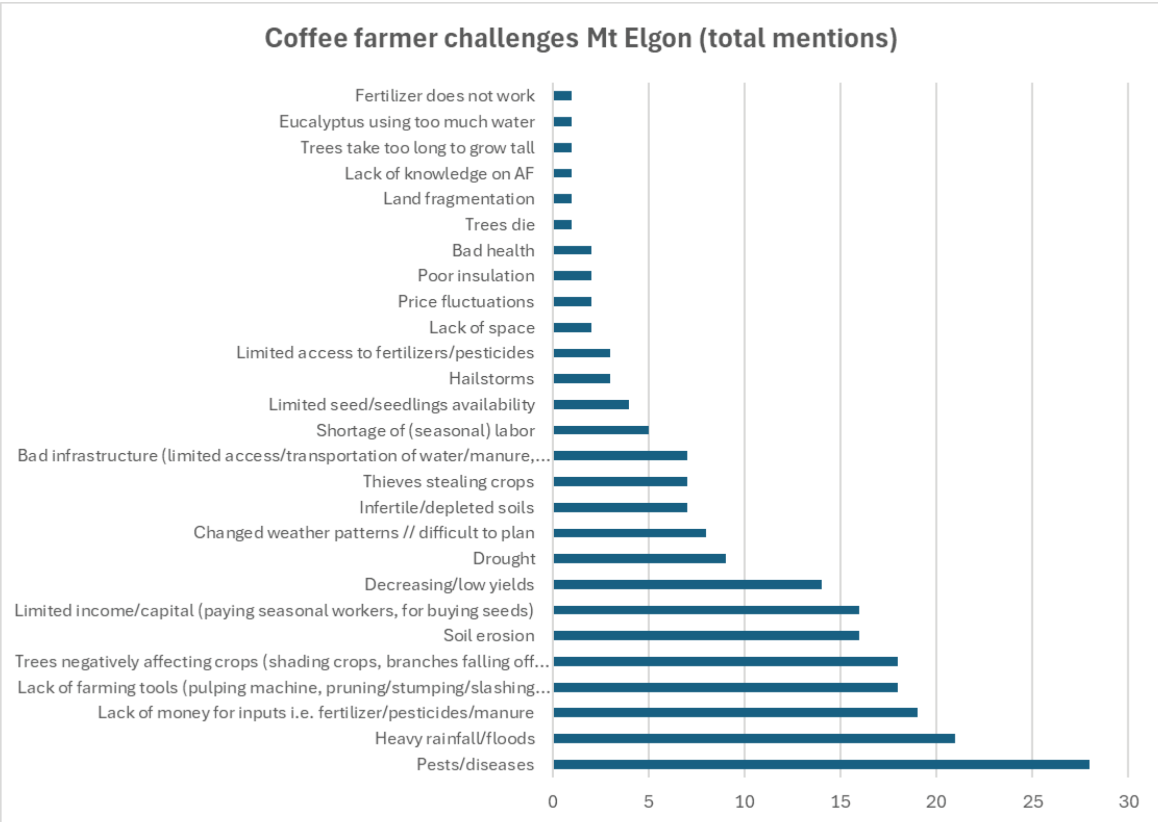

Figure 6*. Self-made chart based upon the 2024 baseline data (Kroijer et al., 2024), combining answers from all four project villages. Farmers were asked about their main challenges. The farmer was encouraged to mention more than one. 81 out of 98 farmers answered the question. Note: AF = agroforestry.*

Conceptual Framework and Theoretical Reflections

In the following section, I will present the main theoretical discussions that the thesis is a contribution to, and the concepts that are directly used in the analysis and discussion or of contextual importance. In the first part, I elaborate how the thesis topics relate to current discussions of themes such as *the Anthropocene*, *invasive species*, *biosecurity* and *biopower.* Throughout the section, I present relevant theories and concepts such as *skilled vision*, *actants*, *novel ecosystems*, *enactment*, *barriers/enablers*, *the ecosystem dis-equilibrium* and *climate injustice*, and finally I specify if and where they will be deployed later.

In 2000, the Anthropocene as a concept was introduced by meteorologist and Nobel Prize winner Paul Crutzen (Steffen, 2021). On several occasions, it has been proposed as the current geological epoch describing the unprecedented scale, rate and complexity of ongoing planetary transformations. These alterations are mainly caused by human activity, thus explaining the concept's etymology. In many ways, the Anthropocene serves as the advantage point from which this thesis' focus emerges. It has sparked my interest in discovering how humans navigate the upheaval of our livelihoods. A research tradition closely linked to the Anthropocene is *posthumanism*, to which *Actor-Network Theory* (ANT) is a central contribution. With ANT, Bruno Latour introduced the term *actants* to describe both human and nonhuman entities, such as animals, other living organisms, and even objects, that are capable of acting, relating, and participating in networks of interaction (Latour, 1996). In recent years, among others in the field of posthumanism, there has been a growing interest in understanding this interconnectedness and in recognising the importance of nonhuman actors for the conditions and flourishing of human life.

In this thesis, one of my claims is that, in coffee farming, developing a multisensory *skilled vision* is essential for understanding the agency of non-human *actants*, such as natural enemies, parasitic plants, pests, and diseases. *Skilled vision* as a notion was presented by Christina Grasseni in her study of stockbreeders, and she formulates it as a: "capacity to look in a certain way as a result of training" (Grasseni, 2004: 41). Alongside visual capabilities, farmers develop other sensory skills that are incorporated in the notion as well (ibid.). Concurrently with my increasing frustration over the fact that farmers were capable of seeing things that I could not, I felt that learning to engage with my host's coffee plants was necessary to access their worldview - just like Grasseni (ibid: 42). The same idea motivated my so-called "field observations"[18], as I wanted to unfold what farmers used their *skilled vision* for.

[18] This methodological approach will be elaborated in the section below.

In his thought-provoking[19] monograph on central issues in conservation biology such as invasive species, *Emergent Ecologies (2015)*, the cultural anthropologist Eben Kirksey asks:

> "When do new species add value to ecological associations, and when do they become irredeemably destructive? When should we let unruly forms of life run wild, and when should we intervene?"
> (Kirksey, 2015: 1).

Given local Arabica coffee farmers' economic dependence on coffee production and the ways coffee pests and diseases (CPaDs) threaten their livelihoods, most farmers appear inclined toward the latter position on both questions. This expressed itself when farmers "enacted"[20] *actants* in terms of their (lack of) applicability for their coffee production. CPaDs and parasitic plants, or "antagonist"[21] species, simply counteract their on-farm productivity and is thus deemed unwanted. Contrary to CPaDs, natural enemies of CPaDs are viewed positively as they protect against antagonist behaviour**.** Considering these views, the farmers could easily be criticised as human-centric in their view of their *nonhuman* surroundings. However, Kirksey encourages a movement away from such traditional views, as they (conservation biologists) see humans as "inherently destructive" (Kirksey, 2015: 5) because *we* are driving "enclosed" ecosystems and species extinct. Instead, Kirksey argues that the loss of previous species and "the emergence of novel multispecies assemblages" has shaped ecosystems for a long time (ibid: 3)[22]. In this statement, he draws on reflections of Arthur Tansley, who in 1935 introduced the term "ecosystem", describing how such systems are not isolated and "pristine" units but interconnected with the human world (ibid: 2-3). However, since contemporary and current ecologists have created the hegemonic discourse that ecosystems are in fact "pristine" and "isolated", Kirksey proposes the term "novel ecosystem" to bring cultural inventions, such as machines and industrial supply chains, and biological elements together into "unusual assemblages" (ibid: 3)[23] and thereby recall Tansley's original idea of ecosystems. Following this logic, the promotion of shaded coffee systems can be perceived as an alternative conservation effort that escapes the idea of nature as something "clean" that is cut off from human interventions and interactions and instead acknowledges the interplay between "natural" ecosystems and "cultural" agricultural production. Following this logic, Schwarze et al. described *novel ecosystems* as "diverse but invaded, neglected but resilient, anthropogenic but wild" (Schwarze et al., 2013: 248). By that, humans are juxtaposed with the *nonhuman* world contrary to Western ideas about the nature/culture divide, human superiority and exceptionalism (DeMello, 2011: 341; Ives, 2019: 1).

[19] The author attempts to view current ecological crises in a less despairing way, being open towards the possibilities that arise along with the ecological changes.
[20] As will be clarified below, *enactment* happens when certain actors are using words with negative connotations to distinguish harmful from beneficial co-species of coffee.
[21] Henceforth, "antagonists" will be used as the collective name for coffee pests, diseases and parasitic plants.
[22] Here it should be noted that, today, the rate of species extinction exceeds that of species evolution. Kirksey might not have been aware of this fact, more than ten years ago.
[23] To make it correspond with the local context, one could add novel entities such as agricultural inputs, plastics, weeds, unprecedented weather patterns and -phenomena to the list.

These views agree with the fundamental assumption in *multispecies ethnography* - a discipline that combines biological and social perspectives to explore the interconnectedness of all living species; non-human *actants* and humans[24]. An example from local coffee farming is how natural enemies and coffee farmers cooperate to "prevent", "fight", "control" or "manage" coffee *antagonists*.

As will be clarified in the analysis, a few species fall outside the binary categories (natural enemies versus *antagonists*) presented here, as they are both beneficial and destructive in local farmers' view. Interestingly, such out-of-category *actants* proved to be a source of vivacious debate[25]. The coffee farmers' view of nonhuman *antagonists*, their agency, and value in coffee cultivation is shaped by perceptions of nature introduced during the British colonial regime. When farmers refer to CPaDs or parasitic plants as "harmful", or as constituting a "threat" or "risk" to their coffee, they indirectly refer to these ideas. Taking action against *antagonists* is an act of *biosecurity*. *Biosecurity* can be described as: "the exclusion, eradication or effective management of risks posed by pests and diseases to the economy, environment and human health" (Johnson et al., 2020: 22). As defined here, *biosecurity*-related actions are human-centred, focusing on human interests rather than admitting that the proliferation of *antagonists* is one of the consequences of monoculture: Self-evidently, the co-species of coffee thrive once their habitat is accessible in large quantities. Notwithstanding this argument**,** *antagonists* stand in the way of optimal coffee yields, which, for most small-scale farmers, are the key to securing the family's livelihood. In this sense, farmers have limited alternatives to applying *biosecurity* measures when competing in a global market under the conditions of the capitalist system.

A "weed" is another example of an *actant* that incites *biosecurity* approaches, being a term that can be deployed to understand farmers' views on parasitic plants such as the dodder weed. *Weeds* have been defined as "plant[s] in the wrong place (...) growing where you would prefer other plants to grow, or sometimes no plants at all" (Mabey, 2010: 4). Considering this, coffee production should be seen as a commercial activity existing in continuation of the criticized paradigm, where even disturbances from species that appear in the original ecology of *Coffea arabica* might be viewed as misplaced.

In all the instances listed here, certain organisms are *enacted* as "pests", "diseases", "natural enemies", "parasitic plants", "weeds", et cetera, as was the case with *atherosclerosis* in Anne Marie Mol's *The Body Multiple (2003)*. Seen through the lens of *enactment,* actors in the coffee sector, including myself, are using words with negative connotations to distinguish harmful from beneficial species, despite potentially being aware that these *actants* can have functions and benefits in other contexts, for example,

[24] Central contributions to this debate include Parathian et al. (2018) who studied human-wildlife interactions, and the the ethological approaches to the study of animal cultures and social behaviors that was seen in Hartigan (2021).
[25] I return to this point in the analysis when exploring the role of "black ants".

in a less human-influenced ecosystem. This process of *enactment* and its consequences can be viewed as an exercise of Michel Foucault's term "biopower", which is described accordingly:

> "The division between what must be maximized, or made to live, and what must be diminished, or allowed to die, is based not on [the] inherent value of an organism but rather on its supposed relation to the population" (Biermann & Mansfield, 2014: 261).

In the case of coffee *antagonists*, their relationship to "the population" is deemed destructive, which explains why farmers choose to "get rid of them". Pest management is thus an example of "biopolitics" in that it targets unwanted species at "the level of the population" (ibid: 259). That is, the eradication of certain species is justified through a generalisation based on the conception of a biologically defined race, called "species" (Biermann & Mansfield, 2014: 258). So, in the posthumanist view, the categorisation of nonhuman *actants* as either "good" or "bad" and the derived actions can be understood as an act of racism (ibid: 261).

Summing up, the current *posthumanist* logic rejects both the preservationist logic that nature is an "inherently valuable external realm" to be protected from humans, and the capitalist logic that nature is "a set of commodities with exchange values determined by the free market" (ibid: 260). Through the application of posthumanist theory and methodological approaches, this thesis aims to recognise the defining role of nonhuman *actants* while also speaking to local farmers' *perceptions* of their natural surroundings.

A short section in the analysis will be dedicated to uncovering the latter phenomenon in relation to climate change, since understanding local farmers' *perceptions* is a prerequisite for successful climate adaptation (Bomuhangi et al., 2016: 3; Aggrey et al., 2024: 2; Reyes-García et al., 2023: 2; Osbahr et al., 2011: 294). According to Bomuhangi et al., *perceptions of environmental changes* refer to "the way local people identify and interpret [weather] observations" (Bomuhangi et al., 2016: 3). Local *perceptions* have proved to be a crucial supplement to scientific, meteorological data, since experiences of climate impacts can be exceptionally local, for instance, depending on the local microclimate and livelihoods (Reyes-García et al., 2023: 1).

Apart from *antagonists* and climate change, local coffee production is faced with other challenges, or "barriers" as well. As was presented in Figure 6 above, these include price fluctuations, limited capital for farm investment, inadequate extension services, et cetera (Figure 6). Normally, *barriers* and *enablers* are used in agroecology to describe the structural conditions that act as obstacles to or supporters of the agroecological transition. In this context, however, *barriers* and *enablers* will be used more specifically to refer to hindrances to or facilitators of local Arabica coffee farmers' (economically and environmentally) sustainable production.

One major *barrier* to future Arabica coffee farming in the region is what Koutouleas et al. termed the "ecosystem dis-equilibrium" (Koutouleas et al., 2025: 168), which is a result of climate change. Climate change is a key driver of alterations in the distribution and severity of coffee *antagonists* owing to their varying microclimatic preferences. The *ecosystem dis-equilibrium*, hence, describes the shift in *antagonists*' geographical ranges, moving most of them to higher altitudes and latitudes (Ma et al., 2025: 265). The authors suggest that this might increase the severity of outbreaks and, over the long term, lead to a geographical shift in regions suitable for coffee production (Koutouleas et al., 2025: 194). The concept is of great importance for the understanding of climate change impacts on coffee farming; a question that will be treated in both the analysis and the discussion. On a global level, coffee farmers and tropical regions are facing "unequal impacts of climate change" (OECD Ecoscope, 2024). The idea behind this is based upon what has been termed "climate injustice", which is "[t]he combination of highly unequal GHG [GreenHouse Gas] emissions and highly unequal vulnerability to climate change" (Healy et al., 2019: 221). In the analysis, both tendencies will be related to local experiences with climate change, after which I will discuss some of their implications for coffee farming.

Methods & Methodological Considerations

Over a period of seven weeks, starting in October 2025, I conducted my fieldwork on the northwestern slopes of Mt. Elgon, combining data collection with project placement. During this period, I was mainly operating in the vicinity of my host family's home in Sipi, Kapchorwa District. However, by the end of October, one intensive week of data collection was spent in Buginyanya, Bulambuli District, where 19 interviews were completed, while the last ten days were spent with AfPEC project representatives from Denmark and Uganda in the project villages and in West Uganda. In total, 50 (semi-) structured interviews, a limited number of informal conversations, and several coffee field observations were conducted. Furthermore, a dozen farm visits were done at the initiative of farmers themselves, most of which focused on identifying CPaDs and signs of infestation. Finally, a self-organised coffee farmer workshop was held in Sipi on the 15th of November, along with other project-related activities during that last period. On a daily basis, I took field notes and pictures when I encountered something of interest to my contextual understanding or to the focus of my research. The overall methodological approach is best described as *mixed methods* (Eilenberg & Harrison, 2023: 2-3), as I am combining both qualitative and quantitative data, and primary and secondary data collection methods. The latter is reflected in my pre-fieldwork desktop research and the baseline data analysis, as well as in the post-fieldwork data processing and analytical work.

In the months leading up to October 2025 and thus departure, I did desktop research (State Government Victoria, 2023) on coffee farming, participated in AfPEC meetings, gave feedback on promotion videos, and analysed one third of the baseline data that was collected through structured interviews by the 2024 AfPEC interns, members of SwB[26] and a representative from YLEC[27] (Kroijer et al., 2024). The report revealed several interesting findings that also inspired my research focus. The parts of the baseline data, I was responsible for, addressed questions such as coffee farmers' challenges, observed environmental changes, and changes in management practices after the initiation of AfPEC. What especially caught my attention was that CPaDs were reported as the greatest challenge across the four project villages, and that Sipi was the area where the largest share of farmers (10 out of 19) mentioned it as a challenge (Figure 6). I also noted that farmers complained about "too much rain" throughout the interviews and that most of them identified a change in weather patterns, with increased unpredictability as a consequence. So, even though I planned to take an open approach to the "field", my interests were somewhat shaped by the answers from the baseline data. However, since the baseline data reflected local experiences with and *perceptions* of climate change, I considered the focus empirically relevant. Similarly, it was the baseline data, combined with insights from initial interviews, that inspired my focus on CPaDs.

During coffee field observations and farm visits, Actor Network Theory (ANT) was the methodological source of inspiration. Following this approach, the agency of *antagonists* and natural enemies was given attention. ANT is a strong methodological approach that can reveal a network of relationships and harms that would be less evident when seen through a traditional, anthropological, human-centred lens. Additionally, a wealth of information is embedded in *local ecological knowledge* (LEK), memory, and culture (Berkes et al., 1998). Therefore, I combined the ANT approach with traditional anthropological methods such as semi-structured interviews and informal conversations. As emphasised above, these methods were complemented by a participatory workshop that facilitated the co-creation of knowledge[28] on CPaDs. In the following section, I go through each data collection method, explaining the procedures, potential challenges, and pitfalls. This is followed by a section on ethical considerations.

Methodological Reflections on the (Semi)-structured Interviews

After several revisions, my interview guide focused on 1) the farmer's livelihood, their coffee farming system, perceived advantages and disadvantages of shade trees, and methods for CPaD identification,

[26] Seniors without Borders (SwB) is a Danish NGO focusing on sustainable development (Seniorer uden Grænser, 2026). Both Danish and Ugandan SwB members and employees have been working on Mt Elgon since 2017, establishing the VSLAs and FFLGs that AfPEC is cooperating with today.
[27] Youth Leading Environmental Change (YLEC) is a Uganda-based non-profit organization that works with public awareness, training, advocacy, and research in environmental conservation (YLEC, 2026).
[28] Co-creation of knowledge is one of the 13 agroecological principles. The objective is to: "Enhance co-creation and horizontal sharing of knowledge including local and scientific innovation, especially through farmer-to-farmer exchange." (HLPE, 2019: 41)

prevention and eradication. The second part contained questions that openly asked the farmer about their experiences with local weather changes, associated challenges, and the reasons for them. The latter half of the interviews included questions about coffee marketing, and, specifically, all interviews in Buginyanya included questions about the collaboration with the Danish coffee retailer, *Frellsen Kaffe*. All interviewed farmers can be categorised as small-scale farmers when using the definition presented in (Wedig, 2019: 1). In Buginyanya and Sipi, the total farm size averaged 2.44 acres and 3.1 acres, respectively, divided between an average of 3.1 and 4.6 fragmented coffee fields (Jacobsen & Kroijer, 2024: 4; Appendix 1)[29]. Most interviewed farmers lived in traditional homes made of cow dung and clay, covering a wooden structure. Adjacent to the main building, a cooking hut, a minor coffee plot and a kitchen garden were often found. In their backyards, domestic animals, except for cattle and goats[30], were freely roaming around. A large part of the interviews was conducted just outside the farmers' homes, typically while sitting on plastic chairs with a view of their home coffee gardens. As mentioned, we also sometimes visited nearby coffee fields at the farmer's initiative. Before the interview, we went through the consent form (Appendix 2), and after the interview, I handed out a bar of soap to express my gratitude. Considerations in relation to this are presented in the coming section.

Implications of Translation and Compensation

The interviews that were the foundation of the baseline study (Kroijer et al., 2024) can be characterised as "structured", meaning that the questions were fixed and asked in a predefined order, one question at a time, leaving no space for follow-up questions. Several of the interviews that I conducted during my fieldwork shared similar traits, which explains why I characterise the 50 interviews as "(semi)-structured". Structured interviews tend to be more straightforward than semistructured interviews, which tend to dwell on details. Considering this, those of my interviews that were unintentionally short-lived or somehow rushed are more appropriately defined as structured interviews. Ideally, I wanted to prompt reflection on most of the questions, especially the latter ones. So, for example, when asking about farmers' experiences with and *perceptions* of climate change, I wanted to be able to ask follow-up questions and follow potential leads. However, this was not always possible, and there are several reasons for that. For example, I see clear differences between the interviews that have been translated and the interviews I conducted in English on my own, as the latter were longer and less structured. Some understanding can be lost in translation from English to Kupsabiny (the language of the Sebei people) or Lugisu (the language of the Bagisu) when a translator, for example, changes the question to make it clearer to the interviewee. Similarly, I had to reformulate some questions because I received answers that did not fit them. In an ideal world, I would have learned to speak the local language, which would have allowed me to have more control over the conversation, ask more follow-up questions,

[29] Please note that the farm size average in Sipi is based upon numbers from the baseline study (Jacobsen & Kroijer, 2024: 4), while the average farm size in Buginyanya was calculated based upon 13 farmers' estimates (Appendix 1).
[30] Cows and goats were often tied to a pole with a rope and continuously moved.

follow leads and make the interview more dynamic - all characteristics of semistructured interviews. That being said, I find the consequences of avoiding interviews that needed translation greater than the implications of translated interviews outlined here. After all, when I compare having a conversation with a diverse group of farmers of varying quality to doing interviews independently, with *elite capture* and limited representativeness as potential consequences, I find the consequences less severe in the former case.

Throughout my fieldwork, I collaborated with four different translators. In Sipi, most interviews were arranged and carried out in cooperation with a young woman, while three were conducted with help from the 20-year-old son of my host family. In Buginyanya, I was accommodated by a young family. The 35-year-old husband assisted me with half of the 19 interviews, and on days when he was busy, an even younger farmer from the same cooperative helped me locate the farmers' homes and translate the interviews. All interviewed farmers in Buginyanya were a part of the same coffee cooperative as the translators. Common to the translators and interviewed farmers was that they are somehow affiliated with AfPEC, either as contact persons, coordinators, members of involved Farmer Field Learning Groups (FFLGs) or Village Savings and Loans Associations (VSLAs). In either case, access to farmers was gained through my project placement. This relationship between the translator and the farmer fostered a trusting, comfortable atmosphere, but at times it also left room for small talk during the brief breaks that arose while I was jotting down notes in my notebook. Prior to the fieldwork, I had considered recording all interviews on my phone to ensure my full presence. However, I decided I could listen while writing. In retrospect, voice recording could have improved the quality and flow of the interviews, creating space for more conversation-like interactions. Another challenge was that, over time, 3 out of 4 translators showed less interest during the interviews, sometimes yawning, texting, answering calls, or even playing on their phones, becoming decreasingly present. As a consequence, I checked in with them between interviews, but they repeatedly assured me that they had time and were interested in continuing the interviews. Regardless, I fear that some farmers also lost interest during the interviews, mirroring the translators' behaviour, and that, in some cases, this limited the length and depth of their answers and thus the quality of the interviews. Whether this is a consequence of paying translators remains uncertain, although it is possible. In accordance with the project's code of conduct, the translators were paid 15,000 UGX[31] per day to compensate for the time they could have spent on other income-generating activities. Despite their busyness, being involved in farming themselves, they allocated time to assist me with translating the interviews, which proved indispensable due to the lack of English skills among most interviewed farmers. Additionally, the translators improved my access to the farmers, both by helping me set up interviews and by increasing mutual understanding between the interviewee and me.

[31] Equals 3.4 EUR. The longest interview days lasted up to 5 hours, including several breaks.

To compensate the interviewed farmers for the time “lost” during interviews, I followed the former year’s interns' approach and gave each farmer a bar of soap worth 3,000 to 4,000 UGX, depending on the quality of soap available. The soap is being used for (dish)washing and cleaning in the majority of households in Buginyanya and Sipi. I made this decision based on discussions with the mother of my host family, the main translator in Sipi, and project representatives, who all emphasised that farmers were busy during the harvesting and processing period meaning that compensation was necessary. Being aware that it could affect the relationship between the interviewer and the interlocutor, I gave the bar of soap after each interview. Commenting on this, Azar Masoumi identified the risk of reinforcing socio-economic hierarchies by creating employer-employee-like relations (Masoumi, 2024: 1). On the positive side, however, compensation has been promoted as a way to recognize research participation as a kind of labour, while improving trust, increasing inclusion and, contrary to Masoumi’s experiences, reducing power imbalances (Camilleri et al., 2025: 1). My personal experience was that all farmers were satisfied with the compensation, and that the only downside of the approach was that it became a motivation for being interviewed. Whether some farmers are left feeling disregarded after my fieldwork remains unclear, but it is possible. That said, all farmers who proposed being interviewed were interviewed. I kept track of this in my notebook.

In addition to soap as compensation, I prepared an overview of the most widespread coffee *antagonists*, their biology, and how to identify and manage them. Initially, the document was developed to deepen my understanding of the same themes and the relationship between the farmers and the *antagonists*. However, as the interest and demand for the specific information increased among interviewed farmers, I decided to refine and design it so that it could be distributed back to them through AfPEC. The result is a draft background document containing information on all identified *antagonists* (Appendix 3). The document consists of background information and references to the literature that has informed preliminary brochures of the four most significant CPaDs: Coffee Berry Disease (CBD)[32], White Coffee Stem Borer (WCSB)[33], Coffee Berry Borer (CBB)[34], and Coffee Leaf Rust (CLR)[35] (Appendix 4). The background document is a collection of a wealth of scientific and local knowledge from Sipi and Buginyanya on coffee *antagonists* and their management[36]. The background document and brochures were designed using Canva. The aim is to enable local coffee farmers to overcome the major *barrier* to coffee cultivation in the region through entirely organic preventive and control practices. If that is to be

[32] The biological name of the fungus is *Colletotrichum kahawae* (Appendix 3).
[33] The biological name of the beetle is *Monochamus leuconotus* (Appendix 3).
[34] The biological name of the beetle is *Hypothenemus hampei* (Appendix 3).
[35] The biological name of the fungus is *Hemileia vastatrix* (Appendix 3).
[36] The background document is based on a wide range of locally relevant literature, handbooks, expert opinions, literature reviews, site-specific knowledge and LEK which might counteract the previous shortage of studies incorporating Farmers’ Perceptions and Knowledge (FPK) (Liebig et al., 2016: 2).

fulfilled, AfPEC project partners, FoW[37], YLEC and JESE[38], are encouraged to create E-learning videos that can be directed towards illiterate or native-speaking farmers with limited English skills. These can be disseminated to farmers in Lugisu, English, and Kupsabiny through Living Labs in the four AfPEC project villages and potentially beyond. Hopefully, AfPEC has the resources to continue developing these so that, eventually, they can be an easily accessible source of knowledge relevant to all Arabica coffee growers in the region. The overall objective is to increase knowledge of the biological and epidemiological nature of coffee *antagonists*, methods for identification, and organic preventive and control measures through the dissemination of multimodal, multisensory knowledge about coffee *antagonists*. In this way all farmers hopefully develop a *skilled vision*, enabling them to effectively manage the coffee *antagonists* in a sustainable way.

Being a comparable study, Liebig et al. highlighted a broad range of reasons for the local need for an overview like the one provided here. Initially, they establish that biological and epidemiological knowledge about coffee *antagonists* and the capability to identify them correctly is the foundation for successful management (Liebig et al., 2016: 14). This was echoed by Ma et al. and Namuyanja et al., who underlined that the improvement of pest identification, monitoring, prediction and management is crucial (Ma et al., 2025: 278; Namuyanja et al., 2024: 277). Contrary to the Arabica Coffee Handbook (UCDA, 2019), which provides general recommendations and guidelines for Arabica coffee farmers across the country, the background document presents updated, locally tailored knowledge drawn from a wide range of sources, including the handbook itself. The overview might also, at the time of the handbook's publication, include unknown solutions to problems with *antagonists* such as the dodder weed, which was only recently discovered in Sipi. Moreover, given that several farmers identified a lack of information on the topic, knowledge of the handbook's existence might be limited in Buginyanya and Sipi, or otherwise abstruse.

Methodological Considerations on Coffee Field Observations

While preparing the background document, I spent several hours in my host family's nearby coffee gardens, identifying CPaDs, natural enemies and practising my picking skills. Three smaller coffee fields, owned by my host family, surrounded their home in Sipi. On days when the weather and my lack of plans allowed it, I went into the coffee gardens to observe, pick coffee, and hopefully discover the co-species active around the plants. The husband and wife taught me which berries to pick and which to avoid. It was considerations about the berries' level of maturation and the signs of CPaD activity that

[37] Forests of the World (FoW), also known as *Verdens Skove* in Danish, is "a Danish Green Development Organisation that Fights for a World with a Rich Forest Nature" (Forests of the World, 2026). FoW is an AfPEC partner that takes care of the Living Labs.

[38] Joint Efforts to Save the Environment (JESE) is a Ugandan NGO "focusing on agriculture, integrated natural resources management, and water, sanitation and hygiene" (YouTube, 2026). Like FoW, JESE is developing the Living Labs in AfPEC.

were emphasised, and hence, I started picking coffee berries in my spare time. When planning the fieldwork, I had expected to be able to do more participant observation with a greater variety of coffee farmers. Despite several arrangements being settled, farmers never showed up[39]. As a consequence, I went into the coffee gardens myself and asked my host parents questions when something new caught my attention. When they were away from home, I took a picture or a video and showed it to them when they returned. In that way, I developed what can be described as a *skilled vision* (Grasseni, 2007): Over time, I was able to identify a wide selection of CPaDs. I also identified several natural enemies of coffee pests, especially chameleons, ants, and a diversity of insects. The berries I picked were a contribution to my host family's harvest, serving as a kind of compensation for their hospitality apart from the weekly payments they received. In general, field observations taught me how physically demanding coffee fruit harvesting is, how weather restricts farm activities, and how farmers develop a *skilled vision* to distinguish between good- and bad-quality berries. This will be further developed in the analytical section.

Along with field observations, I have been *hanging out* (Nair, 2021: 1307) in the parish centres and at the cooperative, Sipi Organic. Moreover, the host family and I had sustained conversations in their living room, during afternoon tea and supper. When travelling to and from Sipi, I had a few informal conversations with other “taxi” passengers, revealing interesting regional variations in both culture and coffee farming practices. Finally, when I had the chance, I helped pick berries while chatting with farmers. Apart from my participation in the processing of coffee into parchment, this was the closest I got to doing participant observation.

Methodological Reflections on the Participatory Workshop

Halfway through November, after a week with sickness and some days of project-related work, I arranged an AIC-inspired participatory workshop (Mikkelsen, 2005: 95) in collaboration with project representatives, focusing on CPaDs. The location was a church in Sipi, which AfPEC often used for FFLG meetings. The workshop started at 11:30 a.m. when 18 farmers had arrived, despite around fifty farmers being expected. The limited number of participants could be caused by several factors. The most likely explanation was that farmers were utilising the favourable weather conditions to pulp, ferment and dry their coffee, as the workshop accidentally coincided with the beginning of the dry season. Another explanation was that farmers were invited to a variety of ceremonies in the afternoon. When this came to my knowledge, I reduced the program and excluded parts on preferred tree species, their advantages and disadvantages. Hence, the coffee farmer workshop centred on identification, ranking and preferred management practices of CPaDs identified in the Sipi area (Appendix 5). At the workshop, participants were randomly assigned to five groups of 4-5 people to facilitate group

[39] As Joseph said, this might be the result of the season's busyness or farmers' limited timekeeping skills.

discussions and knowledge sharing. The group included between no and two AfPEC project representatives. There were four representatives in total which means that two groups did not have a member of the AfPEC delegation. Comparing answers from groups with and without AfPEC representatives showed no notable differences in the responses on the piece of paper they handed in after the group discussion. This could have two reasons: the first being a lack of knowledge about CPaDs among some project representatives, and the second being their calculated reluctance to influence the results of the group work. I allowed the representatives to participate to foster collaboration between them and the farmers and to ensure that each group had a member capable of writing in English. During the workshop, I observed, visited the different groups and listened to their conversations. My impression was that project representatives were either passive, taking notes on the task sheet or trying to facilitate the discussions by asking open questions. I cannot, however, be sure what exact impact they had on the results of the workshop. Specifically, I cannot be certain that the identification of CPaDs has been free of their influence, which means I cannot use it to assess the level of knowledge about CPaDs among this otherwise relatively representative group of Sipi farmers. This had otherwise been my intention: explaining why the first question was not open but instead showed pictures of the most prevalent CPaDs in the area (Appendix 5), which farmers were asked to name.

The second question, asking the group to rank the CPaDs' severity from 1 to 5, was interpreted in various ways. The groups disagreed on whether the assignment was to conduct a general assessment of the most harmful CPaDs in the region or to base their answers on experiences from their own gardens, the latter being the original purpose of the task. In addition, two groups, following the task's original purpose, disagreed to a point where several pests and diseases were given the same rank. As a consequence, the data from the second question could not be processed quantitatively, and, frankly, more participants were needed to ensure representativeness and thus quantitative validity. Nevertheless, the data could be assessed in its own, qualitative right. The last question was about organic management practices that can be applied to prevent or control the specific CPaD. Fortunately, the groups did not limit themselves to listing three, as the task description otherwise stated. This last question sparked a lot of debate, knowledge exchange, and disagreements during the joint discussion that followed the group exercise. Here, we went through the group's answers, one pest or disease at a time, and this approach proved to be useful for the background document (Appendix 3). Another positive outcome of this approach to data collection was real-time knowledge sharing and discussion among farmers, thereby benefiting them directly. In interviews, knowledge flows in one direction from the interviewee to the interviewer, and in such situations, it is up to the researcher to decide whether the knowledge is returned to the collaborators after data collection and processing. When the knowledge from your study can be used locally, I find the applied approach self-evident, and in that sense, the participatory approach is most useful. Insights from the participatory workshop will inform the analytical session and contribute to the information that will be disseminated to local farmers through the brochures and potential E-learning videos. As direct compensation to the participants, the project offered *chapatis* (savoury pancakes) and a soda, which was also the practice at the other three group meetings held in the surrounding days in the remaining project villages. After the workshop, one of the farmers introduced me to a - at that time - yet unknown challenge to local coffee production, namely the dodder weed, a parasitic plant which was only recently spotted in the area. This parasite was also interesting, considering the potential damage the weed can bring. As Sukuku said, “in ten years, all coffee will be dead, if we don’t do anything”. He directly recommended owners of the affected fields and project partners to take immediate action against the parasitic plant

Project-related Activities and the End of the Fieldwork

During my sixth and seventh week in Uganda, the AfPEC delegation and I carried out a number of activities, including FFLG meetings in the four project villages, focus group interviews and individual interviews - the latter two focusing on preferred coffee shade tree species and gender dynamics in tree management. The first week of their visit took place in the project villages. Subsequently, five days were spent travelling to and visiting AfPEC project partners operating in Western Uganda: FoW and JESE. These organisations are experimenting with agroforestry and diversifying Robusta coffee farmers’ incomes by introducing cocoa, vanilla, and macadamia nuts as intercrops. Here, pros and cons were considered to assess what could be promoted to Elgon farmers. The field trip marked the official end of my fieldwork. However, during the last week of November, I returned to Kapchorwa District to join a high-altitude running camp with a group of Danish friends. Between the training sessions, I spent time collecting my thoughts, reading through my notes and organising my material. As if determined by destiny, I was near Sipi, when I lost 250 photographies from the fieldwork during a transfer from my mobile phone to my computer. In that way, it was possible to revisit some of my contacts in Sipi and take the pictures I remembered. So, the photos that I brought back to Denmark might look different and be fewer than if I had not encountered technical issues. The incidence could not be reversed, despite numerous attempts, and it is therefore a limitation to the empirical foundation of the thesis.

Data Processing

After fieldwork, the primary data (fieldnotes, recorded interviews, and photos) were coded using descriptive coding to identify empirical patterns and themes. This process uncovered the relevance of topics scrutinised in this paper. An inductive approach has been applied to let the data speak for itself and, hence, let it call upon relevant theory. Notes from interviews that did not qualify as qualitative data were categorised and simply counted to reveal more general patterns about themes such as CPaD distribution, the coffee farming system, experiences with and *perceptions* of climate change. The quantitative, primary data and secondary data have been organised and processed using Excel (Kroijer et al., 2024; Appendix 6) and Google Sheets (Appendix 1; Appendix 7; Appendix 8). The primary data comes from (semi)-structured interviews and is therefore limited to relatively few respondents. As an example of this lack, the identification of CPaDs depended not on (natural) scientific measurements but on farmers' memory and knowledge that proved to be inadequate. This limits the wider representativity and accuracy of the data. However, the data had a great representativity regarding gender and age, as well as method for cultivation (organic or conventional). Follow-up studies are encouraged to compare the CPaDs mentioned by farmers with biological measurements. This would reveal the gaps in farmers' knowledge about CPaDs that are crucial for the understanding of how to tackle the major challenge for local Arabica coffee farmers.

Ethical Considerations

Some ethical considerations have already been made in the section above. Here, I will go through the ones remaining. The first concerns the (semi)-structured interviews. Ideally, before starting the interviews, I handed out and presented the consent form (Appendix 2), which was based on the EU GDPR rules (Aarhus University, 2026). 49 out of the 50 farmers gave informed, written consent. The 50th farmer refused to take the time to go through the consent form, as he found it "unnecessary". In his mind, oral consent was sufficient. Other farmers had the same attitude but were convinced of the necessity of them after they were introduced adequately. Consent forms from the first eight farmers were signed a few days later, but I should have handed them out before the interview, as was the practice for the subsequent interviews. This would have given the individual farmer a fair chance to consider whether they wanted to participate, once they knew the terms and conditions. To remedy this, the same farmers were revisited; we went through the consent forms, and they were all signed. In cases where the farmer had limited or no English proficiency, the translator went through the consent form in Kupsabiny or Lugisu and ticked the boxes (Appendix 2), acting as the farmer's representative. In the few instances where the farmer was illiterate, the translator presented the form and signed it on their behalf when the farmer allowed it. I decided this was an appropriate practice, given the friendly relationship between the interviewed farmers and the translator: They were either members of the same VSLA and/or FFLG, family friends or even relatives. Secondly, regarding anonymisation, 49 out of 50 farmers explicitly wanted "recognition" (American Anthropological Association, 2009: 3), so that their names appeared alongside their statements. One farmer gave consent but wished to be anonymous, so he was given a pseudonym. Lastly, considering the photographs, I assured that no individuals were recognisable.

In general, I have been deeply aware of the need to conduct "ethical research"[40], as I was working in a postcolonial setting. Regarding this, I was inspired by Smith (2012) and Pali et al. (2022). When deciding where to do my project placement, it was of utmost importance that the partner organisation

[40] Obviously, this is always important.

operated in accordance with these requirements. So, when I learned that AfPEC was engaging in a participatory manner, establishing Living Labs and cooperating with seven FFLGs that have been collaborating with *Seniors without Borders* (SwB) since 2017, I decided to apply for the internship. In connection with this, I have strived to base my thesis project on local knowledge. For example, most of the knowledge about CPaDs that are given back to farmers comes from other local farmers, my own field observations, combined with feedback from my host family, or research that takes local knowledge seriously. This comes together in my applied approach to the thesis, which avoids the traditional one-way flow of knowledge and instead emphasises knowledge exchange.

Analysis

Producing Coffee: *Barriers* and *Enablers* in Coffee Farming

- "After picking only the ready berries, you take them at home, in the house, at a safe place. It sleeps there for a night. Then the following day, you put it into a pulping machine. You pulp. After pulping then you get the pulped coffee, still you put it back in the house for two nights to ferment. Then the following day after fermenting, you take it for washing. You wash. When we wash, we use baskets for washing. Now after washing they become clean. Only the coffee berries [pulps] get off. Now when they are clean, even you touch and feel they are clean. That slipperiness is over. Now you take it to dry. Now the drying. If the season is like now, dry season, drying can take three to four days, but during the rainy season, even drying can take two weeks or three before the [beans] are dry. Now after they have dried, you are either free to sell or keep. For that is now parchment" (AfPEC, 2026b: 1:58-3:23).

The further a farmer refines his or her coffee, the higher the potential revenue. However, all interviewed small-scale coffee producers sold "unprocessed" coffee, which they called "berries"[41] or "processed" coffee called "parchment"[42]. The reasons why they stuck to the lower and least lucrative levels of the coffee value chain were several, but both short-term needs, the fact that processing takes time, and the lack of machines, materials and/or tools were examples of *barriers* to gaining a higher income.

When looking at the entire Arabica coffee value chain, the remaining marketing options include the refinement and sales of "green" coffee beans (without the sand-coloured husk distinctive for parchment), instant coffee, roasted green beans or ground coffee. These latter options are the most lucrative, as they face the highest international consumer demand (Grand View Research, 2026). However, an *intersection* of *barriers* prevents local farmers from refining coffee to a level that would enable them to earn an income sufficient to sustain their families. Apart from the challenges listed above, a major *barrier* is the way the global coffee market is designed. In the global coffee trade system,

[41] Berries could be sold a maximum price of 4,000 UGX (0.92 EUR) for the best quality.
[42] Parchment, the name for dried coffee beans with a husk, can be sold for up to 18,000 UGX (4.12 EUR).

Arabica coffee is grown by smallholders in rural tropical regions, such as Mt Elgon in Uganda, sold to processing facilities (factories) in the larger cities (Mbale and Budadiri in this case) that then turn the coffee into green beans that are shipped to the Global North through harbours such as Mombasa in Kenya. Here, coffee is roasted or ground, distributed and finally sold to a great variety of consumers (Byrnes et al., 2016). These "buyer-driven" (Wedig, 2019: 6) structures limit most farmers to the least lucrative first two steps of the value chain, namely selling as berries and/or parchment. This is a clear example of the unequal distribution of coffee revenues (Ategeka, 2024: 86), where hardworking producers are the least beneficiaries in the coffee value chain (Figure 7). Other related economic *barriers* include limited private sector investments into agricultural production infrastructure, inadequate public spending and small-scale farmers' restricted access to financial services such as loans and credit (Wedig, 2019: 4).[43]

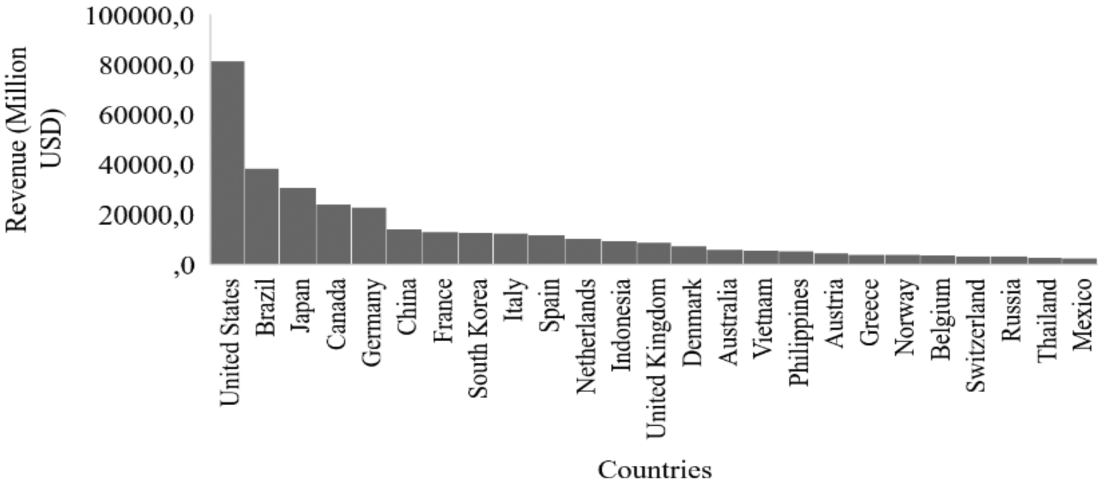

Figure 7. *Global coffee market revenue by country 2021. It is rather consuming countries than producing countries that reap the benefits of coffee sales (Ategeka, 2024: 86).*

Apart from the structural *barriers* presented above, other, rather practical *barriers* or *enablers* either reduce or enhance farmers' potential to move just one step up the value chain: from selling as berries to selling as parchment, which would allow for a four to five times higher income. As will be revealed below, turning coffee berries into parchment is a tedious process that requires considerable effort, specific equipment, and favourable weather conditions. The coming section will take you through the different steps of coffee processing and is based on participant observation. The host family father, Joseph, and I worked together to process a share of their coffee harvest into parchment: He led and instructed me in the art of coffee processing.

[43] Since 2017, however, SwB has worked to establish and maintain local VSLAs that can be a part of the solution. According to local sources, there are more than 16 VSLAs in the Sipi area today. As the name suggests, farmers save together and borrow money from the common pool of savings. In some incidents, this allows the necessary investments in farm equipment.

The Labour-Intensive and Time-Consuming Process of Turning Coffee Berries into Parchment

The first step of coffee processing, *coffee picking* (harvest), is demanding, physical work that requires strength, endurance, agility and specific tools (a ladder, a "panga"[44], a saw, a scissor, et cetera). Moreover, it depends on farmers being in good health and on dry weather conditions, as the vast majority of farmers do not work when it is raining. When picking you need a specific tactile technique[45], you bend, reach, stretch, crawl and pull the top branches to access the berries. Many berries are difficult to reach, some coffee shrubs have dense branches, and some are tall; the soil might be slippery on rainy days, and the heat can be exhausting on sunny days.

The next step is called *pulping*. When I processed coffee with Joseph, his malfunctioning pulping machine could not separate all the beans from the pulp, despite being designed to do so (Figure 8). Instead, approximately one-third of the beans landed on the wrong, left side of the machine. Therefore, I had to hand-pick all the beans, which took me more than an hour because they were covered by a slippery membrane (Figure 8). Meanwhile, Joseph went to his "cousin brother" to borrow his pulping machine (Figure 9), which eventually proved to work more smoothly. Pulping on a manual machine is a laborious, two-person job. One is turning the wheel by hand; the other is either preparing the next load of berries, sustaining the process flow, or sorting beans from pulps using a tray with holes that only fit the beans (Figure 9 & 10). When pulping, Joseph is making a certain constellation, using matooke leaves as a cover under the machine to catch the misplaced beans on the left side (Figure 8). On the other side, a halved matooke stem (Figure 9) is used to direct the beans into the sorting tray (Figure 10). The tray is managed by the other person, who filters the beans into the bucket beneath by moving the mix of misplaced pulps and beans around, guiding the beans through the holes (Figure 10).


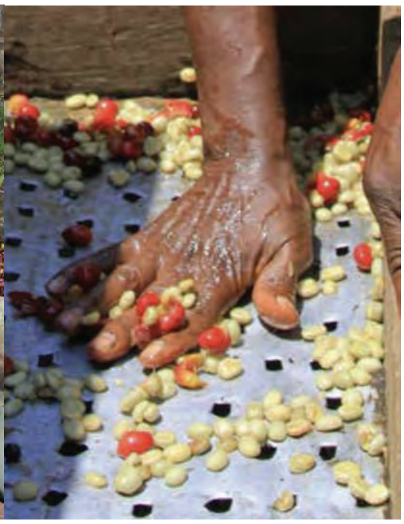

Figure 8. *To the left: An outlived pulping machine separates most of the beans from the berry skin (pulp).*
Figure 9. *In the middle: Two halved matooke stems direct beans and a few pulps into the tray.*
Figure 10. *To the right: A farmer uses the sorting tray to sort the beans from remaining pulps (UCDA, 2019: 14).*

[44] A long, broad blade, also known as a machete in Central America.
[45] … that will be elaborated in the section on *skilled vision.*

Compared to manual pulping machines, a fuel-driven pulping machine can allegedly be four times as productive. However, being a main point of this analytical section, investments in such equipment are less likely. In a study of Elgon farmers' attitudes towards agroforestry, Wienhold & Goulao concluded that:

"[T]here is little capacity to invest resources in (or even talk about) programs related to long-term stability and sustainability until basic family needs are met" (Wienhold & Goulao, 2023: 20).

This is a point that is imbuing several other aspects of coffee farming in the region. In Buginyanya, 12 of 19 farmers complained about their pulping machines and/or inquired about a new one. In Sipi, several farmers told me about constraints linked specifically to the pulping machine. As an example, Joseph emphasised that if a farmer does not have a pulping machine themselves, they might have to wait days or weeks for one to become available to borrow. This can cause a critical delay, which compromises berry quality, making them more refractory in the machine, requiring even more manpower and disrupting the flow, ultimately adding extra time to the already time-consuming process (Figure 11).

Figure 11. *The "over-ripe", black berries have taken most damage from the waiting time, and they are the ones that occasionally get stuck in the machine.*

When most of the pulps are sorted away, the beans are placed in buckets and filled with water to cover them. The remaining pulps, under-ripe and diseased beans, will then come to the surface because of their lower weight (Figure 12). Joseph stressed that: "You have to stir it a couple of times to make the bad ones in the bottom come up". These unwanted beans can be sold to "those on the road" who are drying and selling low-quality beans. As Joseph stressed, "there is a market for all of it".

Figure 12*. The picture shows Joseph stirring the beans to make "bad beans" float to the top.*

Now the beans will need to *ferment* inside for 1-3 days, depending on the air temperature. Fermenting loosens the slippery pellicle from the beans. When it is colder, fermenting takes more time, but Joseph said that one day in their “kitchen” should be sufficient, since a cooking fire is made here three times a day.

After fermentation, beans are *washed* in three different buckets. One for rinsing, one for scrubbing, and one for swirling and removing the remaining “bad” beans and pulps. The first two steps are done by swirling the water and scrubbing the beans both against each other and the sidewalls of the leaky bucket (Figure 13). When the coffee is clean, you roughly *sort* out the white (under-ripe) and black (diseased) beans. Only sand-coloured beans can be used for the high-quality coffee we processed. If cleaned properly, the beans are no longer slippery when you touch them, since the membrane has been removed through the process of fermentation and scrubbing. This is an example of the tactile techniques farmers use when handling coffee, hereby constituting a share of the *skilled vision* they develop.

Figure 13. *Joseph scrubbed the beans against the sidewalls of the leaky bucket.*

Once cleaned, you *dry* the beans in trays (Figure 14) or on tarpaulins (Figure 15). Tarpaulins are laid out on a lawn in a sunny spot, and the beans are spread out to dry faster (Figure 15). Trays can be stacked under the porch roof when it rains, and during the rainy week in Buginyanya, they were in much demand. According to Joseph, drying takes seven days if the Sun is out. However, the unsteady weather in Sipi and Buginyanya prolonged the process. Once the rain comes, the beans are quickly moved inside and stored in bags until the clouds disappear. Evidently, the drying process is highly dependent on weather conditions; dryness and sunshine. And for that reason, it can now take weeks.

After this waiting period, when assessing the marketability of beans, you check if they have a “creamy” colour. Another way to measure the moisture content is to use a “moisture meter” (Figure 16). With either method, you know exactly when they are ready - at least if you are an experienced farmer with a well-developed, *skilled vision*. This ability is necessary since most moisture meters can only be afforded by middlemen or field officers. Joseph, working as the latter, owned a moisture meter and established that he accepts beans with a “12.5% moisture content or below” (Figure 16). Thus, the average farmer relies on his or her visual skills and invites a buyer once they assess that the parchment beans are ready.



Figure 14. *To the left: Trays placed in the Sun on a homemade stand. Trays are made of wood and have a steel-wire mesh at the bottom, allowing air to flow through.*
Figure 15. *In the middle: When spreading out the beans on the tarpaulin, you are using a "spreading stick".*
Figure 16. *To the right: Moisture meter showing the moisture level of beans placed in the cup.*

Now that the procedure of processing from berries to parchment has been described, I dive further into the role of farm equipment in the search for an explanation of why some farmers refrain from selling as parchment, despite the economic potential lying in the refinement of coffee.

Materials and Machines: Opportunities for a Higher Income

According to the baseline data (Kroijer et al., 2024), the majority of Sipi farmers sold their coffee as parchment. 6 out of 22 sold a combination of parchment and berries, while only 3 sold berries. In Buginyanya, the tendency was somewhat the opposite, with only 6 out of 24 farmers selling as parchment, 9 out of 24 selling a combination, and 9 selling as berries. This difference was confirmed one year later during my own fieldwork. A large share of farmers in Buginyanya identified the lack of processing tools, machines, materials, and facilities as the main *barrier* to selling parchment. Hence, various pieces of equipment act as both *enablers* and *barriers* to coffee refinement. As we learned above, a pulping machine is one example. Farmers who do not have (access to) such one need to sell as berries, which equals four to five times lower income as stressed above. Other farmers have old, malfunctioning pulping machines that limit productivity. Together with other farm equipment, a pulping machine is thus a main *actant* in small-scale Arabica coffee farming, capable of hindering or enhancing farmers' economic possibilities. Equipment with comparable agency was mentioned across interviews in Buginyanya. Here, 13 out of 19 farmers inquired for "drying facilities", such as trays, tarpaulins or even indoor drying facilities. The demand for drying materials and/or facilities was closely tied to the increased precipitation levels and the resulting postponement and displacement of ripening, as elucidated further below. However, as noted above, farmers are often unable to make joint investments in new facilities or equipment due to their limited *economic security*, the lack of public support for cooperatives (Wedig, 2019: 78) and limited access to funds. Thus, to ensure *economic security* for coffee farmers, non-state actors must act as proxies, filling the void left by the liberalisation of the coffee sector described in the introduction. AfPEC, *Frellsen* and SwB are three of these non-state actors, and there were several examples of how Buginyanya farmers' opportunities had already increased after the establishment of the cooperative and Village Savings and Loans Associations (VSLAs). As will be emphasised in the recommendations section, however, there is potential for a joint investment in drying and processing equipment, as these are the main *barriers* to coffee refinement in Buginyanya. Moreover, reliance on projects and NGOs is a short-term rather than a long-term solution, as they depend on foreign funding. For instance, so far, AfPEC's DANIDA[46]-funding has enabled five years of operations, which expire in 2029. With this in mind, Ugandan authorities are encouraged to reconsider their stance on public support to Arabica coffee growers, if they wish to achieve their goal to quadruple national coffee production from 2020 and onwards (Namuyanja et al., 2024: 277).

Why are Farmers picking Mixed-quality Berries?

Beyond my interest in uncovering why some farmers were not utilising the opportunity to produce parchment, I also wondered why farmers were picking mixed-quality berries, as selecting and processing high-quality coffee was yet another potential way to earn a higher income. In this section, *local ecological knowledge* (LEK) acts as both a *barrier* and an *enabler*. LEK is a *barrier* when it is limited. In this case, farmers prioritise short-term gains over long-term sustainable production, without knowing the consequences. In the other case, LEK is an *enabler* when it makes you capable of making informed decisions, where you assess the short-term and long-term possibilities of selling the different qualities and compare the advantages and disadvantages of choosing the one or the other. To understand this, let us first look at the advantages of choosing high-quality, ripe berries. As Joseph said:

> "[First] if you pick berries when they are ripe and red, the weight of each berry is higher compared to yellow and green berries. [Secondly] when picking ripe berries, they become ripe at the same time, next year. [Finally] picking green berries can cause a delay of up to one year."

These are three principles that are central to Joseph's understanding of a "proper" coffee harvesting approach. The first implies that you can get a higher price for "red berries" because of higher weight, better bean quality and taste (UCDA, 2019: 83-84). The second refers to yet another long-term perspective in coffee cultivation; that maintaining the maturation cycle is crucial for the alignment of coffee ripening with optimal weather conditions[47]. Finally, concerning the last principle, coffee shrubs need to be ready to let go of their berries when farmers pick them, otherwise the future harvest risks being postponed. Despite being the ideal approach, farmers and their hired labour had other inclinations and considerations, depending on their LEK. I have handpicked a few examples here:

[46] DANIDA is the Danish International Development Agency (Ministry of Foreign Affairs of Denmark, 2026).
[47] Note, however, that the seasons are being altered by climate change, as will be shown in the last analytical section. This adds yet another layer of complexity.

"Berries weigh more than parchment"

In Bugimotwo, close to Sipi, there is a conviction (opposite to Joseph's) that when you sell as berries, you sell more kilos than when selling parchment coffee, since you dispose of the pulp in the latter process. This, combined with the alluring idea of skipping the lengthy process of turning coffee into parchment, makes many farmers in this area sell as berries.

"My workers pick mixed quality even though they are told not to"

In several instances, unskilled workers, like (grand)children and/or neighbours, were observed picking. The small-scale coffee farmers, Soyekwo[48] and Patricia[49] from Sipi both showed me how their (grand)children were picking mixed-quality coffee, including diseased and under-ripe berries (Figure 17). In Patricia's case, her grandsons were scolded, as she wanted to sell high-quality berries. As she told me, they were neither allowed to pick nor using the appropriate technique. Following up, she explained how mixed-quality coffee could only be sold at a reduced price to middlemen, which gave her an immediate but significantly lower income.

Figure 17. *A bucket containing the under-ripe and diseased berries, Patricia's grandsons picked. On some berries, the stalk even remains attached, indicating suboptimal picking methods.*

"Workers pick berries early before…"

In another interview, one of the local priests in Sipi, David, explained to me how they pick berries "early" as soon as they identify a pest or a disease: "before it becomes too infected". An example he gave was that, as soon as a tree is attacked by the stem borer (WCSB), they pick the berries, since they can still earn an income by selling them as under-ripe berries. Similarly, Caroline said that "the main reason for picking under-ripe berries is to pick them before the thieves do it". In a third example, the self-sufficient farmer, Wonasolo[50], from Buginyanya clarified how his hired labour wanted to be: "efficient before the rains come". In both Sipi and Buginyanya, remuneration was based on weight or the number of basins filled with coffee. Thus, hired labour and other workers were interested in picking coffee efficiently, which sometimes involved harmful picking methods (such as strip-picking[51]) or untimely picking (see Figure 18 & 19), both of which have negative consequences for short-term harvest income (UCDA, 2019: 83-84) and future yields, as Joseph initially explained.

[48] Soyekwo is also the local parish chief.
[49] Patricia is a young grandmother and the one in charge of coffee farming in their household.
[50] Wonasolo is the father of the host family, I stayed at in Buginyanya, and therefore also a central collaborator.
[51] Strip-picking is harmful to coffee in several ways. When using the picking method, you mix the berry quality, introducing fermented and under-ripe berries, as well as damaging leaves, "bearing loci" and primary branches that are crucial for the future productivity of the coffee plant (UCDA, 2019: 85).

Figure 18. *To the left: A delivery of coffee berries to the local cooperative, Sipi Organic, from a female farmer who "needed to sort it", according to Sipi Organic's field officer.*
Figure 19. *To the right: The female farmer was busy, so the berries were sorted voluntarily by four young men and I.*

All these short-term priorities are made possible by the global coffee market. As the local revenant and small-scale coffee farmer, Salimo, established: "there is a demand in the market - even for bad quality". Kawacom, the biggest coffee company in the Sipi-area, is buying mixed-quality berries and thereby "pushing down the prices". Additionally, a project representative told me that large multinational companies now have technology that can "sort out the useless berries". However, these remnants were not dumped, as some companies sell what emically is termed "dust"; a mix of "good coffee" leftovers, "dirt" and diseased beans. The examples show how global coffee demand shapes the possibilities for coffee farmers, who, at times, due to various pressures from coffee pests and diseases (CPaDs), weather conditions, limited knowledge and other practical *barriers* presented here, refrain from utilising the opportunity to earn a higher income.

Summing up this section, local Arabica coffee cultivation is limited by a diversity of *barriers*. On the one hand, the availability of well-functioning equipment, especially pulping machines, drying facilities and/or materials. On the other hand, skilled labour that picks ripe berries with the right technique is required, while economic safety nets such as savings and alternative income sources *enable* long-term priorities. Lastly, knowledge, for example, on which berries to pick, optimal fertilisation, and how to prevent and control CPaDs, is a necessity. The better the (access to) equipment and knowledge on coffee management, the better the harvest and the higher the income from coffee sales. This being settled, several crucial *barriers* and *enablers* to coffee farming remain, namely the presence of *antagonists*, natural enemies, and (un-)stable weather conditions.

Skilled vision: Identifying, Preventing and Controlling Coffee *Antagonists*

Self-evidently, being equipped with adequate knowledge about best practices in Arabica coffee farming is a prerequisite for lucrative and sustainable coffee farming. The same principle applies to the management of *antagonists*. Several types of LEKs are present on the mountain. Some are first-hand and experience-based, others are taught in workshops, at schools, through extension agents or living labs. Continually, farmers learn how to *see* and *sense* as a coffee farmer. As established in the conceptual framework, farmers develop a *skilled vision* that allows them to make informed decisions. It becomes a central part of their LEK. Examples are numerous, but a few have been selected here.

During the *sorting* process, Joseph pinpointed the signs to look for when sorting out the "bad" berries. All these signs related to their appearance, thus invoking our visual skills. The berry colour indicates the level of maturation; green berries are under-ripe, while dark berries are over-ripe. Somewhere on the latter part of this colour spectrum, you find perfect, red berries. However, when you turn them, small holes, dark spots, or lesions might appear, indicating an attack by a pest or a disease (Figure 20)[52].

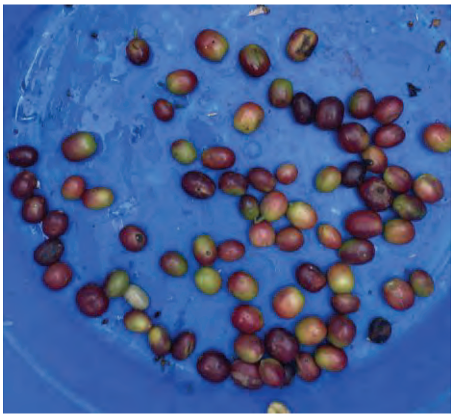

Figure 20. *Picture of the berries we sorted out during processing. Berries with holes are infested by the Coffee Berry Borer (CBB), while berries that are completely black or have dark spots are infected with the Coffee Berry Diseases (CBD) or overripe. Finally, under-ripe (green) berries were also discarded.*

As established in the conceptual framework, "[t]ouch and vision work together" (Grasseni, 2004: 41) in *skilled vision*. Although originally used to describe cattle breeders' multisensoric techniques (ibid.), I argue that similar skills are developed by Arabica coffee farmers, including tactile techniques. An example of this is how farmers and their labourers learn to "pick the right way". In my case, it took me weeks before I could pick berries without also removing the stalk. As Caroline warned, it is an injurious picking method: "When you pick the stalk with the berry, then it is like you give it an injury. If you had picked the berry only, it could grow next year, but it will now need another year to recover". So, while picking berries with the stalk is an efficient technique in the short term, it has consequences for next year's harvest.

What is a Coffee Pest?

If discovered at the early stage of development, the damage from several *antagonists* could be confined (Appendix 3 & 4), thus making demands on farmers' LEK and *skilled vision*. Although about 3000 species of insects and 215 species of fungi are growing with coffee, only a minor fraction can be

[52] Attacks may also appear on under- and over-ripe berries.

considered harmful (Koutouleas et al., 2025: 164). Nonetheless, in 2016, Liebig et al. found that CPaDs were the major constraint for local coffee production (Liebig et al., 2016: 8). As introduced, the AfPEC baseline study (Kroijer et al., 2024) reached similar findings. Combined, the local studies show that CPaDs are regarded as the major challenge to coffee farming on the Western slopes of Mt Elgon. This is problematic given that attacks from *antagonists* limit the coffee quality, quantity and, consequently, the economic return from coffee harvests (UCDA, 2019: 71). A variation of typically microscopic organisms "attack" the coffee plant through infestation (pests) or infection (diseases) of leaves, stems, berries, and/or branches (Koutouleas et al., 2025: 164-165). In some cases, *Coffea arabica* is even parasitised by plants such as the dodder weed (see below) or the "Hemiparasitic Mistletoe" (Appendix 3). Earlier, these were referred to as *antagonists*, but for clarity, I will use the categories "pests," "diseases," and "parasitic plants" separately in this section.

Usually, coffee pests hinder the growth and productivity of the host (Koutouleas et al., 2025: 164-165), but similar to the coffee plant, they need specific microclimatic conditions to thrive. These include a certain "air temperature, humidity, and light optima" (ibid: 178). Just like the coffee plant, this makes them vulnerable to climate change[53]. In this section, I will give a few more examples of how farmers use their *skilled vision* in their struggle against CPaDs. The first example concerns Coffee Mealybugs (CMB, *Planococcus spp.*), which are small, sucking insects about 3 millimetres long (UCDA, 2019: 73) that often appear in "white waxy colonies" on the stem of young roots where the soil is loose, on the underside of leaves, or in soft areas around coffee berries (ibid: 74) (Figure 21; 22 & 23).



Figure 21: *To the left: Microscopic mealybugs on the back of a leaf. Wakadala, Buginyanya*
Figure 22: *In the middle: Root mealybugs eating through the bark (zoom in to see). Sukuku, Sipi*
Figure 23: *To the right: Apart from the granular masses, ants have built a web of debris protecting the mealybugs that are sucking sap directly from the berries (zoom in to see the white spots). Caroline, Sipi.*

[53] This will be elaborated in the discussion.

As is the case with most of the other pests presented here, they are difficult to notice, and as a farmer, you need to be aware of which signs to look for. As mentioned earlier, having a *skilled vision* is essential for a farmer, as it *enables* early detection and the deployment of preventive control measures that limit the eventual harm caused by coffee pests.

Another barely noticeable pest is the Black Coffee Twig Borer, *Xylosandrus compactus* (BCTB). The local distribution of the BCTB is relatively low as it "prefers warmer climates" (Koutouleas et al., 2025: 170). Despite that fact, we identified two examples of the "borer" in the high altitudes of Sipi and Buginyanya. The owner of a sunexposed monocrop coffee field in Buginyanya, Vincent, taught me how to spot the pest (Figure 24).

Figure 24. *Vincent knew exactly where to break the branch and find the larvae.*

When I asked the young farmer whether he had any pests in his unshaded coffee, he rushed to the specific coffee shrub he knew was infected. He explained that: "The plant starts to dry from where the insect entered, not from the tip like dieback"[54]. Using a combination of trained visual and tactile senses (Grasseni, 2004: 41), he broke the branch apart exactly where the caterpillar was located inside (Figure 24). It was impressive that Vincent was capable of spotting the pest, considering that in order to identify it, farmers must be "looking for dry and brittle branches with 1-millimetre circular holes and sawdust on the leaves and branches" (Infante et al., 2023: 219), as shown in Figure 25.

Figure 25. *BCTB infestation of a coffee branch in Sipi. The microscopic hole and frass are the signs to watch for.*

A final example of a pest that is difficult to detect is the White Coffee Stem Borer (WCSB). Liebig et al. declared the borer the most harmful pest in the Mt Elgon region (Liebig et al., 2016: 14). Like the BCTB, early signs of infestation include "wood shaving and frass" (Infante et al., 2023: 216) at the stem

[54] A description of "dieback" can be found in Appendix 3.

and a circular infestation hole (Figure 26; 27 & 28). The borer attacks both young and older coffee shrubs. The former is often "killed", while the latter tends to yield significantly less and become more susceptible to diseases (Jonsson et al., 2015: 283; UCDA, 2019: 72).

Figure 26. *To the left: Sawdust indicating recent stem infestation from WCSB (Samuel, Buginyanya).*
Figure 27. *In the middle: Stem infestation hole of WCSB. The hole has the length of the stick. (Soyekwo, Sipi)*
Figure 28. *To the right: The WCSB drills through the stem, causing a slow die-out (the stem dries and its bark starts to crumble), limiting coffee yields from the whole tree (Soyekwo, Sipi).*

There are several ways for farmers to prevent or control coffee pests. Organic and cultural preventive and control measures have been collected in Appendices 3 and 4. Both chemical, biological and cultural practices were known across the villages. Among biological control measures, we find natural enemies. As settled earlier, these are living organisms that prey on, parasitise, or infect coffee pests. Natural enemies of the specific pests identified in Sipi and Buginyanya include chameleons, ladybirds, mites, parasitoid wasps, lacewings, ants, birds, bats, threadworms, fungi and flies (Appendix 3). The case of CMB illustrates the biological interactions between coffee pests and their natural enemies. For instance, ladybirds and the lacewing insect, *Oligochrysa*, feed on the mealybugs (Figure 29), while parasitic wasps, *Leptmastix dactylopii*, and *Anagyrus kivuensis*, lay their eggs in the coffee pest, ultimately killing it (UCDA, 2019: 75).

Figure 29. *"Ladybird adult feeding on coffee mealybugs" (UCDA, 2019: 75).*

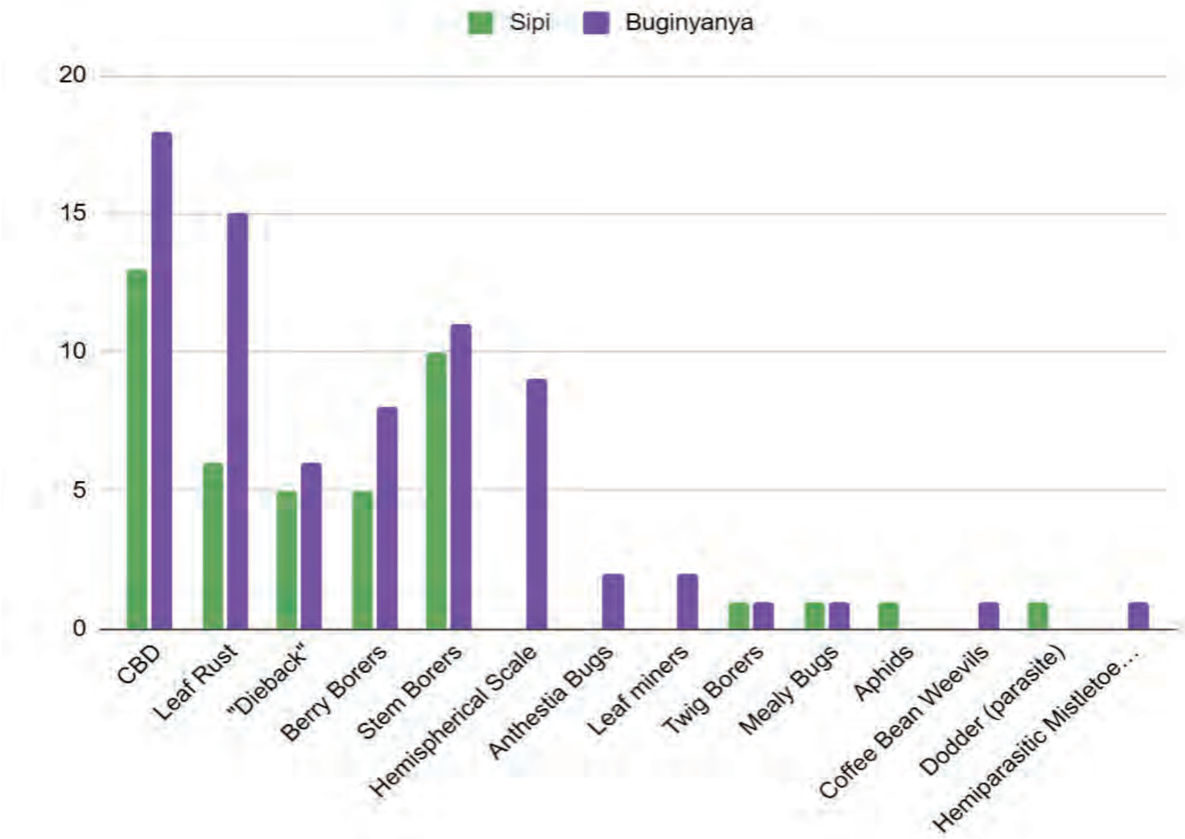

Figure 30. *Bar chart based upon 42 interviews (23 in Sipi, 19 in Buginyanya). Green bars represent the number of farmers who mentioned the antagonist in Sipi, while purple represents Buginyanya farmers' answers. In Sipi, 4 farmers reported having "no pests/diseases". All farmers in Buginyanya had at least one pest, one disease or both on one of their plots. Some farmers (2) even had parasitic plants attached to their coffee plants. Limitation notes: the answers are only representative of the farmers, I interviewed, and the wider representativity is limited by the methodological approach and some farmers' lack of knowledge of CPaDs.*

What is a Plant Disease?

As is evident in the table above (Figure 30), the distribution of coffee diseases, such as the fungal diseases, Coffee Berry Disease (CBD) and Coffee Leaf Rust (CLR), exceeds that of most coffee pests, although the diversity of coffee pest species was higher. The potential reason for the higher disease prevalence in Buginyanya will be discussed later. In their Arabica coffee handbook, the Ugandan Coffee Development Authority (UCDA) describes how Arabica coffee diseases may be fungal or bacterial (UCDA, 2019: 79). As with coffee pests, coffee diseases can reduce the growth, yield, and quality of coffee (ibid.), thus being yet another *barrier* to smallholder coffee businesses. As clarified earlier, coffee diseases rely on specific microclimatic conditions. This will have implications under the projected climate change in the region. As will be discussed further below, some diseases will thrive, while others will diminish.

When visiting their gardens, farmers need to be aware of the visual signs of infection. A disease that is particularly difficult to distinguish at an early stage is the CLR, as it is easy to confuse with malnutrition or "over-maturity", as Joseph called it. As shown in the picture to the right, yellow spots emerge when the coffee plant is "lacking food", as he explained. Comparable indicators appear on leaves when infected by the CLR-fungus, *Hemileia vastatrix*. According to Agriculture Institute: "The disease typically begins its assault on the underside of coffee leaves, starting with small, pale-yellow spots that might easily be mistaken for nutrient deficiencies or minor stress." (Agriculture Institute, 2024). It is not until "masses of fungal spores" (ibid.), typically appearing as orange dots (Figure 31), emerge that farmers can distinguish it with certainty. Then, as the fungal spores spread and develop, the indicators of infection become more distinct, placing less demand on the farmers' *skilled vision* (Figure 32 & 33). Hereby, the frequent presence of farmers in their fields throughout CLR's development allows them to recognise the disease from other distresses and timely apply treatment measures.

Figure 31. *To the left: Early sign of CLR (orange dot): "masses of fungal spores, ready to spread the infection to neighbouring plants" (Agriculture Institute, 2024).*
Figure 32. *In the middle: CLR is developing, and "old parts of the lesions become necrotic and turn brown" (UCDA, 2019: 79).*
Figure 33. *To the right: At its peak, CLR has caused infected leaves and parts of the connecting branches to dry out. Consequently, leaves shed prematurely (Namuyanja et al., 2024: 283; Wonasolo, Godfrey and Wakadala, Buginyanya).*

Parasites - the Dodder Weed

The final part of the generic term, *antagonists*, is parasitic plants. Only two such species were identified by farmers in Sipi and Buginyaya, the most impactful being the dodder weed. The weed is more distinguishable than the CPaDs presented above. However, its management requires just the right tactile technique.

Once you know the yellow appearance of the dodder, it is easy to discover: "Dodder has slender, twining or thread-like bright stems that vary from pale green to yellow or bright orange" (Mutitu et al., 2020: 1), as is also clear on the picture to the right. The parasitic plant extracts the majority of its nutrients and water from the host plant by constantly reattaching to new branches (ibid.) (see upper picture). Hereby, dodder forms a dense mat of intertwined stems that, over time, covers an entire tree or shrub (ibid.), eventually drying and killing the host plant (ibid.). The rapid spread of dodder occurs through a wide variety of *actants,* so-called "vectors". The most impactful vectors include the movement of infected soil, clothes, shoes, farm equipment, children, and water (ibid: 1-2). In this case, "proper management" puts demand on the tactile sense and knowledge of the farmer, as the manual removal or "hand-weeding" (Negewo, 2024: 9) is a difficult practice that requires caution. Improper approaches risk deterioration and further spread of the parasite. Similarly, reluctance towards the removal risks resulting in further damage, as "[t]he most immediate action is to eliminate or reduce the infestation before the invasion gets out of control" (Mutitu et al., 2020: 6), that is, before the plant produces seeds (ibid.). According to the dedicated coffee-agroforestry farmer, Sukuku, the development and spread of the dodder was in its early stages in Sipi. The young, but vigilant, farmer had just identified it for the first time. Despite its novel presence, the seriousness of the situation was underlined by him when he stated that: "In 10 years all coffee will be dead". Here, he referred to Soroti[55], where it was "already a big problem". These considerations agree with Masanga et al., who predicted "high habitat suitability for *Cuscuta spp.*" in coffee-growing regions of Eastern Africa (Masanga et al., 2021: 1457, emphasis in original).

As a final constraint, dodder-infection makes the plant more susceptible to secondary attacks from CPaDs (Mutitu et al., 2020: 2; Figure 34), which reveals the interconnection between the *antagonists*. It is easier for *actants* such as coffee pests, diseases and parasitic plants to emerge in ecosystems that are already degraded or stressed.

Figure 34. *Dodder-infested coffee shrub with yellow leaves and berries lacking nutrition (Sipi).*

[55] Soroti is a district located around 100 km northwest of Sipi, on what the locals call "the plains", i.e. the lowland.

Out of Category: “Black Ants”

As argued in the conceptual framework, a central view in *posthumanism* is that binary categorisations have consequences, especially when they lead to the unsubtle separation of living organisms into “good” or “bad”, as it might provoke suppression of the latter. This is exactly what happens when farmers are *enacting* some species as beneficial and others as harmful, and it is the process that justifies the control of certain species. But what happens when some species escape these categories? An analysis of the case with “black ants” will uncover this question in the following section.

In Sipi, so-called “black ants”[56] are a contested species[57]. As will become evident, the insect neither fits the *antagonist* category nor the natural enemy category. If you move close to a coffee shrub in any organic coffee garden in Sipi, you typically find at least some ants at work. They are rushing up and down the stem, in and out of branches and around berry clusters. But what are they looking for? The role of “black ants” was vivaciously discussed at the end of the coffee farmer workshop. Some farmers saw the ants as pests, as they had seen them in “sick coffee”; others viewed them as a natural enemy, while Sukuku claimed it was neither. Depending on the context, all farmers might however be right. Speaking in favour of ants as natural enemies, Jensen et al. emphasised that ants are polyphagous, meaning they consume a wide variety of food, including other insects, which makes them potential natural enemies (Jensen et al., 2023: 2415). Supporting this, Gonthier et al. showed that ants may attack the pest Coffee Berry Borer (CBB) at several life stages. For example, small ants may enter the coffee berry through the beetle’s “entrance hole” and feed on it inside (Gonthier et al., 2013: 816), which probably explains why I observed two small ants running out of a CBB-infested berry. Ants may also hunt the CBB in old, infested berries, hence limiting infestation levels the following year (ibid.). Finally, the presence of ants on branches with young coffee berries might prevent CBB infestation at the stage when they try to colonise new ones (ibid.). In favour of the ants-as-a-pest explanation, some ant species, such as *Solenopsis geminata*, are likely to attack "beneficial" ant species, thereby limiting ant predation on pests like the CBB (Offenberg, 2015: 1202). Another explanation for the farmers’ opposition towards ants is that they can be “annoying for the berry collectors” (Moreno-Ramirez et al., 2024: 206). Lastly, on the neither-nor-side, we found that some ant species act as myrmecophiles (Hölldobler & Wilson, 1990: 471), protecting their source of sugary honeydew, the coffee mealybugs (CMB), from their natural enemies (Figure 35). When doing this, however, the ants also prevent the development of “damaging fungal molds” (UCDA, 2019: 74) - a feature that farmers view positively. To solve this dilemma, microbiologists, Jørgen Axelsen and Joachim Offenberg recommend feeding the ants with

[56] Emic name. It has not been possible to determine their biological name.
[57] Due to my limited training in the art of biology, it was not possible to specify the biological species.

sugar, which allegedly makes them prey on the CMBs instead (Appendix 3). This example shows that multifunctional *actants* escape the binary categorisation of the coffee plant's co-species, and challenges farmers' inclination to *enact* species as either beneficial or harmful: It sparks debate, as farmers depend on the ability to make this categorisation when operating within the paradigm of *biosecurity*.

Figure 35. *Ants sucking honeydew from mealybugs.*

In conclusion, coffee *antagonists* in all their shapes and sizes are central *barriers* for local coffee farmers, who depend on their *local ecological knowledge* and *skilled vision* to successfully identify and limit detrimental "attacks" on their coffee plantations. Through this categorisation of species as harmful, farmers invoke their "right" to eradicate certain organisms at the species level in the name of *biosecurity* to secure their livelihoods. This is an action that has been termed "racist" in posthumanism (Biermann & Mansfield, 2014: 261), but what other choices do the farmers have?

Local Coffee Farmers are Reporting Environmental Change

As with CPaDs, a stable agricultural production relies on certain weather conditions. Focusing primarily on *environmental security*, this final analytical section will elaborate on how local coffee farmers experience climatic *barriers* and *perceive* ongoing environmental changes. As mentioned in the introduction, variation in precipitation patterns and an increase in the frequency of droughts are some of the main *barriers* that cultivation of *Coffea arabica* is facing, because of the plant's susceptibility towards climatic variations and heat stress. According to neighbouring farmers interviewed in Bomuhangi et al., "climate variability events" could be dated back to 1993 (Bomuhangi et al., 2016: 5), suggesting that climate change is already a locally established phenomenon. So, although being a "wicked problem"[58] (Bubandt, 2021: 246), I view "climate change" as a key *actant* and its impacts as (climatic) *barriers* in the following section, considering how it is already constraining local coffee farmers at a level close to CPaDs. In the baseline data, 81 out of 97 (83,5%) respondents identified climatic *barriers* such as floods, soil erosion, landslides, and drought (Kroijer et al., 2024). The widespread experience of climate change and variabilities agrees with the findings from other locally relevant studies (Tiyo et al., 2015: 253; Aggrey et al., 2024: 5).

Starting in Joseph and Caroline's backyard, I discovered a flower on a sunexposed coffee shrub on the 14th of October 2025. Wonderingly, I turned to Joseph and asked him if the coffee used to flower at this

[58] A wicked problem is a "malignant" problem of great complexity that can only be solved by the creation of other problems.

time of the year. I pointed at a branch to reveal the small, white flowers. Joseph took a step closer and, despairingly, he stated: "No. It used to flower in February". Afterwards, he rationalised that because of the sunny weather, the conditions were there to "favor an early flowering". These considerations led Joseph to declare that "the climate has changed. Everything has changed".

According to Mafabi from Buginyanya, who was one of two farmers who blamed climate change for local weather changes, such displacement of coffee flowering disturbs the coffee maturation cycle, leading to the extension of the subsequent harvest period and therefore it impedes planning. In many ways, this example hints towards the central agency of climate change that constructs a great variety of *barriers* to local farmers.

A weather station at the National Agricultural Research Organisation (NARO) in Buginyanya has collected weather data since 1968. Bomuhangi et al. analysed their weather data from 1993 to 2013, and I gained access to subsequent rainfall data from 2014 to 2025 to explore the development in the local climate. Whereas data from 1993 to 2013 showed a statistically significant seasonal variability in rainfall and no statistically significant trend in annual precipitation for that period (Bomuhangi et al., 2016: 13; Aggrey et al., 2024: 7), data from 2014 to 2025 revealed comparable seasonal variability but also an increase in mean annual rainfall when compared to their data (Appendix 7). Annual rainfall exceeded 2000 millimetres in 38% of the years from 1993 to 2013 (Figure 36), while in 75% of the years from 2014 to 2025, Buginyanya received more than 2000 millimetres of rain (Figure 37). Considering that the optimal rainfall range for coffee was 1100-2000 mm, as established in the introduction, 9 out of 12 years were characterised by excessive rainfall. While aligning with the local farmers' observations, these numbers exceed both the former climate norm of maximum 1800 millimetres (Liebig et al., 2018: 515) and the upper threshold for coffee cultivation of 2000 millimetres**.** The consequences of excessive rain manifests as climatic *barriers*. As will be confirmed in the excerpts I have selected in the following section, these *barriers* are either of unprecedented scale or relatively novel to local farmers. For the same reason, most farmers highlighted *barriers* related to precipitation rather than temperature, as was the case in the following studies (Bomuhangi et al., 2016: 11; Aggrey et al., 2024: 7; Tiyo et al., 2015: 266). This suggests that the impact of rainfall on coffee farming is larger than that from temperature increases, despite of the example of an early flowering given above.

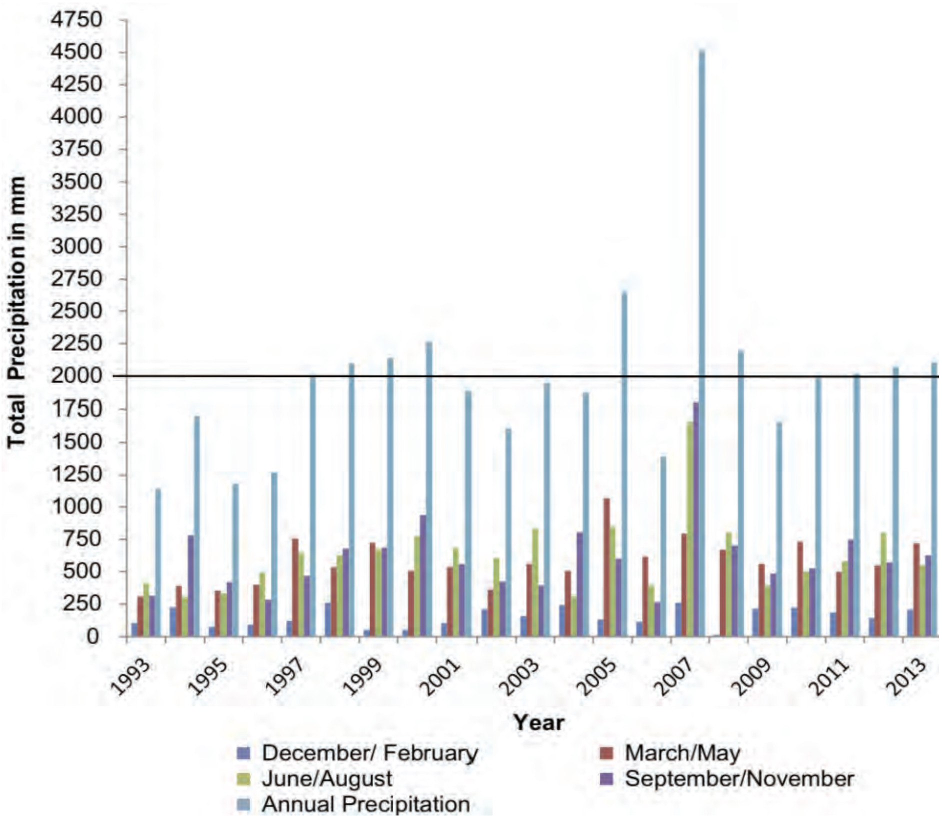

Figure 36. *Seasonal and annual precipitation in Buginyanya 1993-2013 (Bomuhangi et al., 2016: 9, self-inserted line at 2000 mm), based on NARO weather data. Please note that, because of discrepancies in their data, the data might be subject to uncertainty.*

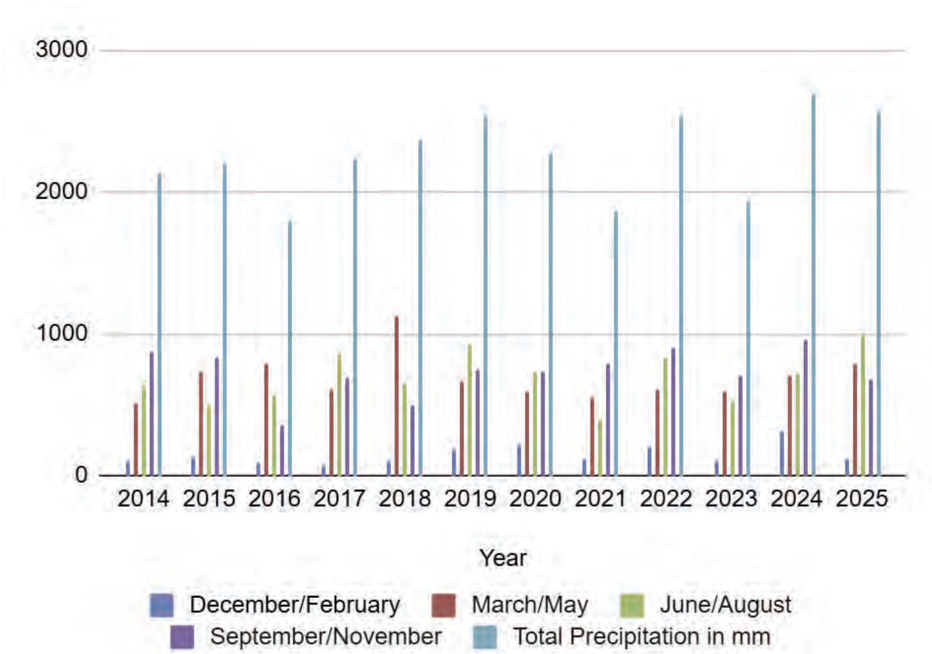

Figure 37. *Self-made bar chart showing seasonal and annual precipitation in Buginyanya 2014-2025 based on NARO Weather Data (Appendix 7).*

When asking Buginyanya farmers openly whether they had experienced any "weather changes", a variety of answers emerged, and some even contradicted each other. Across interviews, all farmers observed climatic changes. The quantitative processing of my interview data showed that most farmers (13 out of 18) gave an answer that fit into the category of *too much/more rain*, while others highlighted *change (with)in seasons*, *temperature increase*, *unpredictable weather or seasons*, et cetera. These *barriers*, especially the majority's emphasis on changes in precipitation levels, patterns, and seasonality, align with those reported by farmers in the baseline data (Figure 38), NARO weather data from 2014 to 2025 (Appendix 7), and the studies referred to above.

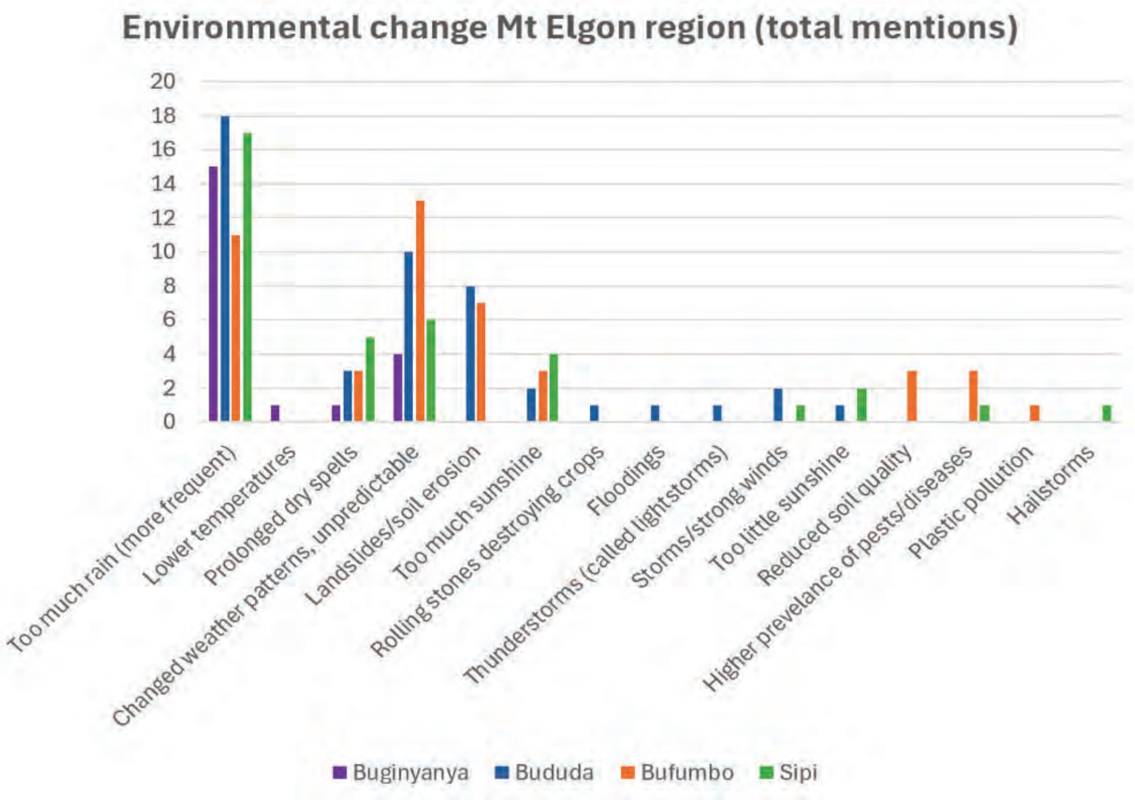

Figure 38. *Self-made bar chart showing which climatic barriers farmers from the four project villages have reported in the baseline interviews. Their answers were grouped into categories and counted manually (Kroijer et al. 2024).*

The most recent climate data from Buginyanya (Appendix 7) showed indications of a new weather pattern, spanning from 1866 millimetres in 2021 (minimum) to 2696.2 millimetres of rain in 2024 (maximum). The observed increases in annual precipitation align with farmers' observations. Additionally, supporting the farmers who had identified a displacement of weather seasons, the 2014-2025 weather data revealed new seasonal weather patterns as well (Table 1 & 1.2).

Table 1. *Self-made table. The upper colour gradient (see Table 1.2 below) indicates the amount of rainfall in the former climate norm identified by (Liebig et al., 2018: 515) and (Aggrey et al., 2024: 4). The one below is inspired by their categorisation but based upon fresh data (Appendix 7).*

Former climate norm	January	February	March	April	May	June	July	August	September	October	November	December
Climate norm (2014-2025)	January	February	March	April	May	June	July	August	September	October	November	December

Table 1.2. *Colour gradient explained.*

Millimetres of rain	Colour gradient
0-100 mm	Dry
100-200 mm	Alternating weather
200-300 mm	Rainy

Summing up, the NARO weather data revealed new weather patterns that are characterised by increased rainfall, greater seasonal precipitation variability, more extreme rainfall events and associated events, and, in recent years, a shorter dry season (see Appendix 7).

Climate change, as it is manifested here, is *enacted* by local small-scale coffee farmers in different ways, yet some climatic *barriers* are more widely reported than others (Figure 39). In the next part, I will elaborate on farmers' experiences with and *perceptions* of climate change by providing a range of qualitative examples. During my stay on Mt Elgon, what most farmers agreed across interviews was that the ongoing rain season was wetter than it used to be[59], but when it came to the implications thereof, some farmers disagreed. As the first *barrier*, a few farmers reported higher precipitation levels but did not experience it as a constraint. According to them, the rains were precipitating berry ripening, thus allowing for a prompter harvest, which was viewed positively. A majority, on the other hand, associated the increases in precipitation with a number of complications (Figure 39). As a first example, the local parish chief, Soyekwo, and a female farmer with restricted mobility, Agnes, from Sipi, as well as the keen agroforestry farmer, Wakadala, and the observant and experienced coffee farmer, Topista, from Buginyanya, highlighted hailstorms as a *barrier*. They explained how the vigorous hailstones destroy crops, for example, by penetrating the husk of the coffee berry and thereby damaging the valuable bean. In other instances, hailstones pierce the coffee leaves, hence limiting the plant's photosynthetic capabilities. Another *barrier* was pointed out by the extrovert small-scale farmer, Sophia, from Sipi, who said that: "the large amounts of rain wash away the nutrients from the topsoil", thereby limiting nutrient uptake for her coffee plants. This phenomenon, called fertiliser leaching, was also reported by half a dozen Buginyanya farmers.

Apart from impacts directly connected to extreme precipitation events, farmers are also challenged by the unpredictability and variability that have more recently come to characterise local precipitation patterns (Appendix 7; Appendix 8): "precipitation variation within seasons influences farmers timing of agronomic practices such as when to start preparation of land for cultivation or when to plant. Any uneven distribution of precipitation distorts their agronomic calendar" (Bomuhangi et al., 2016: 14).

[59] According to the NARO weather data, October 2025 was the October with the highest amount of precipitation. 361.9 millimeters was measured while the average for October 2014-2025 was 262.367 millimetres. In this case, farmers' accounts align with the scientific measurements.

When I dried the “natural coffee”[60] that Joseph and I were processing during my fieldwork, I experienced how bound farmers are to the coffee drying location. Since drying is all about reducing moisture levels, farmers must respond promptly to rain for the drying process to be efficient. However, farmers often have duties far away from home, on distant fields, in the larger cities or attending ceremonies, so in those instances they rely on their ability to predict the weather; a practice that is also being challenged by the increasing weather variability. As a group member of a Village Savings and Loans Association (VSLA) that solely had female members, Rose, from Sipi, and Wakadala from Buginyanya described, all these complications extend the drying period and make planning it more difficult. They both recalled how, back in time, they could rely on the weather to be dry after the picking season, which made it easier to refine coffee berries into parchment. These climatic complications might be one of the reasons why so few coffee farmers in Buginyanya are selling coffee as parchment.

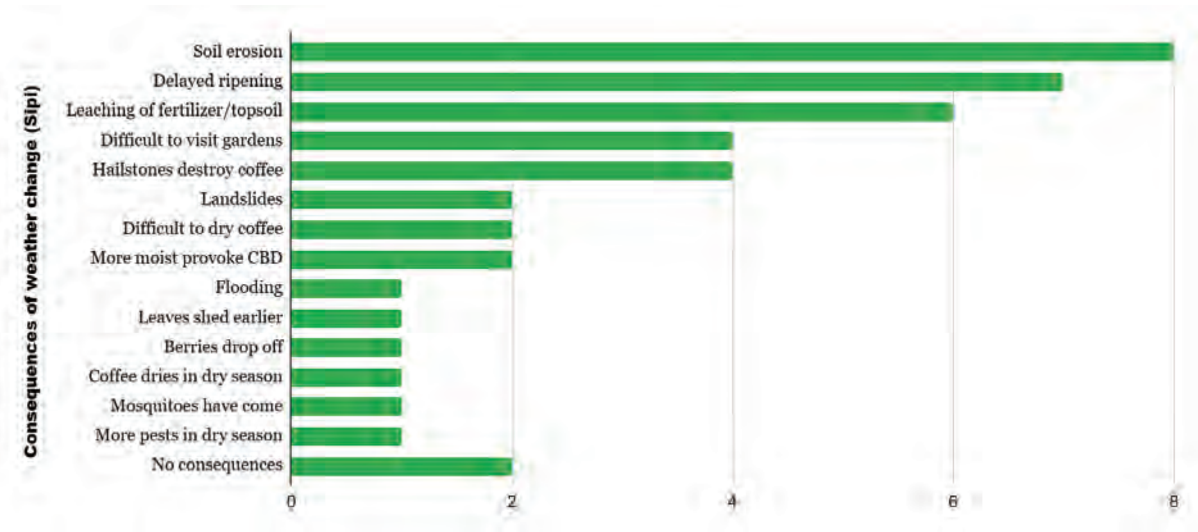

Figure 39. *Self-made bar chart showing the consequences of “weather change” according to the Sipi farmers interviewed.*

Along with increased rainfall, farmers cultivating steep slopes were more exposed to soil erosion and small-scale landslides. This finding aligns with Aggrey et al., who emphasised how this could be attributed to both an increase in settlements on steep slopes and prolonged rainfall (Aggrey et al., 2024: 7). David, the priest from Sipi, lived close to a ridge, explaining why he had implemented erosion control measures such as trenches. Despite his efforts, he admits that “at times the rain is too heavy. It causes soil erosion, even some landslides”. In this way, David indicates that in cases of extreme weather events, farmers are not always able to withstand the effects of climate change, despite implementing adaptation strategies. Accordingly, both incidents of soil movement damage coffee crops, while large-scale occurrences may cause severe material damage and even the loss of human lives (Appendix 6). The latter was the case at the beginning of November 2025. Three landslides hit the northern Sebei

[60] A protracted coffee processing method, where you dry berries directly in the Sun.

region in Bukwo, Kween, and Kapchorwa Districts. Being the result of heavy rains in the past week, approximately 40 people lost their lives (Appendix 6). This adds to the regional historical record of landslides, in which more than 1,000 people have lost their lives since the first landslide was documented in 1997 (Appendix 6). When I returned from Buginyanya to Sipi the day after the catastrophe, I asked Caroline if the landslides were there when she was young, and she replied: “No, it is a new thing”. When merging NARO weather data analysed by Aggrey et al. (2024) with data from the International Disaster Database (CRED, 2025; Appendix 6), I found that the years 1997, 2000, 2003, 2007, 2010, 2011, 2012, 2018, 2019 (4 incidents), 2020, 2024 and 2025 were characterised by the occurrence of landslides in the Ugandan Mt Elgon region (Aggrey et al., 2016: 13; Appendix 6). And even though CRED has data dating back to the beginning of the 20th century, no landslides have been recorded in the region before 1997[61] (CRED, 2025), thus confirming Caroline’s observation.

Figure 40. *Two minor landslides in Chema, near Sipi, destroyed farmland with matooke and coffee. The picture was taken on the 28th of November.*

Like Caroline, farmers did not hesitate to recall their youth, when I asked them about their lifetime observations of environmental change. As an example, the local revenant in Sipi, Salimo, remembered how:

> “At that time, we had plenty of rain, continuously, not like now. You could even see a lot of clouds rising from down the plains, coming up, the rain circle. But nowadays, it comes from this way [he pointed up the mountain]. It used to rain all day, from morning to evening, the whole day, but nowadays, because of global warming, it can even change throughout the day (...) It affects the maturity of the coffee because once it doesn’t rain, and [you] find that the berries are not yet ripe, it affects the quality and quantity”.

In this quote, Salimo notices a greater weather variation during the day, while reminiscing about the opposite. Adding to this, Joseph stated that “you can no longer expect it to be sunshine the day after it

[61] Note that the Natural Disaster Database webpage (CRED, 2025) warns about reporting biases of pre-2000 data (CRED, 2025), which means that, potentially, landslides have occurred before 1997.

has rained"[62]. Previously, coffee farmers relied on the aforementioned "agronomic calendar" (Bomuhangi et al., 2016: 14). As was the case with South-Ugandan farmers in Osbahr et al., these seasonal rainfall patterns are what farmers refer to as the norm (Osbahr et al., 2011: 299, 302). However, such convictions are increasingly challenged by climate change. Throughout his farming career, Wonasolo from Bugninyanya has relied on certain "rain months". As echoed in Aggrey et al., these used to be from March to May and August to October, while dry periods fit in between (Aggrey et al., 2024: 4). Moreover, Wonasolo underlined that "farmers need dryness in November, December, January and February to be able to pick and for the coffee to start flowering in time". However, as evidence of the changed weather patterns in Buginyanya, Wonasolo told me they experienced rain during the dry season in December 2022[63], and that this tendency of "too much rain" has continued since. As explained earlier, rain during the dry period delays the ripening of immature coffee berries (UCDA, 2019: 110), extending the period during which farmers can pick, process, and sell coffee. As a result of these *barriers*, farmers need to pay hired labour for a longer period because they can pick fewer berries at a time. Furthermore, it takes more time to gather enough coffee to be sold through the cooperative, further delaying the payment they ultimately receive. In Buginyanya, this is particularly problematic, since they have to repay VSLA loans and cover school fees around the onset of harvest season. Finally, picking and processing coffee already consumes most of the farmers' time and energy during these months, taking away time from other income-generating activities that could have covered the expenses. To adapt to the increased weather variability brought by climate change, Wonasolo implemented a new strategy for weather prediction. As Salimo also noticed, the "weather comes from up the mountain", so to know the weather in an hour, Wonasolo told me to move farther up the slope "to see if the clouds are coming". Following up, he explained that thunder was a warning of rain he could use to know when to return home from his fields or move his sun-drying coffee under shelter. The development of these techniques has become a necessity under the new, less predictable, weather conditions, while farmers' original perception of seasonality is slowly becoming a guideline rather than a rule.

All the examples selected and presented here constitute evidence that climate change and its impacts are already acting as *barriers* to coffee farming on the Western slopes of Mt Elgon, and that weather patterns and conditions have been altered and continue to change. The section showed how farmers *enact* environmental change differently, depending on their personal experiences with or knowledge about it. Similar patterns will be revealed in the next section, where farmers' *perceptions* of climate change will be analysed. In the extensive quote above, Salimo hinted at how local farmers *perceive* and make sense of ongoing changes when he linked observed weather changes to global warming. As will

[62] The daily weather observations, I jotted down in my notebook, are yet another evidence of the great in-day and day-to-day variability of weather (Appendix 8).
[63] Also reflected in the NARO Weather Data.

be argued, however, the majority of interviewed farmers rather saw a connection between the number of trees and precipitation levels as the reason for observed weather changes.

“Too much rain”: Coffee Farmers’ *Perceptions* of Climate Change

“From the time they stopped people from going to the forest, the rain has increased. What I heard is that when you cut the trees, the rain disappears”.

- *An anonymous female farmer from Sipi, paraphrased in (Kroijer et al., 2024).*

The vignette reflects the most widespread local *perception* of climate change, which is closely linked to the local tree cover (Figure 41 & 42). Inherent in this conception lies the idea that more trees (afforestation, conservation) equal more rain. Conversely, fewer trees (deforestation) lead to less precipitation and drought. Confirming this, a majority of farmers in Sipi (9 out of 15) and Buginyanya (7 out of 12 asked) suggested a mutual relationship between tree presence and precipitation as the reason for changes in the weather, especially the observed increase in rainfall.

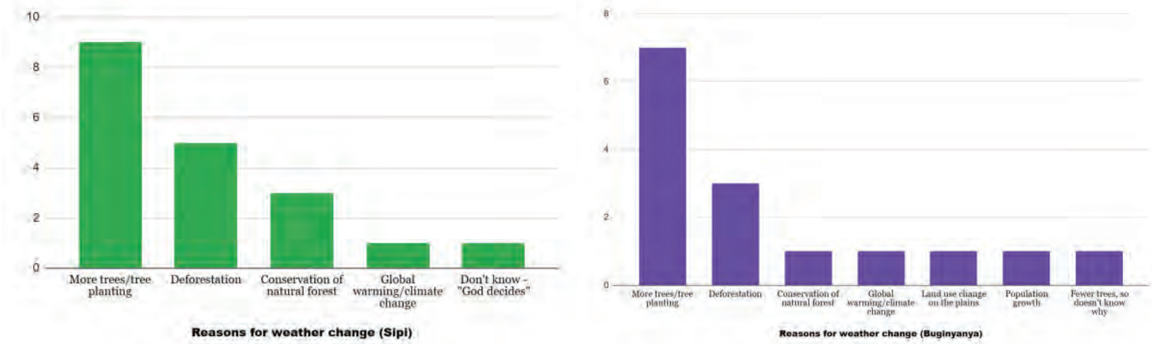

Figure 41 & 42. *Self-made bar chart showing farmers’ explanations of observed weather change. Sipi to the left. Buginyanya to the right. Limitation notes: The bars are only representative for the farmers, I interviewed.*

In this last section, *perceptions* are understood as the way local people identify and interpret weather observations (Bomuhangi et al., 2016: 3). When it came to the identification and interpretation of local weather changes, a few farmers disagreed with the majority that reported increasing rainfall, despite agreeing on the reason for change. Thus, the two ageing but energetic small-scale farmers, Samuel and Mafabi from Buginyanya, explained how it used to be colder 30 years ago when they had “more and bigger trees”. Both agreed that the trees attracted rain and that it could rain all day. According to the two farmers, the amount of rain had recently decreased due to deforestation, although the remaining farmers and NARO weather data point towards a general surge in precipitation levels (Appendix 7). As suggested by Aggrey et al., local farmers are better at perceiving in-season variabilities than annual changes (Aggrey et al., 2024: 7), which can be explained by the fact that “annual rainfall may be less critical to farmers’ production than distribution through a season” (Osbahr et al., 2011: 294). So, while most farmers point to an increase in precipitation, others have observed an overall decline when comparing with the past. What they have in common, however, is their connection of climate change to the presence of trees. So, despite of deforestation being an important part of the explanation of local weather changes, other factors also play a role.

As is somewhat self-evident, a study found that in comparable rural Nigerian contexts, awareness of climate change varies with education levels and access to information about the phenomenon (Abegunde, 2017). This being so, only two farmers in Sipi and Buginyanya respectively, *perceived* climate change as the reason for local weather changes. Mafabi and Salimo both referred to the interplay between deforestation, greenhouse gas emissions, population growth and climate change, which I claim is a more adequate description of the cause. Lastly, a few coffee farmers offered yet a third explanation for the weather changes they are experiencing. In one of the baseline interviews, a middle-aged woman from Sipi explained how: “Rain cannot be controlled, God controls this” (Kroijer et al., 2024). In the same way, Steven, a pest-plagued farmer from Sipi, assured me that “If I pray, God will secure a good harvest next year”. The fact that Christianity is strongly present in the local culture[64] helps explain the two farmers' statements. Similar *perceptions* were identified among Sebei pastoralists in the neighbouring Kween District, where the majority of farmers related climate change and its impacts to God’s will (Aggrey et al., 2024: 7), while only a minor share related it to deforestation and none to climate change (ibid.). This suggests that farmers in Sipi and Buginyanya are more aware of the impact climate change and deforestation have on local weather patterns than their relatives in Kween.

With climate change and associated shifts in weather patterns, coffee farmers will face a variety of climate-related *barriers*. Combining the insights from the introduction with local weather data and the ethnographic accounts presented here, I claim that climate change is already impacting coffee farmers on Mt Elgon. Climate change affects humans who are directly dependent on natural resources more intensively (Reyes-García et al., 2023: 3). Adding to this vulnerability, small-scale coffee farmers are facing unequal impacts of climate change (OECD Ecoscope, 2024). Finally, local coffee farmers’ vulnerability to climate change is accentuated by the effect called *elevation-dependent warming:* “the rate of warming is amplified with elevation, such that high-mountain environments experience more rapid changes in temperature than environments at lower elevations” (Pepin et al., 2015: 424). Along with other non-climatic factors, this causes an *intersection* of *barriers* that challenge the *human security* of small-scale coffee farmers in the region. Summing up the entire analysis, these *barriers* include 1) the global, buyer-driven coffee market, which causes an unequal distribution of coffee revenues; 2) farmers’ limited investment capacities that are hindering coffee refinement to the level of parchment; 3) limited *local ecological knowledge* (LEK) on best management practices and inadequate access to extension services; and 4) climate change and its associated challenges such as soil erosion, hailstorms, landslides, increased weather variability and altered prevalence of coffee *antagonists*.

[64] Most farmers went to church each Saturday or Sunday, depending on the local interpretation of Christianity.

Discussion

Building on the analytical sections that addressed *barriers* to coffee farming, how farmers identify coffee pests and diseases (CPaDs), and their observations and *perceptions* of climate change, the discussion will investigate the following question: How can the recent development in CPaD populations on Mt Elgon be explained? In the search for an answer, this final part will examine whether the explanation lies in the agricultural system, the management methods used, or environmental change. Other possible explanations exist, including globalisation (Ma et al., 2025: 264, 270; Koutouleas et al., 2025: 168; Johnson et al., 2020: 23) and CPaD management experiments: Coffee being the second-most traded commodity in the world means that both plant material, pathogens and pests travel around the globe (Johnson et al., 2020: 22). The international trade of coffee and the movement of organisms can be viewed as a classic example of an *actor-network*, where nonhuman *actants* cause alterations of distant natural environments and thus complications for coffee farmers across continents. Additionally, a few farmers in Buginyanya suspected the National Agricultural Research Organisation (NARO)'s allegedly "open" and "uncontrolled" experiments with a variety of CPaD management methods to be the cause of recent increases in CPaD populations, simply because the CPaDs were introduced in connection with the experiments to test the control measures. It should be noted, however, that this latter theory remains speculation, and no known literature has covered the phenomenon yet.

Climate Change

Numerous publications have examined the effects of climate change on the distribution of CPaDs (Koutouleas et al., 2025; Liebig et al., 2016; Namuyanja et al., 2024; Jaramillo et al., 2011; Gonthier et al., 2013; Infante et al., 2023; Jonsson et al., 2015; Johnson et al., 2020; Agriculture Institute, 2024). They all agree that climate change is a main driver of alterations in their prevalence. For example, Liebig et al. underlined how "recent outbreaks and increased incidences of CPaD have already been reported around the world" and that they "are likely to be aggravated by the effects of climate change and variability" (Liebig et al., 2016: 2). In a more recent study, Namuyanja et al. point towards three central characteristics of the link between CPaDs and climate change. First, as was outlined above, CPaDs depend on certain microclimatic conditions to thrive. Therefore, secondly, they can expand into new environments as a result of the alterations in climate that are projected to cause both a latitudinal and an altitudinal surge in areas suitable for both coffee (ibid: 16) and CPaDs (Ma et al., 2025: 265)[65]. Thirdly, the climatic "stress", that is, extreme weather events, challenges the coffee plant's ability to withstand attacks from *antagonists* (Namuyanja et al., 2024: 284). Moses, the retired pastor from Sipi, had observed similar correlations between CPaDs and local, environmental change. When asked about climate change-related challenges, he mentioned the White Coffee Stem Borer (WCSB), Coffee Leaf

[65] Earlier referred to as the *ecosystem dis-equilibrium* (Koutouleas et al., 2025).

Rust (CLR) and Coffee Berry Disease (CBD). A common feature of these CPaDs was that they "were not there during those days". As a matter of fact, he had not seen them earlier than five years ago. Chiming in with Moses, the young farmer, Chemonges, from Sipi asserted that CBD and the WCSB were not yet a major problem, but certainly a new trend. What the farmers hint at here is a discussion of which CPaDs are expected to thrive and which will diminish under climate change. A central contribution to this discussion is Koutouleas et al., who grouped CPaDs into those with "warm climate preferences" and those with "cool climate preferences" (Koutouleas et al., 2025: 182). In general, crop pests are responding positively to climate warming and increases in precipitation. Temperature increases result in expanded geographical ranges, increased annual reproductive generations, and prolonged pest-damage seasons (Ma et al., 2025: 264-265). This is partly enabled by the fact that their natural enemies are more vulnerable to temperature change (Ma et al., 2025: 267), thus potentially causing the spatial decoupling of pests and their natural enemies as has been the case with the WCSB in East Africa (ibid: 272). In the same say, increased rainfall buffers "thermal-hydro stresses" (ibid: 264) such as extreme temperatures, which can otherwise exceed the lower and upper thermal thresholds of pests (ibid: 267). On the other side, speaking in favour of a decrease in pest levels as a result of climate change, increased rainfall might as well reduce insect activity, increase mortality, and limit larval survival, adult flight and dispersal (ibid: 268). Likewise, some populations might decline under climate change, as most tropical pests thrive only in stable temperatures (ibid: 270). As was also argued by Ma et al., the future distribution of pests is uncertain due to the unreliability of weather and the wide range of potential responses of pests to these changes. This complicates pest management, and especially biological control efforts, which potentially exacerbates the risk of pest outbreaks (ibid: 272).

The weather data and ethnographic records outlined above suggest increases in rainfall (Appendix 7), higher temperatures (Funk et al., 2012: 2; Bomuhangi et al., 2016: 3) and seasonal weather variability (Bomuhangi et al., 2016: 13; Koutouleas et al., 2025: 176; Appendix 7) as characteristics of the new weather pattern. These projected weather changes will potentially favour "warm climate pests" and diseases that spread through water. These include the WCSB, Coffee Berry Borer (CBB), CBD, and CLR, all of which are important in Sipi and Buginyanya and currently rank among the top 5 most widespread CPaDs (Figure 30). Aligning with Moses' observations, Liebig et al. noticed how WCSB had spread into higher elevations (up to 1700 masl.) because of climate change (Liebig et al., 2016: 14). During my fieldwork, farmers identified the WCSB up to 1935 masl. This suggests that the *ecosystem disequilibrium* is already manifesting itself on the mountain. Although not directly determined by Koutouleas et al., the WCSB might fit the definition of a "warm climate" pest, as its presence has been associated with extended drought periods and limited rainfall (Infante et al., 2023: 216). Vincent from Buginyanya confirmed these observations, stating that "in the dry season, we have too many pests, especially the stem borer". Being a "warm climate" pest (Koutouleas et al., 2025: 182), the CBB is also likely to develop faster under increasing temperatures (Johnson et al., 2020: 24), which means that regions currently not considered suitable for the CBB, might become favourable in the future (Jaramillo et al., 2011: 3). The same study emphasized that the CBB has already expanded its range in East Africa (ibid: 1). So, despite the fact that before the millennial change, no CBB attacks had been reported above 1500 masl. (ibid: 2), it aligns with my observations of dozens of CBB infestations in 1887 masl. Additionally, it confirms the study’s prediction that CBB prevalence would increase on East African mountains, including Mt Elgon (ibid.).

The CBD, on the contrary, was categorised as a “cool climate” disease (Koutouleas et al., 2025: 182), which explains why they predicted a low future impact of the disease. Amplifying this claim, they stressed that climate change would bring erratic rainfall and increased minimum temperatures, which would limit the duration of the optimal temperature for CBD development (ibid: 191). However, Liebig et al. saw it differently, suggesting that future climate conditions in high elevations would be preferable for the fungal disease (Liebig et al., 2016: 14). Developing this idea, Mafabi and Topista from Buginyanya had observed that CBD abundance was associated with “too high” levels of moisture, which is underlined by the fact that CBD is dispersed by water (UCDA, 2019: 80; Bieysse & Bedimo, 2010: 325). So, on the one hand, rising temperatures suggest a future decrease in CBD abundance, as Koutouleas et al. argued, while, on the other hand, increases in rainfall and moisture levels might facilitate the dispersal of the disease. This suggests that the future development in CBD distribution is characterised by uncertainty. The prevalence of CBD might as well depend on the presence of shade trees. Experiments in Cameroon demonstrated that coffee shrubs protected from direct rainfall had a substantially lower disease incidence (1.1%) than “unprotected” shrubs (45%) (Bieysse & Bedimo, 2010: 324). This will be followed up in the coming section. Regarding the other impactful fungal plant pathogen, CLR, Agriculture Institute argued that prolonged rainy seasons lead to higher moisture levels and thus increase the risk of CLR propagation (Agriculture Institute, 2024). Along with that, rising temperatures might lead to an altitudinal surge in CLR (Liebig et al., 2016: 12), as the disease requires moderate temperatures and prolonged free water availability for successful infection (Koutouleas et al., 2025: 180-181). Based on these arguments, the CLR might already be thriving in the current local climate (Appendix 7; Figure 30).

Apart from climate change, agricultural management practices also influence the impact from CPaDs (Ma et al., 2025: 270). Therefore, the effect of a selection of management methods on the presence of CPaDs will be elaborated in this final section.

What are the Implications of Management Methods for the Presence of CPaDs?

The Coffee Production System

The choice of coffee production system and its implications for the presence of coffee *antagonists* are more disputed topics than the previous one. Roughly, three coffee production systems exist on the slopes. These are sun-exposed monocrops, coffee-banana intercrops with or without a few shade trees, and agroforestry systems. As mentioned in the introduction, the clear majority of farmers were cultivating coffee using the second method. But what are the implications of the coffee production system for the presence of coffee *antagonists*?

Speaking in favour of agroforestry as the optimal cultivation system when it comes to CPaD suppression, the integration of native trees in coffee systems contributes to decreasing temperatures (Jaramillo et al., 2011: 6) and the preservation of local ecosystems, supporting those species linked to it. In that way, agroforestry increases biodiversity through the promotion of natural enemies of coffee pests (UCDA, 2019: 19; Ayalew et al., 2022: 2), so that, when combined with organic practices, it enhances biological control (Escobar-Ramirez et al., 2019: 1). Another effect of shade trees is that their canopies reduce the energy of raindrops and thereby prevent the dispersal of "disease-causing conidia" (Namuyanja et al., 2024: 284)[66]. Building on these insights, Jonsson et al. emphasised that polycultures are usually less damaged by pests than monocultures (Jonsson et al., 2015: 282). Locally relevant *antagonists* that studies found being limited in well-maintained agroforestry systems are Root Mealy Bugs (Liebig et al., 2016: 11), the CBD (ibid: 9), the Hemiparasitic Mistletoe (*Tapinanthus bangwensis*) (Tabi et al., 2021: 225; Negewo, 2024: 10), CBB (Jonsson et al., 2015: 281; Jaramillo et al., 2011: 6; Koutouleas et al., 2025: 194-195)[67], Coffee Bean Weevil (*Araecerus fasciculatus*) (Mourier, n.d.), WCSB and CLR (Nigussie et al., 2014: 2; Koutouleas et al., 2025: 194-195; Ayalew et al., 2022: 6).

In the case of the latter two, WCSB and CLR, other studies, however, seem to disagree. Some found that a high tree density was associated with increased incidents of the WCSB (Infante et al., 2023: 216; UCDA, 2019: 72; Liebig et al., 2016: 9; Jonsson et al., 2015: 281; Liebig et al., 2018: 517). Yet, optimal spacing and ensuring "good shade" through pruning were linked to reduced WCSB infestation levels (UCDA, 2019: 72), suggesting a pragmatic approach of maintaining a well-managed agroforestry system to limit the impact of the WCSB. Similar recommendations were given in relation to the CLR: "Maintain optimal shade levels (30-50%) by pruning shade trees and removing excessive vegetation" (Agriculture Institute, 2024), as conflicting conclusions were also drawn about the effects of shade trees on CLR infestation levels (Liebig et al., 2016: 9; Koutouleas et al., 2025: 184). Consequently,

[66] Saul from Kaserem had made similar observations stating that "leaf rust is much less under trees, because they reduce the power of raindrops".

[67] Note that the CBB has been reported to be an issue in both, shaded and unshaded systems (Liebig et al., 2016: 11; Johnson et al., 2020: 9). However, this will not be elaborated further here.

Koutouleas et al. called CLR "controversial", stating that other criteria must be considered, like the characteristics of shade tree species and the spatial distribution of trees (Koutouleas et al., 2025: 185-186). What Koutouleas et al. allude to here is the fact that some shade trees serve as alternative habitats for coffee pests. As Namuyanja et al. described, so-called "host plants" might sustain pest populations between harvest seasons (Namuyanja et al., 2024: 284). Pests capable of surviving in co-hosts include the Black Coffee Twig Borer (BCTB), *Persea americana* being the locally most widespread host tree species (Infante et al., 2023: 218-219; UCDA, 2019: 18). Other relevant host trees mentioned in the literature include *Markhamia Lutea* (Koutouleas et al., 2025: 190), *Maeopsis eminii* (ibid.) and *Albizia chinensis* (ibid.; UCDA, 2019: 18). All these tree species are potential host plants for the BCTB. However, given that only two incidents of this pest and limited damage were recorded locally, AfPEC should be cautious about discouraging the implementation of these shade tree species. Backing up this point, Ayalew et al. found that tree cover had a greater impact on coffee pest populations than specific shade tree species (Ayalew et al., 2022: 1)[68]. This explains why no specific tree species were mentioned in Appendices 3 and 4.

The above considerations indicate that the promotion of agroforestry in general and recommendations of shade tree species specifically, depend on a wealth of factors, including the local microclimate, how climate change is projected to affect the area, the native tree species being favourable and which pests they host, how the coffee field is being managed, and local farmers' views on agroforestry. Considering this, recommendations should be both site-specific and informed by socioecological considerations such as the aforementioned. So, depending on which CPaDs are most problematic for the specific farmer (Jonsson et al., 2015: 285), different actions towards shading can be taken. Generally, however, the regulation of shade was recommended rather than completely abandoning shade trees (Liebig et al., 2016: 11; Infante et al., 2023: 215, 219; UCDA, 2019: 72, 81; Tabi et al., 2021: 225; Negewo, 2024: 10; Agriculture Institute, 2024; Liebig et al., 2018: 521; Koutouleas et al., 2025: 194-195). The reason is that land use change from forest to crop production creates "favourable conditions for pests" (Ma et al., 2025: 265) that benefit from increased habitat and food sources (ibid: 278).

Chemical or Organic Prevention and Control of Coffee *Antagonists*?

As we learned in the introduction, the coffee plant incorporates certain macro- and micronutrients during berry development that need to be replenished after harvest (UCDA, 2019: 47; Martinez et al., 2024: 15). Both organic and inorganic options exist for this purpose. The same applies to the prevention and control of *antagonists*. Sipi and Buginyanya farmers employed opposite methods in this regard. Whereas the clear majority of Sipi farmers interviewed were certified organic farmers selling to Mountain Harvest and/or Sipi Organic, 19 out of 19 farmers interviewed in Buginyanya used synthetic

[68] Regarding coffee diseases, however, certain tree species were associated with increased CLR and CBD attacks. Yet only one of these species had local relevance (*Croton macrostachyus*).

approaches and had limited knowledge of biological or cultural management practices. In this final part of the discussion, the implications of organic and inorganic management practices for the presence of *antagonists* will be discussed, focusing on the advantages and disadvantages of each approach.

When comparing the distribution of *antagonists* across Sipi and Buginyanya, an interesting pattern emerges. Although the incidence of major CPaDs (CBD, CBB, and the WCSB) was somewhat similar, the number of mentions of CBB was higher in Sipi, as were CBD and CLR in Buginyanya (Figure 30). Concerning the first tendency, effective pesticide use in Buginyanya might account for the lower impact of CBB. Meanwhile, regarding the latter, a study from Kenya found that the incidence of the two diseases was significantly lower in "eco-friendly" systems compared to conventional ones (Lee et al., 2026: 1). Throughout the interviews, certain *antagonists* were found only in one of the two areas. *Antagonists* exclusive to Sipi were "aphids"[69] and the dodder weed, while in Buginyanya, numerous were identified, including Hemispherical Scales (*Saissetia coffeae*), Anthestia Bugs (*Antestiopsis lineaticollis*), the CLM, Hemispherical Mistletoe and the Coffee Bean Weevil (Appendix 3; Figure 30). This tendency might have multiple explanations. First of all, agrochemical products vary in quality and effectiveness. Several studies and farmers have attempted to clarify how this might be. In Buginyanya, farmers demanded more knowledge about which types of chemicals to apply, in which quantities and when. This coincides with the fact that a number of farmers had been victims of so-called "pesticide adulteration" (Namuyanja et al., 2024: 285), dilution and in other ways dysfunctional agrochemical products (Liebig et al., 2016: 15), being the result of "inadequate technical advice from extension workers" (Namuyanja et al., 2024: 285). This has far-reaching consequences, not only because agrochemicals constitute a large share of Buginyanya farmers' farm investments, but also because of the associated health and environmental effects of such products. I will return to this in a short while. Secondly, the (over)use of pesticides, insecticides, fungicides and/or synthetic fertilisers[70] might have a fatal impact on the natural enemies of CPaDs and it can lead to "pesticide resistance" of plants (Harelimana et al., 2025: 830). When left biologically unregulated, pests such as the CMB (UCDA, 2019: 75), CLM (Infante et al., 2023: 217), and Hemispherical Scales (ibid: 221) often thrive. Interestingly, the CLM and Hemispherical Scales were only identified on conventional coffee plots in Buginyanya. A final explanation, that relates to the aforementioned flaws of my methodological approach, is that coffee farmers in Buginyanya are more knowledgeable about CPaDs. As highlighted earlier, follow-up studies on this matter are encouraged.

Despite the fact that inorganic inputs have great availability, immediate effects and that they can be tailored to the specific nutrient requirements of the plant (UCDA, 2019: 63), there are critical side-

[69] Aphids were called "amphids" locally and were not identified.
[70] Approximately 50% of all pesticide use is unnecessary (Ma et al., 2025: 279).

effects that should be taken into consideration. In terms of health risks, the most critical are their toxicity (UCDA, 2019: 63), the lack of guidelines for application (Namuyanja et al., 2024: 285) and the limited local use of protective equipment (Liebig et al., 2016: 15). Regarding environmental impacts, significant risks are leaching of fertilizer, bioaccumulation of contaminants (UCDA, 2019: 63), down-stream contamination of waterways (ibid: 115) and resistance to pesticides (ibid: 62; Figure 43).

Figure 43. *A picture from Buginyanya allegedly showing plants resistant to pesticides. My translator, Joel, said: "You cannot apply no more".*

Contrary to the disadvantages presented here, Wonasolo from Buginyanya stood by his positive experiences with the use of agrochemicals. The young farmer remembered how the CBD, CLR and WCSB used to be abundant in his gardens, but now he had them under control. Most likely, Wonasolo succeeded in accessing the right products and using the recommended application approaches. Nevertheless, when I asked the organic coffee-agroforestry farmer, Sukuku, about his view on inorganic coffee farming, he argued accordingly:

> "Inorganic is unsustainable. You might get better yields for a few years. Let us say you get 30 bags per year for 2 years, but because of the stress it is causing on the environment, organic might be more profitable in the long term. Maybe you get 10 bags per year for 10 years… and 10 more years"

In our conversation, Sukuku suggested that farmers adopt conventional practices because of their short-term benefits and that the use of chemicals was a new tendency. From his perspective, Wonasolo might have success on his fields the next couple of years but experience long-term consequences. Backing up

Sukuku's point, Saul, a public primary school teacher from Kaserem[71] stated that "organic was the long tradition". During a taxi trip from Mbale to Sipi, the talkative farmer told me that during Idi Amin's dictatorship in the 1970s, farmers abandoned coffee farming due to boycotts by other countries. Replacing coffee, conventional food crop cultivation followed, so that when farmers returned to coffee farming, much of the knowledge about organic coffee farming had been lost. According to Saul, this lack of LEK also applied to experiences with organic management approaches to the prevention and control of CPaDs. Despite this deficiency, a majority of farmers in Sipi were able to share their cultural and biological control practices with me, whereas the opposite was the case in Buginyanya. So far, I have not found an explanation for the clear difference in management practices between the two villages. However, this is crucial to understand if we are to support the transition to sustainable coffee farming in both areas.

Somewhere between organic and inorganic approaches to the management of CPaDs lies the pragmatic approach known as Integrated Pest Management (IPM). It combines biological, cultural, and/or chemical measures (Rutherford & Phiri, 2006: 6; Namuyanja et al., 2024: 286) with considerations of the agroecological system and the cultivation of resistant varieties (ibid: 285-286). IPM is defined accordingly:

"A decision-based process involving coordinated use of multiple tactics for optimizing the control of all classes of pests (insects, pathogens, weeds, vertebrates) in an ecologically and economically sound manner." (Prokopy, 2003: 299).

In IPM, the use of chemicals is optional and considered a last resort, given the adverse health and environmental implications listed above. It requires the "timely application" of "specially formulated pesticides" to ensure effective control (Namuyanja et al., 2024: 285). The bearing methods in IPM are cultural and biological control. When compared to the use of chemicals, these methods are cheaper, readily available, but also more labour-intensive approaches (ibid: 284). As pointed towards earlier, examples of cultural control measures include phytosanitary measures such as pruning, stumping, strip-picking, desuckering, crop sanitation, proper postharvest handling, clean harvesting, uprooting and burning infected trees (ibid: 284; 287). Biological control, on the other hand, is the management of pest populations using "living organisms" (ibid: 285), earlier presented as natural enemies. For the reasons presented, IPM might be the obvious solution to the current challenges of chemical dependence in Buginyanya and could serve as an efficient means of transitioning to more sustainable approaches to managing coffee *antagonists*.

[71] The village, Kaserem, is located at the foot of the spur, Sipi spans over.

Summarising the discussion, climate change and the coffee production system applied are impactful parameters influencing the distribution of CPaDs. Regarding the former, changes in microclimate will significantly influence the future prevalence of specific CPaDs. These include locally relevant CPaDs such as the CBB, WCSB, and CLR that are projected to flourish, while the climatic impacts on other CPaDs remain more uncertain due to the unpredictability of how climate change will manifest. Concerning the latter parameter, the production system, farmers' preferences and experts' recommendations vary significantly. However, most studies agree that a majority of the CPaDs with local relevance are limited in well-managed coffee agroforestry systems. Farm design, including shade tree composition, was also highlighted as an impactful factor. In addition, adequate knowledge of the application of organic or synthetic preventive and control measures is required for effective CPaD management. In many ways, inorganic approaches appear more hazardous than eco-friendly alternatives, especially when considering the long-term sustainability of local coffee production. A pragmatic approach with the potential to aid a transition to more sustainable coffee production in Buginyanya is IPM, which combines a wide range of management strategies, including the deliberate use of chemical treatments. However, the success of this suggestion relies on access to adequate extension services, which were previously described as inadequate. So, the remaining question is: who is responsible for undertaking and supporting the transition to sustainable coffee farming in the region?

Conclusion

Seen historically, the Sebei and Bagisu people of Sipi and Buginyanya went through a transition from being subsistence farmers to becoming labour in the production of export cash crops under British, colonial rule. Today, these occupations are mixed, so that farmers now partly provide for themselves while depending on Western markets for cash income from Arabica coffee harvests. Due to high living costs, especially the high cost of schooling and healthcare, farmers rely to a large degree on income from their cash crops. In many ways, the entire livelihood of local, small-scale coffee farmers depends on successful harvests. Considering this, it is problematic that local small-scale Arabica coffee farmers face, what I have chosen to call *a multitude of intersecting climatic, practical and economic barriers* that chiefly challenge their *environmental* and *economic security*. Throughout the analysis, these *barriers* were presented and analysed, recognising the agency of nonhuman *actants*. When enacted by farmers, climate change, *antagonists* (pests, diseases and parasitic plants), farm equipment, *matooke* and natural enemies all proved to be significant *actants*, affecting Arabica coffee farming in various ways, as *barriers* and *enablers*.

As settled above, the main *barriers* to sustainable Arabica coffee farming were of economic, practical and environmental nature. On the one hand, economic *barriers* included the unequal distribution of coffee revenues, limited public investment in Arabica coffee farming, small-scale farmers' short-term prioritisations, and their restricted access to financial services, such as credit and loans. On the other hand, practical *barriers* were numerous. First, being in good health was a requirement for successful coffee farming. Secondly, well-functioning and available equipment, especially pulping machines and drying materials and facilities, were central *actants*, capable of controlling whether farmers were able to refine coffee to the level of parchment or not. Thirdly, the limited *local ecological knowledge* and lack of the multisensory *skilled vision* of some farmers and particularly their hired labour, were major practical *barriers* to lucrative and sustainable coffee farming, that were also the result of limited access to extension services. Specifically, the lack of knowledge of the identification and effective management of coffee pests and diseases was a critical consequence of this shortage.

The most crucial environmental *barriers* were connected to climate change. In the final, analytical section, new weather patterns were identified, based on local descriptions and data from a local weather station in Buginyanya. The last twelve years' weather pattern was characterised by increased precipitation (ranging from 1866 to 2696 millimetres of rain), greater weather variability (in-day, day-to-day, in-season, and between-seasons), increasing temperatures (including, in recent years, a shorter dry season), and more extreme rainfall events. This underlines that climate change is already a locally established phenomenon, as evidenced by the occurrence of climate variability events that has been experienced since 1993. Environmental *barriers* that relate to climate change include soil erosion, hailstorms, floods, landslides and drought. As a matter of fact, annual precipitation in the last 9 out of 12 years (2014-2025) exceeded the upper threshold of Arabica coffee cultivation (2000 millimetres). Specific consequences for farmers included increased unpredictability, which challenges planning and impedes flexibility. Secondly, excessive rainfall prolongs the drying period and delays the ripening of coffee berries, extending the harvest period and causing associated costs. Furthermore, weather instability and extremes may compromise the quality of the final product or completely hinder production, as *Coffea arabica* is particularly susceptible to heat stress and climatic variations. When combined with the fact that climate change leads to the proliferation of certain pests and diseases, this suggests that the local mountain climate is becoming less favourable for Arabica coffee cultivation: Coffee pests and diseases with the right microclimatic preferences are likely to flourish in mountainous environments such as the current one on Mt Elgon, through an increased number of annual reproductive generations and prolonged pest-damage seasons. Attacks by such insects, pathogens, weeds, or vertebrates reduce the quality and quantity of coffee, limiting farmers' returns from coffee harvests. It is perhaps for this reason that local small-scale farmers regarded coffee pests and diseases as the main challenge to coffee farming on the Western slopes of Mt Elgon.

Following up on this, the AfPEC baseline data showed that, together with farmers' limited investment capabilities, the derived effects of climate change and coffee pests and diseases are the key *barriers* to sustainable Arabica coffee farming in Sipi and Bugiyanya on Mt Elgon. Despite the presence of climate change, only 2 of 27 respondents were aware of the phenomenon. Instead, most farmers acknowledged the consequences of deforestation and used that as the explanation for the increased weather unpredictability, while just a few farmers attributed current weather changes to “God’s will”. In many ways, *local ecological knowledge* and farmers’ *perceptions* shape their possibilities, thus suggesting the need for readily available, high-quality extension services, such as the brochures developed here (Appendix 3 & 4). In their absence, suboptimal management decisions and short-term prioritisations are more likely. Examples of less sustainable practices were the cultivation of coffee under insufficient shade levels, the extensive use of agrochemical products and short-term approaches to coffee harvesting. Adding to this point, long-term investments were less likely if basic family needs were not met. This suggests that improving coffee farmers’ *economic security* is key to improving their livelihoods, which underlines the importance of the work done by AfPEC and *Frellsen Kaffe*. However, there is also a local demand for accessible extension services, which might be provided by AfPEC or, as a more sustainable solution, by relevant national authorities.

In the discussion, I examined how the recent development in the distribution of the locally most significant coffee pests and diseases might be explained by a variety of factors. Beyond climate change that is locally characterised by increases in rainfall, higher temperatures and seasonal weather variability, the globalisation of trade, the choice of coffee production system and conventional or organic approaches to coffee farming proved to be impactful parameters influencing the distribution of these coffee pests and diseases.

While recognising the uncertainty of climate predictions and the lack of knowledge about the concrete impact of climate change on specific species of coffee pests and diseases, relevant literature suggested the proliferation of so-called “warm-climate pests”, as temperature increases result in expanded geographical ranges, increased annual reproductive generations, and prolonged pest-damage seasons. Considering this and the new weather patterns, it was proposed that, among the locally most significant coffee pests, the White Coffee Stem Borer (WCSB) and the Coffee Berry Borer (CBB) might thrive under future microclimatic conditions. In addition, waterborne diseases such as Coffee Berry Disease (CBD) and Coffee Leaf Rust (CLR) might increase their levels of infestation because of the extended availability of water which support their dispersal. That being said, studies disagreed about the development of the CBD, referring to farm design and the composition of shade trees as impactful factors.

In favour of agroforestry as an adaptation strategy against pressures from coffee pests and diseases, factors such as the preservation of local ecosystems that is favouring natural enemies and limiting air temperatures, and the fact that a tree canopy buffers the dispersal of water-borne diseases were highlighted. Locally relevant coffee pests, diseases, and parasitic plants that studies reported as limited in well-maintained agroforestry systems included Root Mealy Bugs, CBD, the Hemiparasitic Mistletoe, CBB, and the Coffee Bean Weevil. On the other hand, the abundance of WCSB and CLR were associated with high canopy levels and excessive vegetation. The impact from these latter two could, however, be limited by maintaining optimal shade levels, ensuring sufficient spacing between shade trees and coffee shrubs, and weeding. Generally, regulating shade was recommended rather than completely abandoning shade trees.

The last factor influencing the distribution of coffee pests and diseases was the choice of organic versus conventional approaches to coffee farming. All interviewed small-scale farmers in Sipi were organic, while 19 out of 19 farmers in Buginyanya relied on agrochemicals. This pattern allowed for a comparative study of the prevalence of coffee pests and diseases in the two villages[72]. An interesting finding was that the number of mentions of the CBB was significantly higher among coffee farmers in Sipi who refrained from using pesticides as a control method, whereas the fungal diseases, CBD and CLR, were more widespread on conventional fields in Buginyanya. So how might this be explained? Firstly, the effective use of pesticides in Buginyanya might explain the lower incidence of CBB infestations. In general, inorganic farm inputs have immediate effects and can be adjusted to the plant's specific nutrient requirements. However, speaking against inorganic approaches to the management of coffee diseases, studies revealed that disease incidence is lower in eco-friendly coffee fields. Additionally, previous studies showed that pests unique to Buginyanya, such as Coffee Mealy Bugs, Coffee Leaf Miners, and Hemispherical scales, are always associated with pesticide use, since pesticides kill their natural enemies. This should be seen together with the potentially adverse environmental and health-related consequences of conventional coffee farming, which includes bioaccumulation of contaminants and the downstream pollution of waterways as well as the lack of guidelines for application and limited use of protective equipment. Considering these arguments, the transition to organic farming in Buginyanya was recommended. Supporting this conversion, Integrated Pest Management is likely an efficient and pragmatic approach, as it combines cultural and biological control practices with the deliberate use of synthetic measures, the cultivation of resistant coffee varieties, and considerations of the agroecological system.

Summing up the entire thesis, small-scale coffee farmers on the Western slopes of Mount Elgon might already find themselves in the middle of the Anthropocene - the proposed geological epoch where human actions are causing environmental changes of unprecedented scale, rate and complexity. Quite accurately these three words describe how the climate crisis manifests itself in the mountainous region:

[72] Please note that, as stated in the methods section, results from this comparative study should be used with caution, as it is based on farmers' mentions of specific coffee pests and diseases and not (natural) scientific methods. The qualitative approach is restricted by farmers' ability to identify and distinguish coffee pests and diseases from one another, which proved to be insufficient in some instances. Therefore, results might not reflect reality when it comes to the actual distribution of coffee pests and diseases in the two villages.

precipitation levels at the current *scale* has not been seen before; the *rate* of change, as well as its implications, are extreme, and, finally, the *complexity* of the alterations are so intricate that most farmers, otherwise known for their well-developed understanding and knowledge about their ecological surroundings, cannot grasp its nature. It remains uncertain whether the future brings effective adaptation of local Arabica coffee farming to the new weather patterns through the reintegration of shade trees and the revival of *local ecological knowledge* on long-term, sustainable coffee management. However, it sounds better than the potential trapping of farmers between the forest conservation border and the lower bioclimatic threshold for coffee production, which could lead to further deforestation, land fragmentation, land scarcity, or the replacement of coffee with food-crop cultivation, as some studies and farmers have warned. After all, income opportunities from the refinement of parchment coffee have the potential to increase farmers' *economic security* and thus improve the livelihoods of local farmer families, so that future generations can benefit from the cash crop on somewhat equal terms as recently. Or, hopefully, industrialised countries will soon take responsibility for the indirect harm they have caused through the combined effects of colonialism and greenhouse gas emissions. In no fair world do phenomena like exploitative trade systems and climate injustice belong. This calls for proper remuneration of Arabica coffee producers as well as adequate climate compensation.

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Recommendations

1. My impression after asking 50 farmers about the advantages and disadvantages of coffee shade trees is that there is some, but limited, knowledge about them. Hence, **there is a potential in disseminating the *ecosystem services* that trees provide for both farmers, the local environment and their coffee production**. This includes shade trees being a source of income (selling firewood, timber and charcoal), protecting coffee from extreme weather events (hailstorms, heavy rain, wind and drought), enhancing the soil structure and fertility (providing nitrogen, manure, etc.), decreasing temperatures, preventing weeds, preventing landslides and soil erosion, contributing to the water cycle and managing/storing water in periods of drought.

2. **Host knowledge-sharing workshops focusing on coffee management practices.** There is a noticeable difference between well-managed coffee plots, where farmers are frequently in their gardens, knowing how to manage them (prune trees/coffee, spray liquid manure, ensure the right spacing between coffee shrubs and shade trees, discover early signs of pests and diseases, apply mulch, etc.), and the gardens of farmers who give less attention to their coffee. The farmers that fall into this latter category generally experience lower coffee yields and a larger impact from coffee pests and diseases.

3. To Frellsen: **Consider replacing the second payment with an advanced payment** once you know the harvest estimates. In this way, you meet farmers' need for money in the beginning of the harvest period (October to December depending on the area). During this period most farmers repay VSLA-loans and cover school fees, while being unable to engage in other income-generating activities because of the harvest-related workload.
    a. A suggestion from one of your hard-working coffee farmers was that farmers could use some of their expected coffee sales (in the shape of an advanced payment from you) to repay the loans they have taken out through their VSLA.
    b. A parallel solution could be to advise farmers to move repayments of VSLA-loans into the new year, hence avoiding coinciding "big" payments.

4. To Frellsen: **Initiate and support a transition from conventional to organic coffee production in relevant project communities**, through the Integrated Pest Management approach; training on cultural and biological control measures of coffee pests and diseases; dissemination of knowledge about organic management practices in general and certification systems, as well as the advantages of shade trees for coffee yields and climate resilience. This can be integrated in your marketing of "Bærekraft", contributing to a healthy, local environment contrary to your current marketing of conventional coffee.

5. To Frellsen: to comply with the lack of extension workers in Buginyanya, you should **consider training Wonasolo**, since he is perceived as an extension worker, without actually being it. Many of his cooperative "colleagues" are asking him for advice, when he visits them, for example in connection with coffee collection.

6. To SwB: **Apply for funding for drying/processing materials/machines**. This can significantly improve the income of the farmers, since it is a main *barrier* to the refinement of parchment coffee.

7. AfPEC: **Encourage local coffee farmers to educate their hired labour**, for example in proper picking methods, which berries to pick and the signs of pest infestation and/or disease infection to ensure proper post-harvest handling of coffee berries.

8. AfPEC: If the partnership with Growing Trees Network is established, Sukuku from Sipi recommends **farmer payment being divided into two; an initial payment when the tree is planted and a payment one year after planting to incentivize tree management**. His idea is to pay farmers in biogas, which is cheaper and more environmentally friendly than charcoal and firewood for example considering deforestation risks.

9. AfPEC: While coffee farmers are aware of climate change-related transformations in local weather patterns, a clear majority of them are lacking knowledge about climate change as a phenomenon despite it being a major explanation. For that reason, **a workshop focusing on the causes of the climatic variability they experience and the optimal responses to them would improve farmers' ability to make the right decisions when navigating adaptation strategies.**
    a. "The ability of farmers to perceive climate change is important for them to make informed decisions for adaptation choices." (Aturihaihi et al., 2023: 55).
    b. "One of the prerequisites to adapt to change is recognition that actually change is taking place. In the context of climate variability, communities must first perceive that changes are in fact taking place" (Bomuhangi et al., 2016: 13).

10. AfPEC/JESE/FoW: **I would strongly recommend using the information collected in the background document** (Appendix 3) **to prepare E-learning videos that communicate the same practices and approaches as presented in the brochures** (Appendix 4)**.** A significant share of farmers is illiterate and/or lack English skills. Additionally, considering that farmers learn better visually, when seeing how things can be done on similar coffee fields (cf. Mathilde's presentation), this would increase the successful adoption of the management practices. You could also arrange a workshop dealing with the topic of Appendices 3 and 4.

Appendices

All appendices are attached in continuation of this document.

Appendix 1: Farm Design

Appendix 2: Consent Form

Appendix 3: Background Document

Appendix 4: Brochures

Appendix 5: Coffee Farmer Workshop

Appendix 6: Regional Extreme Weather Events

Appendix 7: NARO Weather Data 2014-2025

Appendix 8: Daily Weather Observations

Declaration of the use of AI

☒ **I used generative artificial intelligence (GAI) to complete this project.** The following GAI tools were used: • Research Assistant on https://www.kb.dk/. • ChatGPT, version 5.3. • Grammarly, version 1.2.263.1893.
I used GAI tools in the following way:
For feedback on text (I used Grammarly. ChatGPT was used to meet page restrictions in the summary).
For alternative ways of formulating text (same as above).
To aid me in my reading process (I asked questions to the Research Assistant which formulated answers based on online literature available through the online version of the Danish Royal Library. I used it to sort what literature to read and what to omit).
To understand a topic better (Research Assistant, same way as above).
In my literature search (Research Assistant, same way as above).
For grammatical corrections and writing suggestions (Grammarly).
For support in the identification of three unknown coffee pests based on pictures taken on coffee farms (ChatGPT).

Appendix 1

Interviewed farmers had between 1 and 6 gardens in Sipi (3.16 in average) and 1 and 12 in Buginyanya (4.61 in average) at the average size of 0.58 acres in Sipi and 0.577 acres in Buginyanya. Furthermore, the average farm size in Buginyanya was 2.44 acres.

Average Farm Size and Number of Gardens in Sipi

Acres:	2	0.5	1.5	0.25					4.5	5	2	1.5	1.5	0.5	2			
Numbers of gardens	4	1	2	1	3	4	2	6	6	3	4	5	3	3	4	2	2	2
Average size of gardens	0.5	0.5	0.75	0.25					0.75	1.67	0.5	0.3	0.5	0.16	0.5			
Average size of gardens (total)	**0.58**	**acres**	*based on 11 farmers*															
Average number of gardens	**3.16**	**gardens**	*based on 18 farmers*															

Average Farm Size and Number of Gardens in Buginyanya

Acres:						7.5	1	4	1.5	1	0.5	6	1	2.25	4	0.5	1	1.5
Numbers of gardens	7	8	4	3	5	5	4	4	2	1	3	12	3	4	8	2	5	3
Average size of gardens						1.5	0.25	1	0.75	1	0.16	0.5	0.33	0.56	0.5	0.25	0.2	0.5
Average size of gardens (total)	**0.58**	**acres**	*based on 13 farmers*															
Average number of gardens	**4.61**	**gardens**	*based on 18 farmers*															
Average size of "farm"	**2.44**	**acres**																

Appendix 2

Participant Consent Form for Research

Project Title: Mt Elgon Coffee producers' perceptions of climate change and agroforestry, living at the frontier of the current environmental crises

Research student: Oscar Sig Tranberg, Master Student in Human Security

Contact Information: E-Mail: au673704@uni.au.dk or +45 50484975 (WhatsApp).

Aarhus University. Moesgaard Allé 20, 8270 Højbjerg.

Purpose of the Study:

You are being invited to participate in a research study about perceptions of climate change and agroforestry among coffee farmers in the Mt Elgon region, in Uganda.

The purpose of this study is twofold:

1) to collect data for my master thesis which focuses on the theme explained above.
2) to assess the current situation of coffee agroforestry with the intention to improve the AfPEC-project, so that it fits local needs and can be sustained in the future. Here taking into consideration the negative impact environmental change, economic restraints, limited land access and several other challenges have on the area.

What Participation Involves:

- Participation will involve interviews, observations, etc.
- Interviews may be audio/video recorded, with your consent (tick the relevant box below):
  - ☐ Yes, I consent to be audio/video recorded, and that it can be used in the preparation of the thesis/ in the AfPEC-project.
  - ☐ Yes, I consent to be audio recorded (no video), and that it can be used in the preparation of the thesis/ in the AfPEC-project.
  - ☐ No, you can not use any visual material including me.
- You can choose not to answer any question or to stop the interview at any time.

How Your Data Will Be Used:

- Your personal data (e.g., interview recordings, field notes) will be **kept confidential**.
- Data will be **stored securely** on encrypted devices and EU-based servers.
- Data will be used for academic research, publications, presentations, and by people involved in the AfPEC-project.
- No identifying information will be shared without your explicit permission.
- Data **may be anonymized** for long-term archiving after the project ends.

Your Rights:

Under the EU General Data Protection Regulation (GDPR), you have the right to:

- Access your data
- Correct your data
- Request deletion of your data
- Withdraw your consent at any time without giving a reason

If you wish to exercise these rights, you can contact the researcher at any time using the information provided above.

Consent Statement:

Please tick each box if you agree:

☐ I have read and understood the information above.
☐ I voluntarily agree to participate in this study.
☐ I agree to the interview being recorded.
☐ I understand that I can withdraw at any time without consequences.
☐ I understand how my data will be stored, used, and protected.

Participant Name: ____________________________

Participant Signature: ____________________________

Date: ____________________________

Researcher Name: ____________________________

Researcher Signature: ____________________________

Appendix 3

PESTS, PARASITIC PLANTS, AND DISEASES IDENTIFIED OR REPORTED IN SIPI AND/OR BUGINYANYA ON MOUNT ELGON IN UGANDA

- **Their biology, signs, preventive and control measures**

Introduction

In 2020, the Ugandan government set the ambition to "quadruple its coffee production in the coming years" (Namuyanja et al., 2024: 277). However, the fulfillment of this goal is challenged by a variety of threats, including climate change, inadequate management practices, parasitic plants, pests, and diseases.

Coffee pests and diseases affect coffee's nutrition, development, health, and therefore yields. Coffee's physical and chemical qualities are also deteriorated (ibid.).

Farmers in Sipi (Kapchorwa District) and Buginyanya (Bulambuli District) are reporting pests and diseases as the major challenge to coffee farming (see chart below).

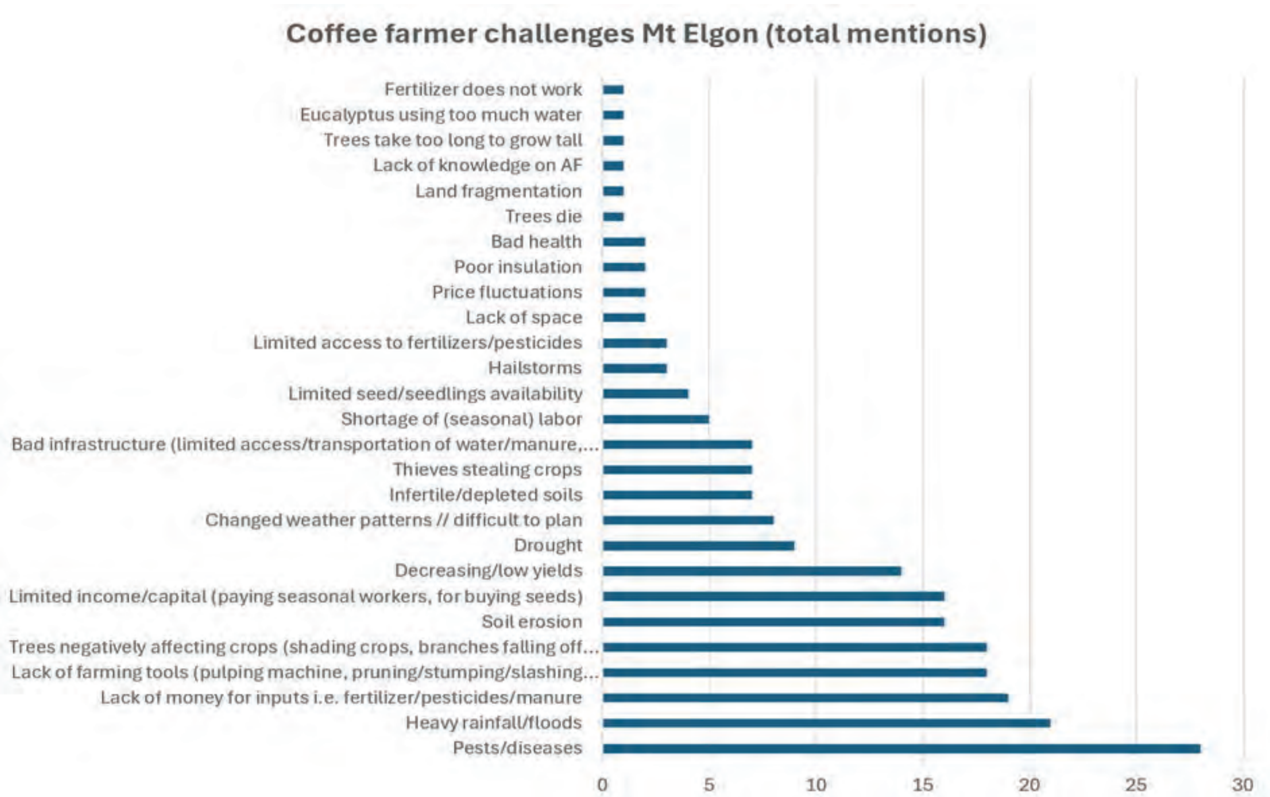
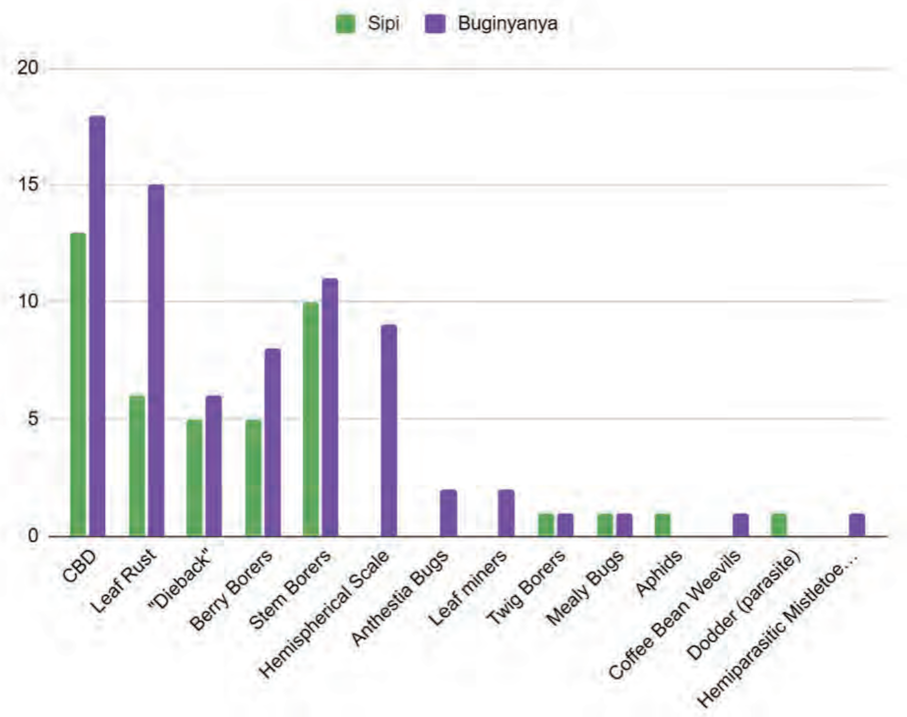


Chart based upon the AfPEC Baseline Data that was collected in 2024 (Kroijer et al., 2024).

Farmers emphasize Coffee Berry Disease (CBD), Coffee Leaf Rust (CLR), White Coffee Stem Borer (WCSB), Coffee Berry Borer (CBB), and "Dieback" as the most harmful pests and diseases (see below).



Worst pests/diseases/parasitic plants in Sipi and Buginyanya. Bar chart based upon 42 interviews (23 in Sipi, 19 in Buginyanya). In Sipi, 4 farmers reported having "no pests/diseases". All farmers in Buginyanya had at least one pest, one disease, or both. A few farmers (2) even had parasitic plants attached to their coffee plants (Dodder Weed and Hemiparasitic Mistletoe).

Background document

Provided here is an overview of the coffee pests, diseases, and parasitic plants that were reported by farmers or identified through field observations in Sipi and Buginyanya. The document is based on a great variety of literature, workshop group discussions, and farmer interviews. It is structured so that the most significant pests and diseases are found at the top. The text is more elaborate than the brochures, and it contains references that did not fit in them. Please note that Aphids and the Coffee Bean Weevil were not included due to insufficient empirical evidence.

Biology / epidemiology	Indicators and consequences	Prevention and control
Coffee Berry Disease (CBD)  CBD is caused by the fungal plant pathogen, *Colletotrichum kahawae.* Rain facilitates the dispersal and infection process of the disease. It either washes down from infected berries above (UCDA, 2019: 80) or spreads through splashes of rain (Bieysse & Bedimo, 2010: 325). The coffee berry disease is severe at high altitudes, above 1600 masl., since cooler temperatures and higher humidity can be found here (Liebig et al. 2016: 14). Berry infection can happen between 17 °C and 28 °C, while the optimal temperature for its development is around 22 °C (Koutouleas et al., 2025: 180).	Once the disease infects the coffee bean, it mummifies, turns black and distorted as seen on the picture below:  The disease can cause flower and leaf defoliation. If young, expanding berries are inflicted, they beans do not develop inside. As a consequence, berries shed-off prematurely (UCDA, 2019: 81; Bieysse & Bedimo, 2010: 324). 	Preventive measures: ● **Introduce resistant plant varieties** (UCDA, 2019: 81). ● **Ensure sufficient spacing** between coffee trees and dig trenches to separate them (Sukuku). ● **Preventive spray:** mix pepper, ash, onion and cow dung (Sukuku). ● **Regulation of shade** (Liebig et al. 2016: 11), pruning and, in severe incidents, stumping (UCDA, 2019: 81). "Most diseased berries fall prematurely, but those that remain attached to branches are the main sources of the secondary inoculum" (Bieysse & Bedimo, 2010: 324). Treatment measures: ● **Strip-picking** at the end of harvest season (Liebig et al. 2016: 14). ● **The use of shade trees.** Liebig et al. (2016) found that the occurence of CBD was "significanly lower" in agroforestry systems (Liebig et al., 2016: 9). Similarly, experiments in Cameroon demonstrated that coffee trees protected from direct rainfall had substantially lower disease incidence (1.1%) compared to unprotected trees (45%) (Bieysse & Bedimo, 2010: 324) ● **If CBD damage is severe:** uproot the coffee tree and burn it (Workshop-group 1).
Coffee Leaf Rust (CLR) The CLR is caused by the fungus *Hemileia vastatrix* (Agriculture Institute, 2024). Rainsplash, insects, wind, and humans are the main disease vectors (UCDA, 2019: 79). However, infected coffee seedlings and cutting can also spread the disease to new locations (ibid.).	The process of infection (and signs to be aware off): 1) The disease typically begins its assault on the underside of coffee leaves, starting with small, pale yellow spots (masses of fungal spores) that might easily be mistaken for nutrient deficiencies or minor stress. These initial lesions usually appear on older, lower leaves first (Agriculture Institute, 2024): 	Preventive measures: ● **Introduce resistant plant varieties** (Agriculture Institute, 2024) ● **Use cover crops** (legiminous plants like cowpea and clover) to prevent the lower branches and leaves from being exposed to splashing water during rains (Caroline & Group 2). ● **Apply manure** in a circle around the coffee stem (Sukuku). ● **Preventive spray** #1: spray a mix of pepper, ash, onion and cow dung (Sukuku). ● **Preventive spray** #2: spray a mix of cow urine and ash (Group 3). ● **Digging trenches and ensuring sufficient spacing** between trees (3 x 3 meters) (Namuyanja et al., 2024: 283) prevents it from spreading through the roots (Sukuku).

Like the CDB, CLR is most problematic in highland coffee-growing regions (1000 to 1800 masl.) where moderate temperatures and high humidity levels persist for longer periods (ibid.). Infection levels intensify during rainy seasons, and the availability of free water for at least 3 to 6 hours is a requirement for successful infection (Koutouleas et al., 2025: 181). However,, extreme rainfall limits the epidemic's growth as spores wash off (ibid.)

Remaining, infected leaves are sources of new infections that starts when the rains begin and the fungus becomes active. New leaves become infected and the disease cycle is repeated (UCDA, 2019: 79).

2) The old parts of the lesions become necrotic and turn brown (UCDA, 2019: 79)

3) Later stage: Black, dried-out branches and leaves falls prematurely (Namuyanja et al., 2024: 283)

According to Agriculture Institute (2024), the premature defoliation of leaves decrease photosynthesis, restrict flowering and limit energy produced for berry development. Berries are lighter, smaller and thus of poorer quality. The potential yield loss is up to 70% (Agriculture Institute, 2024), stored nutrients are depleted and young berries might fall off prematurely (Namuyanja et al., 2024: 283).

- **Keep it healthy**: well-nourished plants show greater resistance to diseases (ibid.)
- **Ensure an appropriate supply of nutrients** but avoid excessive nitrogen fertilization (ibid.)

"Farms with poor air circulation, dense canopies, or valleys that trap moisture face higher disease pressure." (UCDA, 2019: 79).

Treatment measures:

- **Break off the affected branch** and burn it (Joseph; Group 1; Namuyanja et al., 2024: 283).
- **Maintain an open canopy structure** that allows sunlight penetration and air circulation (Agriculture Institute, 2024; UCDA, 2019: 79).
- **Optimal shade levels are 30-50%:** pruning shade trees and removing excessive vegetation (ibid.)
- **Control the weeds**: Remove weeds and undergrowth that increase humidity around coffee plants and impede air circulation (ibid.)
- **Spray with parasitic fungus:** *Lecanicillium lecanii* is a natural enemy (hyperparasite) that can be sprayed to colonize the rust (Perfecto, Vandermeer & Philpott, 2014: 142).

White Coffee Stem Borer (WCSB)

Monochamus leuconotus is the name of the stem borer that is recorded across Africa (CABI & EPPO).

The WCSB is typically 3.0 to 3.5 cm long (Rutherford & Phiri, 2006: 13) and can be found at the beginning of the rainy season when egg-laying occurs (Infante et al., 2023: 216). The WCSB lays its eggs on the coffee stem up to 30 cm above

The WCSB produces large amounts of wood shaving and frass, which fall at the coffee shrub's base under the entrance hole (Infante et al., 2023: 216). At later stages of infestation, plants turn yellow, drop their leaves and look decaying (ibid.). If you see these signs, look for the infestation hole:

Sawdust or "frass" indicating recent stem infestation (Samuel).

Prevention and early management:

- **Detect early stages of infestation** (frass) at the onset of rainy seasons. It is easier to kill adult beetles than larvaes that feed inside the stem (Infante et al., 2023: 216; Liebig et al., 2018: 521)
- **Inspect your coffee field regularly**
- **Covering tree bark up to 50 cm** with banana fibers or maize cob strands prevents it from laying eggs (UCDA, 2019: 72) - **called stem wrapping** (Liebig et al., 2016: 11).
- **Prune shade trees** as less damage occurs under "good shade" (UCDA, 2019: 72).
- **Protect natural enemies**: woodpeckers, ants, parasitoids, entomopathogenic nematodes, and fungi (Jonsson et al., 2015: 286)

the ground. After hatching, the larvae bores a hole in the stem and enters. Inside the main root, it feeds for several months (ibid.). An adult WCSB can fly up to one mile and thus spread to other nearby coffee fields (Liebig et al., 2018: 520).

K) WCSB larvae, L) sawdust from infestation, M) Cross section of an infested stem (Infante et al., 2023: 214).

The insect thrives under dry conditions on fields located at altitudes above 1000 masl. (ibid.). Liebig et al. (2016) found that the prevalence of WCSB was higher at 1,100-1,700 masl. than above 1,700 masl. (Liebig et al. 2016: 13). Today, however, the stem borer is prevalent at 1,700 masl. because of climate change (ibid: 14) - a fact which was confirmed by my observations of WCSB at 1926 masl.

Infestation hole of WCSB in the stem. The hole has the length of the stick (Soyekwo).

According to Liebig et al. (2016), WCSB can be considered the most serious pest in the Mt Elgon region.

Young trees are specifically vulnerable to stem borer damage, and trees under 2 years are often killed. Older trees are less likely to die but often give poor coffee yields (Jonsson et al., 2015: 283). Once attacked, old trees are also prone to infection by *Fuzarium* stilboides, which causes further wilting of leaves and dead trees or branches (UCDA, 2019: 72) One reason is that WCSB affects the plant's vascular transportation system (Infante et al., 2023: 216).

Treatment practices:

- **Cultural practices are useful** at early stages of infestation, for example killing the larvae by **inserting "brick wire"** into the infestation hole (ibid.; Joseph; Sukuku; Group 1, 2 and 4).
- **Starve the borer inside the trunk** by filling the hole with cow dung (Joseph; Sukuku; Group 1 and 2).
- **Block the infestation hole** with fat from a pig to attract natural enemies (Group 3; Joseph).
- **Use pheromones** that attract and kill the female WCSB, thus decre-asing egg-laying (Infante et al., 2023: 216).
- **Stumping**: if the infestation is old and well-developed, you should cut down the coffee to a point below the infestation hole (see picture below).
- **If the tree is dying**: Uproot or stump it and burn the residues to kill the pest (Soyekwo; Joseph; Infante et al., 2023: 216).

If only one of the three stems, you see on the picture, is attacked then you only need to stump that one.

Coffee Berry Borer (CBB)

The bark beetle, *Hypothenemus hampei*, is less than 2 mm long and native to Africa (Vega et al., 2019). It prefers feeding and reproducing in the coffee plant (Moreno-Ramirez et al., 2024: 201).

Picture of the Coffee Berry Borer (Infante et al., 2023: 214)

Signs of CBB infestation is shown on the pictures below. Sawdust on the berry is indicating recent activities (upper picture). Berry infestation can be as indistinct as on the lower picture Here, the CBB has entered through the floral disc, boring a 0.6–0.8 mm hole (Johnson et al., 2020: 5):

Preventive measures:

- **Crop sanitation** can reduce CBB infestation from 70% to 6% (Moreno-Ramirez et al., 2024: 202):
  - **Pruning** unproductive branches and suckers (Johnson et al., 2020: 7)
  - **Weed suppression** (ibid: 24)
  - **Prompt harvesting** at least every two weeks when coffee is ripe (ibid.; UCDA, 2019: 73)
  - **Collection of "mbuni"** from beneath trees, should be given high priority (Rutherford & Phiri: 10; UCDA, 2019: 73).
  - **Slash** during the rainy season to prevent it from being bushy (ibid.)
- **Integration of shade trees**:
  - Low temperature and low humi-dity limit the survival of the be-

The adult female bores a hole in the coffee fruit (berry) and lays her eggs in the seed (bean), leaving it damaged. Young CBB females mate with their own brothers, before leaving the berry and taking flight in search for new fruits, where the cycle can be repeated (Infante et al., 2023: 213).

The berry borer prefers high humidity levels and temperatures between 23 °C and 26 °C" (Koutouleas et al., 2025: 179). Originally, CBB was more widespread at low and medium altitudes. However, as a result of global warming, infestations have been reported at higher altitudes (ibid: 186). During my fieldwork, I observed more than ten CBB infestations at 1887 masl., confirming the tendency.

Apart from changing climatic conditions, a range of vectors, including animals, vehicles, humans, and wind, are responsible for the passive dispersal of the pest (Namuyanja et al., 2024: 280).

(Johnson et al., 2020: 2)

When searching for the CBB, farmers should be aware that they are difficult to see until crops are damaged. The borers are small and stay inside the bean for most of their life (Moreno-Ramirez et al., 2024: 202). This makes preventive measures difficult. Sawdust and microscopic holes are the most useful indications of infestation.

Since the CBB deselect green berries with watery endosperm, most damage is done to beans in mature fruits. The CBB larvae and adult consume the bean's endosperm during its development (Infante et al., 2023: 213), causing the premature fall of berries, flavor deterioration, weight and quality reduction (Rutherford & Phiri, 2006: 8). Additionally, CBB infestation means increased susceptibility to attacks from other pests and diseases (Jonsson et al., 2015: 282). The result is between 50 and 100% yield loss (Namuyanja et al. 2024: 280).

CBB entering a coffee berry through its floral disc (Infante et al., 2023: 214).

This lead Infante et al. (2023) to declare that the CBB is the most devastating coffee pest worldwide (Infante et al., 2023: 213).

etle and its ability to breed (Rutherford & Phiri, 2006: 9)
    - CBB damage was lower in agroforestry systems when compared to sun-exposed (Jonsson et al., 2015: 281; Koutouleas et al., 2025: 190), remaining below the 5% economic threshold level (Jaramillo et al., 2011: 6).
    - With the introduction of agroforestry, a reduction of 4°C would imply a drop of 34% in the intrinsic rate of increase of the coffee berry borer (Jaramillo et al., 2011: 6).
- **Pick and eliminate infested berries** to prevent the CBB from surviving the harvest season (Liebig et al., 2016: 11; Johnson et al., 2020: 18; Mafabi)
    - Remove infested berries from the garden, burn (Namuyanja et al., 2024: 281), boil for minimum 30 minutes (Johnson et al., 2020: 19), and/or bury them at least 12 inches deep (Sukuku, Group 4; Johnsson et al., 2020: 8; Infante et al., 2023: 215). According to Johsson et al. (2020), this was the **most important measure.**
    - Use a wide basket or lay out a tarpaulin under the tree, you are sanitizing (Johnson et al., 2020: 18, 24).
- **Disinfect** harvested berries and collection sacks (Johnson et al., 2020: 8)
    - Place the bag in hot water for at least 15 minutes (ibid: 19)
- **Spray with liquid manure**: a mix of ash, pepper and green matter (from bekuraisi) (Sukuku)

Treatment practices:

- **Alcohol-baited traps** may be an effective method of control if used at a high density (22–25 traps per hectare) and at the appropriate time (post-harvest to early fruit growth) (Johnson et al., 2020: 9).
    - 3:1 or 1:1 combinations of methanol:ethanol (ibid: 16)
- **Biological control:** protect natural enemies by avoiding the use of insectides and maintaining well-managed agroforestry system:
    - Parasitic wasps, *Prorops nasuta* (Johnson et al., 2020: 8), *Cephalonomia stephanoderis* and *Physmaticus coffea,* have been used to control the CBB, since they

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Typically, only one bean is affected (the one to the right. According to Caroline, the other should be marketable.
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parasitize immature stages of CBB and feed on the adult females (Moreno-Ramirez et al., 2024: 203).
Birds (Jonsson et al., 2015: 285; Moreno-Ramirez et al., 2024: 203)
Bats (Perfecto, Vandermeer & Philpott, 2014: 140)
Spiders (Moreno-Ramirez et al., 2024: 208).
Lizards (ibid: 203), including chameleons (Group 1, 2 and 4)
Small ants are important CBB predators, since they are able to enter the berry, and shaded environments increase ant predation (Infante et al., 2023: 215; Gonthier et al., 2013: 816; Moreno-Ramirez et al., 2024: 207-208).
The fungus, Beauveria bassiana (ibid: 204).

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Dieback

Necrosis (death) of a shoot, beginning at the tip and spreading back through the older tissues. (Rutherford & Phiri, 2006: 66).

The reasons for dieback can be several. It depends on the context and the presence of other factors (Group workshop)

Lack of fertility. The plant is prioritizing water and nutrient supply.
Coffee wilt disease, as confirmed by (Rutherford & Phiri, 2006: 48)
CLR, also confirmed by (Rutherford & Phiri, 2006: 37)
Aphids

According to the UCDA (2019), other potential explanations include stresses such as herbicide scotch, weeds, diseases, pest damage or water stress. (UCDA, 2019: 52).
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Branches turn dry and black over time, starting from the tip. This is how you can distinguish it from the twig borer (CTB). In the case of a CTB attack, necrosis starts from the infestation hole that is typically closer to the apex of the branch (Vincent).

Several branches affected by dieback.

In the worst incidents, dieback can result in the death of the whole branch, stem or even the eventual death of the entire shrub (Rutherford & Phiri, 2006: 37).
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Preventive solutions:

Providing shade (Group 2)
Apply organic manure (Group 5)
Weeding (Group 5)

Treatment measures:

If the tree is severily damaged, uproot and burn the tree (Group 2)
Pruning or breaking off affected branches until the point where it stops being dry (Group 2 and 3).

Different examples of dieback. Effective pruning requires the right tactile practice. All these branches were broken off carefully at the point where the dieback had reached.
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Hemispherical scale

Hemispherical scales, Saissetia coffeae, are typically found closely attached to the underside of coffee leaves, stems,
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Preventive measures:

Synthetic insecticides should be avoided (Infante et al. 2023: 221)

Treatment practices:
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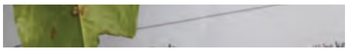
<td>branches, and/or fruits (Infante et al., 2023: 221).

The scales are so-called sucking pests that ingest sap from the coffee plant. When doing this, they secrete honey-dew, which favors the growth of the black fungus, *Capnodium sp.*, that is also known as sooty mould (ibid.).

According to Infante et al. (2023), **their presence is always connected to the misuse of insecticides.** The reason is that such chemicals eliminate the natural enemies that otherwise regulate scale populations (Ibid.). This might explain why they were only spotted on conventional fields in Buginyanya and not on organic fields in Sipi. The appearance of scales is also enhanced under hot and dry climatic conditions (ibid.)</td>
<td>
Hemispherical scales observed on the underside of coffee leaves.

A typical sign of scale infestation is the encrustation of coffee leaves, shoots and berries. They become mottled with discoloured patches and curl down-wards (Rutherford & Phiri, 2006: 24).


Branches and leaves infested with sooty mold.

Infestation reduces the plant's photo-synthetic activity and shoot growth is inhibited (Rutherford & Phiri, 2006: 24). In cases of severe attacks, leaves and fruits fall, the growth stops, and young plants die (Infante et al., 2023: 221).</td>
<td>● Biological control:
○ **Spraying the fungus**, *Lecanici-llium lecanii*, that invades and destroys scales in just two days. The fun-gus should be applied at a con-centration of 1x108 conidia per millimeter (Infante et al. 2023: 221).
○ Protecting natural enemies:
■ *Encyrtidae* parasitoids (wasps)
■ Ladybird larvaes and adults
■ Fly larvaes of the *Syrphidae* family.</td>
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<td>**Antestia Bugs**

The coffee pest, *Antestiopsis lineaticollis,* is a brown or bronze shield bug with yellow/orange patterns (UCDA, 2019: 72).


An antestia bug attached to a coffee branch (UCDA, 2019: 72).

They cause damage through sucking sap from flower buds, flowers, berries, leaves and soft stems (ibid.).</td>
<td>Signs of an antestia bug attack include flower and berry adoption, cracking (look for zebra marks), rotting of beans, and shortening of internode (UCDA, 2019: 72).

The bugs are so ferocious that two or three on a tree can wipe out all the berries. When the fruit is pulped, there is no bean or only badly shaped beans (ibid.).

According to farmers, affected coffee would have the taste of “irish” potatoes.</td>
<td>Preventive measures:

● **Integration of shade trees**. Accor-ding to Ayalew et al. (2022), antestia attacks decreased with canopy co-ver (Ayalew et al., 2022: 6).
● **Avoid using pesticides**. Pesticides kill the weaver ant, *oecophylla longi-noda*, which is a natural enemy of antestia bugs (Way & Khoo, 1992: 484).
● **Regular desuckering and pruning.** Open conditions are unsuitable for the pest, but favorable for its natural enemies (UCDA, 2019: 72).

Treatment:

● Their considerable size taken into account, it is possible for farmers to **physically collect and kill the bugs** (ibid.)</td>
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<td>**Coffee Leaf miners (CLM)**</td>
<td>A common sign of CLM infestation is seen on the picture below, where the leaf appears to be burned.</td>
<td>Preventive measures:

● **Regular inspections** in the garden.</td>
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The coffee pest, *Leucoptera caffeina,* is a 2 mm long micromoth with a 6.5 mm wingspan. Its body is covered with silvery scales (Infante et al., 2023: 217).

Leaf miner adult (ibid: 214).

The CLM can feed and reproduce on a variety of coffee species, including *coffea arabica*. Just after hatching, the larvae penetrate the leaf and consume its mesophyll (ibid.).

Outbreaks are most common at low altitudes in warm areas. In higher altitudes, it is seen during the dry season and on conventional coffee farms, where synthetic pesticides are frequently applied. In wet environments, on the other hand, water enters the mine and drowns the larvae, explaining the low infestation levels in such areas (ibid.).

A coffee leaf damaged by a coffee leaf miner producing necrotic lesions or "blotches" (UCDA, 2019: 76) that reduce the leaf's photosynthetic area (Infante et al., 2023: 214).

In this case, the CLM has eaten itself through the edge of the leaf causing it to curl up (Mafabi & Joel).

During daytime, the moths can be difficult to find, as they hide on the underside of coffee leaves (ibid: 217).

In most cases, a CLM attack causes plant defoliation and in severe incidents (four larvaes per leaf), the premature shedding of leaves. If a CLM infestation happens while coffee berries are still under-developed, it may affect yields considerably (UCDA, 2019: 76).

- **Monthly sampling** from the beginning of flowering until harvesting begins (Infante et al., 2023: 217).
- **Mulching:** maintain a thick mulch coverage of the soil (ibid.).
- **Avoid high plant densities** through pruning and desuckering (ibid.).
- **Integrate shade trees**: a high forest cover was associated with fewer incidents of CLM attacks and the abundance of natural enemies (Shimales et al., 2023: 912; Ayalew et al., 2022: 6).

Treatment practices:

- **Proliferate natural enemies**: Wasps of the *Polistes spp.,* several species of ants (Infante et al., 2023: 217), bacteria and fungi (ibid: 218).
- **Plant and maintain "noble weeds"** along the roadways to sustain natural enemies (ibid.)

Coffee Twig Borers (CTB)

The black twig borer, *Xylosandrus compactus*, is widely distributed across Africa. The small coleopteran is brownish black, and it lives in symbiosis with the fungi, *Ambrosiaemyces zeilanicus* and *Ambrosiella xylebori* (Infante et al., 2023: 218).

Infestation happens when the female CTB bores a hole in the internode of green branches (called twigs). Here they establish a "brood chamber" (Namuyanja et al., 2024: 282) to lay eggs and introduce the fungus. The fungus acts as a food substrate for CTB larvaes

Twig borers inside a branch (Infante et al., 2023: 214)

When looking for signs of the CTB, the farmer should be aware of dry, brittle or withered branches with 1 mm circular holes and sawdust as seen on the picture below (ibid: 219):

Preventive measures:

- **Moderated shade** (Infante et al., 2023: 219).
- **Proper and sufficient fertilization** which keep branches healthy and resistant (ibid.; Liebig et al., 2016: 11).

Treatment practices:

- **Sanitary pruning and cutting affected branches** (Infante et al., 2023: 219).
- **Alcohol traps** with methanol:ethanol at a ratio of 3:1. The traps capture and kill CTB adult females (ibid.).
- **Spraying affected trees** with the fungus, *Beauveria bassiana* (ibid.)
- **Protect and encourage natural enemies:** wasps and ants (see ibid: 219 for specific species; Liebig et al.,

and adults that do not feed on the host plant. After a while, the fungus grows and forms a cottony mass that spreads to the entire chamber (Infante et al., 2023: 218).

The CTB and its symbiotic fungi prefers warmer climates, which explains why it is more widespread in Robusta coffee (Koutouleas et al., 2025: 170) and in unshaded coffee (own observation).

Twig borer larvae identified by Vincent.

Infected branches are weak and they easily break. As elaborated below, the infestation starts from the infestation hole and spreads to the apex (ibid: 218). Consequently, leaves on the infested branch turn light green and starts wilting (Namuyanja et al., 2024: 282), as the fungus interferes its water supply (Infante et al., 2023: 218). After a few days, the branches' bark and leaves turn black (Namuyanja et al., 2024: 282).

When showing me a CTB attack, Vincent told me that the branch starts to dry from where the insect entered as he indicates.

2016: 11). For more biological control agents see (Namuyanja et al., 2024: 282).

(Root) Mealy Bugs

Coffee mealybugs, *Planococcus spp.,* are small sucking insects about 3 millimeters long (UCDA, 2019: 73) that feed by ingesting sap from young coffee shoots and leaves, flower bugs, roots, green and red cherries (ibid: 74). Like the hemisperical scale, they secrete honeydew.

Mealy bugs often appear in white, waxy colonies on the underside of tender leaves and in areas, where the stem is softer and the soil is looser (see pictures below) (UCDA, 2019: 74).

Wobudundu said the ants were looking for a pest underground at the stem.

On the back of the leaves white/brown dots can be seen. All are mealy bugs.

Preventive measures:

- **Intercropping with legumes** (Liebig et al.., 2016: 11)
- **Applying organic manure** (ibid.)

A ladybird feeding on a mealy bug.

Control measures:

- **Prune** badly damaged branches (UCDA, 2019: 75)
- **Avoid using insecticides**: serious infestations of mealy bugs have been reported on conventional fields because pesticides kill their natural enemies (ibid.).
- **Proliferate natural enemies**, including the lacewing insect, *Oligochrysa lutea*, which - like the ladybird - is a recognized predator of mealy bugs. Similarly, parasitic

A mealy bug attached to a green coffee berry.

Plentiful root mealy bugs on the root of a coffee shrub.

Farmers' challenges with mealy bugs are bigger in the dry season when water availability is low.

As seen above, mealy bugs also appear in colonies at berry nodes and fruit clusters. Apart from the granular masses, ants have built a web of debris protecting the mealy bugs as seen below:

If you zoom in, you can see mealy bugs sucking sap directly from the berries.

As indicated on the pictures, an attack from mealy bugs results in yellowing and defoliation of the plants (UCDA, 2019: 74).

wasps lay their eggs in the mealy bug, resulting in its death (ibid.).

- **Apply oils** such as neem, mineral or soapy solutions during non-sunny periods to suffocate the coffee pest (ibid.)
- **Feed "black ants" with sugar** (see below).

Ants sucking honeydew.

"Black ants" prevent the development of damaging fungal molds (UCDA, 2019: 74) by eating the honeydew that is produced by the mealy bugs. But they also protect the source of their honeydew from natural enemies. To solve this dilemma, **farmers should feed the ants with sugar**, so that they prey on the mealy bugs instead (Jensen et al., 2023: 2415; Joachim Offenberg; Jørgen Axelsen). Mix up to 40% sugar with water in a +250ml container (plastic bottle with a wick). For more details see (Jensen et al., 2023: 2416).

The Dodder Weed

Cuscuta reflexa is a parasitic weed with small seeds that easily spread through vectors such as birds, water, vehicles, shoes as well as infected tools, soil and equipment (Mutitu et al., 2020: 1-2). The Dodder weed has a variety of host plants that are also act as vectors.

Once you know the appearance of the Dodder, it is easy to identify.

Dodder attached to a dried-up branch. As Sukuku said, it looks like it strangles the branches (Sukuku).

As the Dodder parasitize the host, it becomes more susceptible to attacks from other pests (Mutitu et al., 2020: 2). The

When compared to identification, prevention and control is the difficult part of Dodder management. Handweeding, specifically, requires caution and adroitness.

Preventive measures:

- **Clean and inspect equipment and clothing** before moving from Dodder-infested areas to "clean" areas (Mutitu et al., 2020: 6).
- **Isolate small infestations** (ibid.)

"The most immediate action is to eliminate or reduce the infestation before the invasion gets out of control" (ibid.)

Treatment practices:

Cuscuta reflexa attacking coffee in Sipi.

Dodder has slender, twining or thread-like, bright stems that vary from pale green to yellow or bright orange (ibid: 1).

Dodder grows by extracting nutrients and water from the host plant. In this process, it continously reattaches, forming dense mats of intertwined stems that ultimately enclose entire trees or shrubs (ibid.).

host plant dries and eventually, it dies (ibid: 1).

Affected coffee tree with yellow leaves and berries lacking nutrition.

Once the Dodder is introduced to a new area, it is difficult to get rid of again. Sukuku told me that in Soroti it is already a big problem, which made him declare that **"in 10 years all coffee will be dead"**.

- **Remove them manually** by hand or prune affected branches before the plant produces seeds that can disperse (ibid.; Negeweo, 2024: 9)
- **Monitor large infestations**, and mow, prune and **burn it** nearby in place where it can not spread to other plants (dirt roads for example), to prevent seed production (Mutitu et al., 2020: 6; Sukuku).

Hemiparasitic Mistletoe

Tapinanthus bangwensis is a coffee parasite as well. It grows by attaching a sticky seed to the host plant's stem or branches, from which it develops into a twig (Mafabi; Haiwe & Enow, 2021: 219).

Seeds are spread by birds, rodents, squirrels, wind and seed rain from taller plants. It might as well be carried by infested harvesting tools and pruners, when they are used on healthy trees (ibid: 225)

As with the Dodder, the Hemisparasitic Mistletoe is easy to distinguish once you know what it looks like. Bark cracking and resin exudation are other signs of infestation (Negewo, 2024: 10).

Once established on the host plant, the parasitic plant is connected to the host, extracting water, minerals and nutrients from it (ibid: 9). When weakened, the host plant becomes more sensitive to attacks from pests and diseases. Parasitism might kill the infested branch, but in severe incidents, it kills the entire host plant (ibid: 10). The mistletoe disrupts the normal functioning of the host plant, causing deformity, abnormal branching, dieback, flower and fruit reduction (ibid: 9).

Preventive measures:

- **30-40% shade from shade trees** (Tabi, Haiwe & Enow, 2021: 225; Negewo, 2024: 10)
    - Growth of the parasitic plant relies on photosynthesis which is reduced by shade trees. Additionally, birds are more likely to disperse their seeds in the shade trees instead (Tabi, Haiwe & Enow, 2021: 225).
- **Scaring away birds** (ibid: 223).
- **Cleaning pruning knives** and other tools (ibid.)
- **Adequate fertilization** makes the plant capable of withstanding infestation (Negewo, 2024: 10)

Treatment practices:

- **Cut the host's branch or stem** 15 to 20 centimeters below the point of attachment (ibid.) when the parasitic plant is flowering (Mafabi).
- **Regular inspections:** remove seeds (Mafabi).

General recommendations

- **Protect natural enemies of coffee pests**: Chameleons, lady birds, mites, parasitoid wasps, lacewings, ants, birds, bats, threadworms, fungi, and flies (for pest-specific recommendations, see above).
    - "The diversity and abundance of natural enemies of insect pests is often higher in agroforestry plantations than in sun-exposed monocultures" (Jonsson et al., 2015: 281).
- **Combine pest and disease management with other "good agricultural practices"** such as irrigation, fertilization, pruning, weed control, shade management, soil and water conservation (UCDA, 2019: 71).
    - **Adequate fertilization** keeps your coffee healthy, helping it withstand pest and disease attacks. Additionally, a healthy coffee plant is drought-tolerant and produces higher-quality coffee (ibid: 49)
    - **Keep the fields clean**: weeds provide alternative habitats for pests.
- **Integrated Pest Management (IPM)**: combine available control measures listed here to manage coffee pests and diseases more effectively (Namuyanja et al., 2024: 286). IPM also includes the monitoring of pests and diseases (see Ehler, 2006 or 787; Jepson, 2022), the agroecological system, such as agroforestry or monocrop, and the cultivation of resistant coffee varieties (Koutouleas et al., 2025: 194).
- **Use collective control strategies**: "if a coffee grower implements one or several available strategies and his neighbor does not, then efforts will be unsuccessful" (Infante et al., 2023: 215).
- **Renovation of old-aged plantations** involves uprooting coffee shrubs that give decreasing yields and smaller berries (Koutouleas et al., 2025: 194). As Joseph explained, a coffee shrub should be replaced when "feeding it" does not help.

Example of an old-aged coffee shrub in Sipi. It has few leaves, low-quality berries, and dried-up branches.

Notes on the interplay between agroforestry and coffee pests and diseases

As argued in the thesis, the presence of **the majority of pests and diseases identified in Sipi and Buginyanya was limited under shaded conditions.** Additionally, natural enemies are thriving in such a production system as the integration of native trees in coffee systems contributes to decreasing temperatures (Jaramillo et al., 2011: 6) and the preservation of local ecosystems. Pests and diseases that were restricted in agroforestry systems include the **CBB** (Jonsson et al., 2015: 281), **CBD** (Liebig et al., 2016: 16), **Root Mealy Bugs** (ibid: 11), **the Hemisparasitic Mistletoe** (Tabi, Haiwe & Enow, 2021: 225; Negewo, 2024: 10), **the Coffee Bean Weevil** (Mourier, n.d.), **Antestia Bugs** (Ayalew et al., 2022: 6), **WCSB** and **CLR** (Nigussie, Taye & Bukero, 2014: 2; Koutouleas et al., 2025: 194-195; Ayalew et al., 2022: 6). In other studies, however, **WCSB** (Liebig et al., 2016: 15; Jonsson et al., 2015: 281) and **CLR** (Liebig et al., 2016: 9) **were more abundant under excessive shade**. Depending on which coffee pests and diseases are the most problematic for the specific farmer (Jonsson et al., 2015: 285), different actions towards shading should be taken. Generally, however, **the regulation of shade** (pruning, sufficient spacing between coffee trees and shade trees) **was recommended rather than completely abandoning shade trees** (Liebig et al., 2016: 11; Infante et al., 2023: 215, 219; UCDA, 2019: 72, 81; Tabi, Haiwe & Enow, 2021: 225; Negewo, 2024: 10; Agriculture Institute, 2024; Liebig et al., 2018: 521). Considering this, **a pragmatic approach involving a well-maintained agroforestry system is recommended.**

Local, organic spray recipes for the prevention of coffee pests and diseases

- **Coffee diseases:**
    - Killing diseases: Mix urine from a cow with a handful of "chili chili", ash, and a kilo of onions. Stir it, mash it, and extract the liquid (Unknown woman from Sipi).
    - Prevention of CBD and CLR: mix pepper, ash, onion, and cow dung. Keep it for 3 weeks before spraying (Workshop Group 1).
- **Coffee pests:**
    - Preventing pests: Mix red pepper, vinegar, soda ash, molasses, stinking needle, and alcohol. Let it ferment for one week and mix 1:20 with water (Immaculate, Gamatui).
    - Liquid manure to treat the berry borer: Mix cow dung, ash, banana stem, tithonia, and water. Let it ferment for 2 weeks (Jenifer, Sipi)
    - Preventing coffee drying and attacks from Root Mealy Bugs: Mix cow dung with soil and spray it on the coffee roots (Sukuku, Sipi).
- **Prevention of both:**
    - Mix ash and water, and spray it (David, Sipi)
    - Local mixture: Mix ash, water, and red pepper, and spray from January to May, while the coffee is flowering (unknown source).

For specifications, please consult the farmers quoted.

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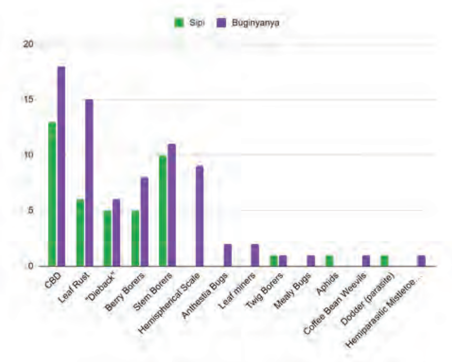
THE MOST HARMFUL PESTS AND DISEASES

In 2020, the Ugandan government set the ambition to "quadruple its coffee production in the coming years". However, achieving this goal is hindered by a range of threats, including **climate change, inadequate management practices, pests, parasitic plants, and diseases.**



Mentions of pests, diseases, and parasitic plants were reported by 38 farmers interviewed in Buginyanya and Sipi.

Coffee pests, diseases, and parasitic plants significantly affect yields and compromise the health of coffee plants by influencing their nutrition, development, and physical and chemical qualities. **This brochure helps local coffee farmers identify, prevent, and sustainably manage these.**

Appendix 4.1

HOW WAS THIS MADE?

BACKGROUND

Coffee farmers from Buginyanya and Sipi informed the brochure, as well as various research articles, handbooks and local experts.

FARM VISITS AND FIELD OBSERVATIONS

Local farmers invited me (Oscar) to see their coffee gardens and showed me signs of pests and diseases.

WHO IS IT RELEVANT FOR?

The information provided in this brochure is site-specific and therefore **most relevant for farmers in Kapchorwa and Bulambuli District.**

WHITE COFFEE STEM BORER

- What is it?
- How do I identify it?
- How do I prevent and treat it?

***Note*: Tailored to coffee farmers on Mt Elgon**

WHAT IS THE STEM BORER?

MONOCHAMUS LEUCONOTUS IS THE NAME OF THE STEM BORER THAT IS RECORDED ACROSS AFRICA

The WCSB is typically **3.0 to 3.5 cm long** and can be observed from the beginning of the rainy season when egg-laying starts. The coffee pest lays its eggs on the coffee stem up to 30 cm above the ground. After hatching, the larvae bores a hole in the stem and enters. Inside the main root, it feeds for several months.

Source: Rutherford & Phiri (2006)

THE WCSB PREFERS DRYNESS

The stem borer thrives under dry conditions on fields located above 1,000 masl. Today, the stem borer is prevalent at 1,700 masl. because of **climate change.**

HOW DO I IDENTIFY IT?

When the larvae bores into the trunk, it produces **frass** which fall at the coffee shrub's base under the entrance hole.

At later stages of infestation, **plants turn yellow, drop their leaves and look decaying**. If you see these signs, look for the infestation hole:

"WCSB CAN BE CONSIDERED THE MOST SERIOUS PEST IN THE MT ELGON REGION."

(Liebig et al., 2016: 14)

The WCSB drills through the stem causing a slow **die-out.** The stem dries and starts to crumble. Young trees are especially vulnerable to stem borer damage, and trees under 2 ye-ars are often killed. Older trees are less likely to die but often **give poor coffee yields**.

HOW DO I PREVENT IT?

1. Inspect your coffee field regularly.
2. **Stem wrapping** up to 50 cm above ground with banana fibers or maize cob prevents it from laying eggs.
3. **Detect early stages of infestation** (frass) at the onset of rainy seasons (and apply cultural control methods - see below)
4. **Prune shade trees** as less damage occurs under optimal shade levels.
5. **Protect natural enemies**: woodpeckers, ants and parasitoid wasps.

HOW DO I TREAT IT?

Cultural practices are useful at early stages of infestation, for example:

- Kill the larvae by inserting "**brick wire**" into the infestation hole.
- Starve the borer inside the trunk by filling the entrance hole with **cow dung.**
- Block the infestation hole with fat from a pig to attract natural enemies.

Other control measures:

- Use **pheromones** to attract and kill the female WCSB.
- If the infestation is well-established and the coffee shrub is dying: Uproot or stump it to the height you see on the picture below. **Burn the residues** to kill the pest.

AfPEC

THE MOST HARMFUL PESTS AND DISEASES

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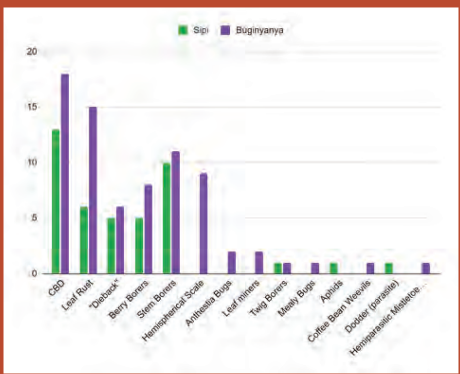

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Appendix 4.2

HOW WAS THIS MADE?

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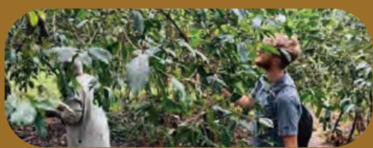

WHO IS IT RELEVANT FOR?

The information provided in this brochure is site-specific and therefore **most relevant for farmers in Kapchorwa and Bulambuli District.**

COFFEE LEAF RUST (CLR)

- What is it?
- How do I identify it?
- How do I prevent and treat it?

***Note**: Tailored to coffee farmers on Mt Elgon*

WHAT IS THE LEAF RUST?

A FUNGAL DISEASE

The CLR is caused by the fungus *Hemileia vastatrix*. Infection happens when the rai-ny season begins. Fungus spores spread with rain splashes, in-sects, wind, and hu-mans. Infected leaves remaining on the coffee shrub, are the sources of new in-fections.

LEAF RUST THRIVES IN THE HIGHLANDS

CLR is most problematic in highland coffee-growing regions (1000 to 1800 masl.) where moderate temperatures and high humidity levels persist for longer periods

HOW DO I IDENTIFY IT?

Coffee leaf rust can be observed on several stages of development:



1. 2. 3.

1. First, CLR appears as **small, pale yellow or orange spots** (fungal spores) on the underside of lower and old leaves.
2. Once developed, the old parts of the lesions become necrotic and turn brown.
3. Finally, black, dried-out branches and leaves falls prematurely.

"THE POTENTIAL YIELD LOSS IS UP TO 70%"

(Agriculture Institute, 2024)

The premature defoliation of leaves decrea-se photosynthesis, restrict flowering and limit energy produced for berry development.

This **reduces the quality of berries**. They are lighter, smaller, and young berries might fall off prematurely.

HOW DO I PREVENT IT?

PREVENT IT FROM SPREADING VIA WATER

1. Cultivate **resistant varieties**
2. Plant **cover crops** like cowpea and clover
3. **Digging trenches** and ensuring sufficient **spacing** between trees (3x3 meters).
4. **Apply sufficient fertilizer**, but avoid excessive nitrogen fertilization.
5. Apply **manure** in a circle around the coffee stem 
6. Preventive spray #1: spray a mix of pepper, ash, onion and cow dung.
7. Preventive spray #2: spray a mix of cow urine and ash.

"FARMS WITH POOR AIR CIRCULATION, DENSE CANOPIES, OR VALLEYS THAT TRAP MOISTURE FACE HIGHER DISEASE PRESSURE."

(UCDA, 2019: 79)

HOW DO I TREAT IT?

- **Break off the affected branch and burn it**
- Keep an open canopy structure
- Maintain **optimal shade levels (30-50%)**
- Remove weeds and undergrowth that increase humidity around coffee plants and impede air circulation
- **Spray with parasitic fungus**
  - *Lecanicillium lecanii*

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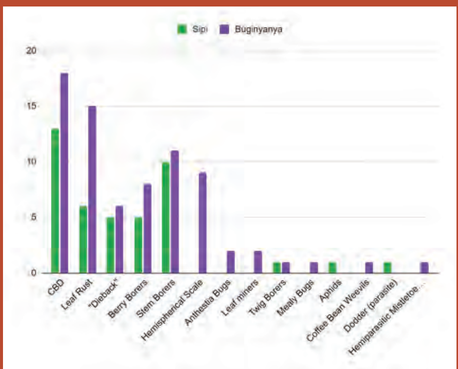
THE MOST HARMFUL PESTS AND DISEASES

In 2020, the Ugandan government set the ambition to "quadruple its coffee production in the coming years". However, achieving this goal is hindered by a range of threats, including **climate change, inadequate management practices, pests, parasitic plants, and diseases.**



Mentions of pests, diseases, and parasitic plants were reported by 38 farmers interviewed in Buginyanya and Sipi.

Coffee pests, diseases, and parasitic plants significantly affect yields and compromise the health of coffee plants by influencing their nutrition, development, and physical and chemical qualities. **This brochure helps local coffee farmers identify, prevent, and sustainably manage these.**

Appendix 4.3

HOW WAS THIS MADE?

BACKGROUND

Coffee farmers from Buginyanya and Sipi informed the brochure, as well as various research articles, handbooks and local experts.

FARM VISITS AND FIELD OBSERVATIONS

Local farmers invited me (Oscar) to see their coffee gardens and showed me signs of pests and diseases.

WHO IS IT RELEVANT FOR?

The information provided in this brochure is site-specific and therefore **most relevant for farmers in Kapchorwa and Bulambuli District.**

Source: Infante et al. (2023)

COFFEE BERRY BORER (CBB)

- What is it?
- How do I identify it?
- How do I prevent and treat it?

Note*: *Tailored to coffee farmers on Mt Elgon

WHAT IS THE CBB?

THE BARK BEETLE
HYPOTHENEMUS HAMPEI

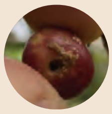
The CBB **prefers feeding and reproducing in coffee**. The female lays her eggs in the coffee bean and stays there until she is impregnated again, from which she flies out to find new berries to infest and lay her eggs.

Source: Infante et al. (2023)

CBB PREFERS HIGH TEMPERATURES

The berry borer thrives in high temperatures, between 23 and 26 degrees celsius, and high humidity. Formerly, it was mainly found in low and medium elevations, but **because of climate change, it has now been found at higher altitudes as well.**

HOW DO I IDENTIFY IT?



When the CBB bores into the bean, it leaves **sawdust** on the berry. It might enter through the floral disc or near it, boring **a 0.6–0.8 mm hole**.

"WITH LOSSES OVER $500 MILLION ANNUALLY, THE CBB IS THE MOST DEVASTATING PEST OF COFFEE."

(Infante et al., 2023: 213)

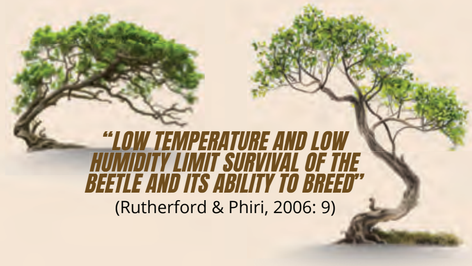
Most damage is caused to mature berries, as it is in these that **CBB destroys the bean** during its development. CBB also infests and damages green berries, but leaves them again. **Premature fall, decay, weight, or quality reduction** are some of the consequences.

"ECONOMIC LOSSES ARE CAUSED BY ADULTS AND PROGENY DIRECTLY THROUGH THEIR FEEDING ACTIVITIES, BY MAKING ATTACKED BERRIES MORE VULNERABLE TO DISEASE INFECTION AND FURTHER PEST ATTACK"

(Jonsson et al., 2015: 282)

HOW DO I PREVENT IT?

1. Pruning of coffee and shade trees
2. **Prompt harvesting** - at least every two weeks when ripe
3. Collection of mbuni from beneath trees. **Burn, boil, or bury leftover berries**.
4. Shade trees limit the temperatures in coffee gardens and thus the survival and reproduction of the beetle
5. Disinfect harvested berries and and clean collection sacks
6. Spray with liquid manure



"LOW TEMPERATURE AND LOW HUMIDITY LIMIT SURVIVAL OF THE BEETLE AND ITS ABILITY TO BREED"

(Rutherford & Phiri, 2006: 9)

HOW DO I TREAT IT?

Alcohol-baited traps at high density (22–25 traps per hectare). 3:1 or 1:1 combinations of methanol:ethanol.

Protect natural enemies: wasps, ants, birds, spiders, bats, and chameleons - avoid pesticides.

Source: Aristizábal et al. (2015)

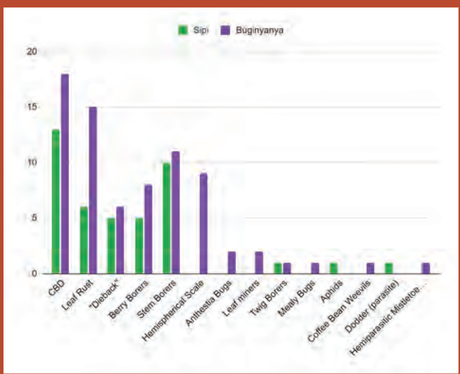
"ANTS ARE IMPORTANT CBB PREDATORS AND SHADED COFFEE PROVIDES A BETTER ENVIRONMENT FOR INCREASING ANT PREDATION"

(Infante et al., 2023: 215)

AfPEC

THE MOST HARMFUL PESTS AND DISEASES

In 2020, the Ugandan government set the ambition to "quadruple its coffee production in the coming years". However, achieving this goal is hindered by a range of threats, including **climate change, inadequate management practices, pests, parasitic plants, and diseases.**



Mentions of pests, diseases, and parasitic plants were reported by 38 farmers interviewed in Buginyanya and Sipi.

Coffee pests, diseases, and parasitic plants significantly affect yields and compromise the health of coffee plants by influencing their nutrition, development, and physical and chemical qualities. **This brochure helps local coffee farmers identify, prevent, and sustainably manage these.**

Appendix 4.4

HOW WAS THIS MADE?

BACKGROUND

Coffee farmers from Buginyanya and Sipi informed the brochure, as well as various research articles, handbooks and local experts.

FARM VISITS AND FIELD OBSERVATIONS

Local farmers invited me (Oscar) to see their coffee gardens and showed me signs of pests and diseases.

WHO IS IT RELEVANT FOR?

The information provided in this brochure is site-specific and therefore **most relevant for farmers in Kapchorwa and Bulambuli District.**

COFFEE BERRY DISEASE (CBD)

- What is it?
- How do I identify it?
- How do I prevent and treat it?

***Note**: Tailored to coffee farmers on Mt Elgon*

WHAT IS THE CBD?

A FUNGAL DISEASE

CBD is caused by the fungal plant pathogen, *Colletotrichum kahawae.* **Rain facilitates the dispersal and infection process** of the disease. It either washes down from infected berries above or spreads through splashes of rain.

Source: Craft Coffee Guru

CBD LIKES COLDNESS AND MOIST

CBD is more severe at higher altitudes (above 1600 masl.) due to higher humidity and cooler temperatures (prefers between 17 and 28 degrees Celsius).

HOW DO I IDENTIFY IT?

"THE BEANS DO NOT DEVELOP INSIDE"

The CBD causes the berries to rot. **Berries mummify, and some drop prematurely**. Flowers might be lost in the flowering season, and CDB might also cause leaves to fall off.

"CBD CAN BE CONSIDERED AS THE MOST SEVERE DISEASE OF THE HIGHER ALTITUDES OF THE MOUNT ELGON REGION"

(Liebig et al. 2016: 14)

As a group of farmers said at a workshop in Sipi, the beans do not develop inside. If the infection reaches the beans, **they become black, distorted, and can not be sold.**

"MOST DISEASED BERRIES FALL PREMATURELY, BUT THOSE THAT REMAIN ATTACHED TO BRANCHES ARE THE MAIN SOURCES OF THE SECONDARY [INFECTION]"

(Bieysse & Bedimo, 2010: 324)

HOW DO I PREVENT IT?

PREVENT IT FROM SPREADING VIA WATER

1. Ensure sufficient spacing between coffee trees.
2. Increase shade from shade trees. A study from 2010 concluded that: "**coffee trees protected from direct rainfall had substantially lower disease incidence**." (Bieysse & Bedimo, 2010: 324)
3. Dig trenches to separate coffee tree rows.
4. Spray with a mix of pepper, ash, onion, and cow dung.
5. Remove all berries from an infected branch after harvest

HOW DO I TREAT IT?

CBD-resistant varieties of coffee exist. Ask your local extension worker which varieties fit the local environment.

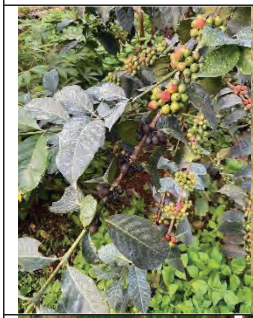
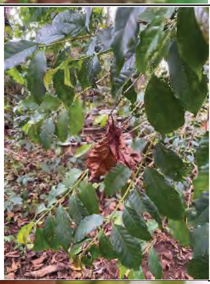
Strip-picking at the end of the harvest season.

Source: First Shot

If the damage is severe, uproot the coffee tree and burn it.

Appendix 5

COFFEE FARMER WORKSHOP NOV 2025 **PCM CHURCH, Sipi**

Sign of the pest/disease	**Name** (English name preferred)	**Rank (1-5)** (The one affecting your coffee yields the most is given 1)	**List up to 3 organic** management practices
 	Write here...		
 			
 			
			
 			

Next in the program: For each pest/disease, 1 group is invited to present the name, its rank and the recommended management practices.

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Appendix 6

Disaster Subtype	Associated Types	Start Year	Total Deaths	No. Injured	No. Affected	Total Affected
Landslide (wet)		1997	20			
Riverine flood	Slide (land, mud, snow, rock)	1997	100		150000	153500
Drought		1998			126000	126000
Riverine flood		2002	17		760	760
Riverine flood		2003	5			1500
Riverine flood	Slide (land, mud, snow, rock)	2003	20		700	700
Riverine flood		2006	3		1680	1680
Riverine flood	Slide (land, mud, snow, rock)	2007	29		435070	718045
Landslide (wet)		2010	388	10	12785	12795
Riverine flood	Slide (land, mud, snow, rock)	2011	27		63075	63075
Landslide (wet)		2012	18	64		3432
Mudslide	Flood	2018	51			
Flood (General)		2019	3		4750	4750
Landslide (wet)		2019	7		1000	1000
Landslide (wet)	Flood	2019	20			
Flash flood	Slide (land, mud, snow, rock)	2019	36		6000	6000
Flood (General)	Slide (land, mud, snow, rock)	2019	65		65250	65250
Landslide (wet)	Flood|Lightening	2019	61	25	129928	129953
Flash flood	Slide (land, mud, snow, rock)	2020	3		100000	100000
Flood (General)		2021	1		75000	75000
Flood (General)	Hail|Slide (land, mud, snow, rock)	2021	1	72	41661	42330
Flood (General)		2022	16			130
Flood (General)		2022	32	10	78328	78338
Flood (General)		2023	23	16	1000	1016
Flood (General)		2024	77	296	57508	57804
Landslide (wet)	Broken Dam/Burst bank|Flood	2024	141	22	30000	30022
Flood (General)		2025	5	50	15000	15050
Landslide (wet)		2025	40	10	225	235

	Start Year	Total Deaths	No. Injured	Total Affected
Landslides	1997	20		
incl. floods w/ landslides	1997	100		153500
	2003	20		700
	2007	29		718045
	2010	388	10	12795
	2011	27		63075
	2012	18	64	3432
	2018	51		
	2019	7		1000
	2019	20		
	2019	36		6000
	2019	65		65250
	2019	61	25	129953
	2020	3		100000
	2021	1	72	42330
	2024	141	22	30022
	2025	40	10	235
	=	**1027**	**203**	**1326337**

	Start Year	Total Deaths	No. Injured	Total Affected
Floods	2002	17		760
excl. landslides	2003	5		1500
	2006	3		1680
	2019	3		4750
	2021	1		75000
	2022	16		130
	2022	32	10	78338
	2023	23	16	1016
	2024	77	296	57804
	2025	5	50	15050
	=	**182**	**372**	**236028**

Droughts	1998			126000

Appendix 7

Climate norm Buginyanya/Kween (Wonasolo; Aggrey et al., 2024: 4) **vs. precipitation measured on NARO weather station in Buginyanya (2014-2025):**

Rain months:	January	February	March	April	May	June	July	August	September	October	November	December		
Dry months:														
2014	28,2	14,4	97,7	94,3	325,4	232,5	171,1	238,9	339,3	358,9	169,6	63,7	mm	
year to date	28,2	42,6	140,3	234,6	560	792,5	963,6	1202,5	1541,8	1900,7	2070,3	2134	mm	
2015	0	11,1	70,6	325,3	341,1	246,9	128,5	126,2	230,5	306,2	**291,2**	**119,7**	mm	
year to date	0	11,1	81,7	407	748,1	995	1123,5	1249,7	1480,2	1786,4	2077,6	2197,3	mm	
2016	**86,8**	2,1	119,8	294,7	375,8	178,9	158,5	223,3	163,8	111,6	86,3	0,8	mm	
year to date	86,8	88,9	208,7	503,4	879,2	1058,1	1216,6	1439,9	1603,7	1715,3	1801,6	1802,4	mm	
2017	1,5	**72,3**	95	177,1	336,2	161,8	303,2	**395,5**	262,4	229,2	199,8	1,2	mm	
year to date	1,5	73,8	168,8	345,9	682,1	843,9	1147,1	1542,6	1805	2034,2	2234	2235,2	mm	*Double miscalculation in original (+155 mm here)*
2018	22,3	41,2	**464,9**	**371**	295,7	325,4	151,9	166,7	243,6	167,5	79,4	38,2	mm	
year to date	22,3	63,5	528,4	899,4	1195,1	1520,5	1672,4	1839,1	2082,7	2250,2	2329,6	2367,8	mm	
2019	11,1	14,3	78,1	201,1	391,7	181,7	249,8	**497,6**	156,6	329,4	262,9	**169,5**	mm	
year to date	11,1	25,4	103,5	304,6	696,3	878	1127,8	1625,4	1782	2111,4	2374,3	2543,8	mm	
2020	**132**	**73,3**	155,2	194,2	249,8	231,7	217,2	288,7	292,8	309,8	126,4	4,7	mm	
year to date	132	205,3	360,5	554,7	804,5	1036,2	1253,4	1542,1	1834,9	2144,7	2271,1	2275,8	mm	
2021	**96,5**	25,6	36,4	239,8	271,4	85	111,4	205,3	**451,6**	240,2	100,8	2	mm	
year to date	96,5	122,1	158,5	398,3	669,7	754,7	866,1	1071,4	1523	1763,2	1864	1866	mm	*No decimal number in December*
2022	33,7	15,9	130,8	253,7	226,5	106,8	**379,6**	346,7	329,7	250,3	**318,6**	**149,9**	mm	
year to date	33,7	49,6	180,4	434,1	660,6	767,4	1147	1493,7	1823,4	2073,7	2392,3	2542,2	mm	
2023	8	33,1	**259,4**	173,2	167,8	209,9	180,7	135,6	315,5	178,2	209,3	66,3	mm	
year to date	8	41,1	300,5	473,7	641,5	851,4	1032,1	1167,7	1483,2	1661,4	1870,7	1937	mm	*No decimal number in December*
2024	**127,6**	**151,4**	168,6	258,9	284,8	206,5	266,7	241,4	266,8	305,2	**382,8**	35,5	mm	
year to date	127,6	279	447,6	706,5	991,3	1197,8	1464,5	1705,9	1972,7	2277,9	2660,7	2696,2	mm	
2025	25,1	2,7	**239,8**	303,9	241,6	198,8	**386,6**	**402,9**	238,5	361,9	76,5	84,7	mm	
year to date	25,1	27,8	267,6	571,5	813,1	1011,9	1398,5	1801,4	2039,9	2401,8	2478,3	2563	mm	*Miscalculation in original (+1 mm here)*
Average	47,73333333	38,11666667	159,6916667	240,6	292,3166667	197,1583333	225,4333333	272,4	274,2583333	262,3666667	191,9666667	61,35	mm	*New climate norm = more rain, rainfall variability, extreme rainfall, and shorter dry seasons in recent years*
												2263,391667	mm	average annual rainfall (2014-2025)

*Note: significantly lower (than average, < 40%) rainfall is underlined, while significantly higher (than average, > 40%) is emphasized **in bold.***

annual precipitation was 1200 to 1800mm (Liebig et al., 2018: 515), referring to a study from 2005

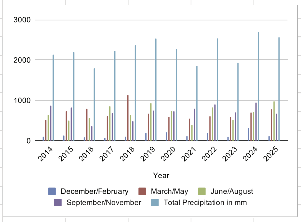
Note: the color gradient indicates the amount of rainfall in the climate norm identified by Wonasolo, (Liebig et al., 2018: 515) and (Aggrey et al., 2024: 4).

NOTE:

Color gradient:	
0-100 mm	Dry
100-200 mm	Somehow rainy
200-300 mm	Rainy
300-400 mm	Very rainy
400-500 mm	Extremely rainy

Table showing precipitation grouped into 4 times 3 month-periods.

# Year/Period	December/February	March/May	June/August	September/Novembe	Total Precipitati
2014	106,3	517,4	642,5	867,8	2134
2015	130,8	737	501,6	827,9	2197,3
2016	89,7	790,3	560,7	361,7	1802,4
2017	75	608,3	860,5	691,4	2235,2
2018	101,7	1131,6	644	490,5	2367,8
2019	194,9	670,9	929,1	748,9	2543,8
2020	210	599,2	737,6	729	2275,8
2021	124,1	547,6	401,7	792,6	1866
2022	199,5	611	833,1	898,6	2542,2
2023	107,4	600,4	526,2	703	1937
2024	314,5	712,3	714,6	954,8	2696,2
2025	112,5	785,3	988,3	676,9	2563



Appendix 8

Local Weather Observations

Date/Time of the day	Morning	Before noon	Afternoon	Evening
6th of October (Sipi)	Rain/hail	Rain/hail	Rain/thunder	Rain/thunder
7th of October (Sipi)	Cloudy, some rain			
8th of October (Sipi)	Sunny	Sunny	Partly cloudy	Partly cloudy
9th of October (Sipi)	Sunny	Partly cloudy	Cloudy	Some rain
10th of October (Sipi)	Sunny	Partly cloudy	Partly cloudy	Sunny
11th of October (Sipi)	Sunny	Partly cloudy	Sunny, 3 showers	Sunny
12th of October (Sipi)	Sunny	Partly cloudy	Rain, partly cloudy	Partly cloudy
13th of October (Sipi)	Partly cloudy	Partly cloudy	Cloudy, thunder	Short showers
14th of October (Sipi)	Sunny	Cloudy, heavy rain	Rain/Sun (shifting)	Sunny
15th of October (Sipi)	Sunny	Sunny	Short showers	Windy/cloudy
16th of October (Sipi)	Sunny	Rain/thunder	Partly cloudy	Rain/windy
17th of October (Sipi)	Sunny	Heavy rain	Cloudy/showers	Partly cloudy
18th of October (Sipi)	Clouds/wind	Cloudy, some rain	Cloudy/rain	Partly cloudy
19th of October (Sipi)	Sunny	Sunny	Rain/cloudy	Partly cloudy
20th of October (Sipi)	Partly cloudy	Cloudy, some rain	Cloudy	Partly cloudy
21st - 23rd: Trip to Kampala (Postal vote)				
24th of October (Sipi)	Sunny	Cloudy	Some rain/cloudy	Partly cloudy
25th of October (Sipi)	Cloudy	Cloudy, some rain	Cloudy/rain	Cloudy
26th of October (Sipi)	Cloudy	Cloudy	Heavy rain	Cloudy/rain
27th of October (Sipi)	Cloudy	Sunny → cloudy	Partly cloudy	Partly cloudy

Local Weather Observations

28/10 (Buginyanya)	Partly cloudy	Partly cloudy	Cloudy, Heavy rain	Rain
29/10 (Buginyanya)	Rain/foggy	Cloudy	Rain → Sunny	Cloudy/rain
30/10 (Buginyanya)	Cloudy/rain	Cloudy/rain	Cloudy/rain	Cloudy
31/10 (Buginyanya)	Partly cloudy	Partly cloudy	Cloudy/rain	Partly cloudy
01/11 (Buginyanya)	Rain/cloudy	Partly cloudy	Partly cloudy	Rain
02/11 (Buginyanya)	Rain/cloudy	Sunny	A lot of rain	Cloudy/rain
03/11 (Sipi)	Partly cloudy	Sunny → Rain	Partly cloudy/rain	Partly cloudy
04/11 (Sipi)	Sunny	Sunny	Partly cloudy/rain	Rain
05/11 (Sipi)	Sunny	Sunny	Cloudy/rain	Cloudy
06/11 (Sipi)	Sunny	Sunny	Cloudy/rain	Rain/windy
07/11 (Sipi)	Sunny	Cloudy/rain	Cloudy/heavy rain	Partly cloudy
08/11 (Sipi)	Sunny	Cloudy	Cloudy/mixed rain	Cloudy
09/11 (Sipi)	Some rain	Cloudy/rain	Cloudy/rain	Cloudy
10/11 (Sipi)	Sunny	Partly cloudy	Partly cloudy	Cloudy
11/11 (Sipi)	Sunny	Partly cloudy	Partly cloudy	Sunny
12/11 (Sipi)	Sunny all day long			
13/11 (both villages)	Sunny (Sipi)	Partly cloudy (Bu.)	Cloudy/rain (Sipi)	Cloudy (Sipi)
14/11 (Sipi)	Sunny	Sunny	Cloudy	Sunny
15/11 (Sipi)	Sunny	Cloudy	Cloudy	Cloudy