



Maastricht University

Small Coffee Farmers Perceptions & Impacts in Uganda

Jorge Garcia Izquierdo - i6313038

BSc – Business Analytics

Faculty of Business and Economics

Amar Sidi

Chandra Tamang

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Overall, these past three years as an individual have taught me so many things I could write a single paper about it, and even though I haven't named all of the people who have been by my side, I will not forget everyone who has been there. I can't say reaching this point has been an easy and smooth journey, but if you are reading it is because thanks to myself and to all the people who have helped me, I have managed to do it. Hope you enjoy reading the thesis as much as I have grown writing it. Sincerely, thanks to all.

Abstract

Climate change has become a crucial global challenge to be fixed, making sectors and labour markets worldwide to reshape their designed structures and eventually, mitigate climate change impacts. Coffee farming in Uganda is one such sector that is continuously battling to cope with the adverse climatic conditions. This research paper aims to analyze this ongoing issue in depth and to identify potential solutions through the application of diverse analytical techniques. To guide the investigation scope and objectives, a central research question and respective hypotheses will be formulated. These question and statements will be examined through the analysis of data collected from a survey which was conducted among people within the coffee farming sector in Uganda.

The different findings will be presented using visual and statistical methods such as plots and logistic regressions including logistic regression, accompanied by a critical discussion of the research's strengths and weaknesses encountered throughout the investigation process.

Lastly, this study seeks to contribute to ongoing analysis in the field being made in hopes of providing useful insights that may inform future solutions, which ultimately alleviate the suffering of so communities throughout the globe and addressing the broader crisis the world is in.

Keywords: Climate Change, Coffee Farming, Adaptation technique, Correlation, Logistic Regression

Table of Contents

1. Introduction	5
1.1 Research Question.....	6
2. Literature Review	8
2.1 Believes & Reactions	8
2.2 Empirical & Statistical Climate-Coffee Analyses	9
2.3 Sector Outputs & Climate Change.....	10
3. Critical Analysis.....	12
4. Methodology.....	14
5. Data Analysis.....	15
6. Discussion	19
7. Conclusion	20
8. References	21
9. Appendix	23
9.1 Appendix A. Map of different African Regions	23
9.2 Appendix B. Table of research variables.....	24
9.3 Appendix C. Justification of Own Thesis.....	25

1. Introduction

Recently over the years, climate change has become a well-known cause to be increasingly affecting all sectors of daily life aspects, and as discovered, farming is not an exception to the impacts that climate change has had. Uganda serves as an example of a region where coffee farming represents the life style of many small local communities inside the country, this industry supposes a crucial income source for many regions around the world. Therefore, throughout this thesis the impact of climate change on coffee farming in Uganda will be deeply explored, while understanding how farmers' beliefs and perceptions define the implemented adaptation strategies.

To explore this issue, certain highlands dedicated to Arabica coffee cultivation in Uganda were examined over time, where specific temperatures and altitude conditions need to be met for successful crop growth. Research suggests that, at the current rate of climate change, between 2030 and 2050, these designated zones may reach a point of no return where this crop becomes unable to grow, which would result in severe negative consequences for the country's economy given the crop's contribution to export earnings. (Laurence Jassogne, 2013) Despite recent coffee production and export volume increase over the past years, the coffee farming sector remains vulnerable to climate change. Different coffee varieties have varying levels of resilience, but even the Robusta variant -generally considered to be more resilient than others- is susceptible to climatic shifts and its associated impacts. Climate change, combined with the many other issues Uganda as a country already faces such as certification barriers and limited value additions, pose an ongoing threat to the development and long-term viability of the coffee industry in Uganda. (Ategeka, 2023)

1.1 Research Question

As previously described, climate change is an ongoing issue affecting many regions across the globe, including Uganda's coffee farming sector. Therefore, to investigate and analyze this threat, the following research question will be suggested:

How do smallholder coffee farmers in Uganda perceive the impact of climate change on their production, and how do these perceptions influence their farming practices?

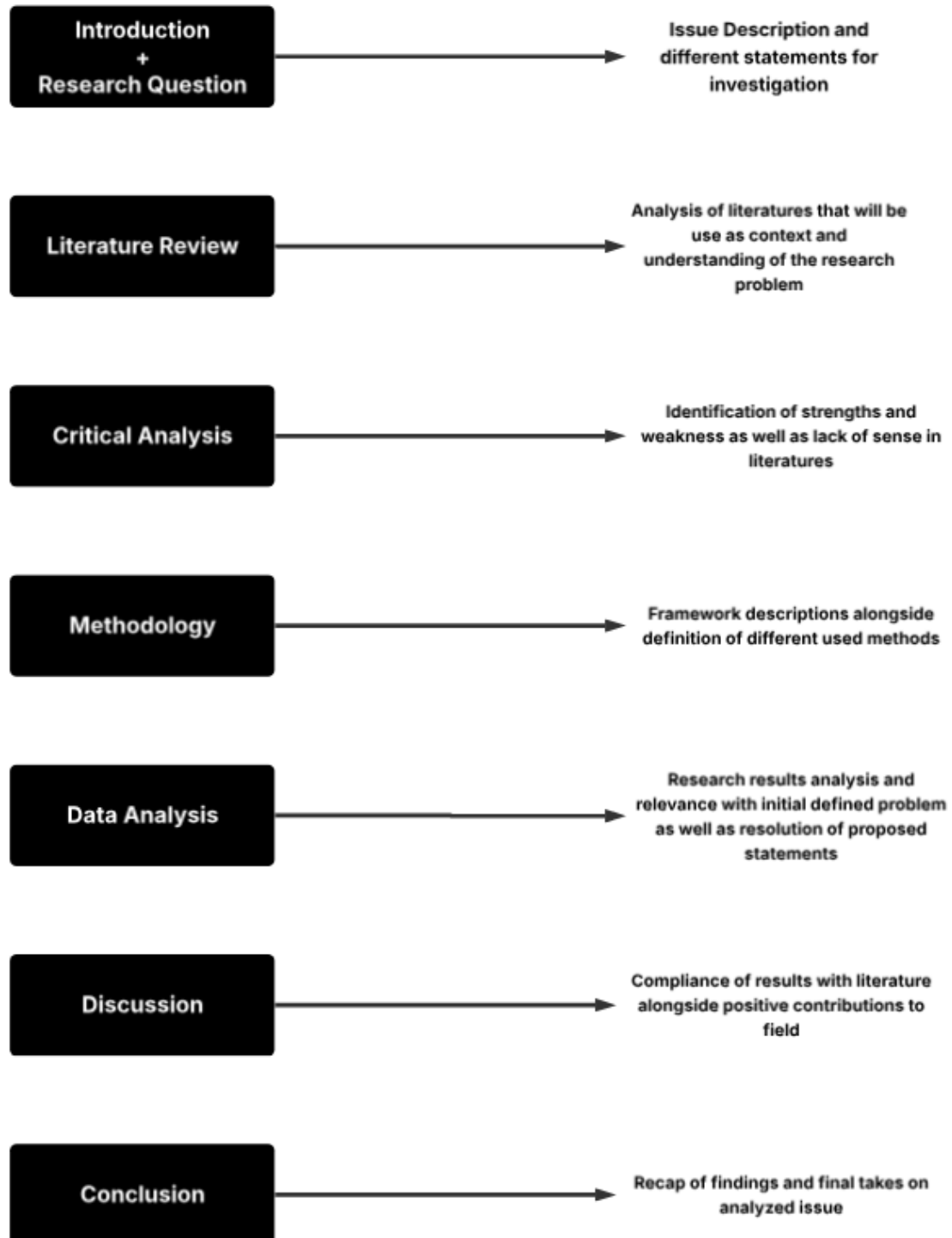
Based on this research question, several sub-statements or so-called hypotheses can be formulated to provide a narrower scope of research:

- Smallholder coffee farmers in Uganda who perceive stronger impacts of climate change are more likely to adopt adaptive farming practices
- Farmers who perceive a variation in temperature or rainfall are more likely to adopt irrigation or soil moisture techniques respectively
- Farmers who believe climate change is already affecting their production are more likely to change planting dates, diversify crops, or invest in drought-resistant coffee varieties
- There is a significant association between the level of education at any degree and the likelihood of perceiving climate change as a serious threat

The results of this research and the answers to the different suggested hypothesis, will allow for meaningful conclusions to be drawn, as well as the steps to try to implement and reverse the situation. To support clarity, Figure 1 below presents an overview of the different report sections and their respective roles for addressing the research problem.

Figure 1

Thesis Outline



Note. Created by author using Lucid Software.

2. Literature Review

As previously described, climate change represents a critical global issue with significant implications for agriculture, which is currently being dealt with. To better understand the impacts, it has had not only on the farming sector in Uganda, but also how objectively it has affected on the sector and crops around the globe, different sections of literature will be described for a better understanding. To do so, a screening of 50 papers for each of the aspects to be now described was done. The key in this process laid on the usage of keywords regarding the particular field, for example, when examining farmers perceptions certain keywords as believes, perceptions, adaptation or resilience were employed. Next, the papers which have been found to be essential in relation to the different sections and issue of climate change, will be walked over and thoroughly explained:

2.1 Believes & Reactions

Ugandan coffee farmers' beliefs and reactions to climate changes represent the main topic when addressing climate change in the context of coffee farming for this paper, this reflects both consideration of environmental challenges and complicated adaptation strategies defined by local contexts. For example, research in the Rwenzori Mountains highlights how farmers perceptions of strong variations in temperature, rainfall variability, and increased amounts of pests and diseases as direct effect of climate change, which many perceive as an urgent threat to their livelihoods and wellbeing (Laurence Jassogne, 2013). This perception aligns with recent large-scale studies which show that Ugandan farmers often define climate risks as outstanding, even this realization exist, they face significant barriers to adaptation, such as limited access to help services or additional financial resources which in such places makes it hard for a change to occur (Mugagga, 2017).

Despite the challenges, farmers have developed diverse strategies, that go from changing planting dates to adopting soil conservation measures and even introducing other crops when coffee becomes impossible to grow (Munyuli, 2011). Though, these adaptations techniques are not always enough, as already created models suggests that suitable areas for Arabica cultivation which is considered to be the most optimal option in regions as Uganda are expected to shrink progressively despite the efforts made, this way making farmers fears seem to become a reality in the long run (Cuni-Sanchez, 2025).

At the same time, lack of education and different beliefs complicate a unified response: while some farmers may point to natural causes as the reason behind climate changes or view them as only temporary, others perceive them as a permanent issue and demand bigger organisms such as the government to help with the cause (Joshua S. Okonya, 2013). This divergence in beliefs, alongside varying levels of risks, and different adaptive capacities, underscore the urgent need for local interventions that not only address the challenges many farmers face but also the reasoning behind the beliefs shaping their responses.

2.2 Empirical & Statistical Climate-Coffee Analyses

While Ugandan coffee farmers describe climate change impacts in local and personal experiences where they point to erratic rainfalls, heat increase, and pest outbreaks. As a counterpart and in order to compare facts with data, empirical and statistical models studied from other major coffee producing regions offer structured, quantitative approaches that can help to check, reshape, or even challenge such farmer perceptions. For example, recent research in Brazil has applied artificial neural networks (ANN) and multiple linear regression (MLR) techniques to predict Arabica coffee production using historical weather variables, demonstrating that ANN models can outperform traditional regression by capturing complex and variable climate relationships (Kittichotsawat, 2022). These methods highlight the

value of advanced machine learning in identifying interactions between factors as temperature, precipitation, and other complex natural phenomena that might be difficult to identify only through observations from local communities. Same way, statistical analyses in Vietnam have robustly quantified the impact of weather on Robusta coffee yields by modelling the influence of temperature and rainfall across different months, discovering delayed seasonal effects and providing specific numerical estimations of sensitivity to changes in climate (Dinh TLA, 2022). Such approaches allow researchers to go on a deeper level than personal narrations would allow them, in order to establish statistically significant links between specific climate variables and production outcomes.

Though these studies focus on Brazil and Vietnam which are different regions to the targeted one in this paper, their methodologies are directly relevant for Uganda, where systematic modelling remains limited but urgently needed. By adopting these techniques, researchers and policymakers in Uganda can check better farmers beliefs, and design evidence-based adaptation strategies tailored to local conditions, thereby reducing the gap between farmers lived experiences and scientific forecasting in a constant developing climate change.

2.3 Sector Outputs & Climate Change

While farmers beliefs and climate change impact highlight perceived and projected risks, objective analyses of Uganda's coffee sector provide key context on how these obstacles are already developing into production trends. For example, a recent trend analysis of Uganda's coffee sector reveals variations and periods of zero increase in production volumes despite demand rising globally, with yield improvements limited by both defined working structure and mounting climate conditions (Ategeka, 2023). The study documents that although Uganda remains one of Africa's leading coffee exporters, the sector faces constant productivity challenges as land-use pressures, and quality concerns, which are constantly tied

to sudden rainfalls, higher temperatures, and spread of pests and diseases. These findings are reinforced by detailed case studies in the Rwenzori Mountains region, where farmers have reported and researchers have measured declining yields due to changing rainfall patterns, more frequent droughts, and increasing pest infestations (Laurence Jassogne, 2013). Faced with these limitations, many farmers have decided to relocating their coffee cultivation to higher altitudes in search of colder weather, but this doesn't seem to last in the long-term given Uganda's geographical conditions and forecasted climate scenarios. Moreover, the sector's adaptive capacity is threatened by socioeconomic constraints such as limited access to credit or agricultural inputs, leaving many farmers vulnerable despite their awareness levels of these risks. The different evidences of trends and yields declining describe the true, measurable impacts of climate change on Uganda's coffee sector, serving as important negative aspects to both local farmer perceptions and made studies. Together, they make clear that addressing climate susceptibility in Uganda's coffee industry requires adaptation strategies that not only combine local knowledge, but also made forecasts, and defined policy and investment interventions to safe both wellbeing and export levels. There is a real need for collaboration between facts and data, farmers alone aren't able as so are not bigger organisms, only way is for cooperation between them to occur. That's why in order to understand this in a better way, throughout this study, call for action from farmers will be compared with appreciated climate impacts and changes.

3. Critical Analysis

While the described literature provides valuable insights into the relationship between climate change and coffee farming, it also reveals important strengths and limitations that shape this study's reasoning.

One positive aspect that prior research have offered is the robust evidence quantifying climate change impact on coffee yields, with improved model techniques such as neural networks and regression analyses, successfully capture complex relationships between temperature, rainfall, and production (Kittichotsatsawat, 2022) (Dinh TLA, 2022). Such methodologies define the forecasting and informed adaptation planning potential it exists. Same way to these, studies taken place in Uganda have successfully documented farmers perceptions of changing weather patterns, sudden pests, and declining yields, while highlighting adaptive responses such as changing planting dates or relocating cultivation to higher altitudes (Laurence Jassogne, 2013) (Munyuli, 2011). These studies provide critical context about lived experiences and the social complexity of adaptation.

However, the literature also shows significant weaknesses and gaps. A big percentage of already made research on Ugandan coffee farming remains unconnected, either focusing narrowly on local perceptions and qualitative accounts, or on statistical modelling in other regions with more data availability. In Uganda specifically, there is limited research that directly analyzes how smallholder coffee farmers perceive and respond to climate change as a result of their limited resources, low technological capacity, and socioeconomic barriers. Many farmers lack access to credit, help services, or even education; factors that limit their ability to implement even well-understood adaptation measures is often underexplored.

Moreover, there is a significant literature gap when connecting farmers beliefs on implementation of adaptation practices to what models objectively suggest is necessary. Existing analyses tend to focus on forecasting suitability zones, but rarely investigate how much actual change is occurring on the ground relative to these projections. As a result, there is limited understanding of the gap between what farmers are doing and what models indicate they should do to ensure prosperity. This gap has significant implications: as without linking scientific forecasting with farmers actual adaptive capacity and responses, interventions risk being misaligned or ineffective.

This thesis aims to target these literature gaps by combining local survey data on farmer perceptions and adaptation practices with analysis of broader climate change risks in Uganda's coffee sector. By doing so, it seeks to provide a more integrated perspective that highlights both the obstacles faced by smallholder farmers and the mismatch between needed and actual adaptation; offering insights to inform more realistic, locally grounded strategies for the sector's resilience.

4. Methodology

To address the proposed research question and evaluate the different suggested hypotheses, survey-based data will be analyzed. A total of 1,500 farmers from 10 different mountain regions were surveyed, as shown in **Figure 4**. The main focus will be on data from the region of Uganda, while responses from the rest of the regions will be used for comparative purposes. (Cuni-Sanchez, 2025)

The survey collected demographical data from farmers among which was included living site, village, household, wealth, adults, gender, age, education, farm size and livestock ownership. Moreover, almost all participants answered regarding their believes based on multiple questions. These responses were transformed into variables and categorized among three different sections: (1) perceived climate changes, (2) impact from climate change, and (3) adaptation strategies to face climate change as shown in **Table 2**.

To analyze the data and present the results, different methodological approaches will be employed. To begin with, bar graphs will be used to visually represent and compare data between the region of Uganda and the rest of African regions. Given that survey responses of are coded as binary variables made by 0s and 1s, logistic regression model will be applied to examine how strongly correlated are various explanatory variables with different adaptation strategies. (Zhao L, 2001) One constraint of the dataset is how easy it is to represent. Because of the reduced number of respondents, around 150 that were surveyed per region, it makes it difficult to extrapolate these findings to other research's. Moreover, data collection in many of the areas is challenging due to reduced infrastructure and accessibility, which may affect the overall reliability and completeness of the data, aspect which will be discussed later on in this research paper.

5. Data Analysis

Initially a grasp at how the average participant looks like will be made, though, we would expect probably adult farmers of an average to advanced age with some kind of education to represent the prototype. Which looks like this:

Table 1

Overview of Average Participant

variable <chr>	mean <dbl>	median <dbl>	sd <dbl>
adults	3.5327481	3	2.1829595
age	50.1586766	50	14.1041424
education	0.6022957	1	0.4895890
farmsize	1.7384402	1	2.2349481
livestock	0.7467927	1	0.4349955

Note. Created by author using R-studio.

From this table it can be understood that the average respondent has an age around 50 years and lives in a household where there tends to be 4 adults, if rounded. Most of these respondents have had an education as 0.6 is closer to 1. Also, its proofed the fact that participants of the survey are smallholder farmers, which can be seen through the mean of the farm size which is of 1.7 ha, moreover, we can get an idea of what may be as a diversification technique because most of these farmers have livestock, meaning that probably over time they have decided not to depend only on crop growing.

Following this and as previously described, multiple logistic regressions were performed in order to check which explanatory variables are the most and least correlated with the different adaptation strategies, also as already talked about, the main reason why logistic regression was used for this dataset instead of for example linear or multiple linear regression lies in the

nature of it. As its composed mainly by 1s and 0s, logistic regression offers a robust way to treat this kind of data, though, it doesn't mean that other approaches would be incorrect. (Perlich, 2003) For a clearer image, this process produces outputs for the different variable correlations which look like the following one, in which for the region of Uganda, for the adaptation of a particular strategy these correlations were obtained:

Figure 2

Logistic Regression on objective variables

```
Call:
glm(formula = uganda_formula, family = binomial, data = uganda_data)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-0.96190 -0.21539 -0.08993 -0.02258  2.93923

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept)  -47.3313   8959.1267  -0.005  0.9958
temp          -2.1793    1.1522  -1.891  0.0586 .
rainfa         3.8918    2.3222   1.676  0.0938 .
drought       -15.4933   6885.9890  -0.002  0.9982
dryspell      -0.9654    1.5062  -0.641  0.5215
floods        -2.2454    2.3563  -0.953  0.3406
wind          -2.5248    1.7907  -1.410  0.1586
hail          -0.7236    1.7447  -0.415  0.6783
fog           -2.3478    2.4945  -0.941  0.3466
frost1        -0.8737    2.5238  -0.346  0.7292
yields        17.7174   3743.5009   0.005  0.9962
pest          13.9447   6703.7742   0.002  0.9983
Animaldisease -3.6335    2.2016  -1.650  0.0989 .
Humandisease  18.7485   4616.4419   0.004  0.9968
erosion        2.3787    2.9664   0.802  0.4226
landslide     -1.3944    2.5556  -0.546  0.5853
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 43.843  on 149  degrees of freedom
Residual deviance: 30.614  on 134  degrees of freedom
AIC: 62.614
```

Note. Created by author using R-studio.

In order to understand the meaning of the outcome first the estimate needs to be looked at, if its positive it means it has a positive correlation with the adaptation strategy, so for example if a particular climate change appreciation or a climate change impact was positive and was

to seen increase, then it would mean that the probably of the objective variable to be 1 would be bigger, or in other words, the probability of the farmer implementing the adaptation technique would be greater. On the other hand, a negative estimate would mean the opposite, for an increase in it, the probability would be smaller.

This is mainly based on the logistic regression equation:

Formula 1

Logistic Regression

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X + \dots + \beta_k X_k$$

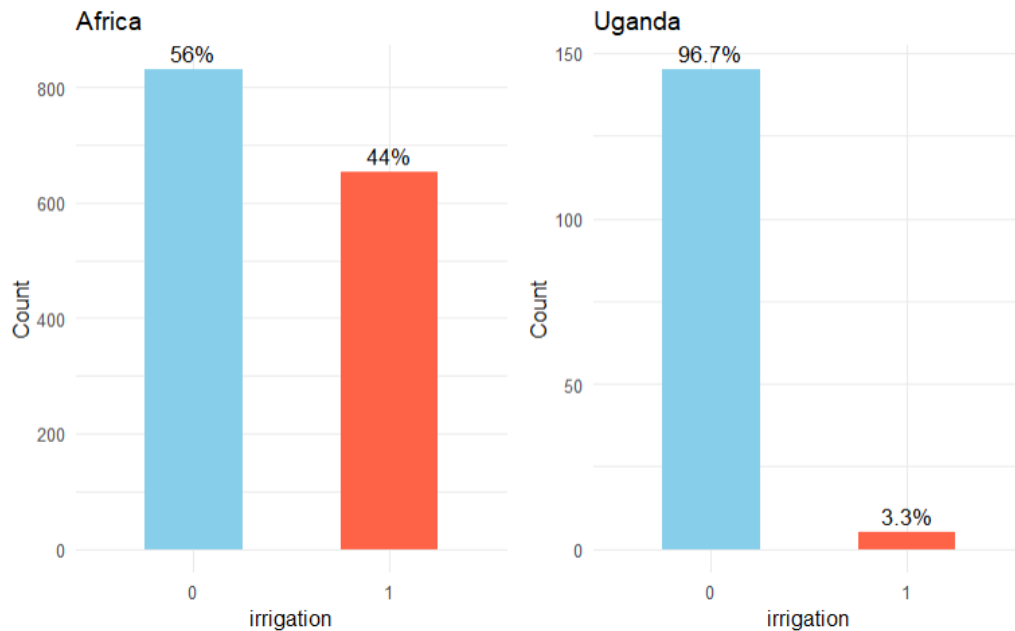
Note. Logistic Regression Formula.

In a more technical way, if the variable had a negative correlation with the adaptation technique or in other words, $\beta_1 < 0$, increasing X would mean reducing the probability of Y to give us 1, making p to go down. Though, it's also important to check the probability of z , the smaller it is, the greater significance it has in the dataset, a variable may be found to have a bigger estimate than other but to be less relevant, so it's important to check both columns. We could do this in order to understand which appreciated climate change impacts or changes represented the biggest motivators in the implementation of the different adaptation strategies. (Chao-Ying Joanne Peng, 2002)

Also as explained earlier, the different mountain African regions served as a way to compare Uganda with respect to the rest of Africa. Here, only the implementation of adaptation techniques was compared, as it's only a visual way to see this difference, in the case of the irrigation it looks as followed:

Figure 3

Irrigation implementation Africa vs Uganda



Note. Created by author using R-studio.

Overall, Uganda is a region where farmers in the past and as analyzed from this survey, have leaned more towards the implementation of adaptation techniques such as the use of an improved crop; change in plantation date; soil conservation; and labour diversification. While Africa as a whole has preferred irrigation; increased use of fertiliser and pesticide; change in location; started to rear animals; and other fruit or vegetable production.

Later on, we will dive deeper in how these results answer the proposed central research question and suggested hypotheses, but we can already tell initially that there exists a connection between the appreciated changes of climate change and the implementation of adaptation techniques.

6. Discussion

The presented findings are in line with the previously reviewed literature, showing that the introduction of adaptation strategies are correlated with farmers climate change perceptions (Laurence Jassogne, 2013). Farmers who recognize changes in temperature, rainfall patterns, and pests tend to be more propense to modify planting dates, adopt soil conservation, or diversify crops.

These results highlight how even though farmers often manage to recognize climate risks, limited resources and institutional support represent drawbacks to effective responses. For policymakers and NGOs, this highlights the need to go beyond increasing awareness and go toward providing practical support through credit access, additional help services, and training individuals regarding local conditions.

Unlike many purely empirical or statistical studies, this research emphasizes on the degree of adaptation by examining how farmers beliefs and perceptions shape their decision-making. This approach offers a more extensive understanding of Uganda's coffee sector challenges under climate change.

However, the study has significant limitations. Sample size was relatively small, around 150 participants per region, with incomplete responses affecting data quality. Logistics in remote areas represent also a challenge which limit depth and consistency. These factors reduce the extrapolation capacity of the findings and should be considered when interpreting results.

That is why to try and fix this issues, future work should expand data size and try to record evolving perceptions and adaptation practices over time. Additionally, research comparing farmers reported strategies to forecasted model projections would help identify gaps between current practices and optimal ones, informing more effective policy and intervention design.

7. Conclusion

This study found that smallholder coffee farmers in Uganda who perceive more frequently climate change impacts are more likely to adopt adaptive practices such as changing planting dates, diversifying crops, or using new soil conservation. Education level also showed a significant association with recognizing climate change as a serious threat, supporting this paper's hypotheses.

These findings answer the research question by showing that farmers' perceptions of climate change directly influence their farming decisions. Though, farmers' subjective understanding of changing weather patterns and related risks is the main driver of their choice of whether to implement adaptation techniques.

To improve adaptation, policymakers and NGOs should focus on improving climate education, offering easier access to credit and inputs, and bigger support for irrigation and resilient crop varieties. Strengthening extension services and farmer networks can help address knowledge gaps and resource barriers.

Overall, this study proof that smallholder coffee farmers' perceptions of climate change meaningfully shape their adaptation strategies in Uganda. By linking local beliefs with practical responses, the research also highlights the need for specialized education, supportive policies, and improved resources to strengthen resilience in the coffee sector. The research question and hypotheses helped define the scope and direction of this work, contributing valuable insight for planning more effective, locally informed climate adaptation efforts.

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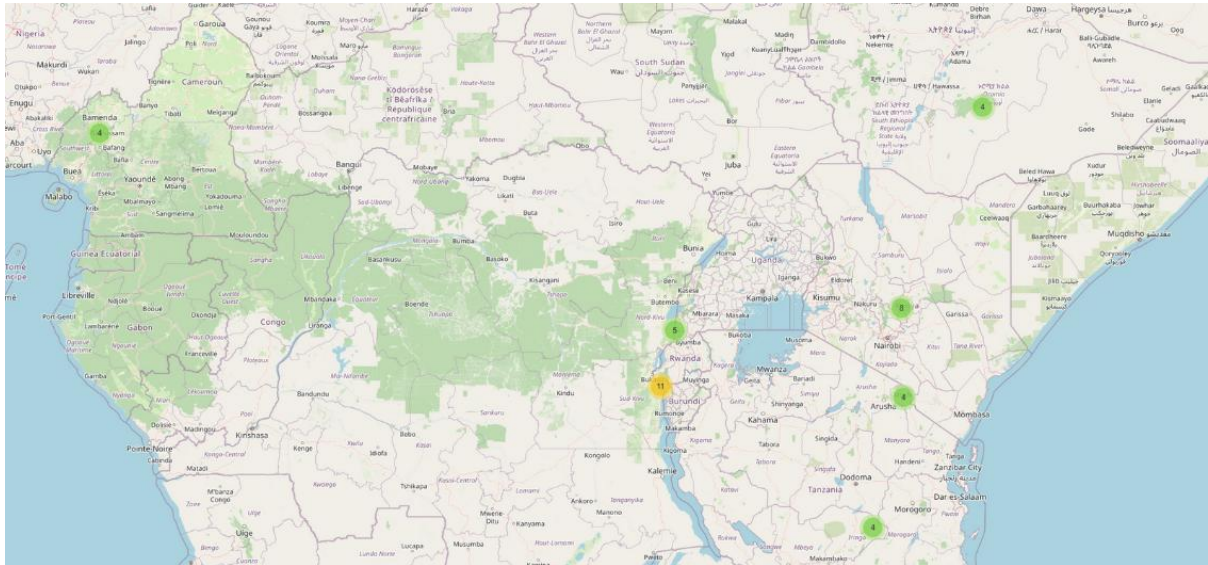
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9. Appendix

9.1 Appendix A. Map of different African Regions

Figure 4

Map of 10 African Regions



Note. Created by author.

9.2 Appendix B. Table of research variables

Table 2

Research Variables

Data type	column name	details
household character	site	study site (n= 10)
household character	village	village (4 per study site)
household character	household	household number (150 per study site)
household character	wealth	wealth (poor, rich, average)
household character	adults	number adults in household
household character	gender	gender (M/F)
household character	age	age (years)
household character	education	completed primary school (yes/no)
household character	farmsize	farmsize (ha)
household character	livestock	livestock (yes/no)
CODES		1=yes, 0=no, NA=not applicable
Climatic change	temp	Increased temperatures (dry season)
Climatic change	rainfa	Reduced rainfall (long rains)
Climatic change	late	Late start long rains
Climatic change	dryspell	More dry spells (long rains)
Climatic change	shower	More showers (dry season)
Climatic change	floods	More extreme floods
Climatic change	drought	More extreme droughts
Climatic change	fog	Fewer foggy days
Climatic change	frost	Less frost
Climatic change	wind	Increased wind strength (rainy season)
Climatic change	hail	Fewer hail storms
Impact	streamflow	Reduced stream flow (rainy season)
Impact	landslide	More landslides (rainy season)
Impact	erosion	More soil erosion (rainy season)
Impact	yields	Lower yields (main staple)
Impact	pest	Increased pests/diseases (main staple)
Impact	cows	Cows produce less milk
Impact	Animaldisea	Livestock have more diseases
Impact	Humandisea	People are less healthy
Adaptation	improved	Change to improved variety (main crop)
Adaptation	date	Change planting date
Adaptation	twice	Sow seeds twice (if they die)
Adaptation	fertiliser	Increased use fertiliser
Adaptation	peticide	Increased use pesticide
Adaptation	irrigation	Increased irrigation
Adaptation	Soilcons	Increased use soil conservation (all)
Adaptation	location	Changed farm location (near stream)
Adaptation	vet	Increased use veterinary care (all)
Adaptation	feed	Increased use feed (cattle)
Adaptation	labour	Diversify: labour
Adaptation	startanimal	Diversify: started rearing animals
Adaptation	vegetable	Diversify: vegetable/fruit production

Note. Adapted from Perceived climate changes impacts and adaptation responses in ten African mountain regions, by Cuni-Sanchez.A, 2025, 153-161. Copyright 2025 by Springer Nature.

9.3 Appendix C. Justification of Own Thesis

Appendix:

Official statement of original thesis

By signing this statement, I hereby acknowledge the submitted thesis (hereafter mentioned as "product"), titled:

Small Coffee Farmers Perceptions & Impacts in Uganda

to be produced independently by me, without external help.

Wherever I paraphrase or cite literally, a reference to the original source (journal, book, report, internet, etc.) is given.

By signing this statement, I explicitly declare that I am aware of the fraud sanctions as stated in the Education and Examination Regulations (EERs) of the SBE.

Place: Maastricht University

Date: 29/06/2025

First and last name: Jorge Garcia Izquierdo

Study programme: Business Analytics

EBT Code: 0017

ID number: 6313038

Signature: 