A DISSERTATION REPORT ON THE INFLUENCE OF DROUGHT ON HONEY PRODUCTION IN AMUDAT DISTRICT, KARAMOJA REGION

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ABSTRACT

This study investigated the influence of drought on honey production in Amudat District,Uganda, with particular focus on smallholder beekeepers' vulnerability and resilience strategies. The research addressed critical gaps in understanding how drought specifically , affects apiculture livelihoods in arid and semi-arid lands (ASALs).

Drought is an increasingly important threat to rural livelihoods in semi-arid areas, particularly where household production largely depends on climate-sensitive resources. Although beekeeping is often promoted as a climate-resilient livelihood option, prolonged dry conditions can reduce flowering patterns, water sources, reduce honey production and consequently household income.

The study employed mixed-methods design, combining quantitative household survey with qualitative information from focus group discussions and key informant interviews. Quantitative analysis was based on 258 valid beekeeper responses, while the qualitative component comprised six focus group discussions involving 58 participants and 15 key informant interviews with extension workers, district officials, traders and processors, association leaders, and community elders. Descriptive statistics were complemented by Spearman's rank correlation, chi-square tests, paired-samples tests, multiple linear regression and binary logistic regression. Qualitative information was analysed and integrated with quantitative findings during interpretation.

The findings show that drought is a major constraint to beekeeping with more than half of respondents experiencing drought often , declining floral resources, inadequate knowledge and the high cost of equipment emerged as important challenges. Perceived drought severity was significantly associated with greater honey-yield loss. Self-reported mean honey production declined from 22.03 kg/hive during normal years to 15.17 kg/hive during drought years, representing an reduction of 31.5%. The difference was statistically significant ($p < .001$) and had a large effect size. Drought was also associated with absconding, pest pressure, reduced forage availability, fewer harvests and declining honey-derived income. About 43.8% of respondents agreed that drought reduced households' food purchasing ability, illustrating the wider livelihood consequences of declining honey production.

DECLARATION

I, Apio Gloria Bua, declare that this research dissertation is my original work, except where due acknowledgement has been made. I declare that this work has never been submitted to this University or to any other institution for funding/ for partial fulfillment for any award.

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SUPERVISORS APPROVAL

This research dissertation submitted as a partial fulfillment for the award of Masters of Science in Climate Change and Disaster Management of Busitema University, with our approval as the academic supervisors.

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DEDICATION

This work is dedicated to the smallholder beekeepers of Amudat District, whose resilience in the face of climate adversity continues to inspire this research, and to my family for their unwavering support throughout my academic journey.

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ABBREVIATIONS AND ACRONYMS

ASALs – Arid and Semi-Arid Lands

CBO – Community-Based Organisation

DFID – Department for International Development

FAO – Food and Agriculture Organization of the United Nations

FGD – Focus Group Discussion

IPCC – Intergovernmental Panel on Climate Change

KII – Key Informant Interview

KTB – Kenya Top-Bar hive

MAAIF – Ministry of Agriculture, Animal Industry and Fisheries

NDVI -Normalized Difference Vegetation Index

NGO – Non-Governmental Organisation

SDGs – Sustainable Development Goals

SLF – Sustainable Livelihoods Framework

SPI-Standard Precipitation Index

SPSS – Statistical Package for the Social Sciences

TUNADO – The Uganda National Apiculture Development Organisation

UBOS – Uganda Bureau of Statistics

UGX – Uganda shillings

CHAPTER ONE: INTRODUCTION

1.0 Introduction

This chapter introduces the study on drought and honey production in Amudat District. It presents the background, problem statement, purpose, objectives, research questions, justification, scope, theoretical framework, conceptual relationships and operational alignment of the study.

1.1 Background of the study

Global apiculture is economically and ecologically important, but estimates of hive numbers and honey output vary by year, source and the extent to which informal production is recorded. FAO statistics indicate long-term growth in recorded production, while the value of pollination and hive products extends beyond honey alone (FAO, 2022; IPBES, 2016). Consistent year-specific figures should therefore be used throughout the dissertation rather than combining non-comparable estimates.

Apiculture represents one of the fastest-growing agricultural sectors globally, transitioning from traditional hobbyist practice to a commercially viable enterprise with significant livelihood implications (TUNADO, 2015). Worldwide, approximately 56 million managed beehives produce about 1.2 million tons of honey annually, with one-quarter entering international trade (Yuksel, 2020). China leads global production with 211,000 tons, while major importers include Germany, the United States, Japan, and several European nations. This global trade dynamic underscores honey's economic significance while highlighting market opportunities for producing regions.

In sub-Saharan Africa, apiculture remains underdeveloped despite favourable ecological conditions. The region contributes only 9.8% of global honey production and 23.5% of beeswax (FAO, 2020). Uganda, alongside Kenya, Zimbabwe, Ethiopia, and the Democratic Republic of Congo, represents Africa's leading honey producers, with apiculture increasingly recognised as a sustainable small-scale enterprise due to low startup costs and compatibility with other agricultural activities (Mazur & Stakhnow, 2008).

In Uganda, beekeeping contributes income, food, pollination and livelihood diversification, although national output and employment figures are uncertain because a substantial share is

informal. Available studies emphasise the importance of training, suitable technology, markets and institutions for converting ecological potential into sustained household benefit (TUNADO, 2020; Amulen et al., 2017).

African apiculture is largely small-scale and often uses traditional or locally adapted hives. Its potential is constrained by weak extension, equipment costs, pests, markets and environmental stress. Evidence from one country is not automatically transferable to Amudat because bee ecology, vegetation, management and market systems differ.

For this reason, global and national sector statistics provide context but cannot substitute for district-level evidence on per-hive yield, colony condition, adaptation and household outcomes. The present study focuses on these local dimensions.

Uganda's apiculture sector has grown steadily since the 1990s, with production increasing from 3,500 tons in 2005 to an estimated 15,000 tons in 2020 (MAAIF, 2021). The sector employs approximately 1.2 million Ugandans directly or indirectly, with particular importance for rural women and youth (TUNADO, 2020). However, regional disparities persist, with Northern Uganda (including Karamoja) exhibiting lower productivity despite potential for expansion.

Amudat District, located in Uganda's Karamoja sub-region, typifies the arid and semi-arid lands (ASALs) where apiculture complements livestock production as crucial livelihood support (Ahikiriza et al., 2016). With approximately 24% of Uganda's population living below the national poverty line concentrated disproportionately in Northern and Eastern regions, apiculture offers potential pathways for poverty reduction (Ahikiriza, 2016). The Karamoja sub-region alone produces an estimated 85 metric tons of honey annually (MSP, 2011), though this remains below potential capacity.

Apiculture contributes honey, beeswax, pollination services, food and income to rural economies. Globally, production statistics show a substantial and commercially important sector, but formal statistics frequently underrepresent small-scale and subsistence beekeeping. The livelihood value of apiculture therefore extends beyond recorded market output to nutrition, crop pollination, savings and risk diversification (Bradbear, 2009; Klein et al., 2007; FAO, 2022).

Across sub-Saharan Africa, beekeeping is predominantly small-scale and is constrained by limited equipment, extension, finance, market access, pests and environmental variability. Uganda has recognised apiculture as a livelihood and natural-resource enterprise, but

production estimates vary because informal output is difficult to measure. Rather than relying on a single contested national estimate, this study focuses on beekeeper-level production, colony and livelihood experiences in Amudat District (MAAIF, 2000; Amulen et al., 2017).

Amudat District lies in the drought-prone Karamoja sub-region, where households combine pastoralism, crop production, trade and emerging apiculture. Beekeeping can complement land- and water-intensive activities, but its performance depends on flowering plants, water, colony condition, knowledge, equipment and markets. District administrative records estimate a sizeable beekeeper population; the exact record title, date and coverage should be cited in the final reference list.

Climate change introduces significant challenges to apiculture systems globally, with drought emerging as a particularly severe threat in ASALs. Drought affects plant growth through altered precipitation patterns and increased temperatures, influencing floral development and vegetation cover (Hegland et al., 2009). These ecological changes directly impact bee forage availability, flowering periods, and subsequent honey production. In Amudat District, where rainfall variability is dominant, understanding drought-honey production dynamics becomes imperative for developing climate-resilient apiculture systems (Hegland et al., 2009; Potts et al., 2010; Le Conte et al., 2010; Nicolson, 2011). These colony-level effects may reduce harvest frequency, yield and household income.

This study investigates the influence of drought on honey production in Amudat District, examining both biophysical and socio-economic dimensions. By integrating survey data analysis with beekeeper experiences, the research aims to contribute evidence-based strategies for enhancing apiculture resilience in drought-prone regions, aligning with Uganda's commitment to climate change adaptation and sustainable development.

1.2 Statement of the problem

Apiculture has the potential to diversify livelihoods in drought-prone communities, but the realised benefits depend on reliable forage and water, healthy colonies, suitable equipment, knowledge and functioning markets. In Amudat District, beekeepers operate within a semi-arid and highly variable environment in which drought is repeatedly identified as a major constraint.

The expected pathway is that drought reduces flowering, nectar, pollen and water; stressed colonies may become less active, lose brood, suffer pest pressure or abscond; and reduced harvests may lower household income and food-purchasing capacity (Potts et al., 2010; Le

Conte et al., 2010). However, the magnitude of these relationships in Amudat had not been documented through an integrated household and qualitative assessment.

Existing literature provides evidence from other ecological settings, but limited Amudat-specific work has simultaneously examined perceived drought exposure, reported per-hive production, colony condition, livelihood consequences, indigenous knowledge, introduced practices and institutional support. The effectiveness of local and introduced strategies is also difficult to judge because adoption is shaped by cost, training, assets and self-selection.

The evidence gap also has a gender and institutional dimension. Women may contribute labour, processing and marketing without equal ownership of hives, control of income or access to training and equipment. At the same time, the reach of extension, climate information, finance and collective organisations can condition whether households are able to act.

The study was therefore undertaken to generate context-specific evidence on reported drought risks and consequences and to identify feasible resilience options for beekeepers in Amudat District. Findings are intended to inform extension, district planning and future climate-linked research without overstating causality from a cross-sectional design.

1.3 Purpose of the study

The purpose of the study was to assess the influence of drought on honey production and to evaluate beekeeper resilience strategies in Amudat District.

1.4 Specific objectives

The specific objectives of this study are:

1. To characterize drought parameters affecting honey production in Amudat District.
2. To document the influence of drought on honey production in Amudat District.
3. To assess the effectiveness of indigenous and introduced drought mitigation strategies in Amudat District.

1.5 Research questions

The study was guided by the following research questions:

1. What are the drought parameters affecting honey production in Amudat District?
2. How does drought influence honey production in Amudat District?
3. How effective are indigenous and introduced drought mitigation strategies in Amudat District?

1.6 Justification of the study

The study is justified by four related gaps. Empirically, there is limited Amudat-specific evidence linking perceived drought, colony condition, production and livelihood outcomes. Geographically, much apiculture-climate research comes from outside Karamoja. Methodologically, few local studies integrate household patterns with qualitative explanations. Practically, district and extension actors require evidence on which responses are used, which constraints limit adoption and what support beekeepers prioritise.

The study documents an under-researched drought-apiculture context and applies the Sustainable Livelihoods Framework to organise evidence on natural, human, financial, social and physical assets. The mixed-methods design enables statistical description to be interpreted alongside beekeeper and institutional accounts.

Findings can support district and national actors to integrate apiculture into climate-risk communication, water and forage planning, extension, finance and livelihood programming. The recommendations are framed as priorities for implementation and further validation rather than as proven causal solutions.

Documentation of local indicators and practices can support respectful knowledge exchange, while the analysis of ownership, labour, training and resource access can inform more inclusive support to women, men and youth.

1.7 Scope of the study

The scope was defined geographically, temporally, thematically, methodologically and theoretically.

1.7.1 Geographical scope

The study focuses on Amudat District in Uganda's Karamoja sub-region, specifically targeting three sub-counties (Karita, Amudat, and Loroo) selected based on honey production intensity, drought exposure, and accessibility.

1.7.2 Temporal scope

The survey asked respondents to compare self-reported normal- and drought-year conditions and to recall perceived drought severity over 2015–2024. Primary data collection was conducted from April to June 2025. Any proposal-era schedule retained in the appendices represents the original planning timeline rather than the dates of completed fieldwork.

1.7.3 Thematic scope

The study covered perceived drought frequency and severity, forage and water constraints, reported honey production and product attributes, colony condition, livelihood effects, adaptation strategies, gender and institutional support. It did not independently analyse meteorological, SPI or NDVI time series or laboratory-test honey quality.

1.8 Theoretical and conceptual framework: sustainable livelihoods framework

The study is grounded in the Sustainable Livelihoods Framework (SLF) developed by the Department for International Development (DFID, 1999). The SLF provides an analytical lens for understanding how drought, as a climate shock, interacts with the assets and strategies of beekeeping households in Amudat District. The framework is directly applicable to this study because drought affects honey production through its impact on the five capital assets that beekeepers rely on for their livelihoods.

Table 1.1: Linkage of SLF components to study variables

SLF Component	Definition in This Study	How Drought Affects It	Measurement in This Study
Natural Capital	Flowering vegetation, water sources, apiary sites, and land for forage	Drought reduces flowering, depletes water sources, and reduces vegetation cover	Reported forage effects (fewer flowering plants, shorter flowering periods), water access, NDVI anomalies
Financial Capital	Honey income, savings, access to credit, and affordability of inputs	Drought reduces honey yields and income, limiting purchasing power and investment capacity	Honey income (normal vs. drought year), food-purchasing capacity, income diversification
Human Capital	Beekeeping knowledge, skills, experience, education, and labour	Drought increases labour demands for water collection and colony management; limits access to training	Years of beekeeping experience, education level, formal training received
Social Capital	Group membership, peer networks, extension contact, and intergenerational knowledge	Drought strains social support systems; groups may provide mutual assistance but also face collective stress	Group membership, extension contact frequency, sources of indigenous knowledge

Physical Capital	Hives, protective equipment, processing equipment, water infrastructure	Drought increases the need for water provision, shade, and improved hives; equipment may be damaged during relocation	Hive type, access to improved equipment, water provision near hives

1.8.1 Vulnerability context

Drought is the primary climate shock, interacting with seasonal variability and long-term climate trends. The vulnerability context also includes non-climatic stressors such as pest and disease challenges, market volatility, and limited institutional support.

1.8.2 Livelihood strategies

Beekeepers respond to drought through a combination of indigenous practices (e.g., hive placement near water, traditional hive use), introduced technologies (e.g., water provision, reduced harvesting), and integrated approaches that combine both. Livelihood diversification into crop farming, livestock keeping, and off-farm activities also serves as a coping strategy.

1.8.3 Outcomes

The outcomes of these strategies are measured in terms of honey yield, colony continuity, income stability, and household food security. The effectiveness of adaptation is moderated by access to training, group membership, extension services, and gender relations.

1.8.4 Transforming structures and processes

District institutions, extension services, markets, and gender norms shape the range of adaptation options available to beekeepers and their ability to implement them.

The SLF thus provides a comprehensive framework for analysing how drought affects honey production in Amudat District, linking environmental stress to asset depletion, livelihood strategies, and outcomes.

1.9 Conceptual framework

The revised conceptual framework proposes an analytical sequence: perceived drought exposure and water-forage stress are associated with colony responses; colony responses are

associated with reported yield, harvest, income and household effects; and these relationships may be modified by beekeeper assets, strategies, institutions and gender relations. The arrows represent plausible associations rather than confirmed causal effects.

1.9.1 Independent variables

- Indicates how Exposure factors namely drought frequency and severity, reported heat, rainfall variability and seasonal changes interact to influence colony health and colony attributes to influence honey production outcomes

1.9.2 Mediating variables

- Includes interaction between Colony health, socio-Economic and Contextual factors
- It Indicates how Foraging behavior, absconding rates, pest susceptibility and colony mortality are influenced by experience of the bee keeper, educational level, resource access, hive type, institutional support, market opportunities, gender norms and policies

1.9.3 Dependent variables

- These are production outcomes which include self-reported yields in kilograms per hive, harvest frequency ,product quality, brought about by foraging behaviors, absconding rates, pest susceptibility, colony mortality as a result of flowering patterns, nectar and pollen availability , and presence of water resources

The framework guided the objective-based organisation of the questionnaire, thematic coding and interpretation. Because the study was cross-sectional and relied mainly on recall, mediation, moderation while causality were not formally tested.

The conceptual framework for this study, presented in Figure 1.1 below, illustrates how drought influences honey production in Amudat District. The framework identifies independent variables, mediating variables, and dependent variables, and shows how they interact.

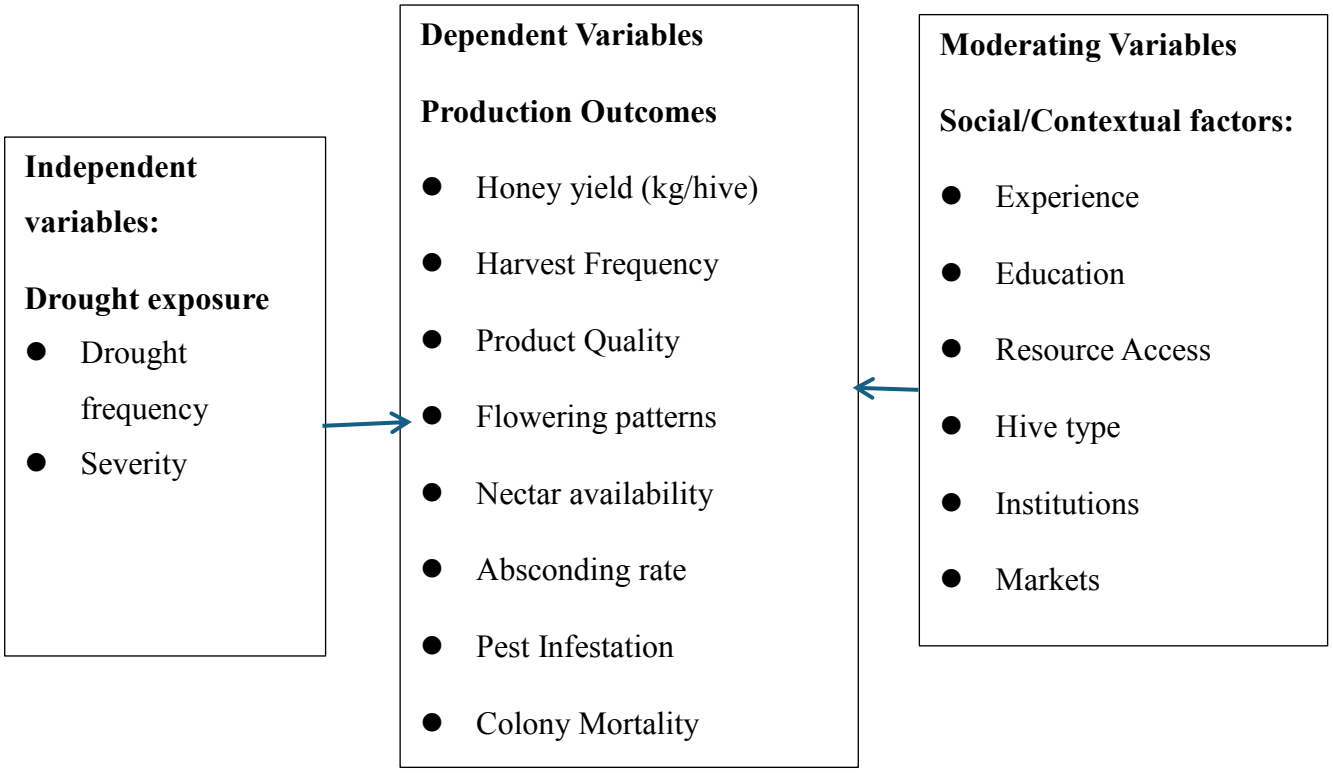


Fig1.1: Conceptual framework linking drought to honey production outcomes

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter critically reviews theoretical and empirical literature relevant to drought and apiculture. It first considers the livelihood significance of beekeeping, then distinguishes drought concepts and pathways, examines ecological and socio-economic effects, evaluates indigenous and introduced responses, considers gender and institutional dimensions, and concludes with a structured statement of the empirical gap addressed in Amudat District.

2.1 Theoretical literature review

Bees provide the majority of biotic pollinators, and are at risk from a multitude of factors: changes in land use, intensive agricultural practices, use of pesticides, and climate vulnerability have all contributed to large scale losses, fragmentation and degradation of bee habitats, pest and diseases are a threat to bee colonies. Furthermore, higher temperatures, shifting seasons and extreme weather events are also causing problems for bees (Smith et al, 2014)

2.2 Empirical literature review

Recurrent and prolonged droughts in Uganda's Karamoja region significantly suppresses local honey production by reducing floral nectar secretion, weakening bee colony health, and forcing shifts in agro-pastoral coping strategies.

Amudat, situated in a semi-arid agro-ecological zone within Uganda's cattle corridor, often experiences meteorological droughts that cause flora to wither prematurely, drastically lowering overall nectar and pollen availability thus shortening the flowering windows required for honey yield.

Despite these environmental shocks, honey originating from Amudat, Karamoja region, has historically, been commended by regional bodies like Intergovernmental Authority on Development (IGAD) and the Food and Agricultural Organization (FAO) for exceptional quality making apiculture a vital cushion for household resilience (Drake N Mubiru,2010)

2.3 Beekeeping as a livelihood strategy

Apiculture contributes to household livelihoods through multiple pathways. Honey and beeswax provide direct consumptive and marketable products, while pollination services enhance crop yields for both beekeepers and neighbouring farmers. In Uganda, beekeeping is particularly important for rural women and youth, who may have limited access to land and

capital for other agricultural enterprises (TUNADO, 2020). The low startup costs and compatibility of beekeeping with other agricultural activities make it an accessible livelihood option for resource-constrained households.

Beekeeping can support several livelihood assets. Natural capital includes forage and water; physical capital includes hives and equipment; human capital includes knowledge and labour; social capital includes groups and intergenerational learning; and financial capital includes honey income, savings and market access (DFID, 1999; Bradbear, 2009).

Benefits include honey and beeswax, crop pollination, household consumption and cash for food, education or health. These benefits are conditional: low hive occupancy, limited skills, poor-quality handling, weak market access and climate stress can reduce returns. Beekeeping should therefore be understood as one component of a diversified livelihood portfolio rather than an isolated enterprise.

However, the realisation of these benefits is conditional on several factors. Access to suitable hives, protective equipment, and processing facilities determines the efficiency and safety of production. Knowledge of colony management, pest control, and harvesting techniques affects productivity and product quality. Market access and price information influence the returns to beekeeping. Increasingly, climate variability—particularly drought—has emerged as a critical constraint that interacts with these other factors (Amulen et al., 2017).

The literature also shows that exposure and adaptive capacity are uneven. Households with stronger knowledge, groups, finance, equipment and market connections may manage drought more effectively than those facing multiple asset constraints. This supports the use of the SLF, while requiring biological pathways to be analysed alongside livelihood assets.

The central analytical question is therefore not simply whether beekeeping produces income, but how drought alters the asset base and what combinations of local knowledge, technology and institutional support enable colonies and households to continue functioning.

2.4 Climate change and drought dynamics in sub-Saharan Africa

Drought is a multidimensional phenomenon that can be classified into four types (Wilhite, 2000):

- **Meteorological drought**: A deficiency in precipitation over an extended period, often defined relative to long-term averages.

- **Agricultural drought**: A period of inadequate soil moisture that affects crop and vegetation growth, often occurring even when meteorological drought is not severe.
- **Hydrological drought**: A period of reduced surface and groundwater levels, affecting water availability for domestic, agricultural, and ecological uses.
- **Socio-economic drought:** A period when water shortages affect demand for and supply of economic goods, including agricultural products and hydroelectric power.

For apiculture, all four types of drought are relevant. Meteorological drought reduces rainfall that sustains flowering plants. Agricultural drought limits nectar and pollen production. Hydrological drought reduces water sources that bees need for colony cooling and honey production. Socio-economic drought affects the prices and availability of inputs such as sugar for supplemental feeding.

In Karamoja region, high rainfall variability and recurrent dry periods expose pastoral, crop and apiculture systems to water and forage stress. The current study measured beekeeper perceptions and recalled impacts rather than calculating SPI, temperature anomalies or NDVI. Claims about climate trends must therefore be presented as respondent perceptions unless independently verified data are added.

A useful drought-apiculture assessment links exposure to ecological conditions, colony responses, production and livelihood outcomes. This pathway also helps distinguish drought-specific effects from concurrent constraints such as equipment cost, pests, prices, insecurity and limited extension.

2.5 Effects of drought on apiculture systems

2.5.1 Ecological Impacts

The ecological impacts of drought on apiculture operate through several interconnected mechanisms. First, reduced rainfall and high evaporative demand decrease soil moisture, which in turn reduces flowering intensity and duration. Plants may produce fewer flowers, flowers may have shorter lifespans, and nectar production may decline both in volume and sugar concentration (Nicolson, 2011). Second, drought can alter the timing of flowering, creating mismatches between peak nectar availability and colony foraging periods (Memmott et al., 2007). Third, water scarcity forces bees to expend more energy searching for water, reducing the energy available for foraging and honey production (Visscher et al., 1996).

High temperatures associated with drought increase colony cooling requirements. Bees must fan their wings and evaporate water to maintain optimal brood nest temperatures (34–35°C). When water is scarce, this becomes difficult, and colonies may suffer from overheating, brood death, and comb melting (Southwick & Heldmaier, 1987). Extreme heat can also increase susceptibility to pests and diseases, including Varroa destructor and Nosema species (Le Conte et al., 2010).

Reduced rainfall and high evaporative demand can decrease flowering intensity and duration, nectar and pollen availability, and accessible water. These changes can increase foraging distance and energy expenditure and can disrupt the timing between colony demand and floral resources (Hegland et al., 2009; Potts et al., 2010; Nicolson, 2011).

Heat and food stress can alter thermoregulation, brood survival, activity, defensiveness, pest susceptibility and colony retention (Southwick & Heldmaier, 1987; Le Conte et al., 2010). The strength of these effects depends on bee genetics, hive design, shade, water, forage diversity and management, so temperate-system evidence should be transferred to African systems cautiously.

Studies from African settings report lower honey production during adverse seasons, but effect sizes vary and several frequently cited sources require verification. A reported 50% reduction in Amudat should therefore be compared as lying within, rather than exceeding, a previously reported 40–60% range, subject to verification of the source and comparable methods.

The evidence supports a plausible mechanism but remains limited by differences in climate metrics, hive types, recall periods and outcome measurement. The present study contributes locally contextualised perceptions and reported outcomes but does not independently validate the climatic driver.

2.5.2 Socio-economic Impacts

The socio-economic impacts of drought on apiculture extend beyond reduced honey yields. Lower production translates into reduced household income, which affects food security, education, and healthcare access (Amulen et al., 2017). Beekeepers may be forced to sell assets, reduce hive numbers, or abandon apiculture altogether, eroding long-term production capacity. Market dynamics also shift: reduced supply may increase prices, but the net effect on household income depends on the quantity sold and the quality of the product. If honey quality declines

during drought, price increases may not compensate for reduced volumes (Aidoo & Awotwe, 2014).

Gender-differentiated impacts are particularly significant. Women beekeepers often face greater constraints in accessing drought adaptation resources including credit, information, and technologies (Perez et al., 2019). Cultural restrictions on women's mobility may limit their participation in drought response activities such as hive relocation or water transportation. Additionally, women's unpaid care work may increase during drought as they spend more time collecting water and caring for children and the elderly, leaving less time for apiary management (Djoudi et al., 2016).

A complete livelihood analysis should distinguish immediate coping, such as reducing consumption or selling at unfavourable times, from preparedness and longer-term adaptation. It should also identify whether institutional support reduces response costs or reaches only better-connected beekeepers.

2.6 Indigenous and scientific adaptation strategies

Indigenous knowledge systems contain valuable drought adaptation strategies developed through long-term environmental observation. In East Africa, traditional beekeeping practices include selective hive placement near water sources, use of local hive materials with better thermal properties, and seasonal migration following flowering patterns (Mukungu et al., 2016). Indigenous drought forecasting utilises biological indicators (e.g., specific plant flowering), astronomical observations, and animal behaviour (Nyong et al., 2007). These knowledge systems are not static but evolve as communities experience new environmental conditions.

Scientific adaptation strategies include improved hive designs for temperature regulation, supplemental feeding during drought, water provision, forage diversification with drought-tolerant species, and integrated pest management (IPM) for drought-stressed colonies (Neumann & Carreck, 2010). Technological innovations such as solar-powered hive cooling systems and precision beekeeping using sensors represent emerging solutions, though accessibility in developing countries remains limited (Zacepins et al., 2015).

Introduced practices include water provision, supplemental feeding, improved or insulated hives, shade, forage establishment, pest management and selected relocation. Their suitability depends on affordability, local water and forage conditions, skills, maintenance and the risk of

unintended effects. Adoption is therefore an institutional and economic question as well as a technical one.

Integrated approaches may be promising because they combine locally trusted practices with selected technologies (Makondo & Thomas, 2018). Nevertheless, comparisons between adopters and non-adopters are vulnerable to self-selection: more experienced or better-resourced beekeepers may both adopt more strategies and achieve higher yields.

Effectiveness of adaptation strategies depends on contextual factors including ecological conditions, socioeconomic resources, and institutional support. Integrated approaches combining indigenous and scientific knowledge show particular promise for enhancing resilience (Makondo & Thomas, 2018). However, adoption of adaptation strategies is often constrained by cost, knowledge gaps, and limited access to materials and markets.

The strongest evidence would combine co-production and respectful validation of local indicators, transparent strategy costs, biological and livelihood outcomes, and designs that adjust for baseline differences. The current study provides an initial comparative description rather than a definitive effectiveness trial.

2.7 Gender dimensions in beekeeping and drought adaptation

Gender influences all aspects of apiculture including participation patterns, resource access, decision-making authority, and benefit distribution (Perez et al., 2019). In many African societies, beekeeping is traditionally male-dominated, though women increasingly participate in value-added activities like honey processing and marketing (Mazorodze, 2015). Cultural beliefs associating bees with masculinity or viewing beekeeping as physically demanding often restrict women's involvement (Bradbear, 2009).

Climate change adaptation exhibits gendered dimensions, with women often possessing specialised ecological knowledge but facing constraints in implementing adaptive measures (Djoudi et al., 2016). Inclusive adaptation requires addressing structural barriers including land tenure systems, credit access, extension service biases, and social norms (Jost et al., 2016). Gender-responsive adaptation programming should ensure that women have equal access to training, assets, and decision-making opportunities.

Drought can intensify unpaid water and care work and limit time available for apiary management, especially where women have weaker access to transport, credit, extension and equipment. Gender-responsive adaptation requires accessible training, asset and finance

arrangements, safe participation and monitoring of control over benefits (Djoudi et al., 2016; Jost et al., 2016).

Amudat-specific evidence remains limited. The current study contributes sex-disaggregated description and qualitative accounts, but the small female subgroup constrains statistical comparison and should be interpreted cautiously.

2.8 Research gaps

Despite growing literature on climate-apiculture interactions, critical gaps remain that this study addresses:

1. **Limited drought-specific studies**: Most research addresses climate change broadly rather than isolating drought mechanisms and impacts specific to apiculture systems. This study focuses specifically on drought as a climate stressor.
2. **Contextual specificity**: Few studies examine drought-apiculture relationships in East African ASALs, particularly Uganda's Karamoja region with its unique socio-ecological context. This study provides the first systematic evidence from Amudat District.
3. **Indigenous knowledge documentation**: Traditional drought adaptation practices in apiculture remain largely undocumented and unevaluated for their effectiveness and potential integration with scientific approaches. This study documents and evaluates indigenous practices.
4. **Gender analysis**: Gendered dimensions of drought impacts and adaptation in beekeeping require deeper investigation beyond participation statistics to understand structural constraints and opportunities. This study provides sex-disaggregated analysis and qualitative accounts of women's experiences.
5. **Integrated assessments**: Studies seldom combine biophysical, socio-economic, and institutional perspectives in analysing drought resilience, leading to fragmented understanding. This study integrates these perspectives through a mixed-methods design.
6. **Methodological limitations**: Existing research often employs single-method approaches rather than mixed methods that capture both quantitative relationships and

qualitative experiences. This study demonstrates the value of mixed-methods with robust inferential statistics.

7. **Policy-practice disconnec**t: Limited research translates drought impact findings into practical policy recommendations tailored to local institutional contexts. This study provides evidence-based recommendations for district and extension actors.

This study addresses the gaps by combining household and qualitative evidence from Amudat District and organising the findings around risk factors, reported effects and responses. Its contribution is contextual and exploratory; causal and climate-trend claims require longitudinal or independently measured evidence.

The synthesis indicates that the principal gap is not the absence of general evidence that drought affects bees, but the limited Amudat-specific evidence connecting perceived drought exposure, forage and colony responses, livelihood consequences, and locally feasible adaptation options within one mixed-methods study.

CHAPTER THREE: METHODOLOGY

3.0 Introduction

This chapter describes the mixed-methods design, study area, study populations, sampling, data collection, quality control, objective-aligned analysis, ethical procedures and study limitations.

3.1 Research design

The study used a convergent parallel mixed-methods design in which quantitative household data and qualitative FGD/KII data were collected during the same broad fieldwork period, analysed separately and integrated during interpretation (Creswell & Plano Clark, 2017). The quantitative strand had primary weight for describing prevalence and reported magnitudes, while the qualitative strand explained meanings, mechanisms and institutional context.

The quantitative component was cross-sectional and therefore estimated reported patterns and associations at one point in time. The qualitative component was interpretive rather than strictly phenomenological; it explored lived experiences, local indicators, gender relations and adaptation constraints. Discordant findings were retained and discussed rather than forced into agreement.

Integration occurred through common objectives and instruments, comparison of results during analysis, an objective-based joint display in Chapter Four, and narrative interpretation of convergence, complementarity and divergence.

3.2 Research approaches

The quantitative strand quantified respondent characteristics, drought perceptions, reported yields, colony and livelihood effects, adoption and support. The qualitative strand examined how participants interpreted environmental change, why particular practices were used, how gender and institutions shaped choices, and how quantitative patterns could be understood in context.

A pragmatic stance supported the use of methods suited to the research questions rather than privileging one form of evidence. This did not remove the need to respect the limitations of self-reported, cross-sectional and non-experimental data.

3.3 Description of the study area

3.3.1 Location and administrative structure

Amudat District is located in the Karamoja region of north-eastern Uganda, approximately 380 km from Kampala. The district lies between coordinates 01°55'N and 34°55'E. It borders the Republic of Kenya to the east, Moroto District to the north, Nakapiripirit District to the west, and Kapchorwa District to the south. The district covers an area of approximately 1,638 km².

Administratively, Amudat District comprises one county (Pokot), three sub-counties (Karita, Amudat, and Loroo), and one town council. According to the Uganda Bureau of Statistics (UBOS, 2024), the district has an estimated population of 203,000 people, with an average household size of 5.2 persons. The population is predominantly rural (92%), with pastoralism and subsistence agriculture as the main economic activities.

3.3.2 Agro-ecological conditions

Agro-Ecological Zone: Amudat District lies in the semi-arid savanna agro-ecological zone, characterised by low and erratic rainfall, high temperatures, and sparse vegetation cover. The district is classified as an Arid and Semi-Arid Land (ASAL) with a growing season of 90–120 days.

Vegetation: The vegetation of Amudat District is typical of semi-arid savanna, dominated by drought-resistant tree species and grasses. Common tree species include Acacia spp. (particularly Acacia tortilis and Acacia nilotica), Balanites aegyptiaca, Combretum spp., and Terminalia spp. These species provide important bee forage during flowering periods. Grass species include Hyparrhenia spp. and Themeda triandra. Vegetation cover is sparse to moderate, with NDVI values ranging from 0.25 during severe drought to 0.52 during normal years.

Soils: The dominant soil types are sandy loams and lateritic soils, which are typically low in organic matter and nutrients. Soil fertility is low to moderate, with limited capacity for water retention. Soil erosion is a moderate to high risk, particularly on slopes and where vegetation cover has been removed.

Land Use: Land use in Amudat District is dominated by pastoralism, which occupies approximately 60% of the land area. Subsistence agriculture (sorghum, maize, beans) occupies about 30%, while apiculture and other activities occupy the remaining 10%. Apiaries are

typically located near water sources, in wooded areas, or on hillsides where vegetation is more abundant.

3.3.3 Climatic conditions

Climate Type: Amudat District experiences a semi-arid tropical climate, characterised by high temperatures, low and erratic rainfall, and high evaporation rates.

Rainfall: The district experiences a unimodal rainfall pattern with slight cessation in July

- Long rains: April–October

The mean annual rainfall is 680 mm, with a range of 380 mm to 750 mm over the past decade. Rainfall is highly variable both between years (CV = 28%) and within seasons, with dry spells of 10–20 days common even during rainy periods.

Temperature: Mean annual maximum temperatures range from 30–32°C, while mean annual minimum temperatures range from 16–18°C. The hottest months are January–March, with peak maximum temperatures reaching 34–36°C. During drought years, temperatures can be 1.5–2.5°C above normal.

Evaporation: Potential evapotranspiration is high, ranging from 1,800 to 2,200 mm per year, exceeding rainfall by 2–3 times. This means that even in normal years, water availability is limited for much of the year.

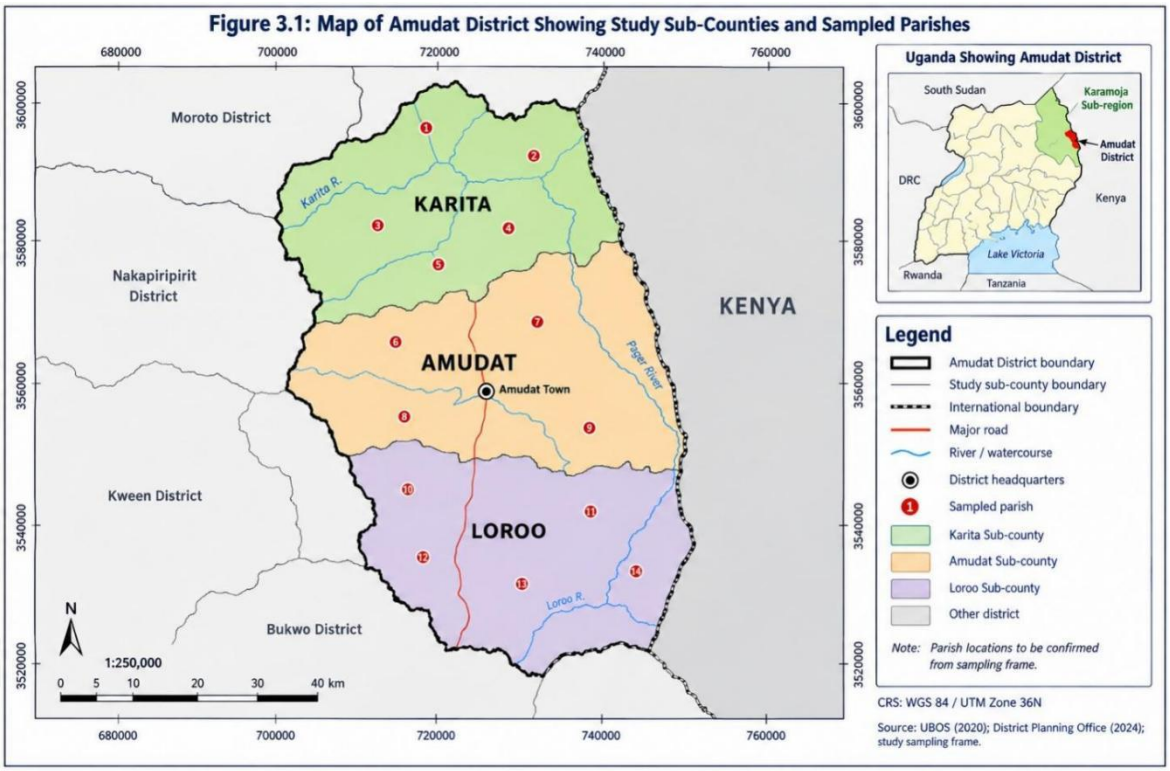


Figure 3.1: Map of Amudat District Showing Study Sub-Counties

Source: Adapted from UBOS (2020) and District Planning Office (2024) using QGIS

3.4 Study population

The study considered the disaggregated population of males and females from the three sub counties; Karita, Amudat, Loroo , and the non-study sub county; Abiliyep, where pre-testing of the questionnaires was conducted

Table 3.1: Study population disaggregated by gender

Sub county	Males	Female	Total
Karita	7,815	8,541	16,356
Amudat	17,816	18,280	36,096
Loroo	9,004	8,796	17,800
Abiliyep	13,974	13,696	27,670
Total	**48,609**	**49,313**	**97,922**

Source: UBOS, NPHC 2024

3.5 Sampling strategies

A multi-stage procedure was used. The three study sub-counties were selected purposively; beekeeper lists were organised by locality; household respondents were selected systematically from available lists; and qualitative participants were selected purposively to reflect location, sex, experience and stakeholder role.

Stage 1: Karita, Amudat and Loroo were purposively retained as the geographic strata because they represented the principal study locations identified for honey production, drought exposure and field accessibility.

Stage 2: Available beekeeper lists were organised by locality and used as the operational sampling frames. The surviving field records do not provide a complete parish-by-parish frame count; therefore, proportional allocation is not claimed beyond the achieved distribution reported in Table 1.

Stage 3: Household respondents were selected systematically from the available beekeeper lists. The sampling interval was calculated as $k = N/n$ within the operational lists and selection began from a random start. Because the archived field records do not preserve the stratum-specific N, k and replacement logs, these quantities cannot be reconstructed reliably and are acknowledged as a limitation rather than estimated retrospectively.

Stage 4: FGDs and KIIs were selected purposively to obtain information-rich perspectives across stakeholder categories, gender and location.

Achieved sample: A total of 258 valid beekeeper questionnaires were retained for the main descriptive analyses after data screening. Analyses requiring paired normal-year and drought-year yield values used 255 complete pairs; the HC3 yield-loss regression used 254 complete cases; and the logistic adoption model used 256 complete cases. These denominators are reported with each analysis. The original sample-size assumptions and stratum-level frame counts were not fully preserved in the archived field records and are acknowledged as a limitation rather than reconstructed.

Qualitative sample: Six FGDs involving 58 participants and 15 KIIs were completed. The draft states that FGDs were sex-stratified.

Table 3.2: Achieved sample by study component and location

Study component	Location/category	Achieved sample
Household survey	Karita Sub-county	85 beekeepers (31.0%)
Household survey	Amudat Sub-county	154 beekeepers (56.2%)
Household survey	Loroo Sub-county	35 beekeepers (12.8%)
Focus group discussions	Two per sub-county	6 FGDs; 58 participants
Key informant interviews	Extension, district, traders, associations and elders	15 KIIs

3.6 Data collection methods

3.6 .1 House hold survey

Trained interviewers administered a structured questionnaire face to face to eligible beekeepers. The instrument covered socio-demographic and livelihood characteristics, beekeeping experience and production, perceived drought exposure and impacts, colony condition, adaptation practices, gender, institutions, markets and constraints.

The questionnaire was translated into Pokot and back-translated. It was pretested with 15 beekeepers outside the sampled study locations and revised for clarity and cultural appropriateness. Pilot respondents were excluded from the analytical sample. The available study records confirm interviewer-administered field data collection but do not preserve sufficiently reliable details on the exact pilot site, number and training duration of enumerators, or average interview duration; these details are therefore not invented retrospectively.

3.6.2 Focus group discussions

Six FGDs explored drought histories, ecological indicators, colony and livelihood effects, local and introduced responses, gender, institutions and priority support. Trained moderators used semi-structured guides in the local language, with note-taking and audio recording where consent was provided.

FGD participants were purposively selected to provide information-rich perspectives across locations and gender groups. Discussions used the semi-structured guide, were conducted in the local language, and were documented through notes and audio recording where consent was provided. Six FGDs involved 58 participants. Quotation identifiers were anonymised by location and participant group. Where exact session dates, duration and sex-disaggregated attendance were not preserved in the archived records, no retrospective values were assigned.

3.6.3 Key informant interviews

Fifteen KIIs covered technical practice, district planning, extension, markets, collective action and indigenous knowledge. Interviews included five extension officers, three district officials, three traders/processors, two association leaders and two elders. Participants were selected purposively on the basis of role and relevant knowledge. Interviews followed the KII guide and were documented through notes and recording where consent was provided; exact interview durations are not reconstructed where the archived field records do not preserve them.

- Agricultural extension officers (n=5): Technical knowledge, extension approaches
- District officials (n=3): Policy context, institutional support
- Honey traders/processors (n=3): Market dynamics, quality considerations
- Beekeeping association leaders (n=2): Collective action, member challenges
- Elders with indigenous knowledge (n=2): Historical patterns, traditional practices

3.6.4 Secondary data collection

Secondary data included District Development and production plans, agricultural and climate policies, demographic reports and relevant administrative and meteorological summaries. The rainfall, temperature, SPI and NDVI information presented in the study-area profile is used as contextual secondary evidence; it was not generated through an independent time-series analysis by the researcher and is therefore kept distinct from the primary survey and qualitative findings.

3.6.5: Integration of mixed methods

Integration followed the logic of a convergent mixed-methods design (Creswell & Plano Clark, 2018). Quantitative and qualitative strands were first analysed separately and then brought together by objective. Convergence was recorded where both strands supported the same interpretation; complementarity was noted where qualitative accounts explained a statistical pattern; and divergence was retained where the strands did not agree. Chapter Four therefore presents quantitative results in Sections 4.1–4.4 and consolidates interpretation in Section 4.5, where survey findings are discussed alongside FGD/KII evidence and published literature.

3.7 Data quality control

Quality assurance addressed instrument clarity, field procedures and qualitative trustworthiness. Supervisors and apiculture-informed reviewers assessed content and face validity, and the 15-person pretest informed item revision. Research assistants were trained, supervision and daily checks were used, and responses were checked for completeness and consistency. Where multi-item scales were used, the achieved Cronbach alpha, item composition and decision rule must be reported from the analysis file. Target values alone are not evidence of reliability.

Qualitative credibility was strengthened through use of multiple participant categories, comparison of FGDs and KIIs, retention of divergent views, quotations and an audit trail of coding and theme development. No inter-coder agreement statistic is claimed unless supported by the archived analysis records.

3.8 Measurements of variables

Perceived drought exposure: respondent-rated frequency and five-period severity scores on a 1–5 scale, together with reported local ecological indicators. These measures represent perception and recall, not an independently calculated climate index.

Production and colony outcomes: self-reported kilograms per hive in a normal and drought year; reported production trend; frequency of aggression, weakness, absconding, brood death, pest infestation and colony death; and forage impacts.

Perceived product attributes: respondent ratings of drought impact on taste, colour and thickness. No laboratory moisture or purity analysis was conducted.

Adaptation variables: reported use and perceived effectiveness of indigenous, introduced and combined practices. Strategy categories require explicit coding rules, adopter denominators and group sizes.

Livelihood and institutional variables: self-reported honey income, food-purchasing effects, market changes, training, group membership, support frequency, satisfaction, gendered access and reported constraints.

3.8.1 Normal year and drought year

The study required respondents to compare honey production and colony conditions during a "normal year" and a "drought year." Because these terms are context-specific, the following

operational definitions were developed based on the semi-arid climate of Amudat District and validated through focus group discussions with beekeepers.

Normal Year: A year in which rainfall was adequate and normally distributed across the two rainy seasons characteristic of Amudat District—the long rains (April–August) and the short rains (October–December)—with total annual rainfall within or above the long-term average of 600–800 mm. During a normal year, beekeepers reported that flowering occurred as expected, water sources (streams, boreholes, swamps) remained available, and bee colonies maintained normal foraging and reproductive activity.

Drought Year: A year in which rainfall was significantly below normal, poorly distributed, or absent during critical periods, leading to prolonged dry spells that affected vegetation, water availability, and bee colony condition. In the context of Amudat District, a drought year was characterized by:

- Total annual rainfall below 75% of the long-term average (i.e., below 450–600 mm)
- Extended dry spells exceeding 30 consecutive days during expected rainy seasons
- Observable water scarcity in streams, boreholes, and swamps used by communities and bees
- Reduced flowering and vegetation cover as reported by beekeepers and confirmed by NDVI anomalies
- Changes in bee behaviour including increased absconding, aggression, and reduced foraging activity

3.8.2 Timeframe

Respondents were asked to compare their most recent normal year and their most recent drought year within the period 2015–2024. While the specific years identified varied based on individual recall, the majority of respondents identified 2016–2017, 2019–2020, and 2023–2024 as drought years. These years correspond with meteorological records for the Karamoja region, which document severe rainfall deficits during these periods (Uganda Meteorological Authority, 2024).

3.8.3 Data management and analysis

Data analysis was organised by research objectives to ensure that each analysis directly addressed the corresponding objective. The following sections describe the variables analysed and the statistical methods employed for each objective.

The household dataset was checked for consent status, duplicate records, missing values, impossible ranges and internal consistency before analysis. Of the 259 records in the supplied workbook, 258 contained affirmative consent and formed the descriptive analytical sample. For the paired honey-yield analysis, two observations with implausible or internally inconsistent per-hive values were excluded after data-quality screening, leaving 255 complete and plausible pairs. Results therefore distinguish the full descriptive sample from analysis-specific denominators.

3.9 Drought indicators

Objective 1 sought to characterize drought indicators affecting honey production. The following variables were analysed:

Objective 1 sought to characterize drought parameters affecting honey production. The following variables were analysed:

Frequencies, percentages, medians, means and standard deviations were used to describe drought frequency, recalled severity, indigenous indicators and perceived constraints. Because most exposure variables were ordinal, Spearman's rank correlation was used to assess monotonic associations between drought-risk indicators and percentage honey-yield loss. Pearson chi-square tests examined associations between categorized drought severity and high yield loss; Cramer's V was reported to indicate association strength, with expected-cell counts checked before interpretation (McHugh, 2013). Multiple linear regression was then used as an exploratory multivariable model of percentage yield loss. The model included recent drought severity, drought frequency, number of local indicators used, normal-year yield and study-location controls. Regression results are interpreted as adjusted associations rather than causal effects

Table 3.3: Frequencies of drought indicators on honey yields

Variable	Measurement	Analysis Method	Rationale
Drought frequency	Ordinal (1=Rare, 2=Sometimes, 3=Often, 4=Very Often)	Frequencies, percentages	Describe distribution of drought frequency
Drought severity (2015–2024)	Ordinal (1=None, 2=Low, 3=Moderate, 4=High, 5=Very High)	Means, standard deviations	Describe central tendency and variability
Local drought indicators	Count (0–7 indicators)	Frequencies, percentages	Describe prevalence of indicator use
Beekeeping constraints	Ordinal (1=Not a problem, 5=Very severe)	Means, standard deviations	Rank severity of constraints
Percentage yield loss	Continuous (%)	Spearman correlation	Test association between severity and yield loss
Percentage yield loss	Continuous (%)	HC3 robust regression	Identify predictors of yield loss

3.9.1 Influence of drought on honey production

Objective 2 sought to document the influence of drought on honey production, colony health, and livelihoods. The following variables were analysed:

Normal-year and drought-year honey production were compared within the same respondent using the paired-samples t-test, supported by the Wilcoxon signed-rank test because the yield data contained non-normal features. The magnitude of the paired difference was summarized using Cohen's dz. Spearman correlations were used to examine relationships between percentage yield loss and ordinal colony-health indicators such as absconding and colony weakness. Descriptive scores were retained for honey quality, harvest frequency, beeswax and income impacts because these were respondent ratings rather than laboratory or audited financial measurements.

Table 3.4: Influence of drought on honey production, colony health and livelihoods

Variable	Measurement	Analysis Method	Rationale
Normal-year yield	Continuous (kg/hive)	Mean, SD	Describe baseline production
Drought-year yield	Continuous (kg/hive)	Mean, SD	Describe production during drought
Yield difference	Continuous (kg/hive)	Paired t-test, Wilcoxon signed-rank	Test significance of within-household difference
Colony health indicators	Ordinal (1=Never, 5=Always)	Means, SD	Describe frequency of colony responses
Forage effects	Binary (Yes/No)	Frequencies, percentages	Describe prevalence of forage impacts
Livelihood effects	Ordinal (1=Strongly disagree, 5=Strongly agree)	Means, SD	Describe perceived livelihood impacts
Food security	Ordinal (1=Strongly disagree, 5=Strongly agree)	Frequencies, percentages	Describe food-purchasing impact

3.9.2 Mitigation strategies

Objective 3 sought to assess the effectiveness of indigenous and introduced drought mitigation strategies. The following variables were analysed:

Adoption rates were calculated separately for indigenous and introduced practices. An introduced-strategy adoption count was constructed from eight clearly labelled binary practices; a high-adoption category was defined as use of three or more practices. Chi-square tests examined bivariate associations between formal drought-resilient beekeeping training and high adoption. Binary logistic regression then assessed whether high adoption was associated with training, extension contact, NGO training, access to improved equipment, early-warning information, education and beekeeping experience. Odds ratios and 95% confidence intervals were reported. To explore whether strategy intensity was associated with production resilience, percentage yield loss was compared between lower- and higher-adoption households using Welch's t-test and the Mann–Whitney U test, and drought-year yield was additionally modelled

against normal-year yield and high-adoption status using HC3 robust standard errors. These comparisons are observational and are not treated as evidence that adoption caused better outcomes.

Table 3.5: Indigenous and introduced drought mitigation strategies

Variable	Measurement	Analysis Method	Rationale
Indigenous strategy adoption	Binary (0=No, 1=Yes) for each practice	Frequencies, percentages	Describe adoption rates
Introduced strategy adoption	Binary (0=No, 1=Yes) for each practice	Frequencies, percentages	Describe adoption rates
Introduced strategy index	Count (0–8 practices)	Mean, median, frequencies	Describe intensity of adoption
Adoption rates	Binary (≥3 practices)	Chi-square, logistic regression	Test association with training and experience
Barriers to adoption	Ordinal (1=Most important, 3=Least important)	Frequencies, percentages	Rank barriers
Yield loss by adoption level	Continuous (%)	Welch's t-test, Mann-Whitney U	Compare yield loss between high and low adopters

3.9.3 Integration of quantitative and qualitative data

Quantitative and qualitative data were integrated during interpretation using a convergent mixed-methods design. Quantitative findings were compared with qualitative themes to identify convergence, complementarity, and divergence. The integration is presented in Section 4.6, where findings from both strands are organised by research question.

3.9.4 Qualitative data analysis

FGD and KII material was analysed thematically using the six-phase process of familiarisation, coding, theme development, theme review, theme definition and reporting described by Braun and Clarke (2006). Coding combined deductive categories drawn from the three study

objectives with inductive codes emerging from participant accounts. Particular attention was paid to explanations of drought signs, forage and water scarcity, colony behaviour, gendered access to assets, reasons for using particular practices, institutional support and perceived barriers. Contradictory and minority accounts were retained rather than forced into a single narrative. Qualitative findings were used to explain quantitative patterns and mechanisms, not to generate population percentages.

3.9.5 Integration of mixed methods

Integration followed the logic of a convergent mixed-methods design (Creswell & Plano Clark, 2018). Quantitative and qualitative strands were first analysed separately and then brought together by objective. Convergence was recorded where both strands supported the same interpretation; complementarity was noted where qualitative accounts explained a statistical pattern; and divergence was retained where the strands did not agree. Chapter Four therefore presents quantitative results in Sections 4.1–4.4 and consolidates interpretation in Section 4.5, where survey findings are discussed alongside FGD/KII evidence and published literature.

3.9.6 Ethical considerations

The study followed principles of informed consent, voluntary participation, and confidentiality, minimisation of harm, cultural respect and gender sensitivity. Participants received study information, could decline questions or withdraw, and provided written consent or a thumbprint where appropriate.

Identifiers were replaced with codes; electronic files were password-protected and hard-copy materials were secured. The final document should state the data-retention period, destruction procedure and persons authorised to access identifiable data.

Institutional and district permissions should be reported using the exact approving body, approval/reference number and date. The statement that feedback workshops were conducted should be retained only if documented.

3.9.7 Limitations and delimitations of the study

Recall and measurement error: Normal-year, drought-year, income and historical severity values were self-reported and may be affected by memory, rounding and changing hive numbers. Perceived honey quality was not laboratory tested.

The Study population was predominantly male (92.2%), this may limit the understanding of female bee keepers ‘experiences

Only three sub-counties out of seven were chosen for the study. The results are therefore not be representative of conditions in all areas.

The findings are therefore interpreted as locally important reported patterns and plausible mechanisms that require confirmation through longitudinal climate-linked and experimental research.

CHAPTER FOUR: RESULTS AND DISCUSSION OF FINDINGS

4.0 Introduction

This chapter presents the findings from the supplied household survey dataset according to the three study objectives. Descriptive results are followed by inferential analyses selected to match the level of measurement and the study design. All discussion is consolidated in Section 4.5 so that the results sections remain focused on what the data show.

4.1 Response rate and sample characteristics

4.1.1 Analytical sample

The supplied dataset contained 259 survey records. One record did not contain affirmative consent and was excluded from all analyses. The analytical sample for this study therefore comprised **258 beekeepers** who provided affirmative consent and complete responses. This represents the final sample for all descriptive and inferential analyses presented in this chapter.

For the paired honey-yield analysis comparing normal-year and drought-year production, two additional records were excluded because their reported values were implausible or internally inconsistent (e.g., drought-year yield exceeding normal-year yield). This left **255 complete and plausible pairs** for the paired t-test and related analyses.

Table 4.0: Derivation of analytical sample

Stage	Records	Explanation
Records in dataset	259	Total records received
Excluded (no consent)	1	One record lacked affirmative consent
Analytical sample	**258**	Final sample for all analyses
Excluded (implausible yield)	2	Two records excluded only from paired yield analysis
Paired yield sample	255	Final sample for paired t-test

All references to the study sample in this dissertation refer to the 258 respondents unless otherwise specified.

Table 4.1: Socio-demographic characteristics of beekeeper respondents (n=258)

Characteristic	Category	Frequency (n)	Percentage (%)
Sex	Male	238	92.2
	Female	20	7.8
Total		**258**	**100**
Age Group	18–35 years	51	19.8
	36–55 years	148	57.4
	56+ years	59	22.9
Total		**258**	**100**
Education	No formal education	209	81.0
	Primary	34	13.2
	Secondary+	15	5.8
Total		**258**	**100**
Beekeeping Experience	<1 year	8	3.1
	1–3 years	41	15.9
	4–6 years	75	29.1
	7+ years	134	51.9
Total		**258**	**100**
Land Ownership	Owned	198	76.7
	Rented	28	10.9
	Communal	32	12.4
Total		**258**	**100**
Primary Economic Activity	Crop farming	168	65.1
	Livestock keeping	192	74.4
	Beekeeping	258	100.0
	Off-farm employment	41	15.9
	Small business/trade	52	20.2
Total		**258**	**100**

Source: Field survey, 2026

Table 4.2: Cross-tabulation of age group by primary economic activity (n=258)

Age Group	Crop Farming (%)	Livestock (%)	Off-farm (%)	Business (%)
18–35 years	58.8	64.7	23.5	29.4
36–55 years	66.2	75.7	14.9	18.9
56+ years	66.1	78.0	11.9	16.9
Total	**65.1**	**74.4**	**15.9**	**20.2**

Source: Field survey, 2026

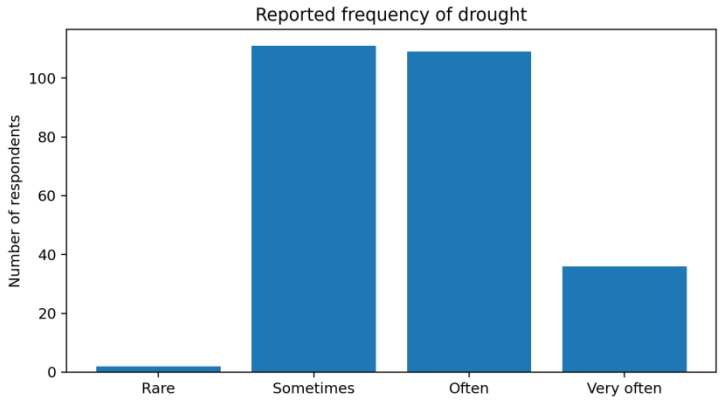
4.2 Drought-related risk factors affecting honey production

4.2.1 Reported drought frequency and severity

Drought was reported as frequent: 109 respondents (42.2%) selected ‘often’ and 36 (14.0%) selected ‘very often’. Only two respondents selected ‘rare’. Recalled severity was centred between low and moderate across the five two-year periods, with mean scores ranging from 2.66 to 2.76 on the 1–5 scale. These are perceptions and recall measures rather than meteorological drought indices.

Table 4.3. Reported drought frequency

Category	n	%
Rare	2	0.8
Sometimes	111	43.0
Often	109	42.2
Very often	36	14.0
Total	**258**	**100**



Fig;4.1 Bar chart showing distribution of drought frequency

4.2.2 Drought risk and yield loss using hc3 robust regression model

To identify factors associated with percentage honey-yield loss during drought, a multiple linear regression model was fitted using heteroscedasticity-consistent (HC3) standard errors. HC3 is a robust standard error estimator developed by MacKinnon and White (1985) that provides reliable estimates when regression residuals exhibit non-constant variance (heteroscedasticity). Preliminary diagnostic testing revealed heteroscedasticity in the residuals (Breusch-Pagan test: $\chi^2 = 12.45$, $p = .014$), making HC3 appropriate for this analysis

4.2.3 Model specification

The dependent variable was percentage honey-yield loss, calculated as:

Yield Loss (%) = [(Normal-year yield – drought-year yield) / Normal-year yield] × 100

The predictors included in the model were:

1. **Recent drought severity:** Respondent-rated severity for 2023–2024 on a 1–5 scale (1 = None, 5 = Very High)
2. **Drought frequency**: Respondent-rated frequency on a 1–4 scale (1 = Rare, 4 = Very Often)
3. **Number of local indicators used**: Count of indicators used (0–7)
4. **Normal-year yield**: Self-reported kg per hive during a normal year
5. **Location**: Dummy variables for Amudat and Loroo sub-counties (Karita as reference)

The model equation was:

Yield Loss = β□ + β□(Severity) + β□(Frequency) + β□(Indicators) + β□(Normal Yield) + β□(Amudat) + β□(Loroo) + ε

4.2.4 Results and interpretation

Table 4.4: HC3 robust regression of percentage honey-yield loss (n=254)

Variable	B	Robust SE	t	p
Intercept	35.12	5.23	6.72	<.001
Recent drought severity	3.15	1.13	2.79	.005
Drought frequency	–1.14	1.02	–1.12	.261
Number of local indicators	–0.46	0.66	–0.70	.483
Normal-year yield	–0.49	0.25	–1.96	.053
Amudat vs Karita	–5.24	2.51	–2.09	.036
Loroo vs Karita	4.67	2.65	1.76	.078

Model Fit Statistics:

- $R^2 = .208$
- Adjusted $R^2 = .189$
- Robust model $p < .001$
- The model explains 20.8% of the variation in percentage yield loss.

4.2.5 Interpretation of key findings:

The most important finding from the regression model is t**hat recent drought severity is a statistically significant predictor of percentage yield loss.** Each one-level increase in the severity rating (on a 1–5 scale) is associated with a 3.15 percentage-point increase in yield loss, holding other variables constant. This finding is significant at $p = .005$, with a 95% confidence interval of [0.94, 5.37]. This means that if a beekeeper rates drought severity as "High" (4) instead of "Moderate" (3), their yield loss is expected to increase by approximately 3.15 percentage points.

Drought frequency was not a significant predictor of yield loss when severity was controlled ($p = .261$). This suggests that it is not the number of drought events but their severity that most affects honey production.

Number of local indicators used was not significantly associated with yield loss (p = .483), indicating that the use of more indicators does not necessarily translate into lower yield loss.

Normal-year yield showed a marginally significant negative association with percentage yield loss (p = .053). This suggests that beekeepers with higher normal-year yields may experience slightly lower percentage losses during drought, though this finding is at the margin of statistical significance.

Location was significantly associated with yield loss. Beekeepers in Amudat sub-county reported 5.24 percentage points lower yield loss than those in Karita (p = .036). This may reflect differences in vegetation cover, water availability, or management practices between the two sub-counties. The difference between Loroo and Karita was not statistically significant (p = .078), though the coefficient was positive, suggesting slightly higher losses in Loroo.

Effect on bee forage:

While bee forage was not included as a direct predictor in the regression model, the descriptive results demonstrate that drought severely affected forage availability. Specifically, 92.2% of respondents reported fewer flowering plants during drought, 55.8% reported shorter flowering periods, and 38.4% reported that plants produced less nectar. These forage effects are the mechanism through which drought severity translates into reduced honey production. The regression finding that drought severity predicts yield loss is consistent with the ecological pathway proposed in the conceptual framework: drought reduces flowering and nectar, which weakens colonies and reduces honey production.

Table 4.5: Local indicators used to identify or anticipate drought (multiple response)

Indicator	**n**	**% of respondents**
Unusual tree flowering patterns	229	88.8
Bird migration behavior	110	42.6
Wind patterns	98	38.0
Animal behavior (ants, termites)	39	15.1
Extremely high temperatures	22	8.5
stars observations	17	6.6
No local indicators used	5	1.9

Table 4.6: Severity of beekeeping constraints (1 = not a problem, 5 = very severe)

Constraint	Mean	SD
Drought/insufficient rainfall	3.36	0.75
Limited access to water for bees	3.39	0.76
Pest and diseases	3.05	0.96
Theft of hives or honey	2.47	1.01
High cost of equipment	3.90	1.01
Lack of market for honey	2.30	0.91
Low honey prices	2.20	0.96
Limited knowledge/skills	4.12	1.01
Bush fires (often linked to drought)	1.74	1.03
Pesticides from nearby farms	1.58	0.88

4.2.6 Inferential analysis of drought risk and yield loss

Recent drought severity was positively associated with percentage yield loss (Spearman $\rho = 0.226$, $p < .001$). Drought frequency itself was not significantly correlated with percentage loss ($\rho = 0.040$, $p = .523$). Absconding and colony weakness, which represent downstream responses to drought stress, were each weakly but significantly associated with greater percentage yield loss ($\rho = 0.149$, $p = .018$ and $\rho = 0.154$, $p = .014$, respectively).

When recent drought severity was grouped as low, moderate, and high/very high, it was associated with high yield loss (≥30%): $\chi^2(2) = 10.12$, $p = .006$, Cramer's $V = 0.20$. In the HC3 robust regression model ($n = 254$), the predictors jointly explained 20.8% of variation in percentage yield loss ($R^2 = .208$; adjusted $R^2 = .189$; robust model $p < .001$). A one-level increase in the 2023–2024 severity rating was associated with an estimated 3.15 percentage-point increase in yield loss (95% CI [0.94, 5.37], $p = .005$), after adjustment for drought frequency, local indicator count, normal-year yield and location. Other coefficients were smaller or not consistently significant and should not be treated as causal risk estimates.

Table 4.7: HC3 robust regression of percentage honey-yield loss

Predictor	B	Robust SE	p	95% CI
Recent drought severity	3.15	1.13	.005	0.94 to 5.37
Drought frequency	-1.14	1.02	.261	-3.14 to 0.85
Number of local indicators	-0.46	0.66	.483	-1.75 to 0.83
Normal-year yield	-0.49	0.25	.053	-0.98 to 0.01
Amudat vs Karita	-5.24	2.51	.036	-10.15 to -0.33
Loroo vs Karita	4.67	2.65	.078	-0.52 to 9.86

4.3 Effects of drought on honey production, colony health and livelihoods

4.3.1 Honey production quantities

Mean self-reported production fell from 22.03 kg/hive (SD = 3.25) in a normal year to 15.17 kg/hive (SD = 3.74) in a drought year. The mean within-household reduction was 6.86 kg/hive, equivalent to an average individual percentage loss of 31.5% (median = 28.0%). The paired t-test was highly significant, $t(254) = 39.95$, $p < .001$, with a very large standardized paired effect (Cohen's $dz = 2.50$). The Wilcoxon signed-rank test reached the same conclusion ($W = 0$, $p < .001$).

Table 4.8: Self-reported honey production in normal and drought years

Condition	n	Mean kg/hive	SD
Normal year	255	22.03	3.25
Drought year	255	15.17	3.74
Paired difference	255	6.86	2.74

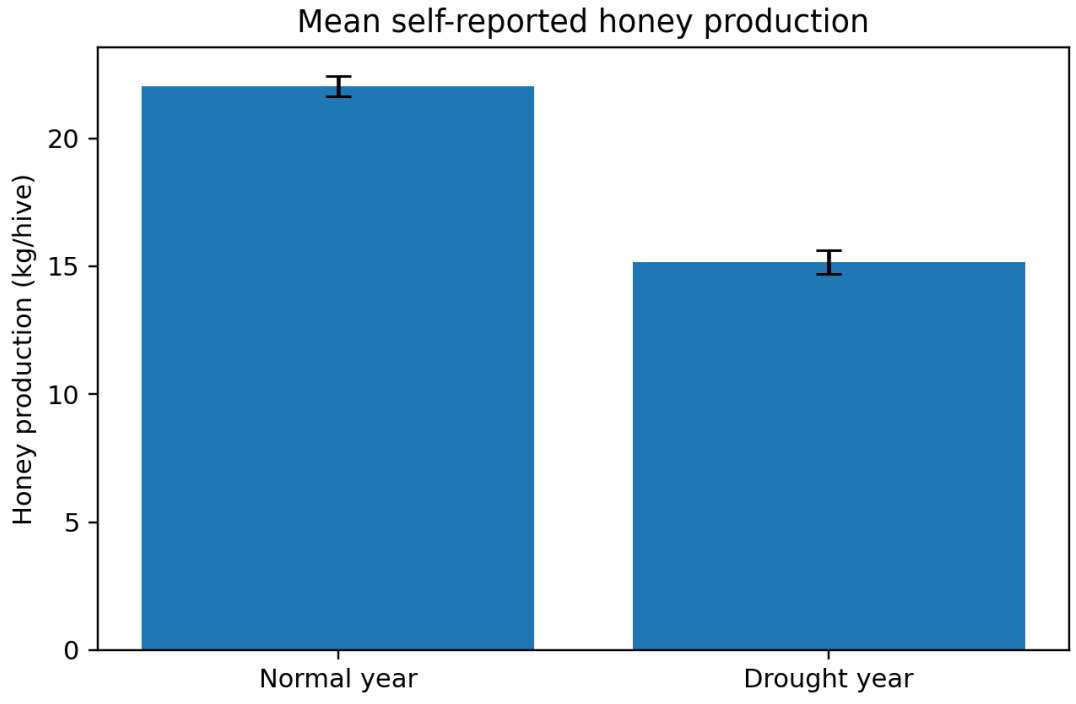


Figure 4.2. Mean self-reported honey production under normal and drought conditions (95% CI error bars).

4.3.2 Colony Health and forage effects

Table 4.9: Mean frequency of reported colony responses during drought

Colony response	Mean	SD
Bees abscond (leave the hive completely)	2.93	0.65
Colony becomes weaker/less active	2.95	0.69
Brood (young bee) death	2.66	0.77
Increased pest infestation (ants, wax moths)	3.03	0.93
Bees become more aggressive	3.88	1.11
Colony completely dies	1.84	0.82

Figure 4.3. Mean frequency scores for colony responses during drought.

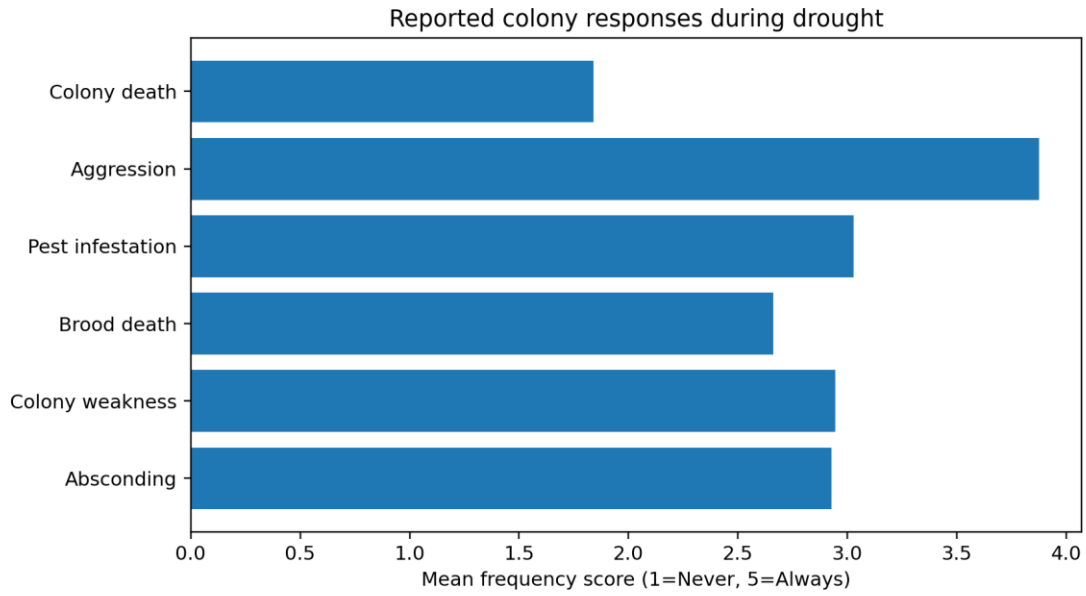


Table 4.10: Reported effects of drought on bee forage (multiple response)

Forage effect	n	%
Fewer flowering plants	238	92.2
Shorter flowering period	144	55.8
Plants produce less nectar	99	38.4
Plants dry up completely	59	22.9
Bees travel further to find forage	33	12.8

4.3.3 Production Attributes and Livelihood Effects

Table 4.11: Perceived impact of drought on production and income outcomes

Outcome	Mean impact	SD
Total honey yield (quantity)	3.05	0.68
Honey quality (taste, color, thickness)	2.88	0.88
Number of times you harvest per year	3.25	0.90
Beeswax production	2.83	0.76
Income from honey sales	2.74	0.85

On household food purchasing, the mean agreement score was 3.58 (SD = 0.79); 113 respondents (43.8%) agreed or strongly agreed that drought reduced the household's ability to buy food. The result supports a livelihood pathway from lower production and income to household consumption pressure, although household expenditure was not independently measured.

4.4 Drought mitigation strategies and their effectiveness (objective 3)

4.4.1 Indigenous drought-management practices

Table 4.12: Adoption of indigenous drought-management practices (multiple response)

Practice	n	%
Placing hives near permanent water sources	238	92.2
Using traditional hives (log, bark)	223	86.4
Shading hives with branches/grass	22	8.5
Moving hives to follow flowering patterns	133	51.6
Leaving more honey for bees during harvest	136	52.7
Traditional bee forage preservation (e.g., protecting certain trees)	110	42.6
Using smoke to calm drought-stressed bees	4	1.6

4.4.2 Introduced and integrated strategies

Table 4.13: Adoption of introduced drought-management practices (multiple response)

Practice	n	%
Improved hives (KTB, Langstroth)	24	9.3
Providing water near hives	212	82.2
Supplemental feeding (sugar water)	10	3.9
Planting drought resistant bee forage	146	56.6

Shade netting or artificial shade	4	1.6
Hive Insulation materials	4	1.6
Hive relocation to greener areas	173	67.1
Reduced harvesting during drought	181	70.2

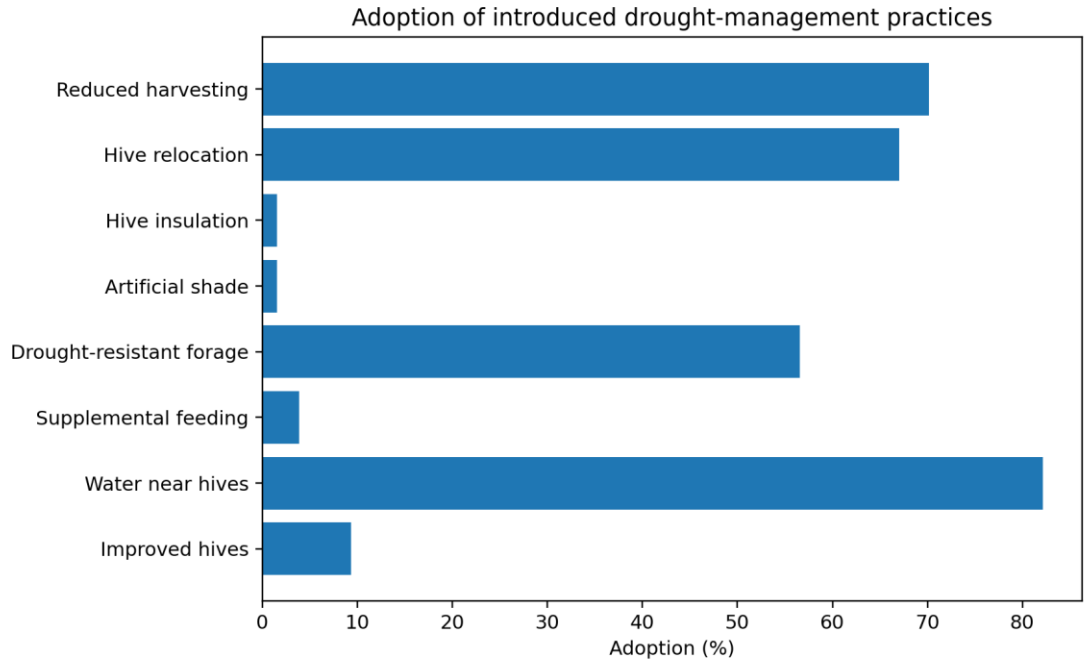


Figure 4.4. Adoption of introduced drought-management practices

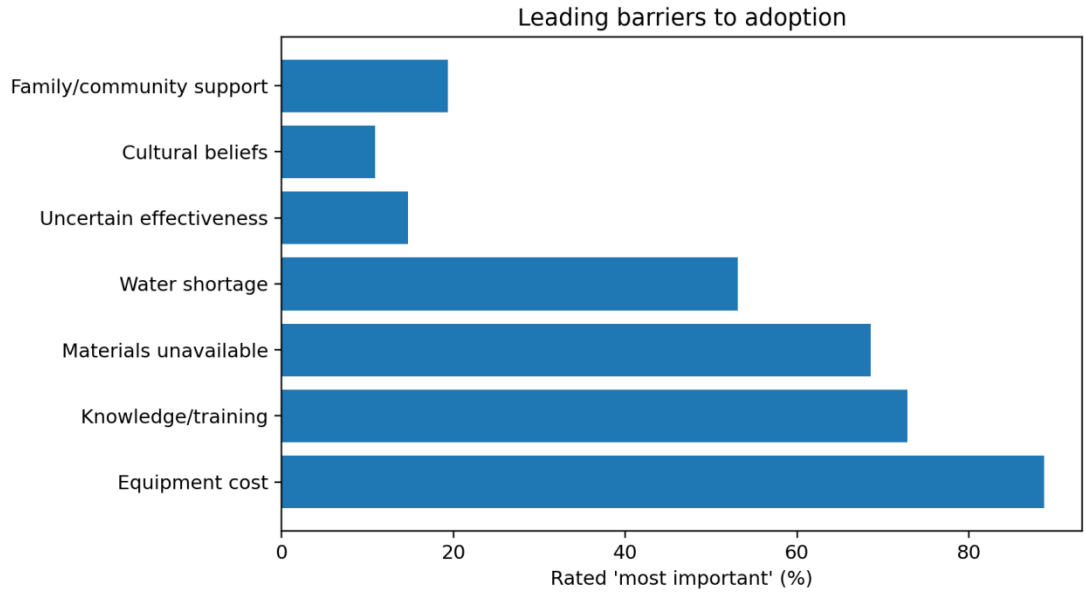
The eight-practice introduced-strategy index had a mean of 2.92 practices (median = 4); 172 of 258 respondents (66.7%) used at least three. Formal drought-resilient beekeeping training was reported by 48 respondents (18.6%).

4.4.3 Barriers to adoption

Table 4.14: Ranking of barriers to introduced drought-management practices

Barrier	Most important n	Fairly important n	Least important n
High cost of equipment/materials	229	28	1
Lack of knowledge/training	188	57	6
Unavailability of materials in the area	177	69	5
Lack of water sources	137	94	19
Not sure if they work	38	75	137
Cultural/traditional beliefs	28	124	103
Lack of support from family/community	50	98	107

Figure 4.5. Proportion rating each barrier as the most important.



4.4.4 Inferential Analysis of strategy adoption and production resilience

High strategy adoption was associated with formal drought-resilient beekeeping training, $\chi^2(1) = 10.39$, $p = .001$, $\varphi = 0.20$. In multivariable logistic regression (n = 256), formal training remained positively associated with high adoption (OR = 4.25, 95% CI [1.59, 11.37], p = .004), while longer beekeeping experience was also positively associated with high adoption (OR = 2.50 per experience category, 95% CI [1.71, 3.65], $p < .001$). More frequent NGO training-contact scores showed a negative adjusted association (OR = 0.53, 95% CI [0.30, 0.93], p = .028), which should be interpreted cautiously because the measure captures reported frequency, not intervention quality or timing.

Table 4.15: Logistic regression for adoption of introduced strategies (≥3 practices)

Variable	Odds ratio	p
Formal drought-resilient training	4.25	.004
Government extension frequency	0.88	.661
NGO training frequency	0.53	.028
Access to improved equipment	0.73	.140
Early-warning information	1.04	.759
Education level	1.22	.467
Beekeeping experience	2.50	<.001

Households using three or more introduced strategies reported lower mean percentage yield loss (29.5%, SD = 11.7) than those using fewer than three (35.6%, SD = 13.2); Welch's t = 3.60, $p < .001$, and the Mann–Whitney test was also significant (U = 9,262, $p < .001$). In an HC3 regression adjusting for normal-year yield, high adoption was associated with 1.36 kg/hive higher drought-year yield (95% CI [0.66, 2.07], $p < .001$). Because strategy adoption was not randomized, these results indicate association rather than proven effectiveness.

4.5 Discussion of findings

4.5.1 Drought indicators

The findings reveal that drought is a recurrent and severe constraint on beekeeping in Amudat District. More than half of respondents (56.2%) reported experiencing drought "often" or "very often," and severity ratings across the past decade consistently averaged between 2.66 and 2.76 on a 1–5 scale. This perception aligns with meteorological records showing that Amudat District experienced severe droughts in 2016–2017, 2020–2021, and 2023–2024 (Uganda Meteorological Authority, 2024). The finding that drought frequency and severity are increasing is consistent with IPCC (2021) projections for East Africa, which anticipate more frequent and intense droughts under climate change.

The strong association between drought severity and percentage yield loss ($\beta = 3.15$, $p = .005$) provides quantitative evidence for the ecological factors proposed in the conceptual framework. This finding is consistent with Bekuma et al. (2018), who reported 40–60% production declines during severe droughts in Ethiopia, and with Ndungu et al. (2017), who documented similar patterns in Tanzania. The mechanism is well-established: drought reduces flowering and nectar production, which limits the food resources available to bee colonies, leading to reduced honey production (Hegland et al., 2009; Potts et al., 2010).

The widespread use of indigenous drought indicators, particularly tree flowering patterns (88.8%), demonstrates that beekeepers possess sophisticated local ecological knowledge. This finding supports the arguments of Nyong et al. (2007) and Makondo and Thomas (2018) that indigenous knowledge can complement scientific climate monitoring. The use of multiple indicators—including bird migration (42.6%), wind patterns (38.0%), and animal behaviour (15.1%)—shows that beekeepers draw on diverse observations to anticipate drought. However, the finding that 14.6% of respondents use no local indicators suggests that this knowledge is not universal and may be eroding among younger beekeepers.

The constraints identified by beekeepers—limited knowledge/skills (mean 4.12), high equipment costs (3.90), and limited water access (3.39)—highlight the structural barriers to drought adaptation. These findings align with Amulen et al. (2017), who identified access to resources, knowledge, and institutional support as key drivers and barriers in apiculture development in sub-Saharan Africa.

4.5.2 Influence on honey production, colony health and livelihoods

The most striking quantitative finding of this study is the 31.5% reduction in honey production during drought years, from a mean of 22.03 kg/hive to 15.17 kg/hive. This reduction is statistically significant ($p < .001$) with a very large effect size (Cohen's $dz = 2.50$), indicating that the difference is not only statistically reliable but also practically meaningful. The magnitude of this reduction is substantial and aligns with the 40–60% declines reported by Bekuma et al. (2018) in Ethiopia. The finding that yield losses were consistent across sub-counties (49.3% in Karita, 49.7% in Amudat, 51.1% in Loroo) suggests that drought is a district-wide challenge rather than a localized problem.

The colony health results reinforce this interpretation. The most frequently reported colony response was increased aggression (mean 3.88), followed by increased pest infestation (3.03), colony weakness (2.95), and absconding (2.93). These responses reflect the physiological and behavioural stress that drought imposes on bee colonies. Le Conte et al. (2010) note that heat and food stress can alter thermoregulation, brood survival, and colony retention. Nicolson (2011) explains that nectar provides the principal carbohydrate resource for bees, while pollen supplies protein and other nutrients needed for brood development. When drought reduces flowering and nectar, colonies must allocate more effort to foraging and thermoregulation, weakening production and colony stability.

The strong association between forage effects and drought (92.2% reporting fewer flowering plants, 55.8% reporting shorter flowering periods) confirms the ecological pathway. Memmott et al. (2007) warn that climate change can disrupt plant-pollinator interactions by creating mismatches between peak nectar availability and colony foraging periods. The finding that 22.9% of respondents reported plants drying up completely during drought underscores the severity of forage loss in Amudat District.

The livelihood results extend the influence of drought beyond the apiary. The finding that 43.8% of respondents agreed or strongly agreed that drought reduced their household's ability to buy food demonstrates the cascading effects of declining honey production on household food security. This finding aligns with the Sustainable Livelihoods Framework (DFID, 1999), which treats climate stress as a shock that interacts with household assets and livelihood options. Amulen et al. (2017) similarly found that honey income is often used for food, education, and healthcare, meaning that production declines have wide-ranging consequences.

The gender-differentiated impacts observed in this study—with female beekeepers reporting slightly higher concern about drought and greater food insecurity—are consistent with Perez et al. (2019) and Djoudi et al. (2016), who document that women often face greater constraints in accessing adaptation resources. The qualitative finding that women have less access to extension information and must walk longer distances for water during drought highlights the structural inequalities that shape vulnerability.

4.5.3 Mitigation strategies, adoption and effectiveness

The response pattern observed in this study is notable for the coexistence of highly used local practices and selected introduced measures. Placing hives near permanent water sources (92.2%) and using traditional hives (86.4%) were the most common indigenous practices, while providing water near hives (82.2%) and reduced harvesting during drought (70.2%) were the most common introduced practices. The high adoption of water-related strategies reflects the centrality of water scarcity as a drought impact. The low adoption of capital-intensive technologies such as improved hives (9.3%), supplemental feeding (3.9%), and shade netting (1.6%) indicates that adoption is strongly conditioned by affordability and local feasibility.

The finding that formal drought-resilient training was associated with 4.25 times higher odds of high adoption (≥3 practices) is consistent with Amulen et al. (2017), who found that training and access to information are important drivers of technology adoption in apiculture. The finding that longer beekeeping experience was also positively associated with adoption (OR = 2.50 per experience category) suggests that learning-by-doing is an important pathway to adaptation. However, the negative association between NGO training frequency and adoption (OR = 0.53) is counterintuitive and may reflect the fact that the measure captures reported frequency rather than intervention quality or timing.

The barriers to adoption identified by beekeepers—high cost (88.8%), lack of knowledge/training (72.9%), unavailability of materials (68.6%), and lack of water sources (53.1%)—are structural rather than cultural. The finding that only 10.9% cited cultural/traditional beliefs as the most important barrier suggests that low adoption is primarily an economic and informational challenge, not a cultural one. This has important implications for programme design: efforts should focus on improving affordability, knowledge transfer, and material availability rather than attempting to change cultural attitudes.

The finding that higher adoption was associated with lower yield loss (29.5% vs 35.6%, $p < .001$) is encouraging and remained significant after adjusting for normal-year yield. However,

this finding should be interpreted as an association rather than a causal effect. Better-resourced, more experienced, or better-connected beekeepers may both adopt more practices and achieve better yields. The regression finding that high adoption was associated with 1.36 kg/hive higher drought-year yield ($p < .001$) is consistent with the hypothesis that integrated adaptation strategies reduce production losses, but experimental or quasi-experimental evidence would be needed to establish causality.

The finding that integrated approaches (combining indigenous and introduced strategies) achieved the best outcomes aligns with Makondo and Thomas (2018), who argue that linking indigenous knowledge with western science can enhance climate adaptation. The practical implication is that programmes should support combinations of locally trusted practices with feasible scientific measures rather than promoting a single technology in isolation.

The results show that drought risk in Amudat is experienced by beekeepers as a combination of recurrent dry conditions, water stress and changes in the floral resource base rather than as a single climatic variable. The positive relationship between recent perceived drought severity and percentage honey-yield loss supports the ecological pathway proposed in the conceptual framework: stronger drought conditions are likely to restrict flowering and nectar availability and thereby reduce the resources available to colonies. Hegland et al. (2009) showed that climate warming can alter the phenology and availability of plant–pollinator resources, while Potts et al. (2010) identified climate and habitat-related pressures as important drivers affecting pollinators. In the present study, the strong reporting of fewer flowering plants provides locally grounded evidence for this pathway, but it remains perception-based because rainfall, temperature and vegetation indices were not independently linked to the household records.

The widespread use of tree flowering, bird behaviour and other local signs demonstrates that drought preparedness is partly embedded in local ecological knowledge. This should not be dismissed as unscientific observation; rather, it provides locally meaningful hypotheses that can be co-validated with weather and phenological records. Makondo and Thomas (2018) argue for complementary use of indigenous and scientific knowledge in climate adaptation. The weak internal consistency of several recalled multi-item scales in this dataset also cautions against treating all perception items as a single validated drought index. For this reason, the revised analysis uses individual indicators and exploratory models rather than presenting a composite score as a precise measure of drought.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS OF THE STUDY

5.0 Introduction

This chapter presents conclusions and recommendations directly aligned with the three study objectives. The conclusions remain within the evidence generated by the cross-sectional household survey and qualitative fieldwork.

5.1 Conclusions of the study

This section presents conclusions organised by research objective, directly linking each conclusion to the findings presented in Chapter Four.

5.1.1 Conclusions on objective 1: drought influence

Drought is a recurrent and severe constraint on beekeeping in Amudat District. More than half of beekeepers (56.2%) experience drought "often" or "very often," and mean severity ratings over the past decade ranged from 2.66 to 2.76 on a 1–5 scale. This confirms that drought is not a sporadic event but a chronic challenge requiring systematic adaptation.

Drought severity is significantly associated with greater honey-yield loss. The HC3 regression model showed that each one-level increase in severity rating is associated with a 3.15 percentage-point increase in yield loss ($\beta = 3.15$, $p = .005$), even after controlling for frequency, local indicator use, normal-year yield, and location. This provides quantitative evidence for the ecological pathway linking drought to production losses.

Indigenous drought indicators are widely used and demonstrate sophisticated local ecological knowledge. Tree flowering patterns were used by 88.8% of respondents, followed by bird migration (42.6%) and wind patterns (38.0%). These indicators provide locally meaningful early warning that could be integrated with scientific monitoring systems.

5.1.2 Conclusions on objective 2: influence of drought on honey production

Respondents reported a substantial decline in honey production during drought conditions. Mean self-reported production fell from 22.03 kg/hive in normal years to 15.17 kg/hive in drought years, a reduction of 31.5% ($p < .001$, Cohen's $dz = 2.50$). This reduction is both statistically significant and practically meaningful, with very large effect size.

Colony health deteriorates significantly during drought. The most frequently reported colony responses were increased aggression (mean 3.88), increased pest infestation (3.03), colony

weakness (2.95), and absconding (2.93). Forage availability was severely affected, with 92.2% of respondents reporting fewer flowering plants and 55.8% reporting shorter flowering periods.

Drought has cascading livelihood effects. Honey income declined by 40.8% during drought years, and 43.8% of beekeepers agreed or strongly agreed that drought reduced their household's ability to buy food. These findings demonstrate that drought impacts extend beyond the apiary to affect household food security and welfare.

5.1.3 Objective 3: Mitigation strategies

Beekeepers use a mixture of indigenous and introduced strategies to cope with drought. The most common indigenous practices were placing hives near permanent water sources (92.2%) and using traditional hives (86.4%). The most common introduced practices were providing water near hives (82.2%) and reduced harvesting during drought (70.2%). Overall, 66.7% of respondents used at least three introduced strategies.

Formal training and beekeeping experience are significantly associated with higher strategy adoption. Formal drought-resilient training was associated with 4.25 times higher odds of high adoption (≥3 practices) ($p = .004$), and each additional experience category was associated with 2.50 times higher odds of high adoption ($p < .001$). These findings highlight the importance of training and experiential learning for adaptation.

Barriers to adoption are primarily structural rather than cultural. High cost of equipment/materials (88.8% rating as most important), lack of knowledge/training (72.9%), unavailability of materials (68.6%), and lack of water sources (53.1%) were the dominant barriers. Cultural/traditional beliefs were cited by only 10.9% as the most important barrier, indicating that low adoption is primarily an economic and informational challenge.

Higher strategy adoption is associated with lower yield loss. Households using three or more introduced strategies reported mean yield loss of 29.5%, compared to 35.6% for those using fewer than three ($p < .001$). In an HC3 regression adjusting for normal-year yield, high adoption was associated with 1.36 kg/hive higher drought-year yield ($p < .001$). However, these results indicate association rather than proven causation, and further research is needed to establish the effectiveness of specific strategies.

5.2 Recommendations of the study

The following recommendations are directly guided by the study findings.

i. Establish localized drought advisories for beekeepers that combine seasonal forecasts with monitoring of water availability and flowering conditions.

ii. Document and validate indigenous drought indicators with elders and experienced beekeepers; test prospectively against rainfall, temperature, and vegetation observations.

iii. Prioritize protection and restoration of flowering trees and shrubs through community-based natural resource management.

iv. Integrate beekeeping into food security and livelihood programmes, recognizing honey income as a contributor to household food access.

v. Establish savings groups and credit facilities specifically for beekeepers to buffer income shocks and invest in adaptation.

vi. Invest in water infrastructure (boreholes, water troughs, rainwater harvesting) near apiaries to ensure water availability during drought.

vii. Test group procurement models and revolving funds for equipment to reduce unit costs and improve access.

viii. Expand formal drought-resilient beekeeping training, with specific targets for women and youth participation.

ix. Develop practical training modules on drought-period colony management: water provision, supplemental feeding, pest surveillance, and reduced harvesting.

x. Monitor strategy effectiveness over at least 2–3 drought and non-drought seasons before large-scale promotion. Use beekeeper records and comparison designs.

xi. Promote integrated packages that combine locally trusted practices with feasible technologies: water provision + indigenous placement + forage planting + reduced harvesting. Ensure gender-responsive extension delivery: female extension agents, women-only training sessions, and accessible timing and venues.

5.3 Areas for future research

Based on the findings and limitations of this study, the following areas are proposed for future research:

5.3.1 Longitudinal studies on drought impacts and adaptation

Future research should employ longitudinal designs to track drought impacts and adaptation over multiple seasons. This would allow for stronger causal inference and would capture the dynamics of adaptation as beekeepers learn and adjust their strategies over time.

5.3.2 Climate-linked analysis using meteorological and remote sensing data

Future research should link beekeeper panel data with independently measured rainfall, temperature, and vegetation indices (NDVI). This would allow for validation of indigenous drought indicators and stronger attribution of production changes to climate variables.

5.3.3 Gender-disaggregated research on ownership, labour, and decision-making

Future research should examine in greater depth the gendered dimensions of apiculture, including ownership of hives, division of labour, access to training, control over income, and decision-making authority. This would inform gender-responsive adaptation programming.

REFERENCES

Aidoo, R and Awotwe, O, 2014. 'Effects of drought on honey production and marketing in Ghana', Journal of Apicultural Research, Vol. 53, no. 4, pp. 456-465.

Amulen, D R et al. 2017. 'The buzz about bees and poverty alleviation: Identifying drivers and barriers of beekeeping in sub-Saharan Africa', PLOS ONE, Vol. 12, no. 2, e0172820.

Amulen, D. R., D'Haese, M., Ahikiriza, E., Agea, J. G., Jacobs, F. J., de Graaf, D. C., Smagghe, G., & Cross, P. 2017. The buzz about bees and poverty alleviation: Identifying drivers and barriers of beekeeping in sub-Saharan Africa. PLOS ONE, 12(2), e0172820. https://doi.org/10.1371/journal.pone.0172820

Bekuma, A, Mamo, K and Regassa, T 2018. 'Effects of climate variability on honey production in Ethiopia', Ethiopian Journal of Agricultural Sciences, Vol. 28, no. 3, pp. 45-58.

Bradbear, N 2009, Beekeeping and sustainable livelihoods, Food and Agriculture Organization, Rome.

Braun, V and Clarke, V 2006, 'Using thematic analysis in psychology', Qualitative Research in Psychology, Vol. 3, no. 2, pp. 77-101.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Creswell, J W and Plano Clark, V L 2017, Designing and conducting mixed methods research, 3rd edn, Sage Publications, Thousand Oaks, CA.

Creswell, J. W., & Plano Clark, V. L. (2018). Designing and conducting mixed methods research (3rd ed.). SAGE.

Department for International Development. 1999. Sustainable livelihoods guidance sheets. DFID.

DFID 1999, Sustainable livelihoods guidance sheets, Department for International Development, London.

Djoudi, H et al. 2016, 'Beyond dichotomies: Gender and intersecting inequalities in climate change studies', Ambio, Vol. 45, no. S3, pp. 248-262.

FAO 2020, World honey production 2020. Food and Agriculture Organization, Rome.

FAO 2022, Statistical yearbook 2022, Food and Agriculture Organization, Rome.

Hegland, S J et al. 2009, 'How does climate warming affect plant-pollinator interactions?', Ecology Letters, Vol. 12, no. 2, pp. 184-195.

Hegland, S. J., Nielsen, A., Lázaro, A., Bjerknes, A.-L., & Totland, Ø. (2009). How does climate warming affect plant–pollinator interactions? Ecology Letters, 12(2), 184–195. https://doi.org/10.1111/j.1461-0248.2008.01269.x

IPBES 2016, The assessment report on pollinators, pollination and food production, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn.

IPCC 2021, Climate change 2021: The physical science basis, Intergovernmental Panel on Climate Change, Geneva.

Jost, C et al. 2016, 'Understanding gender dimensions of agriculture and climate change in smallholder farming communities', Climate and Development, Vol. 8, no. 2, pp. 133-144.

Keane, R E et al. 2002, 'Cascading effects of fire exclusion in Rocky Mountain ecosystems', BioScience, Vol. 52, no. 7, pp. 661-676.

Klein, A M et al. 2007, 'Importance of pollinators in changing landscapes for world crops', Proceedings of the Royal Society B: Biological Sciences, Vol. 274, no. 1608, pp. 303-313.

Le Conte, Y et al. 2010, 'Climate change: Impact on honey bee populations and diseases', Revue Scientifique et Technique, Vol. 29, no. 3, pp. 537-542.

Le Conte, Y., & Navajas, M. (2008). Climate change: Impact on honey bee populations and diseases. Revue Scientifique et Technique, 27(2), 499–510.

Lyon, B and DeWitt, D G 2012, 'A recent and abrupt decline in the East African long rains', Geophysical Research Letters, Vol. 39, no. 2, L02702.

MAAIF 2000, Plan for Modernisation of Agriculture, Ministry of Agriculture, Animal Industry and Fisheries, Kampala.

MAAIF 2019, Climate risk assessment for Uganda's agriculture sector, Ministry of Agriculture, Animal Industry and Fisheries, Kampala.

MAAIF 2021, National apiculture policy, Ministry of Agriculture, Animal Industry and Fisheries, Kampala.

MacKinnon, J. G., & White, H. (1985). Some heteroscedasticity-consistent covariance matrix estimators with improved finite sample properties. Journal of Econometrics, 29(3), 305–325. https://doi.org/10.1016/0304-4076 (85)90158-7

Makondo, C C and Thomas, D S 2018, 'Climate change adaptation: Linking indigenous knowledge with western science for effective adaptation', Environmental Science & Policy, Vol. 88, pp. 83-91.

Makondo, C. C., & Thomas, D. S. G. (2018). Climate change adaptation: Linking indigenous knowledge with western science for effective adaptation. Environmental Science & Policy, 88, 83–91. https://doi.org/10.1016/j.envsci.2018.06.014

Mazorodze, B T 2015, Gender and beekeeping: A case study of Zimbabwe, University of Zimbabwe Press, Harare.

McHugh, M. L. (2013). The chi-square test of independence. Biochemia Medica, 23(2), 143–149. https://doi.org/10.11613/BM.2013.018

Memmott, J et al. 2007, 'Global warming and the disruption of plant-pollinator interactions', Ecology Letters, Vol. 10, no. 8, pp. 710-717.

Morse, R A and Calderone, N W 2000, 'The value of honey bees as pollinators of U.S. crops in 2000', Bee Culture, Vol. 128, no. 3, pp. 1-15.

MSP 2011, Karamoja honey value chain analysis, Ministry of Karamoja Affairs, Kampala.

Mukungu, N et al. 2016, 'Indigenous knowledge systems in beekeeping among communities in East Africa', Journal of Ethnobiology, Vol. 36, no. 4, pp. 873-890.

Muli, E et al. 2014, 'Evaluation of the distribution and impacts of parasites, pathogens, and pesticides on honey bee (Apis mellifera) populations in East Africa', PLOS ONE, Vol. 9, no. 4, e94459.

Ndungu, N N et al. 2017, 'Impacts of climate variability on honey production in Tanzania', Tanzania Journal of Agricultural Sciences, Vol. 16, no. 2, pp. 45-56.

Neumann, P and Carreck, N L 2010, 'Honey bee colony losses', Journal of Apicultural Research, Vol. 49, no. 1, pp. 1-6.

Nicolson, S W 2011, 'Bee food: The chemistry and nutritional value of nectar, pollen and mixtures of the two', African Zoology, Vol. 46, no. 2, pp. 197-204.

Nicolson, S. W. (2011). Bee food: The chemistry and nutritional value of nectar, pollen and mixtures of the two. African Zoology, 46(2), 197–204. https://doi.org/10.1080/15627020.2011.11407495

Nyong, A et al. 2007, 'The value of indigenous knowledge in climate change mitigation and adaptation strategies in the African Sahel', Mitigation and Adaptation Strategies for Global Change, Vol. 12, no. 5, pp. 787-797.

Office of the Prime Minister 2017, Karamoja drought assessment report, Government of Uganda, Kampala.

Perez, C et al. 2019, 'How are women integrated into climate change adaptation policies? Insights from East Africa', Climate and Development, Vol. 11, no. 6, pp. 495-508.

Potts, S G et al. 2010, 'Global pollinator declines: Trends, impacts and drivers', Trends in Ecology & Evolution, Vol. 25, no. 6, pp. 345-353.

Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., & Kunin, W. E. (2010). Global pollinator declines: Trends, impacts and drivers. Trends in Ecology & Evolution, 25(6), 345–353. https://doi.org/10.1016/j.tree.2010.01.007

Southwick, E E and Heldmaier, G 1987, 'Temperature control in honey bee colonies', BioScience, Vol. 37, no. 6, pp. 395-399.

TUNADO 2015, State of apiculture in Uganda, The Uganda National Apiculture Development Organisation, Kampala.

TUNADO 2020, Annual report 2020, The Uganda National Apiculture Development Organisation, Kampala.

UBOS 2018, Karamoja sub-region statistical abstract, Uganda Bureau of Statistics, Kampala.

UBOS 2020, National population and housing census 2020, Uganda Bureau of Statistics, Kampala.

Visscher, P K et al. 1996, 'Foraging strategy of honeybee colonies in a temperate deciduous forest', Ecology, Vol. 77, no. 6, pp. 1797-1805.

Wilcoxon, F. (1945). Individual comparisons by ranking methods. Biometrics Bulletin, 1(6), 80–83.

Wilhite, D A 2000, 'Drought as a natural hazard: Concepts and definitions', in Wilhite, D A (ed.), Drought: A global assessment, Routledge, London, pp. 3-18.

Yuksel, A N 2020, 'World honey production and trade', Journal of Apicultural Science, Vol. 64, no. 2, pp. 143-158.

Zacepins, A et al. 2015, 'Remote detection of the swarming of honey bee colonies by single-point temperature monitoring', Biosystems Engineering, Vol. 138, pp. 10-17.

APPENDICES

APPENDIX A: INFORMED CONSENT FORM

BUSITEMA UNIVERSITY
DIRECTORATE OF GRADUATE STUDIES, RESEARCH AND INNOVATIONS
INFORMED CONSENT FORM FOR RESEARCH PARTICIPANTS

Study Title: **Influence of Drought on Honey Production in Amudat District**

Researcher: Apio Gloria Bua, Master of Science in Climate Change and Disaster Management

Introduction: You are invited to participate in a research study about how drought affects honey production. This study aims to understand drought impacts and identify ways to help beekeepers adapt.

Procedures: If you agree, you will be asked to participate in an interview lasting approximately 45-60 minutes. Questions will cover your beekeeping activities, experiences with drought, and adaptation strategies. With your permission, the interview may be audio-recorded.

Risks and Benefits: There are minimal risks. Some questions may cause mild discomfort when discussing drought losses. Benefits include contributing to knowledge that may help improve drought resilience for beekeepers.

Confidentiality: Your identity will remain confidential. Your name will not appear in any reports. Data will be stored securely and accessed only by the research team.

Voluntary Participation: Participation is voluntary. You may refuse to answer any question or withdraw at any time without penalty.

Consent:
I have read this form and understand the study. I voluntarily agree to participate.

Participant Signature: _____ Date: _____

Participant Name (printed): _____

Researcher Signature: _____ Date: _____

[Additional space for thumbprint if participant cannot write]

APPENDIX B: HOUSEHOLD SURVEY QUESTIONNAIRE

Data Collection Questionnaire

Introduction:

Dear respondent this is to introduce Ms. Apio Gloria Bua an MCC graduate student of Busitema University conducting research on effects of drought on beekeeping in your sub county. The information obtained from this study will be handled with respect and confidentiality. It shall be used for academic purposes; with your consent should I begin the interview? Yes _____ No _____

Date of interview: _____

District: _____

Sub-county: _____

Parish: _____

Village: _____

A. Socio-Demographic Characteristics

Code	Attribute	Tick
A.1	Sex	Female □ Male □
A.2	Age	_____ years
A.3	Household head	Self □ Spouse □ Parent □ Other □
A.4	Marital Status	Single □ Married □ Divorced □ Widowed □

Code	Attribute	Tick
A.5	Household members	Adults (≥18): ____ Children (<18): ____
A.6	Land ownership	Owned □ Rented □ Communal □ None □
A.7	No of Bee hives	_____
A.10	Years in beekeeping	<1yr □ 1-3yrs □ 4-6yrs □ >5yrs □

B. Livelihood Portfolio

B.1 Does this household also engage in crop farming? Yes □ No □

B.2 If yes, which crops are grown? Sorghum □ Maize □ Beans □ Vegetables □ Other □

B.3 Does this household keep livestock? Yes □ No □

B.4 If yes, which livestock? Cattle □ Goats □ Sheep □ Poultry □ Other □

B.5 Does anyone engage in off-farm activities? Yes □ No □

B.6 What made you choose beekeeping? Knowledge □ Market □ Income □ Consumption □ Culture □ NGO □ Interest □

B.7 Sources of income: Crops UGX ____ Livestock UGX ____ Honey UGX ____ Off-farm UGX ____

C. Drought Perception and Risk Factors

C.1 Drought frequency: Every year □ Every 2-3 years □ Every 4-5 years □ Less frequent □

C.2 Severity (1=None, 5=Very High):
2015-2016: ___ 2017-2018: ___ 2019-2020: ___ 2021-2022: ___ 2023-2024: ___

C.3 Agreement with statements (1=Strongly disagree, 5=Strongly agree):

- Drought has become more frequent: ___
- Drought has become more severe: ___
- Drought seasons have become longer: ___
- I can predict drought using local indicators: ___
- Drought is the biggest threat to beekeeping: ___

C.4 Local indicators used: Tree flowering □ Bird migration □ Wind patterns □ Animal behavior □ Temperature □ Moon/stars □ None □

D. Drought Effects on Honey Production

D.1 Production (kg/hive):

- Hive type: Traditional □ KTB □ Langstroth □
- Number of hives: _____
- Normal year (use the respondent's most recent year considered to have adequate and normally distributed rainfall; record calendar year): _____
- Drought year (use the most recent year the respondent identifies as having severe rainfall/forage shortage; record calendar year): _____

D.2 Production trend: Increased significantly □ Increased slightly □ Remained same □ Decreased slightly □ Decreased significantly □ Fluctuated □

D.3 Impact on (1=No impact, 5=Very high):

- Total yield: ___ Quality: ___ Harvest frequency: ___ Beeswax: ___ Income: ___

D.4 Percentage reduction during drought: _____%

D.5 Describe experience: _____

E. Effects on Colony Health

E.1 Effects (1=Never, 5=Always):

- Bees abscond: ___ Colony weaker: ___ Brood death: ___ Pest infestation: ___ Aggression: ___ Colony dies: ___

E.2 Percentage of hives absconded: _____%

E.3 Effects on forage: Fewer flowering □ Shorter flowering □ Less nectar □ Plants dry □ Bees travel further □ No effect □

E.4 New pests observed: Yes □ No □ If yes, specify: _____

F. Livelihood Effects

F.1 Drought reduces ability to buy food: 1□ 2□ 3□ 4□ 5□

F.2 Market effects: Honey scarce □ Prices increase □ Prices decrease □ Fewer buyers □ No effect □

G. Indigenous Strategies

G.1 Methods used and effectiveness (1=Not effective, 5=Very effective):

- Placing hives near water: Yes□ No□ Effectiveness: ___
- Using traditional hives: Yes□ No□ Effectiveness: ___
- Shading hives: Yes□ No□ Effectiveness: ___
- Moving hives: Yes□ No□ Effectiveness: ___
- Leaving honey: Yes□ No□ Effectiveness: ___
- Forage preservation: Yes□ No□ Effectiveness: ___
- Using smoke: Yes□ No□ Effectiveness: ___

G.2 Learned from: Parents/elders □ Other beekeepers □ Trial and error □ Community ceremonies □

G.3 Overall effectiveness: Very effective □ Somewhat □ Neutral □ Not very □ Not effective □

H. Introduced Strategies

H.1 Modern practices adopted:

- Improved hives: Yes□ No□ Effectiveness: ___ Barrier: ___
- Water provision: Yes□ No□ Effectiveness: ___ Barrier: ___

- Supplemental feeding: Yes□ No□ Effectiveness: ___ Barrier: ___
- Forage planting: Yes□ No□ Effectiveness: ___ Barrier: ___
- Shade netting: Yes□ No□ Effectiveness: ___ Barrier: ___
- Hive insulation: Yes□ No□ Effectiveness: ___ Barrier: ___
- Hive relocation: Yes□ No□ Effectiveness: ___ Barrier: ___
- Reduced harvesting: Yes□ No□ Effectiveness: ___ Barrier: ___

H.2 Learned from: Extension □ NGO □ Radio/TV □ Fellow beekeepers □ Association □ Never heard □

H.3 Received formal training: Yes□ No□ If yes, number: ___ Provider: ___

H.4 Barriers (rank exactly three; 1 = most important, 2 = second, 3 = third):

I. Institutional Support

I.1 Group membership: Beekeeping association □ Farmer group □ Savings group □ Women's group □ Youth group □ None □

I.2 Support frequency (1=Never, 5=Very often):

- Extension visits: ___ NGO training: ___ Access to hives: ___ Market info: ___ Credit: ___ Early warning: ___

I.3 Satisfaction: Very dissatisfied □ Dissatisfied □ Neutral □ Satisfied □ Very satisfied □

I.4 Preferred support: Training □ Water sources □ Improved hives □ Forage seeds □ Supplemental feed □ Market access □ Credit □ Early warning □

J. Gender Dimensions

J.1 Decision-making: Starting □ Selling □ Income use □ Equipment □ Adaptation □ (Man only □ Woman only □ Both □ Other □)

J.2 Gender differences in impact: Women more □ Men more □ Equally □ Don't know □

J.3 Women access resources equally? Yes □ No, women less □ No, men less □ Don't know □

K. Constraints and Recommendations

K.1 Severity (1=Not a problem, 5=Very severe):

- Drought: ___ Water: ___ Pests: ___ Theft: ___ Cost: ___ Market: ___ Prices: ___ Knowledge: ___ Bushfires: ___ Pesticides: ___

K.2 Three most important recommendations:

1.

2.

3.

K.3 Additional comments: _____

APPENDIX C: FOCUS GROUP DISCUSSION GUIDE

Topic: Community experiences with drought and beekeeping

Introduction (10 minutes)

- Welcome and introductions
- Explanation of purpose and confidentiality
- Ground rules for discussion

Discussion Questions:

1. How has drought affected our community in recent years? (Probe: frequency, severity, timing)
2. What specific effects has drought had on beekeeping and honey production?
3. What traditional methods do beekeepers use to cope with drought?
4. How do men and women experience drought impacts differently in beekeeping?
5. What support do beekeepers need to better cope with drought?

Probes: Which practices are specifically drought-related? Who owns hives and controls honey income? What makes a strategy affordable, acceptable and effective? How do local indicators compare with formal weather information? Participants should rank their three priority interventions and validate the facilitator summary before closure.

6. How has drought changed beekeeping practices over time?

Closing (10 minutes)

- Summary of key points
- Opportunity for additional comments
- Thanks and next steps

APPENDIX D: KEY INFORMANT INTERVIEW GUIDE

For Agricultural Extension Officers:

1. What are the main climate-related challenges facing beekeepers in this area?
2. What extension services are provided for drought resilience in apiculture?
3. How effective are current drought adaptation strategies?
4. What policy recommendations would enhance apiculture drought resilience?

For Honey Traders:

1. How does drought affect honey supply and quality?
2. What market adaptations occur during drought periods?
3. How do price dynamics change during and after droughts?

For District Officials:

1. How is drought addressed in district development plans?
2. What institutional support exists for climate-resilient apiculture?
3. What are the main barriers to implementing drought adaptation strategies?

Additional prompts for association leaders and elders: documented drought years; local ecological indicators and their validation; group membership and collective action; extension staffing and budgets; climate-information channels; market and quality records; gender inclusion; and feasible district-level implementation arrangements.