



**The Role of State Forests in Sustaining Honey
Production for Beekeepers' Cooperatives. A
Case Study of KUAGA Cooperative, Gatare
Sector, Nyamagabe District, Rwanda**

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Agricultural Production Chain Management – Forest Chains

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Disclosure

I affirm that I have written the dissertation myself and have not used any sources and aids other than those indicated.

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Abstract

Although beekeeping is increasingly taking commercial orientation in Rwanda, it has been of subsistence nature. Beekeepers' own forests are unsuitable for beekeeping as they are small over-harvested plantations with short rotations of 2 to 3 years. In addition, the use of pesticides in agricultural plantations caused honeybees' mortality resulting in the decline of honey production, thus affecting the livelihoods of beekeepers. Realizing the need to increase honey production and improve the livelihoods of beekeepers, the Rwandan government granted access for beekeepers to use state forests to boost their honey production. Urwiru Beekeeper Cooperative of Gatare (KUAGA) under Ubwiza Bwa Nyungwe Beekeeper Union (UBNBU) operates in the buffer zone around Nyungwe National Park (NNP) with 58 beekeepers. A case study was conducted in KUAGA to assess the economic viability and contribution to local development of beekeeping, and environmental sustainability of beekeeping in the working area. The assessment of economic viability of beekeeping in KUAGA was extended to also assess honey value chain development in processing and marketing functions at union level. The data were collected from 32 KUAGA's beekeepers using a survey questionnaire and 8 respondents from different functions in the honey value chain and from chain supporters using interviews. Desk study was conducted to find out the environmental impact of honey collection from the forest. It was found that honey production in the cooperative has increased compared to the situation in the country in 2012; KUAGA's members receive training to ensure honey quality, facilitating the double boiler filtering method of honey processing at union level whose honey is sold to local and national markets; there are markets for beekeepers' honey, though beekeepers sell less to their cooperative; the income has increased compared to that was got in the country in 2012 and the members are able to meet their basic needs through beekeeping; and most of the beekeepers can finance beekeeping by themselves but they want to invest more, and beekeeping farms and skills are transferred between generations. It was also found that honeybees are still dying by pesticides from the crop fields in the surrounding of NNP and there are no illegal activities by the beekeepers themselves in the apiary area or in the park. It is recommended that: UBNBU and WCS increase training to beekeepers for better management of beehives to increase honey production and income; UBNBU collaborates with its partners to get modern honey processing equipment to increase honey quality, expand markets, and benefits its members; KUAGA improves the payment terms for its members (honey price and payment time) to make them sell more honey to their cooperative; UBNBU, WCS, and KUAGA organize beekeepers more, sensitise them about the economic potential of beekeeping to make them like it and stop taking it as a secondary activity; KUAGA's beekeepers and its partners strongly link together for better planning and successfully implementation of supporting beekeeping interventions; the Rwandan Ministry of Agriculture and Animal Resources regulates the use of pesticides in the surrounding of NNP and sensitises the population in the surrounding of NNP to adopt agroforestry to increase biodiversity in the area thus reducing the need for honeybees to collect pollen and nectar from crops to make honey; UBNBU sensitises, helps cooperatives recruit, and train women and youths, and equips them with beekeeping and entrepreneurial skills to increase productive labor, honey production, and profitability; and UBNBU and Wildlife Conservation Society (WCS, their supporter) help KUAGA's beekeepers get access to finances that are needed for beekeeping.

Key words: Rwanda - beekeepers - honey production - value chain development - environmental sustainability

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Acronyms

MINAGRI	Ministry of Agriculture and Animal Resources
RARDA	Rwanda Animal Resources Development Authority
RAB	Rwanda Agriculture and Animal Resources Development Board
FAO	Food and Agriculture Organization of the United Nations
NAEB	National Agricultural Export Development Board
PSTA4	Strategic Plan for the Transformation of Agriculture IV
REMA	Rwanda Environmental Management Authority
NISR	National Institute of Statistics of Rwanda
MoE	Ministry of Environment

KBTH	Kenyan top bar hive
FRW	Rwandan franc
RBS	Rwanda Bureau of Standards
SNV	Netherlands Development Organization
FIOM	The Future in Our Minds
UBNBU	Ubwiza Bwa Nyungwe Beekeeper Union
NNP	Nyungwe National Park
KUAGA	Urwiru Beekeeper Cooperative of Gatare
NGO	Non-Governmental Organisation
WCS	Wildlife Conservation Society
Km ²	Square kilometer
RDB	Rwanda Development Board
Kg	Kilogram
ANOVA	Analysis of variance
SWOT	Strength, Weaknesses, Opportunities, and Threats

Chapter 1 - Introduction

1.1- Background

Honey is an important non-timber forest product in Rwanda as it plays a major role in socio-economic development and environmental conservation (RAB, 2017). It has been given much attention by the government (MINAGRI & RARDA, 2007). Beekeepers have been facilitated to increase their production and improve their income in a healthy environment (Ntibabarira, 2012). Yet, honey production is mainly through traditional methods (RAB, 2021).

Though production is still mainly through traditional methods, the honey industry in Rwanda has made progresses over the past 20 years. Rwanda through its Strategic Plan for the Transformation of Agriculture (PSTA4) projects to increase the net production (FAO, 2021; MINAGRI, 2018). The number of beekeepers in the country is estimated at 120,000, with only 35% using modern beekeeping and others practicing traditional methods. Natural forests with wild plant resources, vegetation, and huge amount of Eucalyptus, provide a conducive ecology for the bees to produce pesticide-free honey (FAO, 2021). Honey is now a very important component with the growing local and export markets. Necessary institutional and legal instruments have been put in place to develop the sector. Rwandan honey producers have been challenged to increase their capacity. Honey has a high value especially in the export markets including the European Union (EU) markets (RAB, 2021; NAEB, 2019).

From 2008 to 2012, the amount of honey produced per household in Rwanda nearly doubled to 45kg and made the income grow from Euro 47 to Euro 88 (SNV, 2014).

Beekeepers in Rwanda use 3 types of hives namely, traditional hives, Kenyan top bar hive (KTBH) and langstroth (SNV, 2009).

The government of Rwanda granted access to beekeepers to use state forests to increase their honey production as an intervention to solve the problem of low honey production that was caused by bees' mortality resulting from the pesticides used in agricultural plantations (Nsabimana, et al., 2020; REMA, 2009; REMA, 2015). 15 cooperatives comprising a total of 1370 beekeepers under Ubwiza Bwa Nyungwe Beekeeper Union (UBNBU) are taking advantage of this intervention. They operate in the buffer zone surrounding Nyungwe National Park (NNP) in 5 districts, namely, Nyamasheke, Karongi, Rusizi, Nyamagabe, and Nyaruguru. KUAGA (Urwiru Beekeeper Cooperative of Gatere) is one of these cooperatives operating in Gatere Sector with 58 beekeepers. Given the long history of illegal activities in the park (Imanishimwe, et al., 2018), the union needs to increase their economic profit while preserving the environment. The knowledge of economic viability of beekeeping and the sustainability of environment in their working area is important.

1.2 - Research Problem

Though it is increasingly taking a commercial orientation, beekeeping in Rwanda has been of subsistence nature. Interventions by the government of Rwanda to increase honey production are targeting particularly small-scale women and youth (MINAGRI, 2020; MINAGRI, 2018). Beekeepers' own forests are unsuitable for beekeeping, as these smallholder plantations (of less than 2 ha, representing 55% of production forests) are the most over-harvested. They are mainly managed under coppice regime

characterized by lowest stock caused by short harvesting rotations of 2 to 3 years. Beekeepers' own forests also give low productivity due to senescent stumps established more than 40 years ago which have lost coppicing capabilities. Unsuitability to long-term investments and vulnerability to land use change driven by agriculture are other hindrances to sustainable management of these small-size forests (FAO, 2018). The effect of pesticides in agricultural plantations caused the deaths of honeybees leading to low honey production (Nsabimana, et al., 2020). The government granted access for beekeepers to use state forests to help them increase their honey production and income as a response to the low yield of honey caused by deaths of honeybees by chemical pesticides from agricultural plantations. However, the history of NNP shows it faced various encroachment threats to the biodiversity including snares, tree cutting, people walking in the park, bamboo cutting, bee hives, fire pits, mining, poaching, cows crossing the park, agriculture, bushfires, honey collection, debarking of trees, mushroom collection, medicinal plants collection, water pollution, forest pollution, and vehicles accident (REMA, 2009; REMA, 2015; Imanishimwe, et al., 2018).

1370 beekeepers grouped into 15 cooperatives under UBNBU operate in the buffer zone of NNP including Nyamagabe District. KUAGA, a beekeepers' cooperative with 58 members, is one of these cooperative operating in the buffer zone surrounding NNP in Gatara Sector. Though beekeeping is one of the common options for making a living in Rwanda with great potential for sustainable development, healthy environment is also extremely important for this livelihood strategy. Honey collection from Nyungwe has a long history, and honey was mainly for medicinal purpose. Prior to Nyungwe became a national park, beekeepers and honey hunters often entered the park during honey collection season. They collected forest products including mature trees for building traditional hives, firewood, and bush meat for food and as a cash product to sell to community members. With the support of the park's managers and Wildlife Conservation Society (WCS, an NGO), beekeepers have recently started to form cooperatives. Their aim is the commercialization of honey production and the improvement of honey collecting techniques, reducing the impact on the forest (Ntibabarira, 2012).

No research has been conducted to assess the sustainability of state forests in honey production. UBNBU needs to gain knowledge on the economic viability of beekeeping to its members and the environmental sustainability in their area. Therefore, a research is needed on the role of state forests in sustaining honey production for the beekeepers' cooperatives under UBNBU. Results from this study will be used to formulate recommendations aimed at improving the sustainability of the beekeeping sector in state forests for the beekeepers operating in KUAGA under UBNBU.

1.3 - Research Objective

The objective of this research is to assess the role of state forests in sustaining honey production for beekeepers' cooperatives under UBNBU in Nyamagabe District of Rwanda with the aim of formulating recommendations for improved sustainability of beekeeping in their area. The union needs to gain knowledge about the economic viability of beekeeping of their members and the health of their working environment.

1.4 - Research Questions

Research question 1

What is the economic viability and contribution to local development of honey production from state forests for KUAGA cooperative's beekeepers in Nyamagabe District of Rwanda?

Sub-questions

- 1) What is the contribution of state forests to honey production from beekeeping in KUAGA cooperative in Nyamagabe District of Rwanda?
- 2) What are the processing techniques and standards of honey produced by KUAGA cooperative from state forests in Nyamagabe District of Rwanda?
- 3) What are the markets of honey produced in KUAGA cooperative from state forests in Nyamagabe District of Rwanda?
- 4) What is the income from beekeeping and the socio-economic impact of beekeeping for KUAGA cooperative's beekeepers operating in state forests in Nyamagabe District of Rwanda?
- 5) What is the economic autonomy and the transferability of farms and skills in beekeeping for KUAGA cooperative's beekeepers operating in state forests in Nyamagabe District of Rwanda?

Research question 2

What is the environmental sustainability of beekeeping for KUAGA cooperative's beekeepers in state forests in Nyamagabe District of Rwanda?

Sub-questions

- 1) What is the honeybees' mortality for KUAGA cooperative's beekeepers operating in state forests in Nyamagabe District of Rwanda?
- 2) What are the illegal activities resulting from beekeeping practices for KUAGA cooperative's beekeepers operating in state forests in Nyamagabe District of Rwanda?
- 3) What is the impact of illegal activities on biodiversity for KUAGA cooperative's beekeepers operating in state forests in Nyamagabe District of Rwanda?
- 4) What is the environmental impact of honey collection from state forests in Nyamagabe District of Rwanda?

Chapter 2 – Literature Review

2.1 - Empirical Review

Various studies were conducted to answer research questions related to the subject of this study. They are discussed in the next paragraphs.

A study about the effects of farming practices on honey production in boundary of Gishwati Forest National Park was done, and it has shown that the use of pesticides and inorganic fertilizers in agricultural fields around Gishwati national forest reserve caused the decline in honey production from 27kg to 6kg per hive after the year 2008, thus affecting the livelihoods of beekeepers. This decline was due to the exposure of honeybees as pollinators to toxicities, especially pesticides that were applied in corn fields in the boundary of the reserve. The study found that there is need to protect national forests to reach sustainable bee biodiversity conservation and to determine land use pattern and socioeconomic factors around national forests (Nsabimana, et al., 2020).

A study carried out in Kayonza district in the Eastern province of Rwanda about the characterization of beekeeping value chain. It found that beekeepers face challenges and limitations including lack of education, gender bias, pests, and diseases, absconding and swarming of bees, high costs, and lack of modern apicultural equipment. On the other hand, the study found there are opportunities for beekeeping development including the abundance of wild bee populations, possibility of women participation, abundance of honey collection centers (market), and availability of technical support from the government and development agencies (Mushonga, et al., 2019).

A study about the contribution of ecotourism to the conservation of NNP in Rwanda revealed several threats to the biodiversity in the park. The study found several threats including snares, tree cutting, people walking in the park, bamboo cutting, beehives, fire pits, mining, poaching, cows crossing the park, agriculture, bushfires, honey collection, debarking of trees, mushroom collection, medicinal plants collection, water pollution, forest pollution, and vehicles accident (Imanishimwe, et al., 2018).

2.2 - Theoretical Literature

2.2.1 – Forests of Rwanda

Forest coverage and density of tree cover forests of Rwanda occupy now about 724,695 hectares of the total country land (30.4%) comprising the categories shown in the next table and map.

Table 1 - Categories of forests of Rwanda

Category	Area (in hectares)	Percentage (%)
Plantations	387,425	53.5
Natural mountain rainforests	130,850	18.1
Wooded savannah	161,843	22.3
Shrubs	43,963	6.1
Total	680,118	100

Source: MoE, 2019

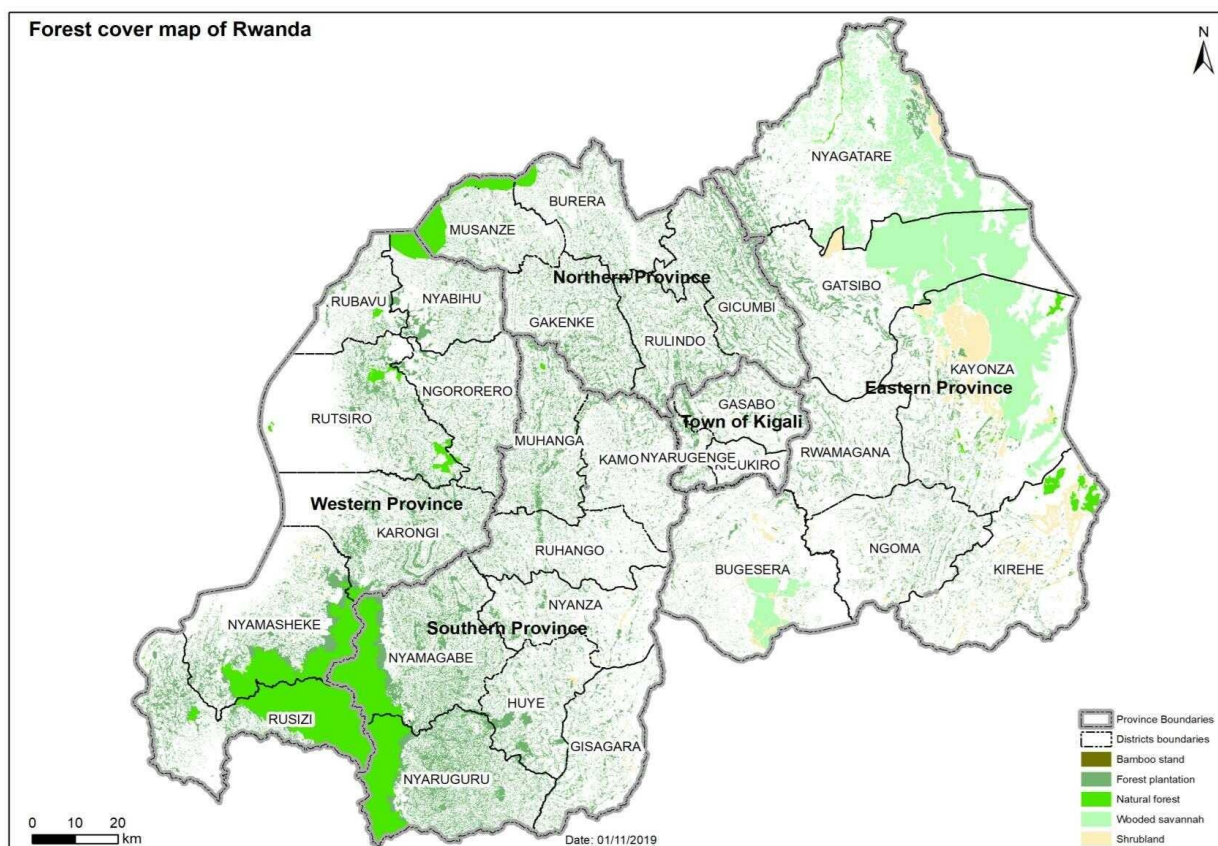


Figure 1 - Map of the country forest cover in 2019

Source: MoE, 2019

Eucalyptus sp. is the dominant species in the woodlands making 90% of all the plantations in the country. Pinus sp. is the second most significant species in the country, representing 6% of the plantations. Natural mountain forests and savannah shrubland are protected in national parks including Nyungwe forest in the South-West, Gishwati and Mukura forests in Central-West, Volcanoes forests in North and Akagera savannah in East (MoE, 2019; MoE, 2018).

The top forested districts are Nyaruguru having 55% (55,759 hectares) of its land occupied by forests, followed by Rusizi district with 53% (48,255 hectares), Nyamagabe with 50% (54,018 hectares), and Nyamasheke with 48% (45,935 hectares) (MoE, 2019).

2.2.2 – Past Trends of Beekeeping Around Nyungwe National Park (NNP)

Nyungwe Forest is a montane tropical rainforest in the southwestern part of Rwanda that took a forest reserve status in 1933. The forest consists of approximately of 1015 km² (101,500 hectares). It is situated in the Albertine Rift with much biodiversity including 1,100 species of flora, 280 species of birds, 43 species of reptiles, 31 species of amphibians, and 14 species of primates

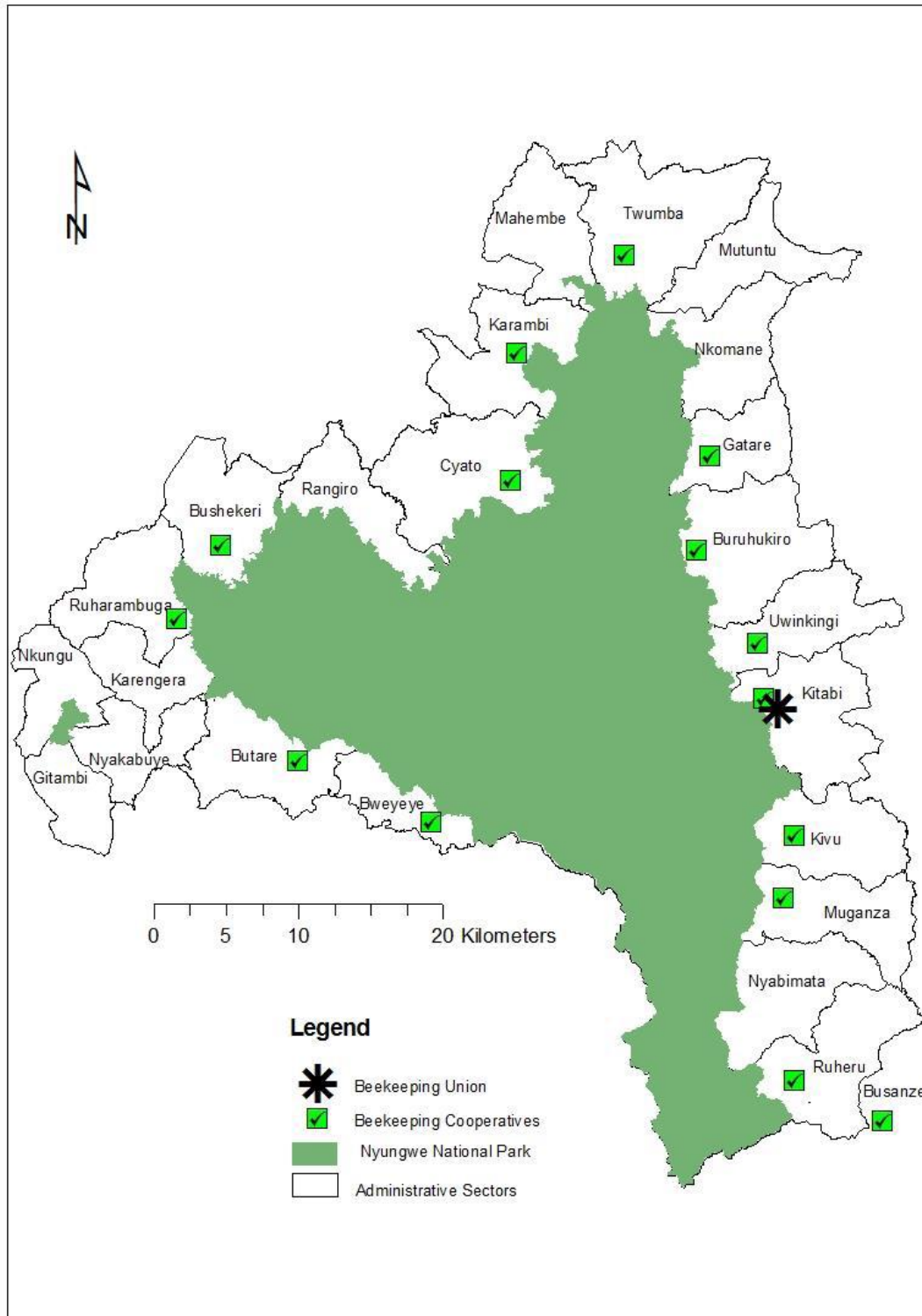


Figure 2 – Nyungwe National Park

Source: WCS (2020), Partner in Conservation- Wildlife Conservation Society Beekeeping progress report

Rwanda has been considering the interaction between conservation efforts and the development of the community around Nyungwe Forest. Residents nearby the forest hope to live on natural resources. As a result, deforestation, poaching, and wildfires become typical threats to the park. During 1996-2006 period, more than 13,000 hectares of the forest were destroyed by fire, with 5-8% of the park's total forest cover destroyed in 1997 alone (Crawford, 2012). Most of these fires resulted from honey hunters entering the forest illegally using smoke to calm honeybees. These wildfires got out of control and lead to massive forest destruction. As a response, beekeepers organised themselves into cooperatives to manage this threat and to develop the communities around NNP. The aim of these cooperatives is to best serve the beekeepers through support and increased market access and protecting the park at the same time. Supported by the WCS and the Rwanda Development Board (RDB), the cooperatives set apiaries in the buffer zone surrounding NNP.

2.2.3 - The Ubwiza Bwa Nyungwe Beekeeper Union (UBNBU)

The UBNBU was created in 2010 and currently oversees 15 cooperatives surrounding NNP. The union has 1370 beekeepers with its processing and sales headquarters at Kitabi. It began purchasing honey harvest from cooperatives in 2012. Harvests are collected from the cooperatives and delivered to the headquarters where they are processed into honey, beeswax, and beeswax candles. Many of these cooperatives were already in existence before the union was created and others are relatively young. The UBNBU is founded on two main principles: (1) to represent the cooperatives' interests through processing/marketing products, providing equipment/training/support, and advocating for the cooperatives, and (2) to protect NNP through professionalizing beekeeping, reducing illegal activities, and reducing accidental forest fires (Hakizimana, 2021).

2.2.4 - Sustainability of Beekeeping Farms

Though honeybee colonies have been managed for honey production for thousand years, it has become a professional activity within the last decades (Daberkow, et al., 2009). There are many management differences between professional beekeeping and other agricultural activities. Adjusting a sustainability assessment tool that was initially designed for other agricultural sectors is not relevant. Therefore, a new framework was designed to define and assess the sustainability of beekeeping. Stakeholders from beekeeping sector were involved during its development (Coline, et al., 2018).

The new beekeeping sustainability framework is shown in the next table (Coline, et al., 2018).

Table 2 - Themes of the sustainability of beekeeping farms

Dimensions	Themes	Indicators
Beekeeping sector and society issues	Quality	Quality and traceability of products, ethics, and apicultural practices
	Food and services production	Pollination and food production
	Contribution to the understanding and recognition of beekeeping sector and issues	Contribution to the awareness of the beekeeping sector realities and issues among the

		general public and among other agricultural sectors
	Collective stakes of beekeeping sector	Involvement in collective structures, contribution to collective stakes of the sector as genetic diversity or prevention of introduction of invasive pests
Economic viability	Income	Match between the real income and the beekeeper's expectation, between the income and the time spent
	Economic stability	Ability to face price variations, diversity of products and outlets
	Economic autonomy	Self-financing ability, capacity to invest
Environmental impacts	Local biodiversity	Contribution to and potential impacts on local biodiversity
	Impacts on the natural resource	Greenhouse gases emission, waste management, use and choice of inputs
	Landscape integration	Landscape integration of buildings
Local development	Exchanges with land managers and local stakeholders	Relationship and exchanges with land managers, neighbourhood, other beekeepers
	Socio-economic and cultural development	Production of local honeybee products, participation in local economy, in social and cultural development
	Transferability	Transferability of the farm, transferability of the beekeeper's skills and knowledge
Ability to ensure the production	Production means	Match between beekeepers' goal and constraints and production means: livestock management, quality and quantity of available resource, material resources
	Autonomy	Technical autonomy, independent decision-making,

		information and training possibilities, exchanges between beekeepers
	Adaptability	Adaptability to annual and long-term changes
Quality of life	Job satisfaction	Happiness
	Wellbeing	Workload and time off
	Health and safety	Safety and health risks, risk control

Source: Coline, et al., 2018

2.2.5 – Honey Market and Marketing

The market for Rwandan honey comprises the next segments:

- Local markets, i.e., friends, neighbours, and surrounding villages.
- Local and external bulking agents, i.e., middlemen, traditional liquor brewers, traders, non-governmental organizations).
- Farmer based co-operatives. These societies are the most popular direct market because it offers better prices as compared to the local and external bulking agents (SNV, 2009; FIOM, 2018).

The capital city Kigali is the main market for bulked honey in Rwanda, and some of it comes back to the larger towns. Honey in Kigali is used for food processing, liquor, and pharmaceutical companies. It is also refined further and packed into containers for sale to domestic consumers as table honey. The bulking agents and farmer-based co-operatives in turn market and sell the bulked honey to processing companies and retail stores in Kigali including Nakumatt and Simba. They also sell to honey, liquor brewing entities and pharmaceutical companies (SNV, 2009; FIOM, 2018).

2.2.6 – The Rwandan Beekeeping Value Chain

The Rwandan beekeeping value chain map and actors and functions can be broadly divided into 3 main tiers (categories) – the bottom, middle, and top tiers. This is based on their roles in honey production ranging from production, handling, processing, and distribution, till the end markets. The beekeeping value chain of Rwanda is explained and present in the next paragraphs (SNV, 2009; FIOM, 2018).

2.2.6.1 - Bottom Tier Actors and Functions

a) Input supply

Input suppliers are organizations and or individual entrepreneurs involved in the construction of hives and sell them to interested producers. Both traditional and modern hives are used. Traditional hives are either made locally by beekeepers themselves or made by local artisans. The two types of modern hives supplied are KTBH and langstroth. Modern hives are expensive (FRW40,000-60,000) and few beekeepers use them. Low apiary colonization rates are observed (30-60%).

The next table illustrates production capacities of different hives used in Rwandan beekeeping against their estimated optimal potentials.

Table 3 - Production capacities of different hives used in Rwanda against their estimated optimal potentials

Type of hive	Average prod. (kgs) /season	Seasons /year	Optimal production /year	Variance
Traditional	5.6	2	15	25%
KTBH	10	2	26	23%
Langstroth	14	2	60	53.3%

Source: SNV, 2009



Figure 3 – Kenyan top bar hives (KTBH) (left) and training on the use of KTBH (right) in UBNBU

Source: UBNBU



Figure 4 – Langstroth hive (left) and traditional hive (right) in UBNBU

Source: UBNBU

b) Production

The production function is male dominated, though records show that women and youth are increasingly taking it up as an emerging income generating activity. Basically, production is carried out through 3 types of ownership and tenure systems:

- Apiaries owned by individuals at farm level.
- Co-operative society advanced hives located in the member's farms.

- Collectively owned apiaries mainly found in adjacent forests of Gishwati, Nyungwe and Akagera forests.

Traditional beekeepers are small-scale farmers who use inherited knowledge and skills and get low average yield of 5-8kg per hive. The yield from traditional hives in potential areas and well managed conditions is 10-15. As result of training by development partners, beekeepers are taking up modern hives. Some have preference for KTBH while others prefer langstroth hives. Collectively owned co-operative apiaries have become popular in many areas including Gishwati Forest, Nyungwe Forest, Akagera, and Volcanoes National Parks.

c) Farm-level semi-processing

This farm-level semi-processing is common for indigenous and KTBH beekeepers and it involves extracting honey from the combs. The process involves using the double cooking pan or self-drip. For modern KTBH and langstroth hives, producers or honey bulking agents use simple tools such as spoons in squeezing honey from the combs. Except those who directly sell honey to their co-operatives, nearly all beekeepers are involved in some form of semi-processing. Yet, this stage is likely to compromise the quality of honey through the introduction of foreign substances and impurities, unhygienic handling techniques and malicious beekeeping entrepreneurs.

d) Primary transportation

While some honey is bought at the farm gate by middlemen/bulking agents directly from beekeepers, other beekeepers transport honey from the farm to nearby bulking centre mostly comprising co-operative society plant or local retailers. The most common means of transportation is by bicycle.

e) Primary collection, bulking, and semi-processing

The actors involved in this function are mainly co-operative societies, local retailers, and commercial bulking agents (middlemen). This process of collection and bulking in the honey chain is of great importance as secondary markets need large quantities of honey. Popular co-operative societies in honey collection and bulking include CAR, KOPAKI, UNICOPAGI and CESAPI, and the make the largest market in honey production zones. There are other local and external paraprofessionals who are involved in trading honey in this function, though their presence is not as much as co-operative societies. The actors in this function either buy crude or semi-processed honey from beekeepers or collect it from their apiaries and package it in 500 and 1000 grams graduated plastic containers.

f) Secondary transportation

This transportation links collection points to honey refining and packaging centers (honey processing companies) and/or end markets comprising domestic consumers in Kigali and large towns.

2.2.6.2 - Middle Tier Functions and Actors

g) Secondary bulking, refining, and packaging

Processes at this function involve further refining and packaging done by medium and large honey processing companies for example CESAPI whose honey is purchased from farmers and co-operatives. The processing at this stage is more advanced than at the primary processing function.

h) Distribution

This function within the value chain is about wholesaling/retailing honey. The actors include large retail stores such as Nakumatt and Simba. Either they purchase packaged honey from secondary processing agents, or they directly purchase honey from primary co-operative unions.

2.2.6.3 – Top Tier Functions and Actors

i) Certification

This is a function of the Rwanda Bureau of Standards (RBS) established by legislation No. 03/2002 of 19/01/2002 to undertake all activities related to the development of standards and quality assurance in the country. RBS seeks to ensure the production of good quality honey and has put in place desired properties of honey by which producers, refiners and exporters must adhere to for getting certification. The RBS's desired properties for good honey are found in the next table.

Table 4 – Rwanda Bureau of Standards' desired properties for honey

Verifiable indicator	Accepted level
Moisture content	Not more than 20%
Fructose and glucose content	Not less than 60g/100g
Sucrose content	Not more than 10g/100g for most trees and flowers except lavender which should not be more than 15g/100g
Water insoluble solids content	Not more than 0.5g/100g
Heavy metals	Not exceeding the maximum levels as per the Codex Alimentarius Commission
Pesticides residues and veterinary drugs	Not exceeding the maximum levels as per the Codex Alimentarius Commission

Source: Revised CODEX Standard for Honey

The RBS's guidelines for inspection and certification add that all honey intended for human consumption should meet the microbiological criteria established in accordance with the Principles for the Establishment and Application of Microbiological Criteria for Foods (CAC/GL 21-1997), the CODEX Standards Issue No. 12 of 1981 - Rev (2001). Together with the Rwanda Animal Resources Development Authority (RARDA) and development partners, RBS works to ensure the establishment of effective and sustainable guidelines for honey production, handling, processing, storage, and transportation. By mainstreaming these guidelines into the honey value chain, honey from different parts of the country will meet the required minimal standards thus expanding its market to export level.

j) Markets

The end markets are mostly eventual consumers of honey including, but not limited to, domestic consumers who use honey as table food and industries that use honey as a food processing or preservation agent.

2.2.6.4 – Supplementary Value Chain Functions and Actors

The actors in this tier provide supportive functions in the chain which are critical to the growth and development of the beekeeping sector. They ensure the effective functioning of the sector especially in the production and processing functions.

2.2.6.5 – The Beekeeping Value Chain Map

The next figure presents the beekeeping value chain of Rwanda.

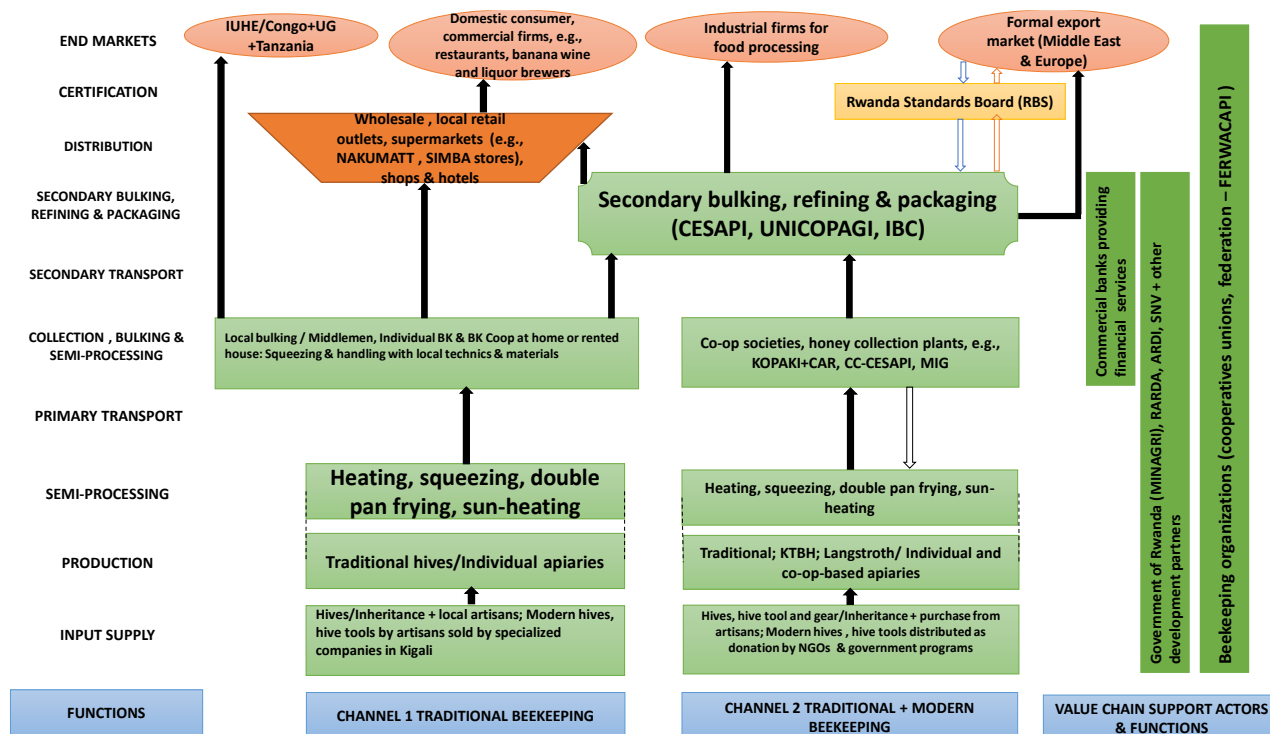


Figure 5 - The Rwandan beekeeping value chain

Source: SNV, 2009; FIOM Rwanda, 2018

Key

↑ Indicates flow of honey

↓ Indicates flow of financial services

⇄ Indicates unusual movement of honey – honey rejected by clients in the export market due to poor quality standards

↑↑ Indicates critical missing linkage

2.3 – Conceptual Framework

The next figure is the conceptual framework for the subject of the present study.

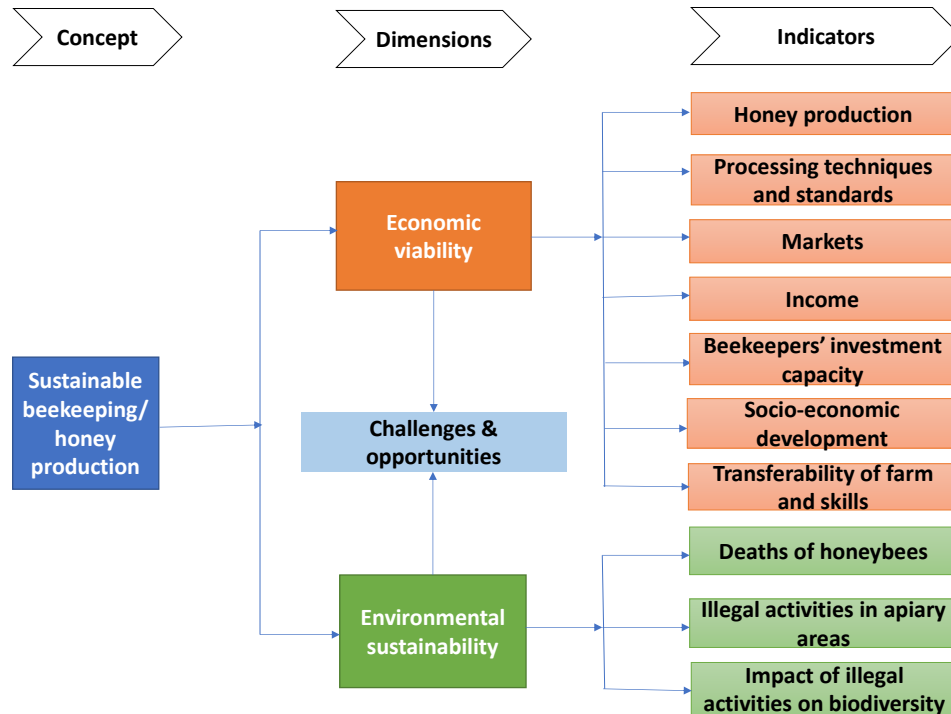


Figure 6 - Conceptual framework of sustainable honey production

Source: Author's compilation and adjustment based on literature review

This framework was adjusted from the sustainability framework by Coline et al., 2018, focusing on two dimensions - economic viability and contribution of beekeeping to local development, and environmental sustainability. This is because the beekeeping in state forests of Rwanda is an intervention to boost honey production and increase the income of beekeepers while reducing the impact on the environment. Indicators of honey production, processing techniques and standards, market, income, beekeepers' investment capacity, socio-economic development, and transferability of farms and skills describe the first dimension. Deaths of honeybees, illegal activities in the apiaries, the impact of illegal activities on biodiversity, and the environmental impact of honey collection describe the second dimension. Challenges and opportunities for this framework were also identified. Then conclusions were drawn, and recommendations were formulated.

Chapter 3 – Methodology

This section presents the methodology that this research used. It presents the study area, research strategy, data collection methods, research framework, and data analysis.

3.1 – Study Area



Figure 7 - Administrative map of Nyamagabe District

Source: NISR, 2012

The study area was Gatare Sector in Nyamagabe District in the Southern province of Rwanda. Nyamagabe is located between Huye District and Rusizi District in the south-west of Rwanda, and it contains much of former Gikongoro prefecture which was disbanded in 2006. It also comprises in the East half of Nyungwe Forest which is a popular tourist destination, one of Rwanda's last remaining forest areas and home to chimpanzees and many other species of primates. Nyamagabe District has a total area of 1007km² and is divided into 17 sectors - Buruhukiro, Cyanika, Gatare, Kaduha, Kamegeli, Kibirizi, Kibumbwe, Kitabi, Mbazi, Mugano, Musange, Musebeya, Mushubi, Nkomane, Gasaka, Tare and Uwinkingi. Its population is estimated at 341,491 with 180,272 women (52.8%) and 161,219 men, representing 13.2% of the total population of the Southern province. The population density of the District is 313 inhabitants per km² (Nyamagabe, 2021; NISR, 2012).

Gatare was chosen because there are enough beekeepers who made the sample complete and a contact person in UBNBU who introduced the researcher to respondents.

3.2 - Research Strategy

Given these challenging times when the whole world is dealing with Covid-19 pandemic, the measures to fight the spread of the pandemic has brought major changes to people's normal lives. Because of Covid-19 related travel requirements including days of quarantine at the destination and the government restrictions on physical contacts now in place in Rwanda, the research was conducted in Rwanda from the Netherlands. To answer the questions of the research subject, case study was used as the overall research strategy. A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident...[and] relies on multiple sources of evidence. It refers to research that investigates a few cases in considerable depth (Rhee, 2004). This strategy was chosen because it fit the current circumstances where people are encouraged to reduce physical contacts to prevent the spread of Covid-19 and because respondents can be easily reached online.

3.3 - Data Collection Methods

The data collection process used three different methods – interviews, survey questionnaire, and desk study - to allow triangulation.

Interview checklists were used to collect data from stakeholders and key informants involved in beekeeping in state forests in Nyamagabe District. The data included honey processing techniques and standards, challenges and opportunities of beekeeping, illegal activities from beekeeping, the impact of illegal activities on local biodiversity, socio-economic development, and transferability of farms and skills. Interviews were suited to collect information from key informants online during these times of Covid-19. The contact person from the union assisted in reaching the key informants for the interview. Microsoft Teams meeting links were sent to the respondents for the interviews.

A survey questionnaire was also used to collect data. As per CambridgeDictionary, 2021, survey is an examination of opinions, behaviour, etc., made by asking people questions. Survey about this subject targeted KUAGA cooperative's honey producers involved in beekeeping in state forests in Nyamagabe

District. Producers were targeted as they are the best to have the required information that was analysed statistically. Through this technique, data about the economic viability of beekeeping in state forests in Nyamagabe District was collected. Also, data about the contribution of beekeeping to local development was collected. The data included honey production, markets, income, beekeepers' investment capacity, and honeybees' mortality. A questionnaire was also suited for the current period of Covid-19 because it was sent to my contact person from the union who assisted in selecting a random sample from the producers, and the respondents' answers were got after filling in it.

Desk study provided the key concepts of the research subject. It was used to find background information including UBNBU, beekeeping sustainability, forests of Rwanda, honey production and marketing in Rwanda, challenges and opportunities of the Rwandan beekeeping sector, illegal activities in the beekeeping area, and the impact of illegal activities on the biodiversity. The review of books, reports, journals, newspapers, and research papers provided the information these issues.

A sample of 40 respondents was used for this subject study. The sample included 8 respondents – 2 producers, 2 representatives from UBNBU, 1 honey processor, 1 honey quality inspector, 1 representative from conservation, and 1 representative from a donor agency - who were selected with purposive sampling for case study. The remaining 32 respondents were honey producers operating under UBNBU who were selected with simple random sampling for survey to make the sample representative enough.

The next table summarises the three different methods that were used to collect data for the research.

Table 5 - Data collection methods

Sub-question	Expected information	Data collection method/tool	From whom	Data processing
Research question 1				
What is the economic viability and contribution to local development of honey production from state forests for KUAGA cooperative's beekeepers in Nyamagabe District of Rwanda?				
What is the contribution of state forests to honey production from beekeeping in KUAGA cooperative in Nyamagabe District of Rwanda?	<ul style="list-style-type: none"> Amount of honey produced by hive per season Amount of honey produced per producer per season and per year 	<ul style="list-style-type: none"> Questionnaire Desk study 	<ul style="list-style-type: none"> Producers 	<ul style="list-style-type: none"> Descriptive statistics Inferential statistics

What are the processing techniques and standards of honey produced by KUAGA cooperative from state forests in Nyamagabe District of Rwanda?	<ul style="list-style-type: none"> • Lists & explanations of honey processing techniques and standards 	<ul style="list-style-type: none"> • Semi-structured interviews • Desk study 	<ul style="list-style-type: none"> • Producers • Representative UBNBU • Honey quality inspector 	<ul style="list-style-type: none"> • Transcribing • Content analysis
What are the markets of honey produced in KUAGA cooperative from state forests in Nyamagabe District of Rwanda?	<ul style="list-style-type: none"> • Markets for honey produced 	<ul style="list-style-type: none"> • Questionnaire • Desk study 	<ul style="list-style-type: none"> • Producers 	<ul style="list-style-type: none"> • Descriptive statistics • Inferential statistics
What is the income from beekeeping and the socio-economic impact of beekeeping for KUAGA cooperative's beekeepers operating in state forests in Nyamagabe District of Rwanda?	<ul style="list-style-type: none"> • Income per producer per season and per year • The contribution of beekeeping to beekeepers' social well-being and economy 	<ul style="list-style-type: none"> • Questionnaire • Desk study • Semi-structured interview • Desk study 	<ul style="list-style-type: none"> • Producers • Producers 	<ul style="list-style-type: none"> • Descriptive statistics • Inferential statistics • Transcribing • Content analysis
What is the economic	<ul style="list-style-type: none"> • Extent of self- 	<ul style="list-style-type: none"> • Questionnaire • Desk study 	<ul style="list-style-type: none"> • Producers 	<ul style="list-style-type: none"> • Descriptive statistics

autonomy and the transferability of farms and skills in beekeeping for KUAGA cooperative's beekeepers operating in state forests in Nyamagabe District of Rwanda?	financing/capacity to invest <ul style="list-style-type: none"> Different ways of transferring farms and skills and knowledge 	<ul style="list-style-type: none"> Semi-structured interview Desk study 	<ul style="list-style-type: none"> Producers 	<ul style="list-style-type: none"> Inferential statistics Transcribing Content analysis
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Research question 2

What is the environmental sustainability of beekeeping for KUAGA cooperative's beekeepers in state forests in Nyamagabe District of Rwanda?

What is the honeybees' mortality for KUAGA cooperative's beekeepers operating in state forests in Nyamagabe District of Rwanda?	<ul style="list-style-type: none"> The status of deaths of honeybees – absent, low, moderate, high 	<ul style="list-style-type: none"> Questionnaire Desk study 	<ul style="list-style-type: none"> Producers Representative conservation 	<ul style="list-style-type: none"> Descriptive statistics
What are the illegal activities resulting from beekeeping practices for KUAGA cooperative's beekeepers operating in state forests in Nyamagabe	<ul style="list-style-type: none"> A list of illegal activities 	<ul style="list-style-type: none"> Semi-structured interviews Desk study 	<ul style="list-style-type: none"> Producers Representative UBNBU Representative conservation 	<ul style="list-style-type: none"> Transcribing Content analysis

District of Rwanda?				
What is the impact of illegal activities on biodiversity for KUAGA cooperative's beekeepers operating in state forests in Nyamagabe District of Rwanda?	<ul style="list-style-type: none"> • A list of impacts of illegal activities on biodiversity 	<ul style="list-style-type: none"> • Semi-structured interviews • Desk study 	<ul style="list-style-type: none"> • Producers • Representative UBNBU • Representative conservation 	<ul style="list-style-type: none"> • Transcribing • Content analysis
What is the environmental impact of honey collection from state forests in Nyamagabe District of Rwanda?	<ul style="list-style-type: none"> • Environmental impact of honey collection 	<ul style="list-style-type: none"> • Desk study 	<ul style="list-style-type: none"> • Research review 	<ul style="list-style-type: none"> • Comparison of findings
	<ul style="list-style-type: none"> • Challenges and opportunities of beekeeping 	<ul style="list-style-type: none"> • Semi-structured interviews • Desk study 	<ul style="list-style-type: none"> • Producers • Honey quality inspector • Representative UBNBU • Donor agency • Representative conservation 	<ul style="list-style-type: none"> • Transcribing • Table and narrative of SWOT

Source: Author

3.4 – Research Framework

The next figure illustrates the framework of this research.

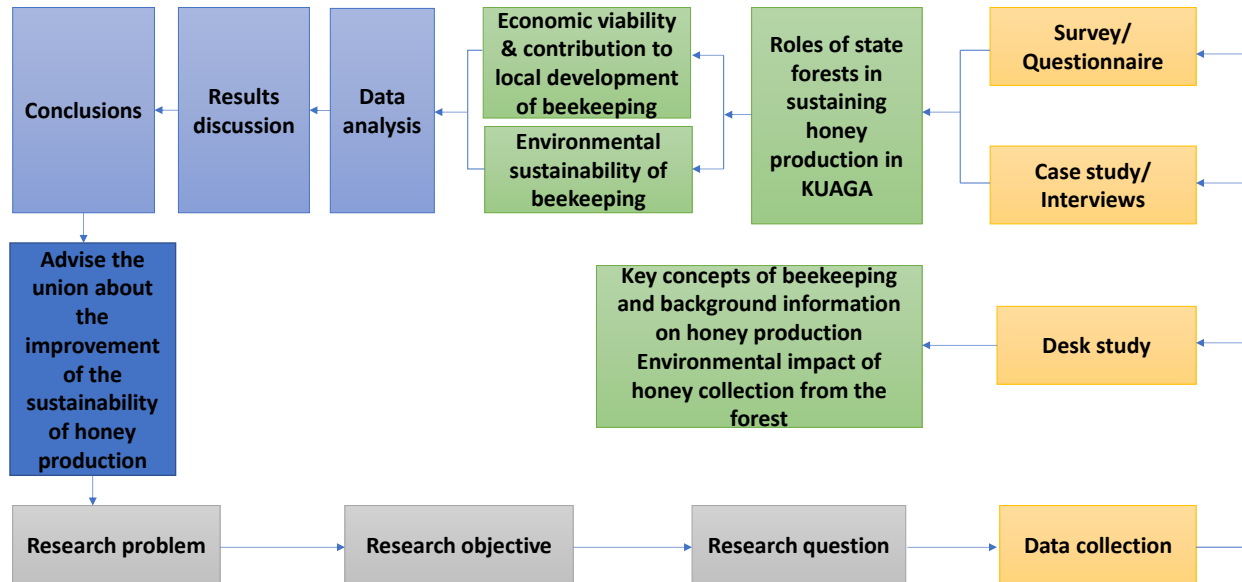


Figure 8 - Research framework

Source: Author

As Figure 9 shows, the research began with problem identification. Then the research objective and questions were set to find the answers to the problem. Then data about the economic viability and contribution to local development of beekeeping, and environmental sustainability of beekeeping was collected using a questionnaire and an interview. Also collected were the concepts of beekeeping and background information on honey production. Then the data were analysed, results were discussed, conclusions were drawn, and finally recommendations were formulated to improve the sustainability of beekeeping in state forests in Nyamagabe District.

3.5 – Data Analysis

The analysis process of this study used both quantitative and qualitative methods. Quantitative analysis method was used for data that were collected through questionnaire. Descriptive statistics, graphs, independent sample t-tests and ANOVA were performed using IBM SPSS Statistics 27. Independent sample t-tests were performed to test the differences of honey production, income, and investment capacity between men and women, and between youth and adult beekeepers. ANOVA was performed to test the differences of honey production, income, and investment capacity between different age groups of beekeepers.

Qualitative data analysis was used for the interviews of key informants from the Rwandan beekeeping sector. As by Laws et al., 2013, the core process of qualitative data analysis consisted of four major steps.

One, categories of answers and numbering of the interviewees were be made. Two, the categories and codes of interviewees were inserted in a table, and each interviewee's responses were filled horizontally per category. Three, the categories of answers were analysed in a vertical form to identify the contradictions and agreements among the interviewees' answers. Four, the analysis of the extent to which the categories of answers answered the research questions was done.

Figures, tables, charts, percentages, SWOT, and lists were used to present the results from both methods.

Chapter 4 – Results

4.1 – Economic Viability and Contribution to Local Development of Beekeeping in KUAGA

4.1.1 – Contribution of State Forests to Honey production in KUAGA

4.1.1.1 – Types of Hives

The next figure shows the types of hives used by the beekeepers of KUAGA cooperative with the respective numbers of the beekeepers using them. The figure shows that 100% (all) of the beekeepers use traditional hives, against only 6.25% who use langstroth hives and 53.13% who use KTBH.

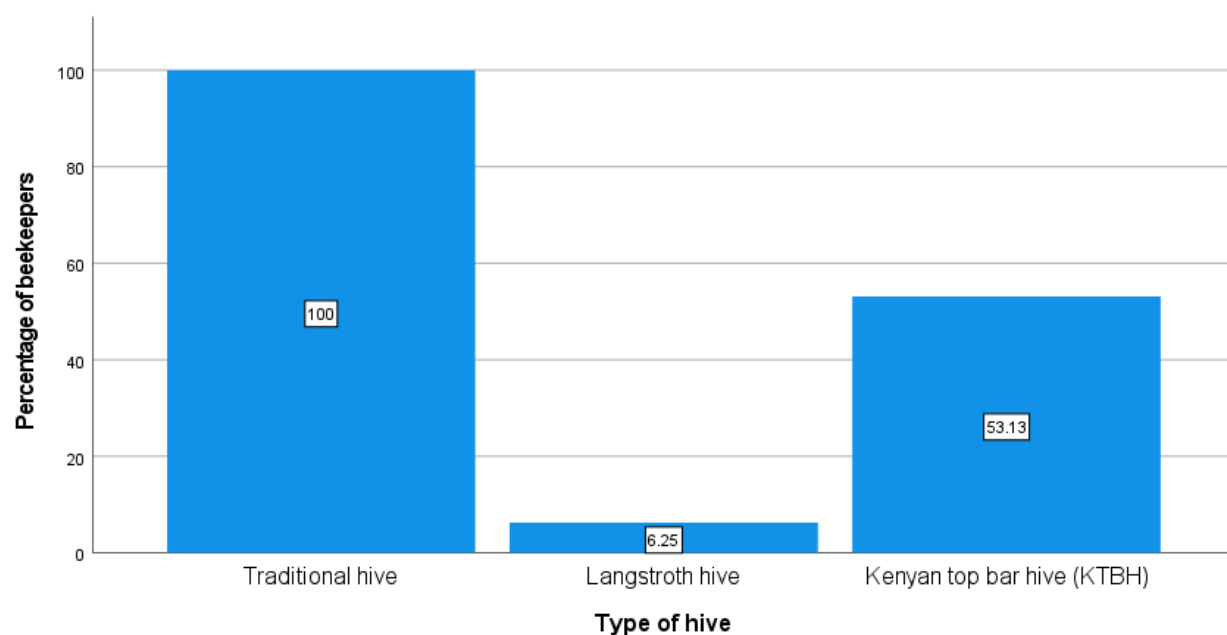


Figure 9 – Types of hives used by beekeepers in KUAGA cooperative

The crosstabulation analysis showed that 53.1% of those who use traditional hives (100%) also use KTBH against 6.3% of them who use langstroth hives. This analysis also showed that only 11.8% of those who use KTBH use langstroth hives. The average amount of hives per beekeeper in KUAGA cooperative is 14.13.

4.1.1.2 – Honey Production

The mean amounts of honey per hive per season in KUAGA cooperative were found to be 3.70kg, 13.00kg, and 8.35kg for traditional hives, langstroth hives, and KTBH respectively. The minimum and maximum amounts were 2.50kg and 5.00kg for traditional hives, 8.00kg and 18.00kg for langstroth hives, and 4.00kg and 15.00kg for KTBH.

The overall total amount of honey per season per beekeeper was 64.61kg. The minimum amount was 10.00kg and the maximum amount was 201.00kg.

The overall total amount of honey per year per beekeeper was 129.22kg, with the minimum amount of 20.00kg and the maximum amount 402.00kg.

It was found that there is no significant difference in the amount of honey produced per season and per year per beekeeper in kg (p-value=0.109) between men and women at 5% significance level.

The ANOVA tests showed that there is a significant difference in the amount of honey produced per season and per year per beekeeper in kg between the age groups (p-value=0.019) at 5% significance level, as it can be seen on the next figure.

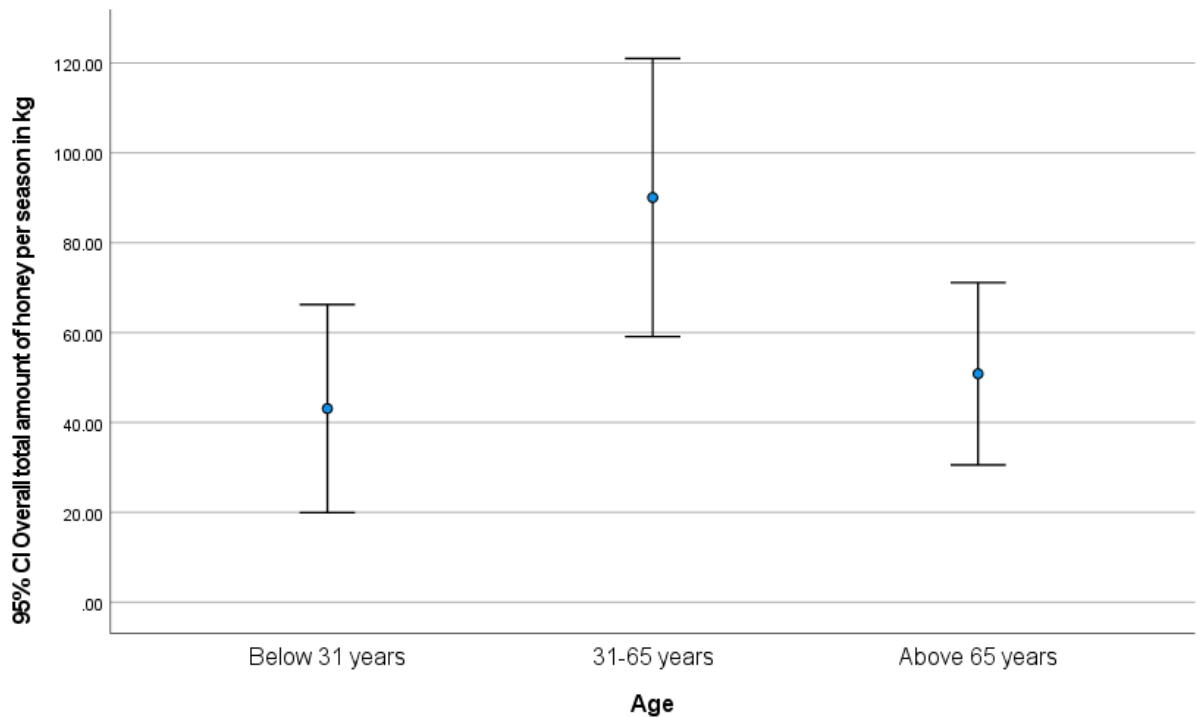


Figure 10 – Amount of honey produced per season per beekeeper by age groups

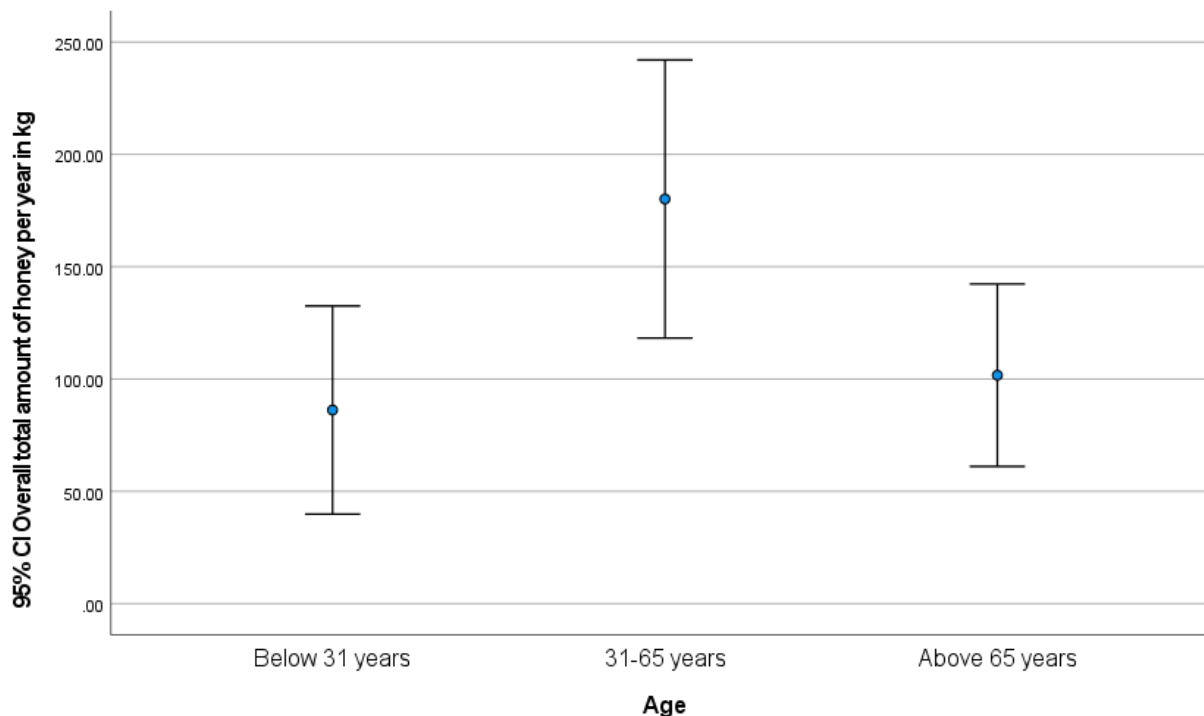


Figure 11 - Amount of honey produced per year per beekeeper by age groups

The significant differences are found between the beekeepers of below 31 years of age and those of 31-65 years of age (p -value=0.011), and between the beekeepers of 31-65 years of age and those of above 65 years of age (p -value=0.026).

4.1.2 – Honey Processing Techniques, Standards, and Markets for KUAGA - UBNBU

The union has set rules/requirements to adhere to for its beekeeper members during harvesting and storage of honey at cooperative level before honey is taken to the union level for processing.

Beekeepers must not harvest during rainy season to avoid water drops into honey that may damage its quality through increasing its moisture content to more than the desired 20% moisture content. Beekeepers must not use smoke or smoke during honey harvesting to keep the original aroma of honey. During honey harvesting, beekeepers must be clean enough to avoid honey contamination. At the storage area, plastic buckets containing honey must not be put directly on the ground but on wood stands to avoid water accumulation into honey and honey fermentation. Metallic containers must not be used to store honey as rust may develop on them and be mixed with honey thus spoiling its quality. Honey must be graded before storage –that with honeycomb cells closed and that with honeycomb cells open are stored separately, as the later has and may accumulate more water.

Honey processing takes place at the union level at Kitabi. As a processing requirement, to remove honey from combs, honey is not cooked but warmed up to avoid destroying its constituents by much heat. Honey is made liquid and taken from the combs through warming it by double boiler.

Three small stones are put on a big saucepan in triangle and water is poured into the pan. A small saucepan with honeycombs is placed on the stones in the big saucepan. The two saucepans are placed on the gas stove and heated – warm water from the big saucepan makes the honeycombs in the small saucepan warm and causes honey to come out the combs; the temperature in the small saucepan is controlled by a thermometer placed in it and must not exceed 40 °C. A double filter is used to filtrate honey and wait for 72 hours. After the 72 hours, wax and honey are separated – honey at the under part and wax at the upper part because of their different densities. Wax is removed to remain with honey. The process is repeated, and a small filter (iron filter) is used to remove small particles, and even propolis, to filtrate honey. After 24 hours, the final product – honey – is ready for packaging and labelling before selling.

The packaging at the union is done using plastic containers – but they are tested by the RBS before they can be used. They are labelled with the producer's name, manufacture date, expiration date, producer address, and brand name as it is registered by the Rwanda Development Board.

Honey processed by the union is sold to local and national markets – supermarkets at Rusizi, Kigali, Musanze – and to tourists. UBNBU targets to export its honey to EU markets.



Figure 12 – Honey processing at UBNBU headquarters

Source: UBNBU

4.1.3 – Markets for Honey

KUAGA's beekeepers sell their honey at local markets (96.88%), local and external bulking agents (71.88%), and farmer-based cooperatives (59.38%).

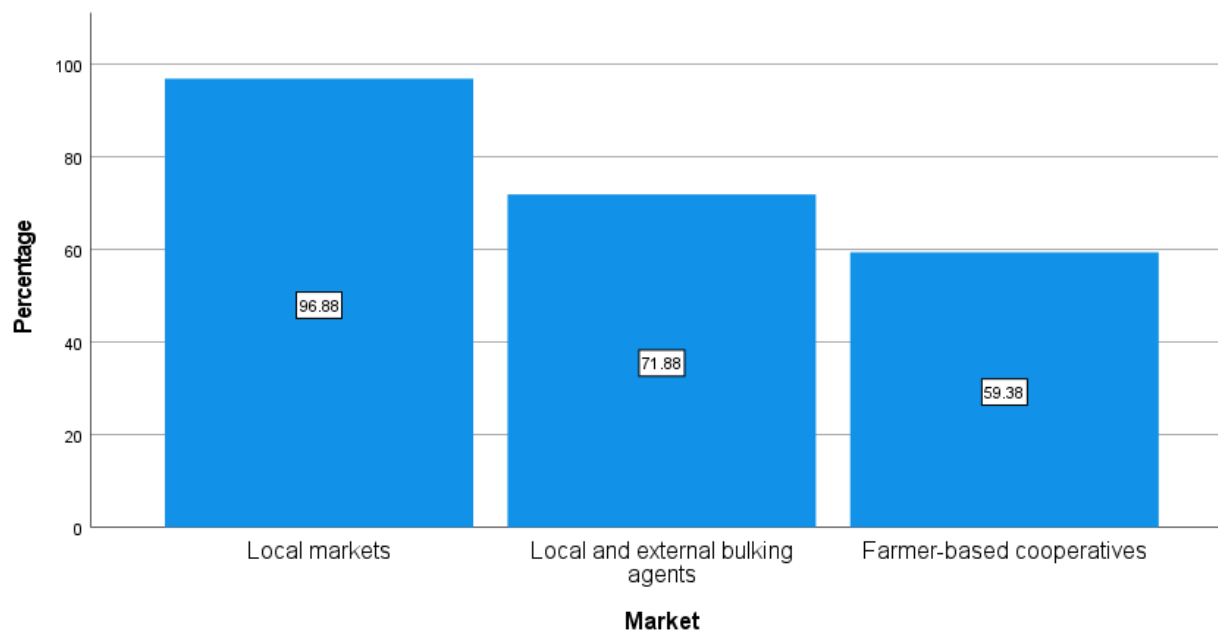


Figure 13 – Markets for honey of beekeepers in KUAGA cooperative

The crosstabulation analysis showed that 71.0% of those who sell to local markets also sell to local and external bulking agents, and 61.3% of them sell to farmer-based cooperatives. The analysis also showed that 52.2% of those who sell to local and external bulking agents also sell farmer-based cooperatives.

4.1.4 – Income and Socio-economic Impact of Beekeeping in KUAGA

4.1.4.1 - Income

The figures collected from beekeepers showed that the mean total income per season and per year per beekeeper in KUAGA cooperative is FRW174,337.5 and FRW340,987.5 respectively. The minimum and maximum total income per beekeeper is FRW28,000.0 and FRW550,000.0 per season, and FRW55,000.0 and FRW980,000.0 per year.

It was found that there is no significant difference in the total income per season (p-value=0.113) and per year (p-value=0.101) between men and women at 5% significance level.

The ANOVA showed that there is a significant difference in the total income per season per beekeeper (p-value=0.27) between age groups at 5% significance level. The significant differences in the total income per season per beekeeper were found between the beekeepers of below 31 years of age and those of 31-65 years of age (p-value=0.016), and between those of 31-65 years of age and those of above 65 years of age (p-value=0.031).

The ANOVA also showed that there is a significant difference in the total income per year per beekeeper (p-value=0.025) between age groups at 5% significance level. The significant differences in the total income per year per beekeeper were found between the beekeepers of below 31 years of age and those of 31-65 years of age (p-value=0.015), and between those of 31-65 years of age and those of above 65 years of age (p-value=0.032).

4.1.4.2 - Socio-economic Impact

Respondents affirmed that beekeeping contributes to their local development. They mentioned different development benefits they get through beekeeping which are: paying school fees for their children (50%); buying food (50%); buying livestock (50%); buying health insurance (50%); house rehabilitation (50%); buying land (50%); opening bank account and making savings (50%); and employment creation (50%).

4.1.5 - Economic Autonomy and Transferability of Beekeeping Farms and Skills in KUAGA

4.1.5.1 - Beekeepers' Investment Capacity

The mean self-financing capacity of beekeepers in KUAGA cooperative was found to be 71.09%. There is no significant difference in the self-financing capacity between men and women (p-value=0.853) and between age groups (p-value=0.578) at 5% significance level.

4.1.5.2 - Transferability of Beekeeping Farms and Skills

There are different ways KUAGA's beekeepers transfer their beekeeping farms and skills between generations. They do so through: assisting the one to inherit beehives join their cooperative (100%); transferring beehives to the one to inherit them according to cooperative guidelines (replacement) (100%); training the one to inherit beehives on beekeeping activities (100%); and giving starting beehives to the new entrant into beekeeping (50%).

4.2 – Environmental Sustainability of Beekeeping in KUAGA

4.2.1 – Honeybees' Mortality

As the next figure shows, most of the beekeeper respondents attested that honeybees' mortality is low (40.6%), against 37.5% of them who attested that it is medium, and 21.9% of them who attested that it is absent.

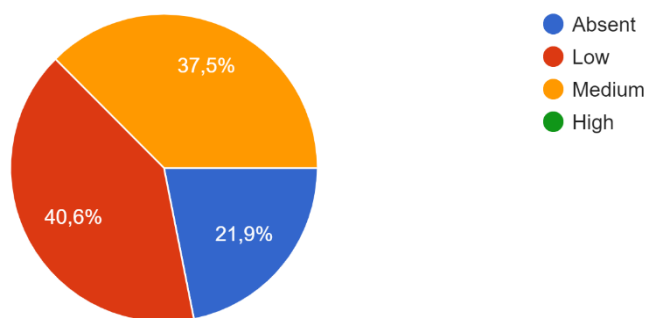


Figure 14 – Honeybees' mortality in KUAGA cooperative

4.2.2 – Illegal Activities in and from the Apiary Area

Respondents attested that there are no illegal activities in or from the apiary area surrounding NNP by the beekeepers themselves. This has resulted from joint efforts from all stakeholders involved in beekeeping in UBNBU, including putting in place mechanisms to report any beekeeper suspected of illegal

activities in the park because of his/her unknown prolonged absence from his home, sensitisation on the importance of biodiversity conservation, and sharing revenue from conservation with people around the park through providing them with livestock.

Yet, respondents mentioned some illegal activities that are still observed in NNP and its buffer zone that they attribute to people other than beekeepers around the park. These activities are tree cutting (80%), medicinal plant collection (40%), people walking in the apiary and NNP (40%), livestock grazing in the buffer zone (40%), hunting in NNP (60%), forest fires in NNP (40%). Only 1 respondent out of 5 (20%) said there are no illegal activities in NNP and its buffer zone.

4.2.3 – Impact of Illegal Activities on Local Biodiversity

All the 5 respondents (100%) attested that beekeeping around NNP itself has no bad impact on local biodiversity as beekeepers are no longer reported for illegal activities because of sensitization about taking the responsibility of conservation. Instead of posing a threat to NNP, KUAGA's beekeepers share opinions about conserving Nyungwe and participate in setting off wildfires in Nyungwe when it occurs from other sources.

4.2.4 – Environmental Impact of Honey Collection from the Forest

Beekeeping has been traditionally considered as a sustainable practice due to the contribution of honeybees (*Apis mellifera*) to the pollination of wildflower and crop pollination. Nonetheless, high densities of honeybees may have an impact on the availability of local pollen and nectar, that in turn may have negative impact on other pollinators. This is aggravated by honeybees' ability to exploit highly rewarding flower patches. Floral resource consumption in rosemary (*Rosmarinus officinalis*) and thyme (*Thymus vulgaris*) was measured in 21 plots that were located at different distances from apiaries in scrubland of Garraf natural Park, Barcelona, and these measures were related to visitation rates of honeybees, bumblebees (*Bombus terrestris*) and other pollinators. Flower density was measured in the same plots, and pan traps were used to characterise the wild bee community. The consumption of flower resource was largely explained by honeybee visitation and marginally by bumblebee visitation. After accounting for flower density, it was found that plots close to apiaries had lower wild bee biomass. This was due to lower abundance of large bee species that are more likely to be affected by honeybee competition. It was concluded that honeybees are the main consumers of pollen/nectar of the two main flowering plants in the scrubland, and that the wild bee community was being affected. Therefore, it is supported that high honeybee densities may have an impact on other pollinators via competition for floral resources (Torné-Noguera, et al., 2016). Based on this, it must be considered that though beekeeping in KUAGA has economic and environmental benefits, it negatively affects other wild bee pollinators in and around the apiaries in state forests in Nyamagabe District.

4.3 - Challenges and Opportunities for Beekeeping in KUAGA

Respondents listed challenges beekeepers in KUAGA cooperative face and opportunities they have for beekeeping.

Next are the challenges faced by beekeepers in KUAGA that respondents mentioned:

- Stealing honey and honeybee colonies (28.6%).
- Lack follow up by stakeholders/partners (28.6%).

- Poor collaboration between beekeepers and partners to decide on activities for support interventions (28.6%).
- Many rainy days in NNP disturbing honeybees to collect pollen to make honey (28.6%).
- Honeybee colony feeding during rainy period making beekeepers to make extra cost (14.3%).
- Use of pesticides in the crop fields in the surrounding of NNP that kill honeybees (57.1%).
- Old beekeepers who are not more productive (28.6%).
- The geographical location of scattered cooperatives in the union making supervision difficult (14.3%).
- Not enough beekeepers (14.3%).
- Chimpanzees destroying beehives looking for honey (28.6%).
- Red ants pests on the ground in the apiary area causing the need to manage them using gasoil (28.6%).
- Less youths' involvement (28.6%).
- More use of traditional hives with lees production (28.6%).
- Poor management of cooperatives (failure to pay loan back causing misunderstanding between beekeepers) (14.3%).
- Honey processing plant located far from the cooperative (14.3%).
- Seasonality of honey production (14.3%).
- Insufficient and expensive beekeeping equipment (28.6%).
- Beekeepers taking beekeeping as a secondary activity (14.3%).

There are several opportunities that beekeepers in KUAGA cooperative can take advantage of for developing their beekeeping. Next are these opportunities:

- Existing honey markets in and outside Nyamagabe District (57.1%).
- The union in place that assures better organization and functioning of its cooperatives (28.6%).
- Existing multiple use of honey (food, medicine, candles, etc.) (28.6%).
- Training of beekeepers on how to handle honey, equipment, and honeybee products (14.3%).
- Local authorities involved in beekeeping facilitating registration of beekeepers' cooperatives at Sector, District, and national levels (14.3%).
- Easiness for honeybees to collect pollen and water in short distance to make honey (14.3%).
- Existence of large zone with enough biodiversity and the possibility for beekeepers to get quantity and quality honey (57.1%).
- Existence of some stakeholders/ partners in beekeeping in Nyamagabe district (14.3%).

Chapter 5 – Discussion of Results

5.1 – Economic Viability and Contribution to Local Development of Beekeeping in KUAGA

All 32 beekeepers surveyed (100%) use traditional hives, against 53.13% who use KTBH and 6.25% who use langstroth hives. All beekeepers use traditional hives because the later are easily available locally as they are made by beekeepers by themselves and bought at a lower price, making them the most choice by beekeepers of limited financial capacity. The next choice of hives by KUAGA's beekeepers is KTBH – this is because, though KTBH are expensive, they easily handled compared to langstroth hives, especially during harvesting. The last choice of hives adopted by KUAGA's beekeepers is langstroth hives, as their handling is difficult compared to KTBH (Hakizimana, 2021). These findings tally the RAB's current information that honey production is mainly through traditional methods, and some modern techniques and equipment introduced have not been successful because of unsustainable implementation projects (RAB, 2021). These findings serve as basis for any intervention aimed at modernizing beekeeping in KUAGA in terms of beehives.

The mean amount of honey production per hive per season is 3.70kg, 13.00kg, and 8.35kg for traditional hives, langstroth hives, and KTBH respectively – which are below the average production capacities of these hives per season (5.6kg, 14kg, and 10kg for traditional hives, langstroth hives, and KTBH respectively) (SNV, 2009). This may be attributed to the fact that beekeepers take beekeeping as a secondary activity (Hakizimana, 2021), the use of pesticides in the surrounding of NNP that kill honeybees and insufficient beekeeping equipment (Bana, 2021), and poor management of KUAGA cooperative (Nsengiyaremye, 2021). However, the overall total amount of honey per season per beekeeper in KUAGA of 64.61kg is greater than that was got by beekeepers in the country in 2012, 45kg (SNV, 2014). Though honey production in KUAGA is greater compared to the situation in the country in 1012, KUAGA still have to look for ways to increase it because it is still lower than the production capacities of the beehives used.

Honey processing doesn't take place at cooperative level, but at the union's honey processing plant at Kitabi. The double boiler method (traditional method) used at Kitabi itself makes honey free from contamination because the processing equipment and the way of handling honey are effective to ensure its quality at the desired level (Hakizimana, 2021). However, as honey comes from beekeepers located in different Districts (Nyamagabe, Nyaruguru, Karongi, Nyamasheke, and Rusizi) where the union doesn't have full control over the beekeepers, this may be a cause of not always having the desired quality (Ngezahayo, 2021).

The markets for KUAGA's beekeepers are local markets (96.88%), local and external bulking agents (71.88%), and farmer-based cooperatives (59.38%). 71.0% of those who sell to local markets also sell to local and external bulking agents, and 61.3% of them sell to farmer-based cooperatives. 52.2% of those who sell to local and external bulking agents also sell farmer-based cooperatives. The largest percentage (96.88%) of KUAGA's beekeepers sell their honey to local markets and the next percentage (71.88%) sell to local and external bulking agents because beekeepers get immediate and higher price and are not tightly bound to quality standards for these markets. Only 59.38% of beekeepers sell to farmer-based cooperatives. Some beekeepers sell at all the three markets at the same time – this is because they want to maximize money profit at the same time keeping on benefiting from the union's advantages (Hakizimana, 2021). These percentages of beekeepers' markets for their honey show that KUAGA make

the smallest market to its beekeepers and that it need to adopt new strategies to overcome the competition for honey with local markets and local and external bulking agents.

The mean total income per season per beekeeper in KUAGA cooperative is FRW174,337.5 which is greater than what was got by beekeepers in the country in 2012, FRW104,756.96 (Euro 88) (SNV, 2014). This may be the results of practicing beekeeping in a safer place with a lot of biodiversity. It may also be a result of the WCS's support to beekeepers in terms of building their capacity through improving their skills, providing them with equipment, and helping them access markets (Bana, 2021). Beekeeping in KUAGA contributes several benefits for the development of local people - paying school fees for their children, buying food, buying livestock, buying health insurance, house rehabilitation, buying land, opening bank account, and making savings, and employment creation. This shows that beekeeping plays an important role in the lives of KUAGA' members. A study was carried out in Kinigi Sector, Musanze District, Rwanda, where respondents ranked beekeeping in the second place as a non-timber forest product (50.7% of respondents) after firewood (100% of respondents) (Nahayo, et al., 2013).

The mean self-financing capacity of beekeepers in KUAGA is 71.09%. This percentage confirm that beekeepers in KUAGA take beekeeping as a secondary activity because there is no way that most beekeepers in KUAGA are still using traditional hives while their self-financing capacity is 71.09%. This means that some beekeepers in KUAGA do not want to invest more in beekeeping. KUAGA's beekeepers transfer their beekeeping farms and skills between generations through assisting the one to inherit beehives join their cooperative (100%); transferring beehives to the one to inherit them according to cooperative guidelines (replacement) (100%); training the one to inherit beehives on beekeeping activities (100%); and giving starting beehives to the new entrant into beekeeping (50%). These ways beekeeping transferability is done in KUAGA is promising as they ensure the continuity of the cooperative and beekeeping skills.

5.2 – Environmental Sustainability of Beekeeping in KUAGA

Though beekeepers in Nyamagabe District have moved to a safer place, the buffer zone around NNP, beekeepers still say that honeybee's mortality is low (40.6%) and medium (37.5%), against only 21.9% of them who say it is absent. This mortality is caused by using pesticides in the crop fields in the surrounding of NNP and ant pests (Hakizimana, 2021; Nsengiyaremye, 2021; Bana, 2021). These findings confirm the findings of a similar study about the effects of farming practices in boundary of Gishwati Forest National Park which found that the use of pesticides and inorganic fertilizers in agricultural fields around Gishwati Forest National Park caused the death of honeybees resulting in the decline in honey production, thus affecting the livelihoods of beekeepers (Nsabimana, et al., 2020). This status of honeybees' mortality in KUAGA shows KUAGA, UBNBU, and their partners still need to solve this problem.

There are no illegal activities in and from the apiary by the beekeepers themselves that are observed. Therefore, beekeeping in state forests in Nyamagabe District itself does not pose any encroachment threats to NNP, and thus it is sustainable to this regard. Beekeeping in KUAGA itself does not endanger plants and animals in NNP and is not a source of wildfires in the park.

5.3 - Challenges and Opportunities for Beekeeping in KUAGA

KUAGA's beekeepers face many challenges as they were listed in section 4.3. A study about the characterization of honey value chain that was conducted in Kayonza District of Rwanda and it was found that beekeepers face challenges some of which are the same to those of this research – pests, lack of modern apicultural equipment, and high costs (Mushonga, et al., 2019). To improve beekeeping in KUAGA, solutions for all the challenges respondents mentioned need to be found. From the same study, it was found that some opportunities for beekeeping development in Kayonza are like those of this research (see section 4.3) - abundance of wild bee populations, abundance of honey collection centers (market), and availability of technical support from the government and development agencies (Mushonga, et al., 2019). KUAGA and UBNBU in general can take advantage of all identified opportunities to improve beekeeping.

5.4 – Reflection as a Researcher

This research was conducted in Rwanda from the Netherlands. Being a new element to KUAGA and UBNBU, the researcher did everything to gain confidence of the members and stakeholders through looking for a contact person in the union to introduce him. The purpose of the research was well explained by both the contact person and the researcher. Besides gaining confidence of KUAGA, UBNBU and their partners, the researcher made sure to get quality data from respondents. This was done by explaining the importance of the research for KUAGA and UBNBU and, assisted by the contact person, requested respondents to give true information. This was achieved because respondents actively participated and took the research as theirs. The researcher made the results as reliable as possible.

The design of this research was suited to the Covi-19 pandemic. Collecting information through online interviews, questionnaire, and desk study made the research possible in the planned time. With this research method, the sustainability of beekeeping in state forests in Nyamagabe District was studied. From the data collected, the research got the results for economic viability and environmental impact of beekeeping in state forests in Nyamagabe District. The researcher adjusted the timeframe for planned activities during the research process. It took longer than planned to find some respondents, and thus there was need to keep on collecting data, analysing data, and writing the thesis at the same time.

The researcher ensured that his own position and ideas had less influence on the results. Having a business image for the research, he made himself appear in the eyes of respondents someone who was looking for quality data with the orientation to improve beekeeping in KUAGA. Thus, figures were handled carefully and transcribing the interviews was done the researcher keeping neutrality.

Chapter 6 – Conclusions and Recommendations

6.1 - Conclusions

From the results of this research, the next conclusions were drawn for the economic viability and contribution to local development of beekeeping in KUAGA:

- Honey production in the cooperative has increased compared to the situation in the country in 2012, however it is still lower the production capacities of the beehives.
- KUAGA's members are trained to ensure honey quality (handling honey in hygienic conditions and grading it), facilitating the double boiler filtering method of honey processing at union level whose honey is sold to local and national markets.
- Markets exist for honey produced by the members, though less is sold to the cooperative as the beekeepers seek for immediate money and higher prices from local markets and local and external bulking agents.
- The income for beekeepers has increased compared to that was got in the country in 2012 because of practicing beekeeping in a safer place with a lot of biodiversity and empowering beekeepers through equipping them with skills, providing them with equipment, and assisting them to access the markets. Beekeeping helps KUAGA's members to meet their basic needs including paying school fees for their children, buying food, buying livestock, buying health insurance, rehabilitating houses, buying land, opening bank account, and making savings.
- The majority of KUAGA's beekeepers (71.09%) can finance their beekeeping but they are not willing to invest more because they take beekeeping as a secondary activity. Beekeeping farms and skills are transferred between generations and this ensures continuity of the cooperative and beekeeping.

Next are the conclusions that were drawn for the environmental sustainability of beekeeping in KUAGA:

- Many beekeepers are still facing honeybees' mortality (40.6% of them facing low mortality and 37.5% facing medium mortality) that is caused by pesticides from the crop fields in the surrounding of NNP, and this negatively impact the amount of honey production.
- There are no illegal activities by the beekeepers themselves in the apiary area or in the park because of the mechanisms in place to report illegal activities and sensitizing beekeepers to take the responsibility of conservation.
- The beekeeping in KUAGA itself is environmentally sustainable about encroachments into NNP, and plants and animals in NNP are not endangered by beekeeping in the buffer zone around the park.
- Though beekeeping is known for its important role for wildflower pollination and crop pollination, it negatively impacts (reduces) wild bee pollinators because honeybees highly compete wild bees for floral resources.

Beekeeping in KUAGA faces several challenges including: poor collaboration between beekeepers and partners; use of pesticides in the crop fields in the surrounding of NNP that kill honeybees; old beekeepers and less youth involvement; more use of traditional hives; poor management of the cooperative; insufficient and expensive beekeeping equipment; and beekeeping taken as a secondary activity. There are opportunities KUAGA's beekeepers can benefit from that are: existing markets for honey; UBNBU's

support; involvement of local authorities; large zone of enough biodiversity for beekeeping; and existence of partners.

6.2 - Recommendations

Based on these conclusions, it is recommended that:

- UBNBU and WCS increase training to beekeepers for better management of beehives so that honey production per hive per season and income can be increased.
- UBNBU collaborates with current partners and look for new ones to get a modern honey processing equipment – the modern honey processing equipment will enable the union to improve honey quality and expand its markets to export, thus increasing profit and benefiting its members.
- KUAGA improves the payment terms for its members (honey price and payment time) to make them sell more honey to their cooperative.
- UBNBU, WCS, and KUAGA organize beekeepers more, sensitise them about the economic potential of beekeeping to make them like it – this will make the beekeepers stop taking beekeeping as a secondary activity, thus increasing their involvement, honey production and profit.
- KUAGA's beekeepers and its partners (WCS, PIC, and Nyamagabe District) strongly link together – this will help putting in place adequate interventions, making the beekeepers take the responsibility, improving the follow-up of interventions, and successfully implementing the interventions.
- The Ministry of Agriculture regulates the use of pesticides in the surrounding of NNP and sensitises the population in the surrounding of NNP to adopt agroforestry to increase biodiversity in the area thus reducing the need for honeybees to collect pollen and nectar from crops to make honey.
- UBNBU sensitises, helps cooperatives recruit, and train women and youths, and equips them with beekeeping and entrepreneurial skills – this will increase productive labor, honey production, and profitability.
- UBNBU and WCS help KUAGA's beekeepers get access to finances that are needed for beekeeping – besides the insufficient equipment provided to beekeepers by WCS, linking them to financial institutions to get credit will be a means to improve their financial capacity and to make them able to shift from traditional hives to modern hives and get other equipment.

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Annex 1 - Definitions of Concepts

Forest	As by Dunster & Dunster, 1996, a forest is a community of vegetation dominated by trees and other woody shrubs, which grow close enough together making the tree tops touch or overlap, creating various degrees of shade on the forest floor. Forests are established for various purposes including timber, recreation, wildlife habitate, etc.
Sustainable beekeeping	Agricology (2015) defines sustainable beekeeping as the beekeeping where humans and bees interact to maintain healthy populations of locally adapted indigenous (where possible) bees which live in the wild and in the apiaries of beekeepers to bring benefits to people and to biodiversity. Sustainability is measured in three dimensions: environmental, the ability that natural ecosystems have to maintain their biological process and functions; social, the ability to meet our own needs without compromising the future generations to meet their own needs; and economic, the just and equitable use and reuse of resources. Each of these dimensions is important. Beekeeping must consider biodiversity conservation. It must be appropriate and provide benefit for communities in the present and in the future. And it must ensure balance between its use and production of resources.
Honey	Bradbear, 2009, defines honey as the natural sweet substance, produced by honeybees from the nectar of plants or from secretions of living parts of plants, or excretions of plant-sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in honeycombs to ripen and mature.
Production	Referring to YourDictionary, 2021, production is the process of making, harvesting or creating something or the amount of something that was made or harvested.

Beekeepers' cooperatives	These are producer organizations that are registered by the Ministry of Trade and Industry and are owned and run jointly by its members, who share the profits or benefits.
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Illegal activity	According to CambridgeDictionary, 2021, an illegal activity is an activity that is not allowed by law.
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Annex 2 – Questionnaire

Sustainable beekeeping is the beekeeping where humans and bees interact to maintain healthy populations of locally adapted indigenous (where possible) bees which live in the wild and in the apiaries of beekeepers to bring benefits to people and to biodiversity. Sustainability has three dimensions: environmental, the ability that natural ecosystems have to maintain their biological process and functions; social, the ability to meet our own needs without compromising the future generations to meet their own needs; and economic, the just and equitable use and reuse of resources (Agricology ,2015).

Beekeepers grouped in 15 cooperatives under Ubwiza bwa Nyungwe Union are practicing beekeeping in the buffer zone around Nyungwe National park including Nyamagabe District. KUAGA is one of these cooperatives, with 58 beekeepers operating in Gatare Sector, Nyamagabe District. This questionnaire was designed for a research about the economic viability and the contribution of beekeeping to local development, and the environmental sustainability of beekeeping in Gatare Sector, Nyamagabe District.

It will take you approximately 20 minutes to answer to this questionnaire. Your honest response is highly valued. Your response will be thoroughly confidential, and it will be used to help in the development of beekeeping in Nyamagabe District.

- 1) What is your sex?
 - a) Male
 - b) Female
 - c) Prefer not to say
- 2) What is your age?
 - a) Below 31 years
 - b) 31-65 years
 - c) Above 65 years
- 3) What is the type of hive do you use in beekeeping?
 - a) Traditional hive
 - b) Langstroth hive
 - c) Kenyan top bar hive (KTBH)
- 4) How many hives do you have?

- 5) What is the amount of honey do you get per hive per season in Kilogram - for traditional hive, if it applies?

6) What is the amount of honey do you get per hive per season in Kilogram – for langstroth hive, if it applies?

7) What is the amount of honey do you get per hive per season in Kilogram – for KTBH, if it applies?

8) What is the total amount of honey do you get per type of hive per season in Kilogram - for traditional hive, if it applies?

9) What is the total amount of honey do you get per type of hive per season in Kilogram – for langstroth hive, if it applies?

10) What is the total amount of honey do you get per type of hive per season in Kilogram - for KTBH, if it applies?

11) What is the overall total amount of honey do you get per season?

12) What is the total amount of honey do you get per type of hive per year in Kilogram - for traditional hive, if it applies?

13) What is the total amount of honey do you get per type of hive per year in Kilogram – for langstroth hive, if it applies?

14) What is the total amount of honey do you get per type of hive per year in Kilogram - for top bar KTBH, if it applies?

15) What is the overall total amount of honey do you get per year?

16) What is the market for your honey?

- a) Local markets
- b) Local and external bulking agents
- c) Farmer-based cooperatives

17) What is your total income from beekeeping per season (in Rwandan francs, FRW)?

18) What is your total income from beekeeping per year (in Rwandan francs, FRW)?

19) From where do you get finance for beekeeping?

- a) From myself
- b) From donor agencies
- c) From financial institutions
- d) From the government

e) Other (Please specify)

20) What is your self-financing capacity as a beekeeper (please give a percent)?

21) What is the status of deaths of honeybees in the apiary?

- a) Absent
- b) Low
- c) Moderate
- d) High

Annex 3 - Interview Questions

Producers (2)

Experiences in Beekeeping

What type(s) of hive do you use in beekeeping

What is the amount of your honey production per type of hive per season and per year?

From where do you get inputs (hives, harvesting and processing equipment, clothing, etc.)?

Could you list and explain honey processing techniques and standards that you use in beekeeping?

Where do you sell your honey?

Have you observed any illegal activities in the apiary area? If any, what can be its impact on local biodiversity?

What is the contribution of beekeeping to beekeepers' social well-being and economy in your area?

How do you transfer beekeeping farms and skills to your offspring?

Membership to Ubwiza Bwa Nyungwe Beekeeper Union (UBNBU)

Are you a member of UBNBU?

What support do you receive from the union, if any?

Challenges and Opportunities

What are the opportunities are there to practice beekeeping in state forest in Nyamagabe District?

What challenges do you face (in production, processing, markets, investment, and management of your honeybees in the apiary)?

Closing

What do you think can be done to improve beekeeping in state in Nyamagabe District?

Is there anything else you would want to add?

Representatives UBNBU (2)

Background

Please could you tell us about your organization?

Who are the members of your union?

Beekeeping

What is the role of UBNBU in beekeeping?

What are honey processing techniques and standards in in the union?

Have there been any illegal activities in or from the apiary area in Nyamagabe District? If any, what can be their impact on local biodiversity?

What are the challenges and opportunities for beekeeping in state forests in Nyamagabe District?

Partnership

Who are your partners in beekeeping?

What is the role of your partners in beekeeping?

Closing

What do you think can be done to improve beekeeping in state forests in Nyamagabe District?

Is there anything you would want to add?

Honey Processor (1)

What are honey processing techniques and standards from cooperative level to processing (UBNBU) level?

How much does KUAGA (and other cooperatives) pay to beekeepers (in FRW) per kg of honey?

What are different markets for beekeepers' honey?

What can be done to improve the Rwandan beekeeping value chain?

Honey Quality Inspector (1)

Introduction

Could you please tell us about your organization?

What are the responsibilities of your organization for honey/beekeeping segment?

Standards

What are the quality standards for honey?

What kind of processing do you expect from honey processors?

How does processing and quality standards affect honey value?

Closing

What do you think can be done to improve honey value chain at each of its level in Rwanda?

Is there anything else you would want to add?

Representative Conservation (1)

What is your partnership with Ubwiza Bwa Nyungwe Beekeeper Union?

What is the honeybees' mortality in the apiary in the buffer zone surrounding Nyungwe National Park in Gatware Sector?

Are there illegal activities in or from the apiary in the buffer zone of Nyungwe National Park in Gatware sector? What can be their impact on local biodiversity, if any?

What challenges and opportunities are there for beekeeping in the buffer zone surrounding Nyungwe National Park?

What do you think can be done to improve beekeeping in state forests in Nyamagabe District?

Is there anything else you would want to add?

Representative Donor Agency (1)

What support do you give to beekeepers in Ubwiza bwa Nyungwe Union in Nyamagabe District?

Who are your partners in supporting beekeeping in state forests in Nyamagabe District?

What are the opportunities and challenges for beekeeping in state forests in Nyamagabe District?

What do you think can be done to improve beekeeping in state forests in Nyamagabe District?

A) Beekeepers consulted through passing the questionnaire in Urwiru Beekeeper Cooperative of Gatare (KUAGA)

Table 6 – Questionnaire respondents, their function, and number of beehives

Date	Serial number	Names	Function	Number of hives		
				Traditional	KTBH	Langstroth
Monday, August 2, 2021	1	Bazigoboka Juvénal	President of KUAGA and trainer of training on beekeeping methods and techniques (ToT) of cooperative members	24		
	2	Rimenyande Juvénal	KUAGA member and ToT of cooperative members	10	8	2
	3	Ntibakunze Abraham	KUAGA member and ToT of cooperative members	13		
	4	Niringiyimana Pascal	KUAGA member and ToT of cooperative members	14	3	
	5	Mutareshya Célestin	KUAGA member	20		
	6	Habiyaremye Daniel	KUAGA member and ToT of cooperative members	6	4	
	7	Ntawuyicinyuma Célestin	Vice President of KUAGA	8	6	
	8	Iyaremye Célestin	KUAGA member	5	2	1
	9	Ntagoramba Joseph	KUAGA member	3	11	
	10	Nsabimana Edouard	KUAGA member	4		
	11	Mugemangango Cassien	KUAGA member	21	12	
	12	Iyaremye Vincent	KUAGA member	16		

	13	Ntibamenyera Thacien	KUAGA member	2	4
	14	Sibobugingo Augustin	KUAGA member and ToT of cooperative members	14	5
	15	Nyaminani Laurien	KUAGA member	9	2
	16	Ugezekure Valence	Advisor of KUAGA and ToT of cooperative members	19	9
Tuesday, August 3, 2021	17	Habiyambere Védaste	KUAGA member	7	
	18	Gapyisi Claver	KUAGA member	19	
	19	Ndorimana Célestin	KUAGA member	26	
	20	Ayinkamiye Béatrice	KUAGA member	5	
	21	Mukasare Anathalie	KUAGA member	3	
	22	Mugenga Boniface	KUAGA member	15	2
	23	Sibomana Claude	KUAGA member	25	4
	24	Nsengumukiza Evariste	Secretary of KUAGA	11	
	25	Mukeshimana Cassien	KUAGA member	12	3
	26	Sibomana Dominique	KUAGA member and ToT of cooperative members	8	
	27	Kwisanga Laurent	KUAGA member	15	10
	28	Mudaheranwa Esdor	KUAGA member	6	3
	29	Ntawuhorabyibushye	KUAGA member	2	
	30	Sibomana Straton	KUAGA member	5	2
	31	Rukemampunzi Elias	KUAGA member	6	
	32	Ntamuhoranye Evariste	KUAGA member	4	
Totals				357	90 3
Averages				11.15	2.8 0.09

Source: UBNBU

B) Interview Respondents with an Outline of Their Main Points

Producers (2)

JMV Kanyeshyamba, Honey Producer, KUAGA Member and ToT of Cooperative Members, Gatare, August 5, 2021

- Has 9 traditional hives, 6 KTBH.
- Gets 66 kg and 132 kg of honey per season and per year respectively.
- Gets inputs from WCS. Also finances himself through locally made beehives.
- As honey processing techniques/standards, honey harvesting equipment is prepared (cleaned), harvested honey is put in clean container, honeybees are not smoked, and harvested honey is graded (old and new honeycombs are kept separately).
- Sells his honey at union and local market.
- There is observable tree cutting, medicinal plant collection, and people walking in the apiary and NNP (but these illegal activities are attributed to people other than beekeepers).
- As contribution of beekeeping to social well-being and economy in local area, paying school fees for children, meeting family needs including food, purchasing of domestic animals, and employment creation are the derived benefits.
- Transferability of farm and beekeeping skills is done through inheritance, replacement (for someone who is a member of cooperative) and sensitising and training the successor on beekeeping.
- Is a member of UBNBU.
- Bonus from honeybee products sales, training, and equipment provision make the support from UBNBU.
- Honeybees' pests and honeybee predators (red ants and bees' eaters), weather conditions, and bees' exposure to pesticides are the beekeeping challenges.
- Availability of markets for honey and availability of bee forage (Eucalyptus and Pinus) are opportunities for beekeeping.
- Sensitizing, recruiting, and training women may improve beekeeping as they have enough force to work, and they may be creative. Needed to improve beekeeping is also capacity building through knowledge and skills development as well as business skills development.

Joseph Ndutiye, Honey Producer, KUAGA Member and UBNBU's Advisor, Gatare, August 5, 2021

- Has 16 traditional hives and 5 KTBH.
- Gets 91kg and 182 kg of honey per season and per year respectively.
- Gets inputs from WCS donor and from money he earns from the sale of honeycombs.
- As honey processing techniques/standards, clean plastic containers are used to store honey, honey is not cooked, smoke is not used, and more moisture content added to honey is avoided.
- Sells his honey to the UBNBU and to his neighbors.
- Tree cutting and livestock grazing in the buffer zone and hunting in NNP are illegal activities that are observed, but that are committed by people other than beekeepers.

- Health insurance payment, house rehabilitation, land purchasing, and opening a bank account and saving are the contribution of beekeeping to local development.
- To transfer beekeeping farms and skills, this done through inheritance or replacement (according to cooperative's guidelines), this is also done through training the new entrant on beekeeping activities and giving him/her her own hives.
- He is a member of UBNBU.
- As support from UBNBU, he received equipment (local veil, hive tools) and training on honey harvesting and candle making.
- Seasonability of honey production, insufficient and expensive beekeeping equipment and chimpanzees destroying beehives looking for honey are the challenges.
- Presence of bee forage (Eucalyptus and Pinus) is an opportunity for beekeeping.
- Reduced use of pesticides in the surrounding of NNP and training beekeepers on using modern hives can improve beekeeping. Also, local authorities should link beekeepers to partners to improve beekeeping.

Representatives UBNBU (2)

Béathe Yamfashije, Manager of UBNBU, Kitabi, Friday August 6, 2021

- UBNBU is an umbrella to beekeepers grouped into 15 cooperatives operating on NNP perimeters. It was created in 2009 to reduce wildfires set on by beekeepers or other honey collectors.
- Next is the role of UBNBU in beekeeping:
 - Represent beekeepers' cooperatives at governmental institutions.
 - Advocate for the beekeepers at national and international level.
 - Facilitate collaboration between the beekeepers and partners.
 - Improve the capacity of beekeepers through training, visit tours, etc.
 - Collect, transport, process and market honey and honeybee products on behalf of union members.
- Next are honey processing techniques and standards in the union:
 - Scaling the honeycombs to be filtered.
 - Taking liquid honey out of the honeycombs.
 - Filtering honey by double filter.
 - Packing liquid honey into different sizes of containers.
 - Batching and labelling the containers.
 - Respect honey moisture content of less than or equal to 20%.
- Tree cutting, hunting, and forest fires are illegal activities observed in the park – but that are caused by other people outside beekeeping.
- Challenges of beekeeping in KUAGA:
 - People who steal honey and bee colonies.
 - Lack of follow up by partners/stakeholders.
 - Lack of collaboration between beekeepers and partners to decide on activities/interventions for support.
- Opportunities of beekeeping in KUAGA:

- Multiple use of honey (food, medicine, candle, etc.).
- Existing markets in and outside Nyamagabe.
- Existence of the beekeepers' union.
- Partners of UBNBU in beekeeping:
 - WCS – provides training, equipment, and finances to beekeepers.
 - District – Helps in the union headquarters management, union registration, and taxes payment.
 - RBS – controls honey quality.
- To improve beekeeping, reduced use of pesticides in crops fields in the surrounding of NNP, collaboration of beekeepers and all the stakeholders and government support are needed.

Vincent Hakizimana, Community Conservation and Beekeeping Development Officer/WCS, Bushekeri, Sunday, August 8, 2021

- About Vincent Hakizimana:
 - Community Conservation and Beekeeping Development Officer/WCS.
 - Initiator and technician of UBNBU in honey processing, honeybee products diversification, methods, and techniques of modern beekeeping.
 - Silva medal Winner in beekeeping and honey processing technology for developing countries, 2019, Changsha, China.
 - Golden medal winner in Rwanda handcraft competition 2011, Kigali-Rwanda.
 - Overall Best Winner in Africa Apitrade Exhibition 2016, Kigali-Rwanda.
 - Winner of Best food processor at Made in Rwanda, 2018, Kigali-Rwanda.
 - Technical committee member at Rwanda Bureau of Standards (RBS) on code of practice in food hygiene.
 - Field coordinator, research facilitator for students from University of Rwanda, University of Virginia/USA, University of Deutschland, and University of Ireland.
 - Founder member of Kibogora Polytechnic, Nyamasheke-Rwanda.
 - 37 years of experience, from 8 years of age, works for UBNBU since 2008.
- Before the UBNBU was created, beekeepers were disorganized – entering illegally in NNP for honey collection, tree and grass cutting for shelter, cannabis cultivation, and snaring.
- Then in 1997, WCS in partnership with RDB started organizing the beekeepers. In 2006 there were already 58 beekeepers' associations.
- In 2009, the Rwandan government started joining the associations to form cooperatives. From 2009 till now, there are 15 cooperatives grouped under UBNBU, operating in Nyamagabe, Nyaruguru, Karongi, Nyamasheke, and Rusizi.
- UBNBU in support of the government enables beekeepers access markets for their honey and get involved in NNP conservation to reduce wildfires.
- WCS through UBNBU helps in capacity building through increasing beekeeping skills, increasing honey quantity and quality, better cooperatives management, honeybee products diversification (candles, propolis, and bee waxes), data recording and analysis (using Sage software), equipment

provision, honey collection and transportation to the processing and selling center, getting certification (S-mark), participation in the exhibitions.

- The investigation by UBNBU with RDB shows there are no illegal activities in NNP by beekeepers themselves – the beekeepers are “the eyes of Nyungwe.” They report any of their fellow beekeeper suspected of illegal activities in Nyungwe, share opinions about conserving Nyungwe and participate in setting off wildfires in Nyungwe when it occurs from another source. However, tree cutting, medicinal plant collection, people walking in the apiary and NNP, livestock grazing in the buffer zone, hunting in NNP, forest fires in NNP are still present, and they are attributed to people other than beekeepers.
- At the beginning, the members of UBNBU were those who used to be illegal honey collectors from NNP. Later, UBNBU started recruiting women and youths. Women perform better in honey transport to collection centers, cleaning, and making candles. Now there are six groups of women and youths at Sector levels.
- Beekeeper cooperatives members take their honey to cooperative collection centers, then honey is taken to processing and selling center at UBNBU’ headquarters at Kitabi.
- The quality requirements for honey at cooperatives level are 20% moisture content for honey, not use smoke during harvesting to preserve honey aroma, honey free from contamination, avoiding metallic containers to store honey to prevent rust, and honey grading. At the union level (processing), the quality requirement is that honey is not cooked – honey is taken out honeycombs by double boiler (with the temperature not exceeding 40°C).
- Honey is sold to local and national markets – supermarkets at Rusizi, Kigali, Musanze – and to tourists. UBNBU targets to export its honey to EU markets.
- Beekeepers in support of RDB participate in forest cleaning by removing plastics from the roads in the forests.
- Lack follow up by stakeholders/partners, poor collaboration between beekeepers and partners, many rainy days in Nyungwe National Park disturbing honeybees’ activities, honeybee colony feeding during rainy period causing beekeepers make extra cost, Rwanda Agriculture Board’s pilot site at Kitabi that uses pesticides, old beekeepers, not enough beekeepers, chimpanzees destroying beehives looking for honey, red ants pests, cooperatives scattered in 5 districts making their supervision difficult, and beekeepers taking beekeeping as a secondary activity are challenges of beekeeping in KUAGA and UBNBU in general.
- Existing honey markets in and outside Nyamagabe District, better organization and functioning of UBNBU and its cooperatives, existing multiple use of honey (food, medicine, candles, etc.), training of beekeepers, local authorities’ involvement in beekeeping, and short distance for honeybees to collect pollen and water in and from the apiary to make honey are the opportunities for beekeeping in KUAGA and UBNBU in general.

Honey Processor (1)

Jean Bosco Uzabakiriho, UBNBU Honey Processor, Kitabi, August 6, 2021

- Next are honey processing techniques and standards from cooperative level to processing level:
 - Harvesting equipment are cleaned.

- Harvested honey is stored in a clean plastic container.
- Smoke is not used in harvesting.
- Old honeycombs are separated from new ones.
- Honey processing is done by double boiler filtering.
- Liquid honey is packaged and labelled in plastic containers.
- KUAGA (and other cooperatives) pay to beekeepers FRW3,000-4,000 per kg of honey.
- Beekeepers sell their honey to their cooperatives, local and external bulking agents, and to local markets.
- To improve the Rwandan beekeeping value chain, there must be strong link between beekeepers and all stakeholders. Also. beekeepers should be trained on beekeeping and business skills. Cooperatives management should also be improved.

Food Quality Inspector (1)

Diogene Ngezahayo, Food Registration and Assessment Specialist at Rwanda Food and Drugs Authority (FDA), Kigali, August 25, 2021

- FDA is a regulatory body – regulating food processed products, pharmaceutical products, and medicines.
- The FDA segment responsible for honey is Food Registration and Assessment.
- Expected quality standards are pure honey (not mixed with added food ingredient), honey must be free from objectionable odor, aroma, flavor, and color, it must not be fermented, it must be from honeybees, it must not be heated, it should have the flavor and aroma derived from the plant origin.
- The only accepted processing technique is filtration.
- As honey processing (including processing) is important in handling honey, the honey value chain is challenged by the fact that sometimes processors fail to check honey quality at arrival. Also, the value chain is challenged by environmental problem (the required biodiversity and conditions for beekeeping are only found in state forests).
- The requirements to export honey to external markets include compositional requirements (sugar and water content), contaminants (heavy metals from the environment, pesticides residues, and veterinary drugs), environmental requirements (clean environment) and labeling.
- Honey processors failing to meet national standards (and thus international standards) can't export honey to international markets.
- Improved national infrastructures, adequate equipment, adequate packaging, more reduced pesticides use may improve the Rwandan value chain.

Representative Conservation (1)

Venuste Nsengiyaremye, Sector Agronomist, Gatare, August 11, 2021

- Beekeepers' training and equipment and modern beehives provision to beekeepers, sensitising beekeepers on conserving biodiversity through avoiding illegal activities in NNP, and sensitising local population on adopting agroforestry trees on their farms to help in increasing biodiversity and boost honey production are the services offered to KUAGA by the Sector in its partnership with UBNBU.
- Honeybees' mortality by pesticides is medium.
- No illegal activities by beekeepers are recorded. Only stealing beehives between beekeepers is recorded.
- The challenges of beekeeping in KUAGA are old beekeepers and less youths, more use of traditional hives with less production, seeming unavoidable use of pesticides in integrated pest management (IPM), poor management of cooperatives (failure to pay loan back causing misunderstanding between beekeepers), honey processing plant located far from the cooperative, and stealing honeybees between beekeepers.
- Opportunities for beekeeping in KUAGA are the existence of large zone with enough biodiversity and the possibility for beekeepers to get quantity and quality honey.
- Improving beekeeping in KUAGA requires organizing beekeepers more and make them like beekeeping, involving many youths, creating a zone of agroforestry trees in the farms surrounding NNP to reduce beekeepers' mortality, increase training, and improve honey marketing (advertisement).

Representative Donor Agency (1)

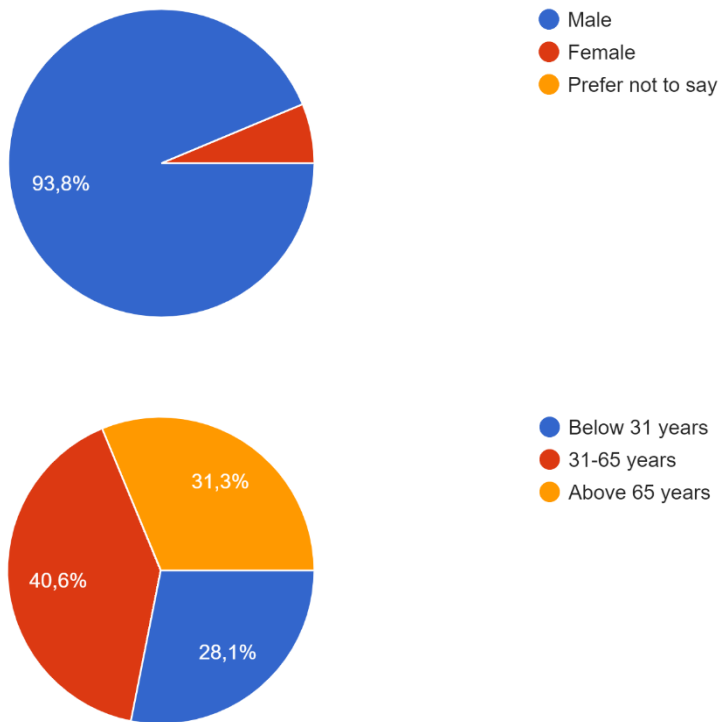
Mediatrice Bana, Nyungwe Forest Conservation Project Director and Sustainable Conservation Finance Manager - WCS, Programme Officer - International Gorilla Conservation Programme, Kigali, August 29, 2021

- The support WCS gives to beekeepers in UBNBU in Nyamagabe District is:
 - Basic beekeeping equipment such as KTB, local veils, bee suits, bee brushes, hives tools, honey containers, tools of establishing of apiary (sheet, metallic stands, etc.).
 - Capacity building in modern beekeeping (beehive installation, beehive inspection, apiary management, honey harvesting and honey processing techniques, methods and techniques for preventing / fighting against bee enemies and bee predators, etc.).
 - Support in marketing of honey and bee products in participation trade fair at District level for example Joint Action Development Forum (JADF)/Nyamagabe District's exhibition, at national level (made in Rwanda exhibition) or at international level (Apitrade Africa Expo).
 - Help them to find out the infrastructure (the honey processing and sales center of UBNBU) in which they must sell their honey production after being processed.
 - Beekeepers are being helped to honey transport from beekeepers' cooperatives to union.

- Build their skills in cooperative administration, organizational, financial, and cooperative management where they received the national cooperative registration certificate.
- Diversify the added bee products value such as Ubuzima bee aromatic oil, Ubuzima candles, Ubuzima cerate, and Ubuzima bee propolis not being fixed on honey only as bee product.
- Partners of WCS in supporting beekeeping in state forests in Nyamagabe District are:
 - PIC (Partners in Conservation) for sustaining financially the beekeeping.
 - RCA (Rwanda Cooperative Agency) for cooperative registration.
 - Nyamagabe District for locating the cooperative and its union.
 - RSB (Rwanda Bureau of Standards) for S-mark.
- Challenges for beekeeping in state forests in Nyamagabe District are the beekeepers still using traditional equipment because they are not sufficient to them and production mainly through traditional method even if they received those equipment, bee pests and bee enemies destroying the beehives in looking for honey, use of pesticide that kills bees, and lack of youths and women to be involved in beekeeping.
- Opportunities for beekeeping in state forests in Nyamagabe District are the abundance of bee forages in apiaries area, the availability of honey production market for beekeepers, and the existing of some bee stakeholders/ partners in beekeeping in Nyamagabe district.
- WCS thinks that regulation of agrochemicals use in some beekeeping area of Nyamagabe District and integration of youth and women into the existing beekeeping cooperatives can improve beekeeping in state forests in Nyamagabe District.

Annex 5 - Questionnaire Results

A) Sex and Age of Respondents



B) Frequency Tables Honey Production and Income

Table 7 – Average amount of honey per hive per season in kg for 3 different beehives used in KUAGA

		Amount of honey per hive per season in kg for traditional hive	Amount of honey per hive per season in kg for langstroth hive	Amount of honey per hive per season in kg for KTBH
N	Valid	32	2	17
	Missing	0	30	15
Mean		3.7031	13.0000	8.3529
Std. Error of Mean		.12472	5.00000	.67487
Std. Deviation		.70550	7.07107	2.78256
Minimum		2.50	8.00	4.00
Maximum		5.00	18.00	15.00

Table 8 – Amount of honey per hive per season for traditional hive

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2.50	2	6.3	6.3	6.3
	3.00	8	25.0	25.0	31.3
	3.50	6	18.8	18.8	50.0
	4.00	11	34.4	34.4	84.4
	4.50	1	3.1	3.1	87.5
	5.00	4	12.5	12.5	100.0
	Total	32	100.0	100.0	

Table 9 – Amount of honey per hive per season for langstroth hive

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	8.00	1	3.1	50.0	50.0
	18.00	1	3.1	50.0	100.0
	Total	2	6.3	100.0	
Missing	System	30	93.8		
Total		32	100.0		

Table 10 - Amount of honey per hive per season for KTBH

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	4.00	1	3.1	5.9	5.9
	5.00	2	6.3	11.8	17.6
	6.00	1	3.1	5.9	23.5
	7.00	1	3.1	5.9	29.4
	8.00	6	18.8	35.3	64.7
	9.00	2	6.3	11.8	76.5
	10.00	1	3.1	5.9	82.4
	12.00	2	6.3	11.8	94.1
	15.00	1	3.1	5.9	100.0
	Total	17	53.1	100.0	
Missing	System	15	46.9		
Total		32	100.0		

Table 11 – Overall total amount of honey per season per beekeeper in kg

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10.00	1	3.1	3.1	3.1
	12.00	2	6.3	6.3	9.4
	20.00	2	6.3	6.3	15.6
	21.00	1	3.1	3.1	18.8
	24.00	1	3.1	3.1	21.9
	32.50	1	3.1	3.1	25.0
	33.50	1	3.1	3.1	28.1
	37.00	1	3.1	3.1	31.3
	38.50	1	3.1	3.1	34.4
	40.00	2	6.3	6.3	40.6
	48.00	1	3.1	3.1	43.8
	50.00	1	3.1	3.1	46.9
	54.00	1	3.1	3.1	50.0
	57.00	1	3.1	3.1	53.1
	58.00	1	3.1	3.1	56.3
	66.50	1	3.1	3.1	59.4
	70.50	1	3.1	3.1	62.5
	72.00	1	3.1	3.1	65.6
	78.00	1	3.1	3.1	68.8
	91.00	2	6.3	6.3	75.0
	92.00	1	3.1	3.1	78.1
	96.00	1	3.1	3.1	81.3
	99.00	1	3.1	3.1	84.4
	102.00	1	3.1	3.1	87.5
	125.00	1	3.1	3.1	90.6
	132.00	1	3.1	3.1	93.8
	144.00	1	3.1	3.1	96.9
	201.00	1	3.1	3.1	100.0
	Total	32	100.0	100.0	

Table 12 – Total income per season per beekeeper in FRW

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	28000.00	1	3.1	3.1	3.1
	30000.00	1	3.1	3.1	6.3
	32000.00	1	3.1	3.1	9.4
	55000.00	1	3.1	3.1	12.5
	60000.00	3	9.4	9.4	21.9
	90000.00	2	6.3	6.3	28.1
	100000.00	2	6.3	6.3	34.4
	110000.00	1	3.1	3.1	37.5
	120000.00	1	3.1	3.1	40.6
	130000.00	1	3.1	3.1	43.8
	135000.00	1	3.1	3.1	46.9
	150000.00	1	3.1	3.1	50.0
	155000.00	2	6.3	6.3	56.3
	160000.00	1	3.1	3.1	59.4
	190000.00	2	6.3	6.3	65.6
	200000.00	1	3.1	3.1	68.8
	250000.00	4	12.5	12.5	81.3
	260000.00	1	3.1	3.1	84.4
	268800.00	1	3.1	3.1	87.5
	350000.00	2	6.3	6.3	93.8
	400000.00	1	3.1	3.1	96.9
	550000.00	1	3.1	3.1	100.0
	Total	32	100.0	100.0	

Table 13 – Total income per year per beekeeper in FRW

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	55000.00	1	3.1	3.1	3.1
	62000.00	1	3.1	3.1	6.3
	65000.00	1	3.1	3.1	9.4
	100000.00	2	6.3	6.3	15.6
	110000.00	1	3.1	3.1	18.8
	122000.00	1	3.1	3.1	21.9
	170000.00	1	3.1	3.1	25.0
	185000.00	1	3.1	3.1	28.1
	190000.00	1	3.1	3.1	31.3
	200000.00	2	6.3	6.3	37.5
	210000.00	1	3.1	3.1	40.6
	250000.00	1	3.1	3.1	43.8
	275000.00	1	3.1	3.1	46.9
	300000.00	3	9.4	9.4	56.3
	350000.00	1	3.1	3.1	59.4
	375000.00	1	3.1	3.1	62.5
	395000.00	1	3.1	3.1	65.6
	420000.00	1	3.1	3.1	68.8
	460000.00	1	3.1	3.1	71.9
	480000.00	1	3.1	3.1	75.0
	520000.00	2	6.3	6.3	81.3
	537600.00	1	3.1	3.1	84.4
	540000.00	1	3.1	3.1	87.5
	600000.00	1	3.1	3.1	90.6
	750000.00	1	3.1	3.1	93.8
	790000.00	1	3.1	3.1	96.9
	980000.00	1	3.1	3.1	100.0
	Total	32	100.0	100.0	