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# Beekeeping Productivity: Why is the Beekeeping Sector less Productive in Tanzania?

Nicholaus Bhikolimana Tutuba[1], Consolatha Kapinga[2]

[1]Mzumbe University, School of Business, P.O. Box 6, Mzumbe, Morogoro - Tanzania

[2]Ministry of Natural Resources and Tourism P.O Box 1351, Dodoma - Tanzania,

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**Abstract**

Why is the beekeeping sector in Tanzania less productive? The average annual productivity of a bee colony is estimated to be 15 kgs and 2 kgs of honey and wax respectively. But the condition is Tanzania scandalous: Why is it the case? The study analyses the potential challenges to the underperformance of bee colonies in Tanzania. This study used an experimental design, and qualitative approach to analyze the productivity of bee colonies in Tanzania. The sample was selected through a purposive approach and data were collected through interviews and observation. The Current-Tree-Reality of the Thinking Process techniques was used to identify constraints that limit the productivity of the beekeeping sector in Tanzania. Size of the colony, bee species, availability of fodder, technology, knowledge and skills, and post-harvest losses were constantly mentioned as underlying factors limiting productivity in the beekeeping sector. Other factors include occupancy rate, human activities like farming/agriculture, bee diseases, and pests and predators. We concluded that the size of the colony, availability of fodder, and bee species are the limiting factors for colony productivity in Tanzania. A study on bee breeding, colony selection, and productive bee species is suggested. The study provides empirical evidence and theoretical understanding of beekeeping, colony productivity, and theory of constraints to researchers, beekeepers, and policymakers.

**Keywords:** beekeeping, colony productivity, Theory of Constraints, and Tanzania

## 1. Introduction

Beekeeping, or apiculture, is the art and science of raising and harvesting bees to collect honey and other hive products like beeswax (Cadwallader, 2011). The products from the activity include honey, live bees or bee colonies, and beeswax (United Republic of Tanzania [URT], 1998); propolis, bee venom, royal jelly, brood, bee soup, and queen bee (The Beekeeping Act, 2002; Tutuba & Vanhaverbeke, 2018); bee-collected pollen and pollination services (Abdu & Al-Samie, 2012; Food and Agricultural Organization [FAO], 2012). Promoting the productivity of beekeeping and enhancing the commercialization of the products provides economic value to beekeepers and society. Therefore, we define beekeeping as a sustainable management of bees to gain its social, ecological, and economic benefits.

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Whilst the available multi-flora and forest vegetation provide an ideal bee fodder and hence a favourable environment for beekeeping, its purported production potential in sub-Saharan Africa remains relatively untapped. For example, Kenya and Uganda harvest only 14.6 percent and one percent of the annual estimated production potential of honey respectively (Amulen et al., 2017). While Tanzania captures only seven percent and three percent of its estimated production potential of honey and beeswax respectively (Pinda, 2014; Tutuba et al., 2019a). Moreover, Africa's share of the world's honey and beeswax trade remains low despite its production potential for the products. Likewise, productivity, quality of products, and the management of bee colonies remain meager (Tassinari et al., 2013; Tutuba & Vanhaverbeke, 2018) regardless of the high value of apiculture products (International Trade Centre [ITC], 2015; Tutuba et al., 2019b; Tutuba, 2021a) and the recognized social, economic, and ecologic benefits of the sector. If this is the case, why is beekeeping activity in Tanzania less productive? What is limiting bee colonies to produce honey and wax to their full capacity? This study analyses potential factors that affect colony productivity in Tanzania.

Following this introduction, this study is organized as follows: first, we present the theoretical understanding of key concepts and variables of the study, followed by the approach and methodology. Then, we present the main findings. Lastly, we present the discussion and conclusion.

*1.1Beekeeping in Tanzania*

The World Bank Group (2011) states that Tanzania has 35 million hectares of forests, it covers about 40 percent of the land in Tanzania (Msamula et al., 2016; Tutuba, 2021b). This endowed multi-flora vegetation is exceedingly favourable for beekeeping; It makes Tanzania among the countries with the highest potential for producing bee products (Tutuba et al., 2019a; Tutuba & Vanhaverbeke, 2022). The estimated production potential of bee products is about 138,000 tons of honey and 9,200 tons of beeswax per annum (ITC, 2015). In Africa, Tanzania is the second-largest honey producer, after Ethiopia, and the tenth globally (Nyatsande et al., 2014; Ismail et al., 2021).

In Tanzania, beekeeping has been practiced across many generations (Tutuba & Vanhaverbeke, 2018). It is often promoted as a rural economic activity as it integrates agriculture (FAO, 2012; Tutuba, 2021b) without competing for resources (Bee for Development, 2006; Tutuba & Vanhaverbeke, 2018; Tutuba & Tundui, 2022). Similarly, Kugonza (2009) and Nyatsande et al., (2014) argue that beekeeping conserves the environment, is inclusive and has relatively lower start-up costs compared to other rural economic activities like farming, fishing, and animal husbandry. Therefore, beekeeping in Tanzania is a traditional honey hunting (Guyo & Solomon, 2015) and rural-based activity (Tutuba et al., 2020; Tutuba, 2021b). It is mostly practiced by rural communities (Nyatsande et al., 2014; Tutuba, 2021a) through local means in which management of bee colonies is critical (Tutuba & Vanhaverbeke, 2018; Tutuba & Msamula, 2020). The sector is less invested as people perceive it not as a commercial activity worth investing in. The beekeeping technology is at the inception stage as beekeepers prefer local hives and use local harvest, processing, and trading means. Also, the sector is less productive (Tutuba, 2022) quality of honey and quantity produced are not sufficient to feed the required amount in

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the market (Tutuba et al., 2020; Tutuba& Msamula, 2020). It is important then to transform the sector into a commercial and more productive activity.

*1.2 Beekeeping productivity in Tanzania*

Productivity is the efficient use of resources; an ability to transform resources to produce anticipated outputs. It is the measure of input-output ratio: achieving more for less input connotating highly productive. Furthermore, productivity is the ability to produce or achieve more with the same amount of resources (Tutuba & Tundui, 2022); attaining higher output from the same level of inputs. Al-Ghamdi et al., (2017b) defined the productivity of beekeeping as a measure of yield per colony. But, Tassinari et al., (2013) argued that beekeeping productivity includes the increasing numbers of beekeepers, a variety of bee products, and high returns in the beekeeping business. The former considers productivity at the bee colony level while the latter considers the measure of productivity at the sector level. Therefore, we adopt the former as we consider beekeeping productivity as the volume of hive products (honey and beeswax in this case) produced by the bee colony with given inputs or resources.

In the beekeeping activity, four inputs are important and necessary: beekeeping resources (people/beekeepers, technology, and skills), bees, fodder/flowers, and water (Abdu & Al-Samie, 2012; Al-Ghamdi et al., 2017a, b; Tutuba & Vanhaverbeke, 2018). Beekeeping resource ensures proper management and control of the beekeeping value chain activities. Bees are necessary and important because they are the producers without which nothing will be produced. Flowers provide the necessary and basic ingredients, nectar and pollen, to make honey and wax. Water is useful in cooling, controlling the humidity of the colony, and feeding the larvae. Also, bees need water for digestion and dilution of stored honey that has been crystallized. Therefore, the existing potential of beekeeping inputs provided an excellent opportunity to promote beekeeping and hence increase productivity.

Despite the existing production potential in the beekeeping industry in Tanzania bee colonies are still less productive. Different studies (Tutuba & Vanhaverbeke, 2018; Ismail et al., 2021) indicated that productivity is still low and beekeeping markets are still under-served (ITC, 2015; Tutuba et al., 2020; Vanhaverbeke et al., 2021). That is, there is a lower yield per colony than predicted by scientists (MMA, 2012; Tutuba, 2021b). For example, the National Beekeeping Policy (URT, 1998) suggests average annual production of 10 kg of honey and 1kg of beeswax for a standard commercial hive. But, data from the Ministry of Natural Resources and Tourism show average annual production of less than 1 kg of honey per bee colony.

> *"... in the year 2017, the Tanzania Forest Services collected 6,519kgs of honey and 218kgs of beeswax from 143 apiaries containing 9,448 hives"* (Jamuhuri ya Muungano wa Tanzania [JMT], 2018, 27).

Nevertheless, if Tanzania has a high potential to foster beekeeping activities as it has vast of all the hive productivity inputs, why is the sector less productive? If the bee colonies are increasing, why is the production of hive products decreasing? What are the factors constraining colony productivity in the beekeeping industry in Tanzania? This study, therefore, uses the Theory of Constraints to analyze the factors responsible for low productivity in the Tanzanian beekeeping

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sector. Colony productivity is limited to the production of honey: The average annual production or harvest of honey per colony.

*1.3 Theory of Constraints*

The Theory of Constraints (TOC) has been commonly known as a management philosophy that aims to improve productivity (Sumatupang et al., 2004; Avraham, 2009). It does so by focusing on "a link" [factor] that prevents "a system" from achieving a higher level of performance. The theory views a system as a chain composed of strong symbiotic links [interdependent and interconnected activities] which contribute to the system's goal (Goldratt & Cox, 2004; Avraham, 2009). Consequently, if the system fails to achieve its goal, the main reason will be the underperformance of at least one of the links. The underperforming link is called the weakest link or a constraint of a particular system.

> *"A constraint is any element or factor that prevents a system from achieving a higher level of performance with respect to its goal"* (Watson et al., 2007, 391).

Therefore, if that system wants to improve its performance, the first step must be to identify its weakest link. Then, the rest of the system links will be restructured around the identified weakest link. To identify the weakest link in a system, TOC uses a focusing technique through the cause-and-effect thinking process (Dettermer, 2000; Goldratt& Cox, 2004). This process is described through three questions: *What to Change, what to Change into, and how to cause the Change?* (Rahman 2002; Watson et al., 2007; Avraham, 2009). However, since the purpose of this study is to identify factors that limit the productivity of a bee colony, we focused on the first question: what to change?

In the beekeeping industry, scholars have pointed out several constraints that limit the performance of the bee colony. Some constraints include human activities like farming and casual burning (Melhim et al., 2010; ITC, 2015), poor management of the bee colony (Al-Ghamdi et al., 2017a), and climate change (Melhim et al., 2010). Other factors are bee species (Hilmi et al., 2012), absconding and swarming (Kinati et al., 2012; Birhan et al., 2015), drought (Guyo & Solomon 2015), shortage of bee forage and rainfall (Abebe & Ranjitha, 2011; Birhan et al., 2015). Also, the death of colonies and reduction of honeybee colonies (Abebe & Ranjitha, 2011), low plant species richness (Kimaro et al., 2013), and low occupancy rate (Tutuba & Vanhaverbeke, 2018). However, within the TOC, a core principle is that there are not tens or hundreds of constraints, but a few or at least one because some constraints are only symptoms or output/results of another constraint. For example, drought and shortage of fodder are symptoms of environmental degradation or negative externality of human activities. Correspondingly, declining in colony size could be a result of poor harvesting, predators and diseases, dearth season, and prolonged drought. Therefore, it is important to understand the origin of the underperformance of the bee colony so that a real constraint and no symptoms can be identified.

Furthermore, TOC points out that a constraint is external when supply is higher than demand and internal when demand is higher than supply (Tutuba & Vanhaverbeke, 2018; Goldratt & Cox, 2004).

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> *"... constraints generally take one of three forms: physical (resource capacity less than demand), market (demand less than resource capacity), and policy (formal or informal rules that limit the productive capacity of the system)"* (Watson et al., 2007, 391).

Since, the demand for beekeeping products in both local and international markets is higher than what the system can provide (ITC, 2015), therefore, productivity is affected from an internal perspective. Therefore, this study was limited to internal constraints.

## 2. Method

This qualitative action study was conducted for four years, from the year 2017 to 2021, in seven purposively selected regions of Iringa, Shinyanga, Tabora, Kigoma, Singida, Morogoro, and Kilimanjaro. The regions are considered to be the most potential for beekeeping, hence ideal for study. A total of 160 bee colonies from 10 beekeepers and11 producer groups were purposively sampled. Also, 12 experts from tertiary education, Tanzania Forest Services (TFS), and the government were contacted during the study.

Data collection were done through personal interview and observation (Creswell, 2009; Yin, 2018), and data were collected until saturation. Two trials/experiments were also conducted in Morogoro and Singida to confirm some observed factors that limit colony productivity. Comparative production of honey and beeswax to selected bee colonies has been experimented with. The purpose of the study was introducing to the sample before data collection. Whenever possible voice recorded, photos, short clips, and note-taking strategies were used to capture information.

The Current Reality Tree (CRT) of the Thinking Process (TP) approach (Avraham, 2009; Goldratt and Cox, 2004) were used for data analysis. The cause-and-effect technique (Watson et al., 2007) of the CTR was used to sort out the factors that were symptomatic rather than core constraints. The findings are presented in the next section.

## 3. Findings and discussions

This section presents the findings and discussion on the cause-and-effect technique regarding the impact of the factor on colony productivity of beekeeping in Tanzania.

### *3.1 Honeybee diseases, pests, and predators.*

Respondents confirmed that they had observed ants, wasps, and spiders inside their beehives. Also, they saw their honeybee colonies confronted with ants, hive beetles, and wax moths. Also, during the inspection, snakes and lizards were seen inhabiting the hives. Moreover, humans are reported to be the most dangerous predator due to fire, thieving, and poor harvesting.

The cause-and-effect approach shows that diseases pests and predators have resulted in low productivity due to destructed bee colonies and apiaries: death of the bees and brood, preventive hive colonization, and decreasing size of the bee colony affect colony productivity. Conversely, pests, diseases, and predators are caused by inadequate knowledge and skills on pests, diseases, predators' control, and poor apiary management practices. For example, proper hive inspection

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and management can control available pests and predators, this should not be a problem for colony production.

*3.2 Swarming, absconding, and migration*

Swarming is a natural process where a colony divides to make new colonies. Absconding and migration is the situation where a colony un-inhibits its habitat. It happens mostly when bees are disturbed, do not feel safe, and lack fodder. The study findings show that both swarming and absconding are available in the study area. However, swarming affects the production of honey because during the colony division the swarm eats a lot of honey and leaves behind a small colony. Similarly, an absconding colony leaves nothing behind except empty combs.

The study findings, however, show that absconding and migration of honeybee colonies are mostly caused by wildfire, poor harvesting practices, and pests and predators. For example, open fire instead of smoke is mostly used to control bees during harvesting, and also, all combs are taken out of the hive. This practice kills a large part of the colony and also leaves the colony without food. This situation disturbs the colony and hence it absconds.

Also, through observation, it is revealed that swarming is caused by a lack of appropriate knowledge and skills in apiary management. If apiaries are well managed, then all the factors that because absconding can be controlled. Also, swarming can be controlled. Therefore, appropriate beekeeping knowledge and skills, and proper apiary management practice can be used to effectively reduce the damage caused by these bee behaviours.

*3.3 Bee species*

In the study area, all beekeepers own local bee races. There were neither crossbreeds nor imported bee races found. The local races are preferred mainly due to their adaptability to the environment and local hive types. Also, beekeepers do not struggle to get bee colonies, they hang the hives after baiting and wait for the swarm to colonize.

Observations made from three apiaries of Kigoma, Singida, and Morogoro, identified two bee races: *Apis mellifera manticore and Apis mellifera liforea*. We observed the production abilities of the races for two consecutive seasons and found that the latter specie is more productive than the former. Similarly, the number of combs and colony size in hives comprising *the liforea* specie exceeded that of the *manticore* specie. This finding confirms the finding from other studies (Tassinari et al., 2013; Al-Ghamdi et al., 2017b) which show that bee races have a significant contribution to colony productivity. Moreover, experts suggested the following bee traits desirable for beekeeping: gentleness, resistance to disease and bad weather, and low tendency to swarm and abscond. Also, highly productive, calm on combs when the colony is worked, and little brood rearing during dearth periods. Therefore, keeping other factors constant, the type of bee race has a direct effect on colony productivity. Beekeepers must own selected races that produce a high yield of honey.

*3.4 Bee fodder*

The study findings show that a decline in fodder caused a decline in both the number and size of colonies. Also, harvesting seasons were affected. One group in Kilimanjaro (Same District)

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reported a decline in harvesting season from three to one due to a decline in fodders. They decided to implement the planting for the bees' project to restore the fodder, and the hive productivity improved. Other studies (Birhan et al. 2015; Kimaro et al., 2013) had the same observation. *"... shortage of bee forages are the major productivity challenges encountering the beekeeping subsector* (Al-Ghamdi et al., 2017b:1087). They suggested supplementary feeding as a management practice to improve fodder and increase colony efficiency.

Also, productivity is affected by the shortage of fodder because nectar and pollen from plants are the main sources of honey. Moreover, the decline in fodder leads to a decrease in the size of the colony since bees will be controlling food, and hence the queen will reduce the laying rate. If the fodder problem persists, the colony migrates. Therefore, if beekeepers want to improve colony productivity, they should ensure the availability of nectar and pollen sources.

*3.5 Colony size*

In this study, some groups reported a decline in both the number and size of colonies as a result of swarming and bee deaths. In Morogoro, the decline in colony size was reported as a result of bee death from palm wine. Many bees die either in containers as a result of sinking or in the hives due to the sucked wine. We also observed that in areas where horticulture is high, bee colonies and beekeeping activities are limited. Colony decrease was also reported in Tabora and Kigoma due to poisonous materials coming from polluted forage.

This has affected colony productivity because when colonies are declining, foraging decreases. Production of harvestable amounts of extracted honey and other hive products requires colonies that are strong and do not swarm. Therefore, beekeepers need to have appropriate skills for colony management, site selection, and apiary location. Supers of drawn comb or foundation can be added as needed. Colonies can be strengthened by keeping a healthy and young queen, controlling swarms, colony unification, and extra feeding.

*3.6 Beekeeping inputs*

All things being equal, the use of advanced beekeeping inputs increases productivity. For example, bees will produce more extractable honey than they will honey in the comb for you to harvest. Extracted honey is more economical to produce since combs used for extracted honey can be reused over several seasons.

The study findings show that the productivity of beekeeping is constrained by access to quality beekeeping inputs. It was found that protective tools, beehives, and harvesting and processing equipment are the most beekeeping inputs constraining the productivity of beekeeping in the area. For example, the study findings show that about 75% of beehives used are local ones. And those who are using top-bar hives, most of the hives have no queen excluder. Also, some beekeepers couldn't harvest for about two years because they were lacking protective suits.

Similarly, we observed that during harvesting, processing, and packaging most beekeepers use local types of equipment and tools. For example, generally, beekeepers use recycled containers during harvesting, processing, storage, and packaging. Therefore, productivity becomes low because of post-harvest loss.

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> *"Using traditional hives affects our productivity in several ways. The size of the hive, the layout of the combs, and the free movement of the bee queen affect the volume of honey. For example, our association has 4350 beehives. But last season we got about 2,500 Kg of honey. This would have been different if we had good hives. Also, we don't have good honey extractors. Extracting by hand squeezing leave so much honey in the combs. – MWAKILA, Kigoma"*

Through the TP, it is revealed that beekeepers are not investing in modern beekeeping tools and equipment for some reasons: Firstly, the willingness of beekeepers to invest in beekeeping inputs. Secondly, lack of enough capital to invest in beekeeping inputs. Thirdly, lack of appropriate knowledge on the importance, efficiency, and effectiveness of using appropriate inputs in beekeeping. We draw this conclusion after the observation that, despite commercial inputs being available in the market, beekeepers were reluctant to acquire them. Some beekeepers are not even informed that such tools and equipment are available in the market. It is, therefore, important to create awareness about the significance of using commercial tools.

*3.7 Knowledge and skills*

Experts in the industry confirmed that limited beekeeping knowledge and skills, and over-reliance on local experience have limited the progress of the sector. The industry is less productive because beekeepers have limited knowledge, skills, and experience to manage bee colonies and apiaries.

> *"...most of our beekeepers are poor rural people who depend on their indigenous inherited knowledge and experience in beekeeping. This has affected not only the resistance to technology adoption but also failed to improve the quality and productivity of the sector" Hon. Mizengo P.K. Pinda, Prime Minister (2007 – 2015) of the United Republic of Tanzania, and a Beekeeper were interviewed on March 7, 2017.*

> *"I have 20 hives, 16 are colonized. But I have not managed to harvest because I have neither experience nor expertise to harvest. I have consulted an experienced beekeeper in my locality but he managed not to harvest to date"* Beekeeper in Morogoro, August 2018

This indicates that beekeeping knowledge is very limited, and also beekeepers are not experienced enough. They mostly rely on traditional knowledge and skills inherited from the localities. Similarly, study findings show that most beekeepers have limited expertise in core activities involved in beekeeping. Beekeepers capture colonies by sitting in a hive on a tree and waiting for the bees to enter and occupy the hive. This should not be the case. They need to know what they should do to improve the occupancy and hence productivity. Also, they should plan on how to work in the whole beekeeping value chain so that they can be more productive and profitable.

## 4. Discussion

From the findings, seven factors have been pointed out to be the weakest link that prevents the colony from being productive. However, using the cause-and-effect technique, it can be observed that, the most constraining factors are symptoms and outcomes of another factor. For example,

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colony size is affected by poor harvesting and swarming. Absconding is caused by poor harvesting, pests, and predators: which are also caused by inappropriate apiary and colony management. Also, post-harvest losses and poor quality is caused by a lack of beekeeping tools and equipment. Therefore, using a thinking tree process of the theory of constraints shows that, colony size, bee species, and fodder are the most important factors towards colony productivity.

Moreover, beekeeping is a knowledge-intensive activity. It requires appropriate knowledge and skills to be productive. In commercial beekeeping, appropriate knowledge and skills on queen rearing, apiary management, harvesting, processing, and handling are inevitable; lack of which leads to colony inefficiencies, and low-quality products.

## Conclusion and implications of the study

Production of harvestable amounts of extracted honey and other hive products requires good forage, strong colonies which do not swarm, and appropriate knowledge and skill. Therefore, colony size, bee specie, availability of fodder, and beekeeping management practices are the core factors for improved productivity of beekeeping in Tanzania. Also, beekeeping technology i.e., the use of modern beekeeping types of equipment and tools is important in improving productivity.

Despite low colony productivity, beekeeping remains a profitable and remunerative enterprise in Tanzania. It is relatively less labour intensive and capital demanding compared to other rural economic activities like agriculture. Moreover, it plays an important role as an additional source of income generation and diversification for beekeepers.

### *Limitations and areas for further studies*

The study uses the TOC which aims at answering three questions: What to change? What to Change to? and How to Cause the Change? However, this study was focusing on analyzing the factors responsible for low colony productivity in Tanzania. It was therefore limited to answering the first question only. In this regard, future studies may consider answering the remaining two questions of the TOC. In Addition, this study observed that productivity can be improved by using appropriate technology, hives in particular. Therefore, a comparative study to analyse productivity differences between commercial hives is equally important. The ongoing debate on appropriate hives to be adopted in Tanzania cement the need for such a study. Consequently, since the study was limited to the qualitative experimental case study design, we suggest for a comparative experimental study. It will provide an opportunity to experiment with productivity differences for the same colony in different hives and different fodder.

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