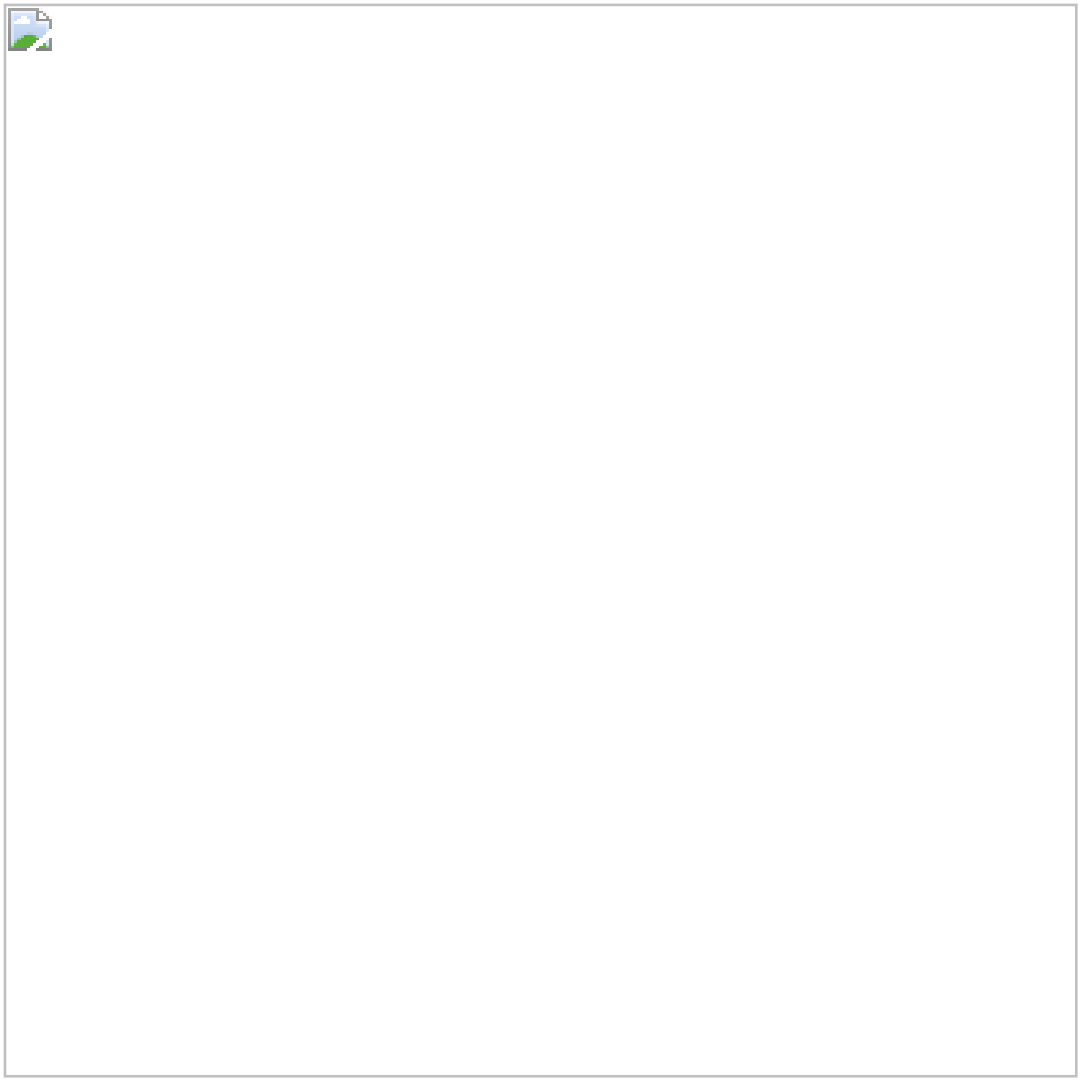

# Is Beekeeping Commercially and Environmentally viable? an assessment of the adoption of hanging frame beehives in semi-Arid Area of central Tanzania

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# Is Beekeeping Commercially and Environmentally viable? an assessment of the adoption of hanging frame beehives in semi-Arid Area of central Tanzania

**Charles Felix Chami[1], Emma Teresa Liwenga[1], and Catherine Aloyce Masao[1]**

**Abstract**

In Tanzania, beekeeping contributes to the natural ecosystem growth and livelihood of rural poor people. This activity provides income and ensures food security as generated from bee products. This paper explores adoption of hanging frame beehives and its implications for livelihoods and forest conservation in the Chemba district, Dodoma region. Data was collected through interviews and Focus group discussions using structured and unstructured questionnaires. Quantitative and qualitative information were analysed through a statistical package SPSS version 16 and content analysis. The research revealed that 37.9% of the beekeepers obtain an average income of above 50,000 (21.57 USD) Tshs per year from using hanging frame beehives and 36% of other beekeepers obtain less than 50,000 (21.57 USD) Tshs per year from using log beehives. The average income from beekeeping indicates that the communities are not yet receiving reasonable income to emphasise the activity as a main source of income. Furthermore, traditional beekeeping has remained a preferred technique, thus jeopardising the forest ecosystems around the areas. Implying that adoption of hanging frame beehives is still to ensure forest conservation. The study recommends that the government, in collaboration with private stakeholders, should plan to improve beekeeping by introducing improved beehives that can be affordable to rural communities and ensure forest conservation.

**Keywords**

Tanzania, Chemba, Forest Conservation, Beekeeping, Beehives

## Introduction

Most countries and development agencies attempt to collectively address the two problems of extreme poverty and degraded forests. Currently, conservation methods aim to provide incentives to local communities by linking livelihood and economic growth with the conservation of natural resources (Roe et al., 2015). Beekeeping as a livelihood project is an important example of related development and conservation approaches (Wagner et al., 2019). Beekeeping plays an essential role in conserving natural forests (Wagner et al., 2019). It also provides the rural poor people with other economic earnings from the forest resources as they have a strong interest in protecting trees that are the source of their honey (Nyau et al., 2013; Ricketts & Shackleton, 2020). In Africa, beekeeping is still operating in the old traditional method, particularly log beehives (Serda et al., 2015). Log beehives are constructed from the logs of a tree for keeping bees. The beehives are the oldest method operating for a thousand years (Keshlaf, 2017). The use of logs as hives reflect the reminiscences of the ancient bee knowledge, descended traditionally through generations (Kasangaki et al., 2014). Due to

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poor management practices, the log beehives have been linked to low honey production and environmentally unfriendly (Beyene & Verschuur, 2014; Kuboja et al., 2016; Seyoum & Anja, 2018). For instance, in Ethiopia, where most of her areas are the potential for beekeeping activities, the farmers have not benefited from the beekeeping subsector because of traditional beekeeping systems (Seyoum & Anja, 2018). Most Ethiopian beekeepers are small-scale producers practising traditional beekeeping (Gratzer et al., 2021). Also, in Burkina Faso, traditional beekeepers use useful plant parts like tree bark and logs to construct beehives. These methods are environmentally unfriendly as they are against the conservation efforts of the forests (Schweitzer et al., 2013). Therefore, the above facts create a need for modernisation (Miklyaev et al., 2014).

Hanging frame beehives are now being advocated in Africa to replace log beehives to promote sustainable honey production and conservation of natural forests. The hanging frame beehives also known locally as 'top bar' are fixed wooden hives with accurate or critical measurements of the top bar width so that combs will be aligned rightly (Kasangaki et al., 2014). In Tanzania, beekeeping is a traditional and rural-based activity by local communities. In 1998, the National Beekeeping Policy was established under the Ministry of Natural Resources and Tourism (MNRT, 1998). In integration with the 2002 beekeeping act, the National Beekeeping Policy was established to support various efforts such as training, extension services, and improved beekeeping technology to enhance the beekeeping sector to contribute to local community development and forest conservation, specifically in rural areas. These various efforts were established to reveal the socio-economic significance of beekeeping and ensure its commercialisation. Despite these interventions to enhance beekeeping production, the challenges persist in rural communities: Most beekeepers prefer using local beehives such as bark or log hives to frame beehives. However, these traditional methods are of low productivity and poor quality of honey.

Furthermore, in recognising the potential of their environment in beekeeping, people in Chemba District have agreed to adopt 1250 hanging frame beehives with various specialist beekeeping groups (The United Republic of Tanzania, 2019). The hanging frame beehives were adopted as a new technology to effectively increase income and conserve natural forest and bee colonies. However, despite this adoption, it is unclear whether the hanging frame beehives have commercially brought profit and conservation of forest resources. Therefore, along with this background, the study was set to determine whether hanging frame beehives in Chemba District were commercially and environmentally viable to ensure sustainable livelihood and forest conservation.

## Methods

### Study Area

This study was conducted in the Chemba district in Tanzania's Dodoma region (Figure 1). The district is found within latitude 5° 20' 16" S and longitude 35° 41' 29" E. The study areas included four villages: Mwailanje, Gwandi, Igunga and Kwamtoro (Figure 1). Dodoma region is among the semi-arid areas of central Tanzania, which have a high potential for beekeeping. Chemba district is one of the seven districts of the Dodoma region. The district is generally semi-arid due to low and erratic rainfall (The United Republic of Tanzania, 2019). Rainfall is one of the important climatic factors in the district. The region has a single rainy season between November and December or April and May (The United Republic of Tanzania, 2019). According to the 2012 Tanzania population census, Chemba district had a total population of 235,711 people (Tanzania, 2013). Geographically the district is located northwest of Dodoma through a highway road from Dodoma to Kondoa. It covers an area of 7289.7 square km. The district comprises of Swagaswaga game reserve with 871 square km, consisting of thickets, acacia, and shrubs, which are the habitat of different animal species, including elephants.

### Data Collection

This study used purposively sampling and focus group discussions on targeting only the beekeeping farmers in the selected villages of Mwailanje, Gwandi, Igunga and Kwamtoro. Before the beginning of data collection, we obtained permits from the district and village leaders. Our study used a mixed approach, including quantitative and qualitative data sources. We conducted focus group discussions comprising 6–10 people in each study village to make a total of four focus groups. A total of 30 members participated. We held mixed discussions with men and women, considering the nature of beekeeping in the country, in which few women are involved in beekeeping production (Silvano & Kweka, 2021). Group members were selected based on age, gender balance, knowledge and experience in beekeeping. During the discussions, participants were asked about the contribution of hanging frame beehives and log beehives to livelihood regarding honey production, income level and natural forest conservation. Also, information on the challenges and efforts to increase the adoption of hanging frame beehives to improve livelihood and ensure natural forest conservation was obtained.

Lastly, we conducted a household survey using a semi-structured questionnaire to collect quantitative data. The survey was conducted between September and October 2020 and involved 74 respondents from the four study villages. The respondents were selected based on sampling intensity of 5% of households' total number in a study area (Krejcie & Morgan, 1970). With support from the district beekeeping and forest officers, four villages were purposively selected based on the presence of *Apis mellifera* (honeybee) species, beekeeping production with the use of log and hanging frame hives (Table 1), environmental conditions, particularly natural forests, and last, their infrastructural accessibility.

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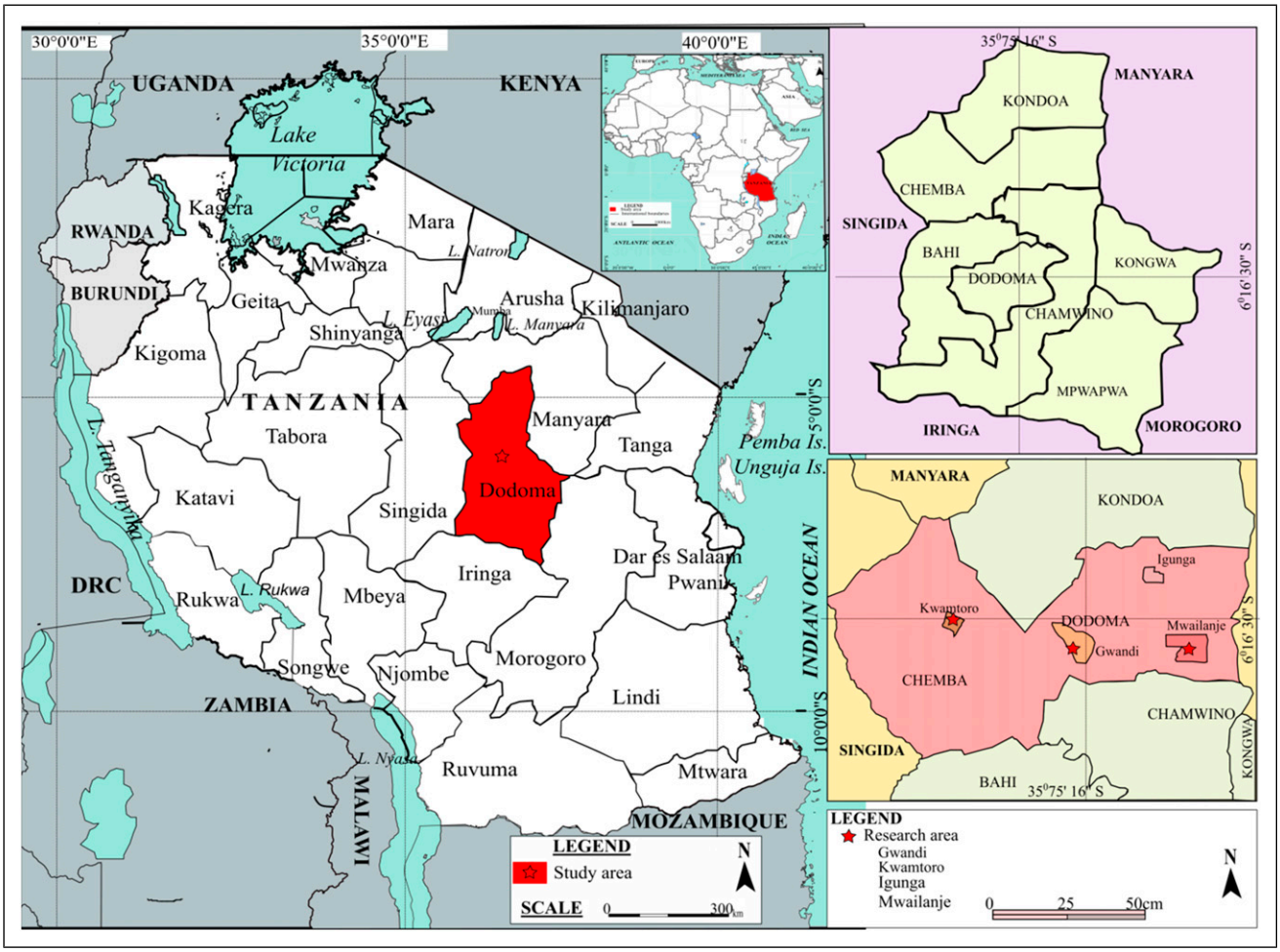


**Figure 1.** A map of Tanzania showing the locations of kwamtoro, Igunga, Mwailanje, and Gwandi in Chemba district, Dodoma..

**Table 1.** Advantages and disadvantages of log and hanging frame beehives.

| Log Beehives | | Hanging Frame Beehives | |
|---|---|---|---|
| Advantages | Disadvantages | Advantages | Disadvantages |
| Materials for making these hives are easily available by cutting trees | Very destructive to the trees contributing to forest destruction | Allow beeswax production compared to log beehives | Always expansive than log beehives |
| Less capital is needed to purchase or make these hive types | Hard to manage (inspect, harvest, etc.) when needed. Hence, low quality and quantity of bee products | Honey production is mostly high compared to local beehives. A well-managed hive can produce 25 kg–50 kg | It May have poor ventilation or other problems if not built properly |
| Less skill is required to make these hives | They are not long-lasting. Most get destroyed in one harvesting period | Allow management such as inspection, harvesting unlike log beehives. Hence, good for conservation of bee colonies and ecosystem | It may not have extension services for this type of beekeeping |

During the household survey, male and female household head beekeepers were included. These beekeepers only recognise and use *A. mellifera* (honeybees) for their honey production. The honeybees *Apis mellifera* is one of the most successful species in the animal kingdom. It is highly productive and can adapt well in different climatic conditions (Vaziritabar & Esmaeilzade, 2016). They were further requested to provide information on the nature of beekeeping

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activities, including the type of beekeeping, beehives and their production trend. Also, information on products and income obtained from the types of beehives and the role of beekeeping in ensuring the conservation of natural forests. We conducted the interviews in Swahili to easily help the respondents understand the questions.

### Data Processing and Analysis

Quantitative information from the structured questionnaire was coded and analysed using the IBM SPSS Statistics version 16. Most of our analysis was based on descriptive statistics such as frequencies, percentages and means. Descriptive statistics were used to determine the types of beehives in the study area. Also, it was used to characterise the income obtained from beekeeping products to contribute to the household economy. Also, it was used to establish frequencies and percentages of the influence of beekeeping on forest conservation.

We analysed qualitative information using the content analysis method and grouped open-ended responses according to themes. The content analysis involved techniques in which verbal discussion components from different respondents were broken into the smallest meaningful units of information, such as respondents' perceptions, values and attitudes. The content analysis included data collected from Focus group discussions while the field observation and summaries were made.

### Ethics consideration

The Tanzania Commission for Science and Technology (COSTECH) granted the permit to conduct this study through the University of Dar es Salaam (UDSM). We later presented the research permit to respective region, district, ward and village leaders. Before the interviews, we obtained the verbal consent of all respondents to ensure their willing participation. All respondents' names are anonymous to maintain confidentiality.

## Results

### Types of Beekeeping Technology

The study shows that most beekeepers (59.5%) $n = 74$ in the Chemba district still practice traditional techniques including the use of log hives. Very few (8%) respondents indicated that they had adopted hanging frame hives as a modern beekeeping technique in the areas. Moreover, 32.4% of the beekeepers sustained both log and hanging frame hives. Table 2 shows different beekeeping technologies found used in the study area. In terms of beehive technology preferences, it was noted that most beekeepers own log beehives. Log beehives were largely owned, with a majority (44.6%) having more than 10 beehives (Table 2). Besides, these log beehives were constructed from tree log or bark materials easily available from the natural forest resources. Therefore, they cut and destroy natural forests around their villages, affecting the natural forest ecosystem (Figure 3). The results reveal that despite awareness and use of hanging frame hives, traditional beekeeping is largely practised in the area, as there are enough resources for hive construction and management compared to modern technology, which is expensive in terms of purchase, equipment, and management.

### Economic Earnings from Beekeeping in the Study Areas

The analysis of finances reported by the interviewed respondents in the study areas has indicated that the average annual earnings from beekeeping were slightly above 50,000 TZS (Table 3). Results showed that a total of 37.9% of the frame hives beekeepers received more than 50,000 (21.57 USD) Tshs sales of bee products per year, while majority (36.5%) of the log hives beekeepers received less than 50,000 (21.57 USD) Tshs per year (Table 3). This situation is caused by different levels of production and management practices of both log and hanging frame beehives. Hanging frame beehives involve good production and management practices. These practices, such as hive inspection, cleaning, filtering, and using smokers during honey harvesting, ensure great quantity and quality of honey.

### Contribution of Beekeeping to Natural Forest Conservation

When asked about the role of beekeeping in forest conservation, 95% of the respondents revealed that traditional beekeeping practices contributed to cutting down trees. Traditional beekeepers use bark and log hives with local apiary management. Despite a low rate, this method destroyed the natural forest ecosystem contributing to the impact of other economic activities such as charcoal production in the area. Also, poor harvesting methods such as the use of fire may cause wildfires affecting the natural forest. However, the majority (51.4%) of the beekeepers agreed that they use modern ways of apiary management. In supporting that, during field observation, it was found that apiaries with hanging frame beehives were in a good environmental condition with a lot of vegetation cover compared to apiaries with log beehives (Figure 2). Therefore, hanging frame beehives have been essential but not attractive enough to influence natural forest conservation.

## Discussions

### Types of Beekeeping Technology

Our study found out that the construction and use of log beehives was still a preferred system despite awareness and

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**Table 2.** Types of beekeeping technology in Chemba district.

| Description | Variables | Frequency | Percentage |
|---|---|---|---|
| Type of beekeeping | Traditional | 44 | 59.5 |
| | Modern | 6 | 8.1 |
| | Mix of both | 24 | 32.4 |
| | Total | 74 | 100 |
| Number of hanging frame beehives | Below 5 | 14 | 18.9 |
| | 6–10 hives | 9 | 12.2 |
| | Above 10 | 7 | 9.5 |
| | N/A | 44 | 59.5 |
| | Total | 74 | 100 |
| Number of log beehives | Below 3 | 6 | 8.1 |
| | 3–5 hives | 12 | 16.2 |
| | 6–10 hives | 18 | 24.3 |
| | Above 10 | 33 | 44.6 |
| | N/A | 5 | 6.8 |
| | Total | 74 | 100 |

**Figure 2.** An apiary with hanging frame beehives covered by vegetation.

adoption of the hanging frame hives technology in the region. Moreover, many factors were contributing to community preference for log beehives. The focus group discussions revealed that hanging frame beehives were expensive compared to log beehives. A hanging frame beehive was priced from TZS 80,000 to TZS 120,000 (34.45–51.68 USD), which hindered beekeepers from adopting and using the technology. Apart from the perceived high costs of hanging frame beehives, tradition was another important aspect mentioned during discussions. It was further revealed that tribes such as Sandawe and Rangi preferred to use log beehives due to their cultural values and norms, such that traditional beekeeping is a way of honouring ancestors. The system has become part of their daily family life, making it difficult to adopt hanging frame beehives as it will go against their norms. These ethnic groups are conservative with their traditional ways of living, a situation that characterises beekeeping as their sub-economic activity. Since they do not consider it for business, they fail to adopt hanging frame beehive technology essential for commercial beekeeping production. This finding is similar to Minja and Nkumilwa (2016) study in Moshi rural district, Tanzania. In Ethiopia, also despite nearly all beekeepers recognising the existence of frame beehive technology, they did not use it because of different reasons, including lack of equipment, farming experience, access to financial resources and lack of extension services (Bekuma, 2018). However, the results were dissimilar to the study in Tigray region, Ethiopia, where most of beekeepers preferred a frame hive technology over a log hive (Gebreyohans & Gebremariam, 2017).

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### *Economic Earnings from Beekeeping*

Our finding suggests that despite the low adoption of hanging frame beehives with the high cost of production, the hives still have the potential to create more income for the user's household than log beehives. The implication arises as traditional beekeeping technology which includes log beehives involves the use of fire during honey harvesting killing many adult bees hence honey production is limited. Also poor cleaning and filtering results in mixed honey with pollen, brood and ashes causing a low quantity and quality of honey produced. As a result, hanging frame beehives where combs can be selected to be free of pollen and brood produce a great quantity and quality of honey of about 15–20 kg. The production is different from log beehives, which yield a low quantity of about 5–10 kg. Therefore, modern beekeepers earned more profit than traditional beekeepers, who earned less than 50,000 (21.57 USD) Tshs per year (Table 3). This finding differed slightly from a survey in Niger delta, Nigeria, where the total honey production for each colony was 12.35 kg for modern beekeepers and 6.72 kg for traditional beekeepers (Fadare et al., 2008). In Ethiopia, also, Belayhun (2014) reveals that honey production was higher among frame beehive users than log hive users; thus, the level of economic development is high among frame beehive users than log hive users.

On the other hand, there is a slight difference in the profits earned from hanging frame and log beehives. Despite the profit obtained from hanging frame beehives being higher than log beehives, the profit is still very low. Moreover, this low profit from using hanging frame beehives in the selected villages (Table 4) is not attractive to other beekeepers in other

**Table 3.** Sales of bee products.

| Description | Sales of Bee Products | Frequency | Percentage |
|---|---|---|---|
| Hanging frame beehives | 50000–100,000 Tshs | 6 | 8.1 |
| | 110,000–200,000 Tshs | 11 | 14.9 |
| | Above 200,000 Tshs | 11 | 14.9 |
| | None | 46 | 62.2 |
| | Total | 74 | 100 |
| Log beehives | Less than 50,000 Tshs | 27 | 36.5 |
| | 110,000–200,000 Tshs | 15 | 20.3 |
| | 50000–100,000 Tshs | 11 | 14.9 |
| | Above 200,000 Tshs | 14 | 18.9 |
| | None | 7 | 9.5 |
| | Total | 74 | 100 |

**Figure 3.** Debarking and cutting down trees for log or bark beehive construction.

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**Table 4.** Beekeeping earnings per village.

| | Log Beehives Sales (Tshs) | | | | | |
|---|---|---|---|---|---|---|
| Villages | Less than 50,000 | 500,00–100,000 | 110000–200,000 | Above 200,000 | None | Total |
| Gwandi | 13 | 1 | 0 | 0 | 4 | 18 |
| Igunga | 1 | 5 | 6 | 7 | 0 | 19 |
| Mialo | 5 | 5 | 3 | 6 | 0 | 19 |
| Mwailanje | 8 | 4 | 2 | 1 | 3 | 18 |
| Total | 27 | 15 | 11 | 14 | 7 | 74 |
| | Hanging frame beehives sales (Tshs) | | | | | |
| Gwandi | 0 | 6 | 7 | 3 | 2 | 18 |
| Igunga | 0 | 0 | 0 | 6 | 13 | 19 |
| Mialo | 0 | 0 | 0 | 0 | 19 | 19 |
| Mwailanje | 0 | 0 | 4 | 2 | 12 | 18 |
| Total | 0 | 6 | 11 | 11 | 46 | 74 |

villages using traditional method in the district. Thus, this circumstance may also influence the low adoption of hanging frame beehives. However, it has been 2 years since the adoption of hanging frame beehives. Hence, this low profit at this early stage of investment provides a good indication of the high profit that will be attained if the technology is well implemented shortly. Therefore, this study further suggests that the hanging frame beehive is still an appropriate beekeeping technology that can contribute more income to the beekeepers by producing quantity and quality bee products than Log beehives if all the required services are well-performed. The results are not very different from those of Akinmulewo et al. (2017), who found an increase in the farmers' annual income before and after using improved beekeeping technology. Also, Onwumere et al. (2012), Abdullahi et al. (2014) found that frame beehives contributed more income than the traditional system despite high investment costs. Therefore, this study emphasises that an increase in the adoption of hanging frame beehives will contribute more to the household economy than log beehives in the area.

It should also be noted that honey and beeswax are the only two beekeeping products in the area. The research in the Chemba district revealed that most beekeepers do not separate the two bee products. Most traditional beekeepers produce unprocessed honey, while few modern beekeepers have processing equipment separating beeswax from honey to make skin oil, candles and batik. In addition, it was found that lack of equipment and other key beekeeping services push beekeepers to sell honey and beeswax together unseparated at low prices. Traditional beekeepers lose much profit to the buyers who process the products and get refined honey with clean beeswax. Our finding is similar to the study in the Tabora region, Tanzania, where variation in income levels between traditional and modern beekeepers may also be caused by buyers who do not differentiate the quality of bee products from different systems of production (Kuboja et al., 2016).

## *Contribution of Beekeeping to Natural Forest Conservation*

On the contribution of beekeeping to environmental conservation, most of our respondents agreed that the use of log beehives has been contributing to cutting down trees with the use of fire during honey harvesting compared to hanging frame beehives in the area. The findings are not very different from Burkina Faso, where Schweitzer et al. (2013) revealed that about 35% of plant species were used in traditional beekeeping. Also, 55% of plants (organs and parts) were used to construct traditional beehives and 7.50% involved the use of fire as a smoker. Schweitzer et al. (2013) explained that traditional beekeepers used some parts and organs of plants to construct local beehives and other traditional methods remain environmentally unfriendly, affecting conservation efforts of these plants and the development of beekeeping in general. Moreover, the findings were contrary to Augustino et al. (2016), who found out that traditional beekeeping is considered an effective system of managing and conserving forest resources, as it helps in preventing cutting down of trees as well as disturbance from livestock grazing and influence growth of vegetation cover through pollination. Also, contrary to Belayhun (2014) and Sialuk (2014), who found out that the majority of the respondents use frame beehives and they practice better honey harvesting methods that are environmentally friendly. This situation connotes that the environment was minimally pressured (Belayhun, 2014).

## *Implications for Conservation*

Beekeeping as a livelihood activity provides employment opportunities and other benefits to rural communities in many villages in Tanzania. The results from this study show that although adoption and use of hanging frame hives for beekeeping in villages in the Chemba district have been practised for 2 years now, the frame beehives are still not preferred by

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most communities. The rare use of hanging frame beehives indicates a continuous adoption of log beehives. The high use of log beehives indicates a continuous contribution to cutting down trees for hives construction which jeopardises the natural forest around the villages in the district. Despite threatening at a low rate, failure to adopt hanging frame beehives or other modern beehives may increase the contribution of traditional beekeeping to the degradation of natural forests in Tanzania and Africa in general. While good work has been done on promoting beekeeping, particularly adoption of frame beehives, there is a need to create actions that will facilitate knowledge exchange between extension officers and beekeepers on beekeeping benefits, especially forest conservation. Communities should be well informed in broader new beekeeping technologies and benefits for all modern beehives not only hanging frame beehives. More emphasis should be directed on balancing charcoal production and grazing near apiaries in order to maintain honeybee species and bee fodder plants that might contribute to beekeeping production and conservation of the natural forest ecosystem. Therefore, in collaboration with private stakeholders, the government should plan to improve beekeeping technology by constructing beekeeping centers aim at promoting commercial beekeeping through empowering beekeepers on developing cheaper technologies such as the use of cement for making concrete beehives that can be affordable to rural communities. Also, more sensitisation is required in terms of the value chain and considering log and frame beehives in rural communities. Also, supporting and providing necessary services such as extension services, training and access to financial resources could help venture into other bee products and ensure sustainable conservation. Lastly, to understand further the impact of traditional beekeeping on forest conservation, more study and analysis is required to quantify the number of tree cut for log or bark beehives construction in developing countries including Tanzania.

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