Tanzania Journal of Forestry and Nature Conservation, Vol 93, No. 1 (2024) pp1-20

An exploration of honeybees' threats in Tanzania: Implication for conservation

Kashumba, F.M.

Institute of Development Studies, The University of Dodoma, Tanzania
Corresponding: fkashumba@gmail.com

ABSTRACT

Pollinators, including honeybees, contribute significantly to livelihood improvement as well as socio-economic and environmental conservation, a fact that is globally undisputed. However, their survival is not guaranteed due to increasing rate of habitat degradation. This review intends to harmonize the uneven understanding of honeybees' threats and their sources in Tanzania so as to develop their conservation plans and strategies. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Model was adopted in selection of relevant literature. The Metadata was analyzed using Aggregative Synthesis Approach (ASA) and coded based on the content analysis of the related honeybees' threats. The review found that pesticide use, counterfeiting and inadequate knowledge and skills among farmers on pesticide application and management were major threats to honeybees. Additionally, insufficient knowledge among beekeepers on apiary management was identified as another key threat. Other threats include continuous use of traditional beekeeping technologies, invasive pests and predators, climate variability, and a lack of coordinated effort across sectors on forest conservation. These findings emphasize the need for more efforts and studies to update and mitigate the impacts caused by the aforementioned honeybees' threats for sustainable conservation of honeybees in Tanzania.

Key Words: Honeybees' threats-anthropogenic activities-hazardous pesticides-neonicotinoids-habitat loss-pollinators.

INTRODUCTION

Background information

The contribution of honeybees and other pollinators in socio-economic improvement and environmental conservation is globally undisputed (Li *et al*. 2022). In Tanzania for example, Beekeeping sector is estimated to generate 61,770,428,377Tanzanian shillings per annum mainly from honey and beeswax, and employing about two million people (URT 2021a). Through pollination services offered by managed bees to 168 out of 32,008 farmers in Tanzania (0.5% of farmers), more revenue can be generated (URT 2022a, URT 2022b). Pollination services improve 40% of crop production in Sub-Saharan Africa (Khalifa *et al*. 2021). However, the survival of these pollinators including honeybees is not assured due to increasing rate of habitat degradation caused by various anthropogenic activities globally (Muli *et al.* 2014, Khalifa *et al*. 2021, Li *et al.* 2022). Pollinator loss, especially honeybees, contribute to crop decline in the agricultural sector hence threatens food security and rural livelihoods in Tanzania and many developing economies (Ollerton *et al.* 2011, Anguilet *et al.* 2015, IPBES 2016, Elisante *et al.* 2020, Wakgari and Yigezu 2021). Finding ways to alleviate these threats is a global challenge (IPBES 2016). Identifying these threats and their causes can contribute to effective planning for their mitigation.

Tanzania is estimated to have 9.2 million stinging honeybees and non-stinging bees' colonies (Meixner *et al.* 1989, URT 1998a, Kashumba 2018). It is the second-largest honey producer in Africa after Ethiopia (URT 1998a, URT 2015). It is estimated that the capacity of honey production in

Tanzania is 138,000 tons of honey, 9,200 tons of wax, and about 5% of managed honeybees pollination services per year, respectively (URT 1998a, URT 2022b). Despite of all these potentials, honeybees is threatened due to increasing rate of habitat degradation (URT 2015). Recent statistics show that the rate of forest degradation and deforestation has increased (URT 2017).

A holistic approach is envisioned where by a comprehensive list of key threats are identified and sound management strategies are drawn to address them. However, there are no such studies that have attempted to exhaustively compile all possible threats of honeybees in Tanzania, possible causes of these threats, and available efforts in the conservation of honeybees in Tanzania. This study therefore is geared to address this knowledge gap. It is hypothesized that the outcome of this review will contribute to the understanding of the existing major threats of survival of honeybees in Tanzania and ways to address them through a holistic approach. It also serves as a point of departure for policy makers and implementers in honeybees' conservation in Tanzania.

METHODOLOGY

Description of study area

Tanzania is estimated to have a total area of 93,046,000ha, where 48,090,000ha is the forest cover, 15,290,000ha is other related woodland, and 29,666,000 ha are categorized as other lands as illustrated in Figure 1. The country is endowed with rich natural resources with potential for beekeeping and honeybee conservation, including savanna woodlands and Miombo Woodlands, making it the second country in honey production in Africa and 11th globally (URT 1998a, URT 2015, Kashumba 2018, URT 2021a). Tanzania is estimated to be a home to about 9.2 million honeybee colonies. Three types of stinging honeybees are found in Tanzania: *Apis mellifera scutellata* in mainland and semi-arid regions; *Apis mellifera litorea* in coastal zones; and *Apis mellifera monticolla* in highland regions (Meixner *et al.* 1989). The country is also endowed with about three types of non-stinging honeybees, namely Melipona, Meliponula, and Trigona that are spread all over the country (Meixner *et al.* 1989, Bradbear 2003). The number of wild and managed honeybees is inadequately visible in the reviewed literature, as the honeybee census has not been updated since 1998 (URT 2022c).

The Potentiality and the country's political will and efforts toward conservation and integration of honeybee resources in national development have attracted a considerable amount of local and international support in the sector (URT 2021a, URT 2021b, URT 2022b). Despite the registered policy instruments put in place and conservation efforts in the beekeeping sector, the reviewed literature is inadequately providing a picture of the prospect of honeybees' health in the midst of the threats facing them including habitat loss in form of deforestation as illustrated in Figure 1. It is estimated that Tanzania is losing 372,000ha of forests annually (URT 2015). This means that the habitat for important pollinators including honeybees is in danger. Various anthropogenic activities are blamed to continue being the major causes of this loss despite the effort put forth by the government and other stakeholders to address them (URT 1998, Lahr *et al.* 2016, URT 2021a, URT 2022b).

Research design

A case study research design has been adopted in this review because of its ability to develop an in-depth understanding of the studied phenomena, including the paradoxical understanding of honeybee threats versus policy directives and available conservation efforts (Ridder 2017). Case study research design is one of the social science research designs that generate a qualitative understanding of specific issues affecting a certain group of people, an event, or issues restricted to a

certain geographical area or a real-life phenomenon (Ridder 2017). As a social science research design, especially focusing on qualitative research approaches, case studies guided this review in providing a summary and coding for qualitative information. It further provided an in-depth and exhaustive description of honeybees' threats against current conservation efforts, taking Tanzania as a case study.

Data collection

A systematic literature review methodological procedure was adopted in this study for data collection to ensure scientific precision and establish evidence-based findings from online literature. According to Ndibalema (2022), a systematic literature review entails the identification and critical review of accessible online literature on the studied theme. To be able to select relevant literature with Metadata, this review adopted only articles that possessed primary data. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) model was adopted to guide criteria for inclusion and exclusion of the relevant literature (Page *et al.* 2020). Under PRISMA, four steps as indicated in Figure 2 were followed to make sure that relevant literature was selected (Page *et al.* 2020, Ndibalema 2022, Ndibalema 2024).

The first step included a critical search of the review honeybees' threats in scientific databases and libraries, including Dimensions, Google Scholar, Research Gate, and Research 4 Life. The triangulation of scientific resource databases assisted in capturing sources from both local and international databases. Research keywords or phrases, namely "anthropogenic activities" and "honey-bee sustainability", "bee health and sustainability", "neonicotinoids" and "bee health", "habitat loss and sustainability of honeybees", and "bee colony collapse disorders," were established to guide a critical search from an identified Open Access (OA) online scientific database with a timeframe between 1998 and 2024 of beekeeping policy implementation in Tanzania (URT 1998a).

Screening of the articles, academic thesis, and government documents and reports with a considerable amount of primary data source information that responds to research objectives was the second step, guided by the PRISMA inclusion and exclusion criteria, where a total of 4,762 pieces of literature were identified related to searched honeybees threats as illustrated in Figure 2. The third step was to rigorously scrutinize the eligibility of qualified literature based on the credibility of the qualified literature on the methodology for data collection, presented data, analysis, argumentation, conclusion, and its scientific contribution from the interpretation of the primary data (Ndibalema 2024).

The fourth step included the selection and adoption of the articles and documents. The rest of the references have been used to develop background information and methodology. All references and citations used to develop the research methodology were excluded from the 36 references used in the data analysis and discussion of the findings as shown in Figure 2. Open access (OA) databases were among the criteria used for the eligibility of the literature sources. The adopted scientific resource databases, such as Dimensions, Google Scholar, Research Gate, and Research for Life, provided inadequately eligible sources that were based on OA from the review area and plotted the review timeframe. As a result, much of the sources, including Tanzania's national policy documents and reports, were openly accessed from Google Scholar and Research Gate. Inadequate literature from reputable scientific resource databases is one of the limitations identified in this review.

Data analysis

The Aggregative Synthesis Approach (ASA) for qualitative research was adopted to enable scrutinization of the accessed

online meta-data and aggregating them into reviewed honeybees' threats (Hannes *et al.* 2017, Ndibalema 2022). ASA is a qualitative data analysis approach that aggregates and harmonizes metadata sources to summarize policy statements that can be used by researchers, development practitioners, or policymakers to address specified policy issues (Hannes *et al.* 2017). It provides an a priori protocol and standardized framework for presenting results from a mega-aggregated literature review (Ndibalema 2022).

In this study, ASA has been used to guide interpretation of the data, including paradoxical facts and figures on honeybees' threats vis-à-vis available efforts for honeybees' conservation in Tanzania. Data sources were grouped and categorized based on the studied honeybees' threats. It was at this point that the results were summarized, harmonized, and coded based on the types of identified honeybees' threats. A list of 36 selected pieces of literature was selected as the unity of analysis, including articles (n = 18), policy documents (n = 15), workgroup meeting proceedings reports (n = 1), conference papers (n = 1), and scientific reports (n = 1).

RESULTS

The major honeybees' threats in Tanzania

The results on the major honeybees' threats in Tanzania based on the systematic literature review are presented in Table 1. The National policies and sectoral coordination challenges turned out to be more prominent in the literature followed by habitat loss, and the use of hazardous pesticides. Theft of bee products in unprotected apiaries and Climate change and variability were the least.

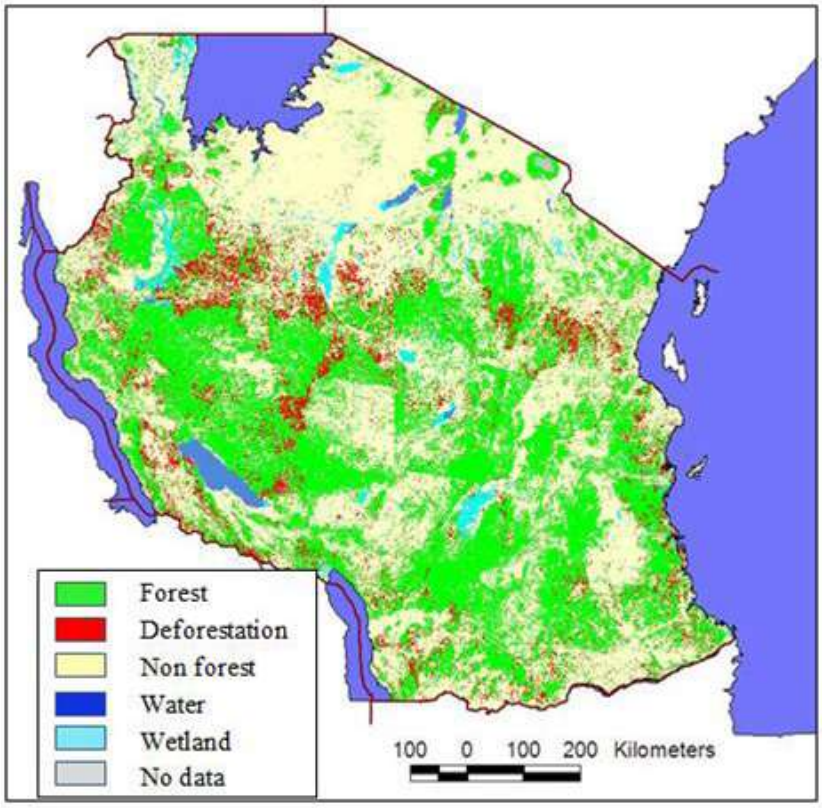

Figure 1. A map of Tanzania mainland showing existing forest cover and deforested areas (Source: URT 2017)

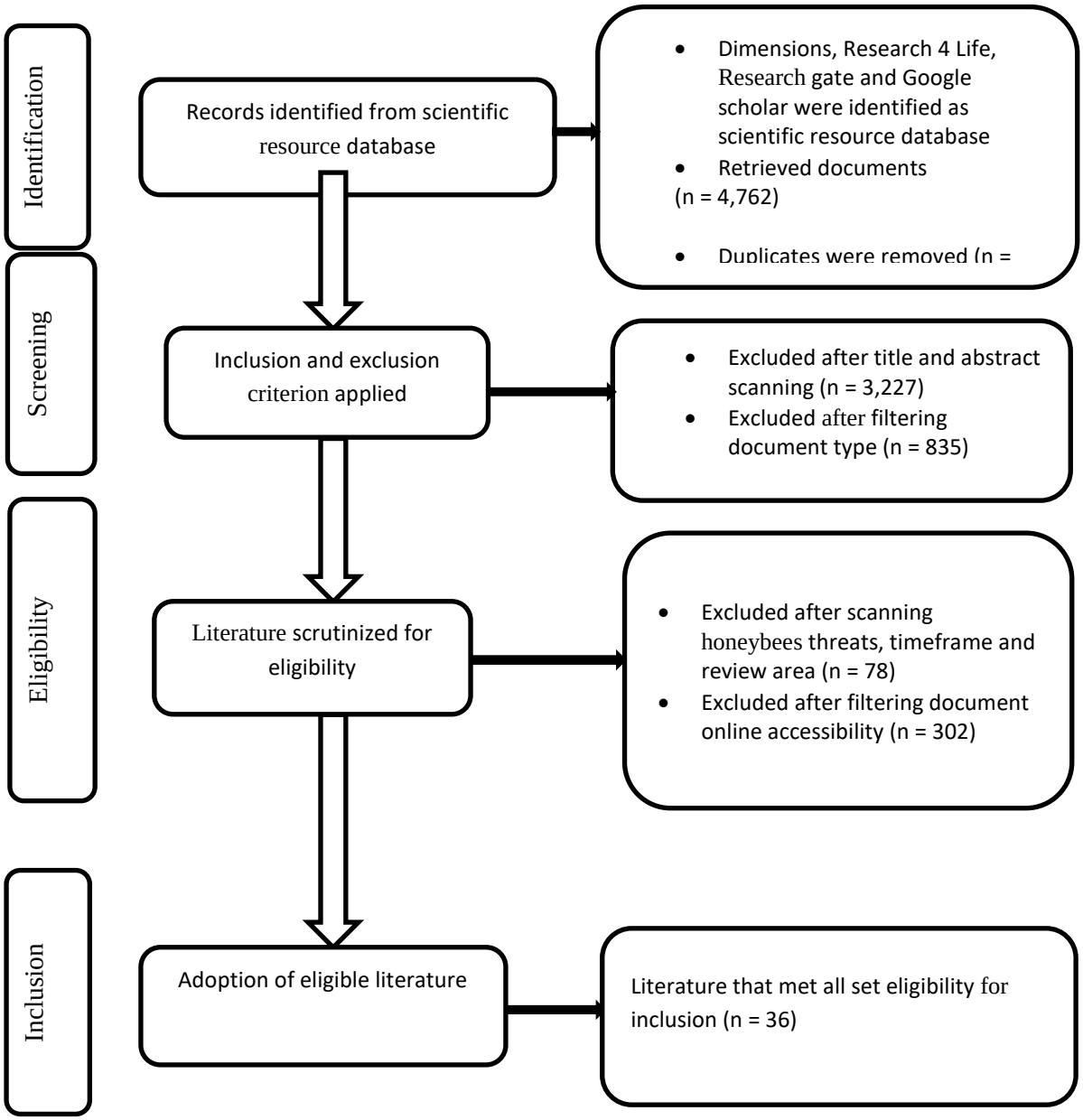

Figure 2: Procedure for sampling on-line Metadata for analysis based on the PRISMA Model. Source: Adopted and modified from Page et al. (2020) and Ndibalema (2022).

Efforts to conserve honeybee resources in Tanzania

Table 2 shows the results of the list of efforts put forth by the government and other stakeholders in conserving honeybee resources in Tanzania. Establishment of honeybees' conservation strategic plan turned out to be more prominent in the literature followed by policy guidelines and legal framework, whereas establishment of forest educational and research institutions were the least.

Table 1. List of honeybees' threats and their causes in Tanzania reported from published and un-published documents (n = 36)

SNo	Name of the threat	No. of occurrences in the literature	Causes	Source/references
1	National policies and sectoral coordination challenges	13	Inadequate communication among sectors	Lema *et al.* 2014, Katambo 2018, Kiwango *et al.* 2018, Tibesigwa *et al.* 2019. Matowo *et al.* 2020, Sawe *et al.* 2020, URT 2020, URT 2021a, URT 2021b, URT 2022a, URT 2022b, URT 2022c, Lahr *et al.* 2016.
2	Habitat loss	9	Deforestation	URT 1998a, Whitaker 1999, Rutinwa *et al.* 2003, Berry 2008, URT 2015, Ngina and Wawa 2020, Nyunza 2018, Sawe *et al.* 2020, Lusambo 2021.
3	Use of hazardous pesticides	8	Harmful pesticide application	Lahr *et al.* 2016, Katambo 2018, URT 2018, URT 2020, Kiwango *et al.* 2018, Massomo, 2019, Pallangyo *et al.* 2019, Matowo *et al.* 2020.
4	Inadequate farmers' know-how in pesticide handling and application	7	Low knowledge in pesticide application among farmers	Lema *et al.* 2014; Lekei *et al.* 2014, Lahr *et al.* 2016, URT 2018, Massomo 2019, Matowo *et al.* 2020, Ngina and Wawa 2020.
5	Honeybees diseases	6	Honeybees diseases	URT 2003, URT 2013, Muli *et al.* 2014, Lahr *et al.* 2016, URT 2018, Sawe *et al.* 2020.
6	Counterfeit agrichemicals	5	Presence of fake agrichemicals in the market	Lahr *et al.* 2016, ASSAf 2019, Stadlinger *et al.* 2011, URT 2018b, Massimo 2019.
7	Continuous use of traditional technologies in beekeeping	5	Continuous use of traditional technology in beekeeping	Minja 2016, Tutuba and Vanhaverbeke 2018, Ngina and Wawa 2020, Chami *et al.* 2022, Tutuba and Kapinga 2022.
8	Presence of invasive species	4	Invasive species and predators	Muli *et al.* 2014, Mumbi *et al.* 2014, Giliba *et al.* 2020, Lasway *et al.* 2021.
9	Inadequate apiary management knowledge among beekeepers	4	Low beekeeping knowledge	Minja 2016, Tutuba and Vanhaverbeke 2018, Chami *et al.* 2022, Tutuba and Kapinga 2022.
10	Climate change and variability	3	Weather fluctuations	Mumbi *et al.* 2014, Nyunza, 2018, Giliba *et al.* 2020.
11	Theft of bee products in unprotected apiaries	2	Theft of honeybee products	Tutuba and Vanhaverbeke 2018, Tutuba and Kapinga 2022.

Table 2. Efforts to conserve honeybee's resources in Tanzania

SNo.	Type of Effort	No. of occurrences in the literature	Output	Sources/References
1	Establishment of honeybees' conservation strategic plan	5	• National Biodiversity Strategy and Action Plan (NBSAP) 2015-2020 • National Beekeeping Policy Implementation Strategy (2021-2031)	URT 2015a, URT 2015b, URT 2021a, URT 2021b, URT 2022c
2	Policy guidelines and legal framework	4	• National Beekeeping policy, act and guidelines • National Forest policy, act and related guidelines	URT 1998a, URT 1998b, URT 2000a, URT 2000b, URT 2022a
3	Establishment of honeybees and forestry resources	4	• 21 honey-bee management areas, • 3 Ramsar Sites, • 419 natural forests, • 20 nature forest reserves, • 12 bee reserves, • 24 public forest farms	URT 2015a, URT 2017, URT 2022c, URT, 2021a
4	Establishment of beekeeping training manuals	3	• The National Beekeeping Training and Extension Manual • Guideline for Management and Use of Honeybee Colonies for Pollination Services in Tanzania,	URT 2021a, URT 2021b, URT 2022c
5	Establishment of forest educational and research institutions	2	• Tanzania Forest Research Institute (TAFORI), • National Biodiversity Strategy and Action Plan (NBSAP) 2015-2020 • Olmotonyi Forest Training Institute (FTI) • Beekeeping Training Institute (BTI) in Tabora, • Tanzania Forest Fund (TaFF)	URT 2015, URT 2022c

DISCUSSION

Honeybees' threats in Tanzania

Based on the literature review, a total of 11 honey bees' threats and their causes have been identified to occur in Tanzania (Table 1). Although numbers of their occurrences in the literature differ from each other, still they indicate some levels of challenges facing the honeybees in Tanzania. The National policies and sectoral coordination challenges have been acknowledged by many sources to be one of the threats jeopardizing the prospect of honeybee's existence in the country. For example while the National Beekeeping Policy (NBK) identifies bees as among important insects for honey production (URT 1998a, URT 2013), and they can be kept or managed by beekeepers, and the beekeepers are not categorized as farmers, and all the bee products are categorized as non-timber forest products (NTF) (URT 1998a), still the NBK recommends that apiaries be located at least five kilometres away from agricultural activities. Despite the fact that honeybees have a socioeconomic impact on agricultural production, still beekeepers are directed to keep away their beekeeping activities close to the agricultural activities. The major reasons could be to avoid the honey from being contaminated with the remnants of the pesticides or herbicides used in the farms. But the implied benefits of pollination services for increasing food production from the beekeeping activities is not considered (URT 1998a, URT 2022a).

It is further been noted that sectoral coordination between beekeeping, agriculture, pesticide registration authorities, and environmental regulatory sectors remain not only a policy but also an institutional issue likely to jeopardize the available honeybees' conservation efforts (Lahr *et al.* 2016, Lema *et al.* 2014). The National Agricultural Policy inadequately provides practical directions on how pesticides can be managed without affecting non-targeted insects, including honeybees (URT 2013).

In addition, almost all neonicotinoids globally debated as hazardous to honeybees such as Sulfoxaflor, Acetamiprid, Imidacloprid, Thiamethoxam, Clothianidin, Thiacloprid, Dinotefuran, and Nitenpyram have been registered for use in Tanzania between 1998 and 2020 (Lema *et al.* 2014, Lahr *et al.* 2016, Katambo 2018, Kiwango *et al.* 2018, URT 2018, URT 2020). Other hazardous pesticides registered in Tanzania comprise Chlorpyrifos, Pirimiphos-methyl, Dizinon, Fennitrothion, Profenofos, Dimethoate, and Alphacypermethrin (Katambo 2018). Indeed, the application of neonicotinoids in horticultural and cash crops such as tobacco, cotton, and coffee in various parts of Tanzania is apparent (Lema *et al.* 2014, Lahr *et al.* 2016).

The presence of pesticides which are harmful to pollinators, including honeybees, in Tanzania was also reported by various authors (Stadlinger *et al.* 2011, Van Der Sluijs *et al.* 2013, Lema *et al.* 2014, Lekei *et al.* 2014, Kiwango *et al.* 2018, Massomo 2019, Pallangyo *et al.* 2019, Matowo *et al.* 2020). These include Chlorpyrifos in 54 products, Pyrimiphos-methyl in 3 products, Dizinon in 6 products, Phenolthion in 42 products, Profenofos in 52 products, Dimethoate in 21 products, and Alphacypermethrin in 23 products, which were registered in 2020 (URT 2020). Most of the mentioned hazardous pesticides are systemic and broad-spectrum-based with the ability to actively survive in soil, water, and plant life spans and are likely to affect honeybees anytime they go for foraging (Mulati *et al.* 2019, NASAC 2019, Fikadu 2020). Traces of pesticides in pollen and honey have been reported globally (Alburaki *et al.* 2015, Da Silva *et al.* 2015). However, data on the effects of pesticides on honeybees in Tanzania is inadequately established, though the decline of bee colonies has been acknowledged in the country (URT 2021a, URT 2021b, URT 2022b). Several other studies have discussed the weak tradeoff between Integrated Pest Management (IPM) conservation measures and agricultural food security programs that promote the use of pesticides that are highly toxic to non-targeted insects, including pollinators like honeybees (Lema *et al.* 2014, Lahr *et al.* 2016, Kiwango *et al.* 2018). The tradeoff between agricultural transformation, environmental conservation, and the implementation of Integrated Pest Management (IPM) remains a development discourse in Tanzania (URT 2013, Lahr *et al.* 2016, Matowo *et al.* 2020). As a result, farmers' capacity building and institutional arrangements for the transaction between the implementation of IPM and the application of registered pesticides noted to be harmful to non-target insects remained at their infant stage (URT 2003, Lahr *et al.* 2016, URT 2018). The weak multispectral challenges on pesticide application in Tanzania by themselves are translated in this review as honeybees' conservational threat that need concerted attention from policy planners and the related development stakeholders to solve the multisectoral challenges.

Habitat loss was the second among the identified threats of honeybees in Tanzania. Anthropogenic activities such as overgrazing, forest fires, unsustainable farming practices, and timber production have been noted to increase deforestation in Tanzania hence altering the potential habitats for honeybees (URT 1998, Whitaker 1999, Rutinwa *et al.* 2003, Berry 2008, URT 2015, Nyunza 2018, Sawe *et al.* 2020, Lusambo 2021).

According to the National Forest Resources Monitoring and Assessment of Tanzania Mainland (2015) and Global Forest Watch (2024), Tanzania is ranked 4th among the 10 top countries leading in deforestation globally with 372,000ha/year as illustrated in Table 3. For instance, it was estimated in 2015 that land degradation increased from 42% in 1980 to 50% in 2012. It was further noted in Tanzania's National Biodiversity Strategy and Action Plan 2015–2020 that from 1980 to 2005, the country lost 18% of its forest cover (URT 2015a, URT 2015b). The annual forest cover loss is estimated at 0.7% as the deforestation rate has increased from 337,000ha per year in 2015 to 372,000ha in 2024 (URT 2015a).

Table 3: Top 10 countries with the highest deforestation rates in the world

Rankin	Country Name	Deforestation Rate (in thousands ha/year)	Forest Area (ha) (In millions)
1.	Brazil	1,780	519.5
2.	Australia	662	133.6
3.	Mexico	441	64.8
4.	United Republic of Tanzania	372	35.3
5.	Zimbabwe	309	15.6
6.	Argentina	301	33.0
7.	Bolivia	289	53.0
8.	Mozambique	219	40.1
9.	Sudan	174	69.9
10	Peru	165	73.0

Source: Global Forest Watch (2024)

It is estimated that 80% of deforestation, equal to 6.18 million hectares of cleared forests, is caused by anthropogenic activities (Global Forestry Watch 2024). Studies on the relationship between continuing deforestation and honeybees' habitat loss and the acknowledged bee colony decline are currently inadequately updated (IPBES 2016). The above discussed deforestation rate has direct negative implication on the conservation of honeybees in Tanzania. Continuous habitat loss to honeybees' calls for attention from policy makers, the related ecosystem conservationist and the associated development stakeholders to refocus on the best and sustainable way to address anthropogenic activities blamed to accelerate alarming deforestation in Tanzania.

Farmers' lack of technical knowledge on pesticide application was among the listed threats of honeybees in Tanzania (Lema *et al.* 2014, Lahr *et al.* 2016, URT 2018, Fikadu 2020). For instance, a review conducted in Arumeru district in the Arusha region indicated that farmers' know-how in the handling of pesticides was inadequate, where the majority of farmers (93%) poisoned themselves when applying pesticides to their farms, while 81% of them confirmed storing pesticides in their residential homes (Lekei *et al.* 2014). Inadequate knowledge of pesticide application in Tanzania was further confirmed in vegetable production in Uvinza district in the Kigoma region (URT 2018, Massomo 2019) and in rice production in Rufiji district, Tanzania's coastal mainland, and in Cheju, Zanzibar (Stadlinger *et al.* 2011). Various studies have identified cleaning of sprayers and disposing of empty containers, as well as poor storage systems, as honeybees' threat exposing pesticides to honeybees through groundwater spillage and contamination (Lema *et al.* 2014, Lahr *et al.* 2016, Massomo 2019, Matowo *et al.* 2020). The reported mishandling of empty pesticide containers, including dumping them in the field, reusing them for other household activities, and burying them, is likely to be among the honeybees' threat exposing pesticides to honeybees. On the other hand, some studies have contended that agro-vet retailers had inadequate knowledge or that part of their business was not to give instructions as prescribed by pesticide manufacturers, resulting in farmers mishandling prescribed pesticides (Massomo, 2019, Matowo *et al.* 2020). More efforts in Education and extension services is needed to improve farmers knowledge on integrated pest management in agricultural activities as part and parcel of

honeybees' conservation efforts in Tanzania.

The empirical evidence on the status of honeybees' diseases and pathogens in the country is scanty. However, Pirk *et al.* (2016) indicate that European Foulbrood (Melissococcusplutonius) and fungi (Nosemaapis and N. Ceranae) are present in Tanzania and neighbouring countries. Viruses such as the deformed wing virus, the chronic bee paralysis virus, and the acute bee paralysis virus were discovered in Kenya and are likely to have cross-border effects in neighbouring countries such as Tanzania (Muli *et al.* 2014). The presence of the mentioned honeybees' diseases and predators has implication on the current honeybees' conservation efforts that demands collaborated cross boarder innovative research and policy implementation strategies to address the mentioned diseases as part and parcel of the available honeybees' conservation package.

Counterfeit Agrichemicals was another identified threats for honeybees in Tanzania. In 2014, Tanzania was counted as one of four hotspots of fake agro-products in Africa, including Egypt, West Africa, and Uganda (Shao and Edward 2014). Approximately 40% of agro-inputs (seeds, fertilizers, and pesticides) in the country were reported to be counterfeit, which is likely to have a negative impact on agricultural production, human health, and the environment (Shao and Edward 2014). Improper labelling of pesticides, re-packaging of pesticides, application of pesticides without proper instructions, illegal importation, and the availability of substandard pesticides were viewed by various scholars in Tanzania as among the honeybees' threats (Stadlinger *et al.* 2011, URT 2018b, Massimo 2019).

The Performance Audit Report on the Management of Pesticides in Agriculture in Tanzania indicated that in 2016, there were 5 pesticide counterfeit products reported in Mwanza, Geita, Shinyanga, Singida, and Tabora, and in 2017, there were again 10 illegal pesticide products in Dodoma, Morogoro, Iringa, Tanga, Singida, Dodoma, Kilimanjaro, and Mbeya regions, suggesting that pesticides counterfeited in Tanzania are a reality (URT 2018b). The porosity of the country's boundaries, inadequate inspection, scant monitoring mechanisms, frail environmental impact assessment (EIA), and feeble sanctions against product counterfeiters are reported as among the honeybees' threat influencing increased scenarios of pesticide counterfeiting in Tanzania (URT 2018b). The deficiency of EIA on pesticide application vis-à-vis their impact on honeybees implies that their health and sustainability are not assured in the mentioned proliferating counterfeits in the country. Strong and effective cross-broader pesticide checks and balances are desired to make sure substandard and hazardous pesticides and herbicides are prohibited from entering into the market.

The continuous use of traditional technologies in beekeeping activities was also mentioned in various studies as one of the honeybees' threat in Tanzania. Despite the fact that transformation of traditional beekeeping into modern one has been stipulated as one of the policy objectives for about 20 years of policy implementation in the country, and its available efforts to modernize the sector, current studies have indicated that beekeeping in Tanzania is still at a subsistence level, mostly using traditional technology despite available policy efforts (Ngina and Wawa 2020, Chami *et al.* 2022, Tutuba and Kapinga 2022).

Continuous use of bark and log hives by most beekeepers and hanging them on trees is also counted as one of the honeybees' threats contributing to habitat loss and colon decline, as they are not user-friendly in apiary management, colon multiplication, queen rearing, and honey harvesting (Tutuba and Kapinga 2022). The use of traditional technologies on the honey harvesting contributes to after-harvest losses of bee products. Despite the fact that the

National Beekeeping Policy is advocating the use of modern technologies in beekeeping, such as modern hives, tools, and protective gear, various studies, such as Minja (2016), Chami *et al.* (2022), and national policy documents comprising URT (2020), URT (2022a), URT (2022b), and URT (2022c), have indicated that beekeepers' purchasing power has remained low. This develops a vicious cycle of poverty through the continuous use of traditional methods, which in turn minimize income generated from beekeeping activities that could have been used to improve the purchasing power of modern technologies (Tutuba and Vanhaverbeke 2018, Tutuba and Kapinga 2022). Considerable efforts among policy makers and the related development stakeholders is needed to find and invest in innovative ways to empower beekeepers with user-friendly and cheap modern technologies beekeepers can afford. Beekeepers groups, associations and cooperatives are among approaches that can be harnessed to improve beekeepers purchasing power of desired innovations and marketing joint venture of both modern technologies and marketing joint venture of both inputs and products.

Another registered threat is the presence of honeybees' invasive species (Table 1). In 2014, Tanzania was first found with Varroa mites of the Varroa species (Parasitiformes: Varroidae) in honeybees. Like a tic in a cow, Varroa mites are one of the most deadly invasive species, reproducing quickly and impairing honeybee colon function (Vanbergen *et al.* 2018). They are able to hibernate in a colony of capped cells and reproduce quickly, feeding on both brood and honeybees. They vary in size. However, in most cases, the individual mite can measure about 1.05 to 1.2 mm in length and 1.5 to 1.6 mm in width, be oval-shaped, and have eight legs (Mumbi *et al.* 2014). A review conducted by Mumbi *et al.* (2014) in Tanzania found that 23 (92%) out of 25 sampled districts had traces of Varroa mites, with Uyui district leading with 97 mites, followed by Sikonge district with 76 mites. However, the mite load per hive was found to be low (about 3 mites per colony) compared to those in Europe (about 1000 mites per colony). A nearly identical review was conducted in neighbouring country Kenya, and the Varroa mite findings were nearly identical with those in Tanzania, indicating the availability of mites (89.5%), but in a significantly small amount per hive and seemingly not to affect bee colony functioning (Muli *et al.* 2014). This implies that the invasion of Varroa destructors is a reality in East African countries in general and Tanzania in particular.

The Varroa mite is, therefore, if not controlled, a serious threat to the beekeeping industry in Tanzania. This parasitic mite has the potential to decimate the feral bee population, which provides free pollination services to farmers. A coordinated response that addresses multiple needs is required (Mumbi et al. 2014:188).

Other honeybee invasive species and predators reported in various parts of Tanzania include hive beetles, moths, ants, bee lice, bee pirates, squirrels, honey badgers, and lizards, mostly feeding either on adult bees or wax, honey, and brood (Mumbi *et al.* 2014, Pirk *et al.* 2016). Almost all the diverse ecological and geographical conditions in Tanzania seem to favour the breeding of the above-stated invasive bee species. However, the degree of influence of the mentioned invasive species on bee decline is inadequately established all over the country (Lasway *et al.* 2021). Furthermore, beekeepers' lack of knowledge about invasive species, particularly Varroa mites, is another factor that may influence the spread of bee invasive species in the country. This is furthered by unfrequented inspections and inadequate technical know-how in the management of bee colonies among beekeepers (Mumbi *et al.* 2014). However, its severity is inadequately and empirically predicted. These calls for researchers, policy planners and related development partners

to invest in research that will enable the country to have updated and scientifically-based information on the typologies and severity of the honeybees' invasive species to enable policy makers make informed honeybees' conservation decisions and strategies to address invasive species in Tanzania.

Inadequate beekeeping know-how among beekeepers was cited by various studies as one of the honeybees' threat (Minja 2016, Tutuba and Vanhaverbeke 2018, Ngina and Wawa 2020, Chami *et al.* 2022). Inadequate knowledge, skills, and techniques in apiary management are among the reasons causing increased invasive pests and predators in beekeeping activities in Tanzania.

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… Pests and predators have resulted in low productivity due to destroyed 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 (Tutuba and Kapinga 2022:203).

Nonetheless, distance between beekeepers homestead and apiary location, especially those ones located in government forest and bee reserves and the related controlled zones (especially those that need entrance permits), is another challenge that makes day-to-day apiary management almost impossible among beekeepers (Kashumba 2018, URT 2020). On the other hand, the aggressiveness and defensiveness of the mentioned honeybee species found in Tanzania are among the challenges that make friendly apiary management difficult. Colony multiplication and queen rearing have been challenges not because of their technology but because of the aggressiveness of the bees inhibiting the process (Tutuba and Kapinga 2022).

Inadequate know-how and skills among beekeepers in honey harvesting are among the honeybees' threats in Tanzania. For instance, a review conducted by Tutuba and Kapinga (2022) in Tanzania, covering the main honey-producing regions including Iringa, Shinyanga, Tabora, Kigoma, Singida, Morogoro, and Kilimanjaro, indicated that inadequate skills in honey harvesting are the major cause of forest fires, post-harvest losses, and the abscondment of honeybees. Inadequate know-how on handling available aggressive, defensive, and stinging honeybee species found in Tanzania and East Africa in general, including *Apis Mellifera scutellata*, *Apis Mellifera litorea*, and *Apis Mellifera monticolla* (Meixner *et al.* 1989; Kashumba, 2018), renders beekeepers to defensively use of fire during honey harvesting. This, in turn, kills bees, combs, and their habitats. Again, inadequate honey harvesting skills among beekeepers on 'what to harvest' and 'what to retain' in the hive is counted as one of the honeybees' threats causing absconding and colony decline.

Open fire instead of smoke is mostly used to control bees during harvesting, and 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 (Tutuba and Kapinga 2022: 204).

Considerable efforts on beekeeping extension services are needed to improve beekeepers skills and know-how on modern beekeeping.

Climate variability is undisputedly argued to be among the honeybees' threat that cause bee colony loss (Giliba *et al.* 2020). There are variations in weather or not these patterns are claimed to have an impact on pollinator flights, foraging behavior, and increased susceptibility to diseases and invasive species (Nyunza 2018). For

example, a review conducted in eight Tanzanian regions confirms the existence of a link between climate change, increased spread of suitable environments, and the reproduction of Varroa mites in Tanzania (Mumbi *et al.* 2014, Giliba *et al.* 2020). It was further noted by Nyunza (2018) that drying of water sources, drought, and loss of foraging plants were among the honeybees' threat influencing low bee colonization and a decrease in hive occupancy rate in the Manyoni district in the Singida region. A review conducted by Nyunza (2018) indicated that colonization in the review area was about 50 percent, mostly caused by water and forage shortages. Climate change, mostly causing long dry spells, increased temperatures, and excessive rain in some parts of the country, is regarded as one of the honeybees' biggest risks, threatening their survival. Multisectoral, locally based approaches and investment on Climate change mitigations are desired to mitigate the current alarming deforestation in Tanzania.

Apiaries located far away from homesteads their security is not guaranteed (Tutuba and Vanhaverbeke 2018). As it is a reality in wild animal poaching, the same happens in the theft of honey and related honeybee products in apiaries located in forest reserves. Honey theft is characterized by the destruction of hives and the use of fire. Forceful use of fire during honey harvesting is among the causes of honeybees' deaths, colony collapse disorders, abscondment, forest fires, and eventually the recurrent decline of hive occupancy rates (Tutuba and Kapinga 2022).

Current efforts to conserve honey-bees in Tanzania

Based on the literature review, a total of five current efforts put forth by the government and other stakeholders in conserving honeybees resources in Tanzania have been identified to occur in Tanzania (Table 2). Although number of their occurrences in the literature differ from each other, still they indicate some levels of efforts taken to protect the honey bees in Tanzania. Various biodiversity conservation efforts have occurred over the last two decades, particularly in the forestry sector, including institutional arrangements such as increasing government-owned forestry reserves, human resource development, and biodiversity conservation research and development (URT 2016, URT 2022). Through public-private sector partnerships at both local and international levels, various synergies in biodiversity conservation have been witnessed in the conservation of bee's habitats and minimize recurrent honeybee threats (URT 2022). Conservation of honeybee resources has been the paramount objective of National Beekeeping and Forest Policies and Acts (URT 1998a, URT 1998b, URT 2000a, URT 2000b). It is through this objective that a total of 48.1 million hectares of forest have been conserved, and of that, 39,811 ha are bee reserves, including 37,794.1 ha of village bee reserves, and 2,126.9 ha national bee reserves, respectively (URT 2015, URT 2022c). The establishment of national forest and beekeeping policies and their related acts are among the efforts to recognize beekeeping and its related resources.

Tanzania has designated a large network of national bee reserves and forest protected areas covering 22 national parks, 1 conservation area, 27 game reserves, 42 game-controlled areas, 21 honey-bee management areas, 3 Ramsar Sites, 419 natural forests, 20 nature forest reserves, 12 bee reserves, and 24 public forest farms (URT 2015, URT 2022c). It is further estimated that 36 apiaries are established in13 central government-owned forests (URT, 2021a). Tanzania has also established various institutions to foresee and manage natural resources, including the Tanzania Forest Services (TFS) Agency as one of both beekeeping and forest policy implementation instruments.

It is through TFS that all beekeeping resources and products are managed. Other institutions include Tanzania Forest

Research Institute (TAFORI), Tanzania Wildlife Research Institute (TAWIRI), Olmotonyi Forest Training Institute (FTI), Beekeeping Training Institute (BTI) in Tabora and Tanzania Forest Fund (TaFF) (URT 2015, URT 2022c). The government of Tanzania has put in place policies, Acts, Regulations, and institutional arrangements to make sure forests and related natural resources are sustainably and effectively used and conserved. The establishment of guidelines for management and use of honeybee colonies for pollination services, Management of Bee Reserves and Apiaries in Tanzania, National Beekeeping Policy Implementation Strategy (2021–2031), National Beekeeping Research Master Plan I (2020–2030), and The National Beekeeping Training and Extension Manual of 2021 are among undisputed efforts towards conservation of bee resources in Tanzania (URT 2021a, URT 2021b, URT 2022c).

Despite the aforementioned government efforts to manage and conserve honeybees, forests, and related natural resources, the sustainability of honeybees remains a development discourse. The trade-off between the registered conservation efforts and the bee threats remains unsynchronized.

This problem continues to exist due to a lack of a formal cross-sectoral coordination mechanism between beekeeping authorities, institutions governing pesticide application, and the Ministry of Agriculture (URT 2021a:11).

Inadequate updated database on the status of honeybees' population and health status remains one of the challenges facing the sector (URT 2021a).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

It has been observed that several threats for honeybees exist in Tanzania. Thus, the sustainability of honeybees in Tanzania is not guaranteed due to the observed honeybee threats likely to have long-term damaging effects on honeybee's population, including bee colony decline, weakening of honeybees as pollinators, and their related repercussions on crop production and biodiversity conservation in Tanzania.

Recommendations

While there have been various initiatives to conserve bee populations in Tanzania, such as increased government-owned forestry reserves and biodiversity research, there is still a need for more targeted efforts to mitigate the impacts caused by the honeybee threats and improve citizens' education on sustainable practices of honeybee related natural resources. It is also recommended that further studies be conducted with regard to the extent and impact of the presented threats on the sustainability of honeybees in Tanzania.

ACKNOWLEDGMENTS

The author would like to thank Prof. Abiud Kaswamila, Prof. Odass Bilame, Mr. Stephen James Kamugisha, and staff from the Institute of Development Studies (IDS) at the University of Dodoma who secured their time to reshape this work. The comments and inputs received from two anonymous reviewers are highly acknowledged. The management of the University of Dodoma is acknowledged for availing the necessary office facilities and time to complete this study.

REFERENCES

Academy of Science of South Africa (ASSAf) 2019. Neonicotinoids and their Impact on Ecosystem Services for Agriculture and Biodiversity in Africa. Working Group Meeting Proceedings Report.DOI. org/ 10.17159/assaf.

Alburaki, M., Boutin, S., Mercier, P.L., Loublier, Y., Chagnon, M. & Derome, N. 2015. Neonicotinoid-

Coated Zea mays Seeds Indirectly Affect Honeybee Performance and Pathogen Susceptibility in Field Trials. *PLoS ONE* 10(5): DOI:org/10.1371/journal.pone.0125790.

Amulen, D., Spanoghe, P., Houbraken, M., Tamale, A., de Graaf D. & Cross, P. 2017. Environmental contaminants of honeybee products in Uganda detected using LC-MS/MS and GC-ECD. *PLoS ONE* 12(6): DOI:org/10.1371/journal.pone.0178546.

Anguilet, E., Nguyen, B., Ndong, T., Haubruge, É. & Francis, F. 2015. Meliponini and Apini in Africa (Apidae: Apinae): A review on the challenges and stakes bound to their diversity and their distribution. Biotechnology, *Agronomy and Society and Environment* 19(4):382-391.

Berry, L. 2008. The impact of environmental degradation on refugee-host relations: a case study from Tanzania. New Issues in Refugee Research, Research Paper No. 151, Graduate School of International Studies, University of Denver, Colorado. 27p.

Chami, C., Liwenga, E. & Masao, C. 2022. Is Beekeeping Commercially and Environmentally viable? an assessment of the adoption of hanging frame beehives in semi-Arid Area of central Tanzania. *Tropical Conservation Science* 15 (1): DOI:org/10.1177/19400829221125393.

Da Silva, I.P, Oliveira, F.A.S, Pedroza, H.P, Gadelha, I.C.N, Melo, M.M. & Soto-Blanco, B. 2015. Pesticide exposure of honeybees (*Apis mellifera*) pollinating melon crops. *Apidologie* 46:703-715. DOI: org/10.1007/s13592-015-0360-3.

Elisante. F., Ndakidemi, P., Arnold S.E.J, Belmain S.R, Gurr G.F, Darbyshire, I., Xie G., Stevenson P.C. 2020. Insect pollination is important in a smallholder bean farming system. *PeerJ* 8:DOI:org/10.7717/peerj.10102.

Erkkila, A., Herdieckerhoff, I., Mustalahti, I., Tumaini, U.J, Maro, A.H. 2024. Ambiguity and forest-based bioeconomy: The case of forest fires in the Southern Highlands of Tanzania. *Forest Policy and Economics* 160: 103159. DOI:org/10.1016/j.forpol.2024.103159.

Etxegarai-Legarreta, O. & Sanchez-Famoso, V. 2022. The Role of Beekeeping in the Generation of Goods and Services: The Interrelation between Environmental, Socioeconomic, and Sociocultural Utilities. *Agriculture* 12(551).DOI:org/10.3390/agriculture12040551.

Fairbrother, A., Purdy, J., Anderson, T. & Fell, R. 2014. Risks of neonicotinoids insecticides to honeybees. *Environmental Toxicology and Chemistry* 33(4): 719–731. DOI: 10.1002/etc.2527.

Fikadu, Z. 2020. Pesticides use, practice and its effect on honeybee in Ethiopia: A Review. *International Journal of Tropical Insect Science* 40: 473–481. DOI:org/10.1007/s42690-020-00114-x.

Giliba, R.A, Mpinga, I.H, Ndimuligo, S.A. & Mpanda, M. M. 2020. Changing climate patterns risk the spread of Varroa destructor infestation of African honey bees in Tanzania. *Ecological Processes* 9(48): DOI:org/10.1186/s13717-020-00247-4.

Global Forest Watch. 2024. Global FAO Deforestation. https://www.globalforestwatch.org/dashboards/global/?category=forest-change. Site accessed in 07/06/2024.

Hannes, K., Petry, K. & Heyvaert, M. 2017. The meta-aggregative approach to qualitative evidence synthesis: a worked example on experiences of pupils with special educational needs in inclusive education. *International Journal of Research & Method in Education* 41(3): 291-305.DOI:org/10.1080/1743727X.2017.1299124.

Irungu, J., Fombong, A.T., Kurgat, J, Mulati, P., Ongus, J., Nkoba, K. & Raina, S. 2016. Analysis of Honey Bee Hive Products as a Model for Monitoring Pesticide Usage in Agroecosystems. *Journal of Environment and Earth Science* 6(8): 9-16.

IPBES 2016. Summary for policymakers of the assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production. S.G. Potts, V.L. Imperatriz-Fonseca, H.T. Ngo, J.C. Biesmeijer, T.D. Breeze, L.V. Dicks, L.A. Garibaldi, R. Hill, J. Settele, A.J. Vanbergen, M.A. Aizen, S.A. Cunningham, C. Eardley, B.M. Freitas, N. Gallai, P.G. Kevan, A. Kovács-Hostyánszki, P.K. Kwapong, J. Li, X. Li, D.J. Martins, G. Nates-Parra, J. S. Pettis, R. Rader, and B. F. Viana (eds.), Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 36p.

Katambo, M. 2018. Neonicotinoids and their impact on ecosystem services in Tanzania. A paper presented at special workshop on Neonicotinoids and their impact on ecosystem services for agriculture in Africa, South Africa from 14-16 November, 2018.

Khalifa, S.A.M., Elshafiey, E.H., Shetaia, A.A., El-Wahed, A.A.A., Algethami, A. F., Musharraf, S. G., AlAjmi, M. F., Zhao, C., Masry, S.H.D., Abdel-Daim, M.M., Halabi, M.F., Kai, G., Naggar, Y.A., Bishr, M., Diab, M.A.M., El-Seedi, H.R. 2021. Overview of Bee Pollination and Its Economic Value for Crop Production. *Insects* 12(8):688).DOI:org/10.3390/insects12080688.

Kashumba, F. 2018. The Influence of Innovations Intervention on Beekeepers' Livelihoods in Sikonge District of Tabora Region in Central Tanzania. Unpublished PhD Thesis at The University of Dodoma. 357pp.

Kiwango, P.A., Kassim, N. & Kimanya, M. E. 2018. Pesticide Residues in Vegetables: Practical Interventions to Minimize the Risk of Human Exposure in Tanzania. *Current Journal of Applied Science and Technology* 26(1): 1-18: DOI.org/10.9734/CJAST/2018/38976.

Lahr, J., Buij, R., Katagira, F. & van der Valk, H. 2016. Pesticides in the Southern Agricultural Growth Corridor of Tanzania (SAGCOT): a scoping study of current and future use, associated risks and identification of actions for risk mitigation. *Wageningen Environmental Research rapport*; No. 2760. DOI.org/10.18174/394164.

Lekei, E.E., Ngowi, A.V. & London, L. 2014. Farmers' knowledge, practices and injuries associated with pesticide exposure in rural farming villages in Tanzania. *BMC Public Health* 14:389. DOI: 10.1186/1471-2458-14-389.

Lema, E., Machunda, R. & Njau, K. 2014. Agrochemicals use in horticulture industry in Tanzania and their potential impact to water resources. International *Journal of Biological*

and Chemical Sciences 8(2): 831-842: DOI:10.4314/ijbcs.v8i2.38.

Li, Q., Sun, M., Liu, Y., Liu, B., Bianchi, F.J.J.A., van derWerf, W. & Lu, Y. 2022. High Pollination Deficit and Strong Dependence on Honeybees in Pollination of Korla Fragrant Pear, Pyrus sinkiangensis. *Plants* 11:1734.DOI.org/10.3390/plants11131734.

Lusambo, L. 2021. Households' woodfuel consumption and deforestation in Morogoro and Songea Districts, Tanzania. *Tanzania Journal of Forestry and Nature Conservation* 91(1):196-205.

Matowo, N.S., Tanner, M., Munhenga, G., Mapua, S.A, Finda, M., Utzinger, J., Ngowi, V. & Okumu, F.O. 2020. Patterns of pesticide usage in agriculture in rural Tanzania call for integrating agricultural and public health practices in managing insecticide-resistance in malaria vectors. *Malaria Journal* 19:257. DOI.org/10.1186/s12936-020-03331-4.

Masaquiza, D., Vargas, J., Ortíz, N., Salazar, R., Curbelo, L., Pérez, A. & Arenal, A. 2021. Hygienic Behavior of Apis mellifera and Its Relationship with Varroa destructor Infestation and Honey Production in the Central Highlands of Ecuador. *Insects* 12(11): 966. DOI: 10.3390/insects12110966.

Massomo, S.M.S. 2019. Vegetable Pest Management and Pesticide use in Kigoma, Tanzania: Challenges and way Forward. *Huria Journal* 26(1):195-227.

Mgina, M. & Wawa, A. 2020. Assessment of Wildfires in Tanzania Forest Plantations: A Case of Sao Hill in Mufindi District. *Huria Journal* (2):30-55.

Minja, G.S. & Nkumilwa, T.J. 2016. The Role of Beekeeping on Forest Conservation and Poverty Alleviation in Moshi Rural District, Tanzania. *European Scientific Journal* 12(23): DOI.org/10.19044/esj.2016.v12n23p366.

Mulati, P., Kitur, E., Taracha, C., Kurgat, J., Raina, S. & Irungu, J. 2018. Evaluation of Neonicotinoid Residues in Hive Products from Selected Counties in Kenya. *Journal of Environmental & Analytical Toxicology* 8(4): 577. DOI.org/10.4172/2161-0525.1000577.

Muli, E., Patch, H., Frazier, M., Frazier, J., Torto, B., Baumgarten, T., Kilonzo, J., Kimani, J.N., Mumoki, F., Masiga, D., Tumlinson, J. & Grozinger, C. 2014. Evaluation of the Distribution and Impacts of Parasites, Pathogens, and Pesticides on Honey bee (Apis mellifera) Populations in East Africa. *PLoS ONE* 9(4): e94459. DOI.org/10.1371/journal.pone.0094459.

Mumbi, C.T., Mwakatobe, A.R., Mpinga, I. H., Richard, A.& Machumu, R. 2014. Parasitic mite, Varroa species (Parasitiformes:Varroidae) infesting the colonies of African honeybees, Apis mellifera scutellata (Hymenoptera:Apididae) in Tanzania. *Journal of Entomology and Zoology Studies* 2(3):188-196.

Network of African Science Academies (NASAC) 2019. Neonicotinoids Insecticides: Use and effects in African Agriculture. A review and recommendations to policymakers. Network of African Science Academies, Nairobi. 54p.

Ndibalema, P. 2022. Constraints of transition to online distance learning in Higher Education Institutions during COVID-19 in developing countries: A systematic review. *E-Learning and Digital Media* 19(6): 595-618.

DOI.org/10.1177/204275302211075 10.

Ndibalema, P. 2024. Barriers to accessibility of learning among minority refugee children: A Systematic literature review. *Children and Youth Services Review* 156, 107261: DOI.org/10.1016/j.childyouth.2023. 107261.

Nyunza, G. 2018. Anthropogenic and climatic factors affecting honey production: The case of selected villages in Manyoni District, Tanzania. *Journal of Agricultural Biotechnology and Sustainable Development* 10(3): 45-57. DOI.org/10.5897/JABSD2017.0292.

Ollerton, J., Winfree, R. & Tarrant, S. 2011. How many flowering plants are pollinated by Animals? *Oikos* 120: 321-326. DOI.org/10.1111/j.1600-0706.2010.18644.x.

Ridder, H. 2017. The theory contribution of case study research designs. *Business Research* 10:281-305.DOI.org/10.1007/s40685-017-0045-z.

Rutinwa, B., & Kamanga, K. 2003. Impact of Refugees in North-Western Tanzania. Study by Center for Study of Forced Migration, University of Dar Es Salaam. 7pp.

Pallangyo, B., Mdily, K., Mkondo, C. & Kibola, A. 2019. Crop Pests, Control Measures and Potential Impacts in Kihansi Catchment Area. *Tanzania Journal of Science* 45(4): 650-660.

Page, M.J., Mckenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann,T. C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., Mcdonald, S., McGuinnes, L. A., Stewart, L. A., Thomas, J., Tricco, A.C., Welch, V. A., Whiting, P. & Moher, D. 2020. The PRISMA 2020 statement: an updated Guideline for reporting systematic reviews. *Systematic Reviews* 10:89. DOI.org/10.1186/s13643-021-01626-4.

Pirk, C. W. W., Strauss, U., Yusuf, A. A., Démares, F. & Human, H. 2016. Honeybee health in Africa- a review. *Apidologie* 47: 276-300. DOI: 10.1007/s13592-015-0406-6.

Shao, D. & Edward, S. 2014. Combating Fake Agro-Inputs Products in Tanzania using Mobile Phones. *International Journal of Computer Applications* 97(17).

Sawe, T., Nielsen, A. & Eldegard, K. 2020. Crop Pollination in Small-Scale Agriculture in Tanzania: Household Dependence, Awareness and Conservation. *Sustainability* 12(2228).DOI.org/10.3390/su12062228.

Stadlinger, N., Mmochi, A.J., Dobo, S., Gyllba¨ck, E. & Kumblad, L. 2011. Pesticide use among smallholder rice farmers in Tanzania. *Environmental Development Sustainability* DOI.org/10.1007/s10668-010-9281-5.

Tibesigwa, B., Siikamäki, J., Lokina, R. & Alvsilver, J. 2019. Naturally available wild pollination services have economic value for nature dependent smallholder crop farms in Tanzania. *Scientific Reports* 9(3434). DOI.org/10.1038/s41598-019-39745-7.

Tesfaye, B., Dadi, G., Lelisa, W. & Gelgelu, T. 2021.Assessment of pesticides use effects on honeybee colonies and its financial impact in some selected districts of Bale Zone, South Eastern Ethiopia. *International Journal of Aquaculture and Fishery Sciences* 7(1). DOI.org/10.17352/2455-8400.000066.

Tesfaye, B., Dadi, G. & Gelgelu, T. 2017. Assessment of honeybee enemies (pests and predators) in Bale zone, southeastern Ethiopia. *Journal of Agricultural Extension and Rural Development* 9(4): 53-61.DOI.org/10.5897/JAERD2016.0844.

Tutuba, N.B. & Kapinga, C. 2022. Beekeeping Productivity: Why is the Beekeeping Sector less Productive in Tanzania? *International Journal of Economics, Business and Management Research* 6(9): DOI.org/10.51505/ijebmr.2022.691.

Tutuba, N.B. & Vanhaverbeke, W. 2018. Beekeeping in Tanzania: Why is beekeeping not commercially viable in Mvomero? *Africa focus* 31(1): 213-239.

URT 1998a. National Beekeeping Policy. Ministry of Natural Resources and Tourism. Government Printer, Dar es Salaam.

URT 1998b. National Forest Policy. Ministry of Natural Resources and Tourism. Government Printer, Dar es Salaam.

URT 2002a. Beekeeping Act. Ministry of Natural Resource and Tourism. Government Printers, Dar es Salaam.

URT 2002b. Forest Act. Ministry of Natural Resource and Tourism. Government Printers, Dares Salaam.

URT 2013. National Agriculture Policy. Ministry of Agriculture Food Security and Cooperatives, Dar es Salaam.

URT 2015a. National Biodiversity Strategy and Action Plan (NBSAP) 2015-2020. Vice President's Office. Division of Environment. United Republic of Tanzania, Dar es Salaam.

URT 2015b. National Forest Resources Monitoring and Assessment of Tanzania Mainland (NAFORMA). Ministry of Natural Resource and Tourism. Government Printers, Dares Salaam.

URT 2016. Beekeeping in Tanzania: Country Situation. Paper Presented at ApiExpo Africa 2016 Camp Kigali Rwanda. Ministry of Natural Resources and Tourism.

URT 2017. Tanzania's Forest Reference Emission Level. Submission to the United Nations Framework Convention on Climate Change, Ministry of Natural Resources and Tourism, Dar es Salaam.

URT 2018a. Registered Pesticides for use in the United Republic of Tanzania. Issued by The Registrar of Plant Protection Substances. Ministry of Agriculture, Dar es Salaam.

URT 2018b. Performance Audit Report on the Management of Pesticides in Agriculture: A Report of the Controller and Auditor General. National Audit Office, Dar es Salaam.

URT 2020. Registered Pesticides for use in the United Republic of Tanzania. Issued by The Registrar of Plant Protection Substances. Ministry of Agriculture, Dodoma.

URT 2021a. National Beekeeping Policy Implementation Strategy (2021-2031). Ministry of Natural Resources and Tourism, Dodoma.

URT 2021b. The National Beekeeping Training and Extension Manual: Beekeeping for Improved Livelihood, Forestry and Beekeeping Division, Ministry of Natural Resources and Tourism, Dodoma.

URT 2022a. Guideline for Management and Use of Honeybee Colonies for Pollination Services in Tanzania. Forestry and Beekeeping Division, Ministry of Natural Resources and Tourism, Dodoma.

URT 2022b. National Sample Census of Agriculture 2019-2020. National Bureau of Statistics, Office of the Chief Government Statistician, Zanzibar.

URT 2022c. Budget speech during presentation of the Ministry's Financial Year's Income and Expenditure Budget 2022/2023. Ministry of Natural Resource and Tourism, Dodoma.

van Der Sluijs, J.P., Simon-Delso, N., Goulson, D., Maxim, L., Bonmatin, J. & Belzunces, L.P. 2013. Neonicotinoids, bee disorders and the sustainability of pollinator services. *Current Opinion in Environmental Sustainability* 5: 293-305.

Vanbergen, A.J., Espíndola, A. & Aizen, M. A. 2018. Risks to pollinators and pollination from invasive alien species. *Nature Ecology & Evolution* 2:16-25. DOI.org/10.1038/s41559-017-0412-3.

Wakgari, M. & Yigezu, G. 2021. Honeybee keeping constraints and future prospects. *Cogent Food & Agriculture* 7(1). DOI.org/10.1080/23311932.2021.1872192.

Whitaker, B.E. 1999. Changing opportunities: refugees and host communities in western Tanzania. New Issues in Refugee Research. Working Paper No. 11. University of North Carolina. 18pp.