DOCTOR OF PHILOSOPHY

Estimating the contribution of beekeeping to household wellbeing and conservation motivations in the Tanzanian Miombo

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Award date:
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Estimating the contribution of beekeeping to household wellbeing and conservation motivations in the Tanzanian Miombo

A thesis for a joint degree of Doctor of Philosophy

by

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and

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SUMMARY

Beekeeping is used by numerous development agencies in their efforts to promote livelihood activities that reduce poverty and provide incentives for forest conservation. Besides short-term monetary focused project evaluation reports, there is little evidence on the effectiveness of beekeeping to achieve the above goals. In this thesis I set out to examine the contribution of beekeeping to household wellbeing and conservation motivations. I conducted this study in four rural communities in Central Tanzania using a mixed methods approach. First, I identified predictors of beekeeping adoption, dependence, and success. I found that beekeepers were often also livestock keepers and wild honey hunters. The results also indicate that beekeeping uptake was mainly motivated by the prospect of cash income, but the lack of suitable land, means to acquire hives and technical knowledge were significant inhibitors. I also found that beekeeping training provided by governmental organisations did not lead to improved beekeeping success when compared to local training provided by neighbours and family members. Lastly, elite capture of project benefits was a frequent occurrence when project participation was linked to the requirement to form associations. I then assessed whether beekeepers were better-off in ten crucial life domains than their non-beekeeping peers and whether beekeeping was effective in filling an income gap during the agricultural year. I observed that beekeepers were more food secure, more resilient and had more farm-and non-farm assets. I found that beekeeping income contributed to additional cash income during distinct periods of the year, but did not fully bridge shortage periods. Finally, I analysed the associations between beekeeping and conservation by assessing a range of factors contributing to forest-friendly behaviour. I found beekeeping to be linked to more intensive forest use, more positive attitudes towards the forest and a stronger appreciation of conservation benefits. These observed effects were however mitigated by beekeepers' engagement in forest destructive behaviours and their insufficient influence within their communities to protect forest resources. These findings are of importance, as considerable efforts are being paid to the promotion of beekeeping in developing countries, including in the context of REDD+. The methodology chosen for this research as well as the short extent of time spent in study communities preclude however definite conclusions on differences between beekeepers' and non-beekeepers' wellbeing and conservation impact. Given how ubiquitous

engagement in beekeeping in Tanzania is, it is entirely conceivable that the benefits of beekeeping on wellbeing and conservation motivations are either much larger - yet not captured in the data collected for this study – or that they offer a relative easily accessible supplement to local livelihoods where alternatives are scarce. The results of this study can still point to opportunities for better-targeted investment in beekeeping in the context of linked conservation and development interventions by improving the selection of beneficiaries and the design of project delivery mechanisms, setting in place a range of factors which can improve beekeeping benefits and identifying further measures potentially needed to achieve enhanced livelihood and conservation goals.

SAMMENDRAG (DANISH SUMMARY)

Biavl benyttes af et stort antal udviklingsorganisationer i deres indsats for at fremme levebrødsstrategier, der reducerer fattigdom og skaber incitamenter til skovbevarelse i udviklingslande. Bortset fra projektevalueringsrapporter med kortsigtet økonomisk fokus foreligger der kun begrænset dokumentation for biavls effektivitet som middel til at opnå de nævnte mål. I denne afhandling har jeg undersøgt biavlens bidrag til husholdningernes velbefindende og naturbeskyttelsesmotivation. Jeg gennemførte studiet i fire landsbysamfund i det centrale Tanzanias landområder og benyttede en fremgangsmåde baseret på blandede metoder. Først undersøgte jeg, hvilke forhold der betinger den enkelte husholdnings igangsætning af biavl, samt husholdningernes afhængighed af og succes med biavl. Jeg fandt at biavlere ofte også holdt husdyr og indsamlede honning fra vilde bier. Resultaterne indikerer også at igangsættelse af biavl hovedsagelig er motiveret af udsigten til at opnå en pengeindkomst, men mangel på egnede arealer, midler til anskaffelse af bistader eller teknisk viden begrænser i høj grad igangsættelsen. Jeg fandt endvidere at træning i biavl, tilbudt af organisationer under regeringen, ikke fører til øget succes med biavl sammenlignet med lokal oplæring fra naboer og familiemedlemmer. Endelig sker det ofte at landsbyens elite tilegner sig de fordele som projekterne tilbyder, når projektdeltagelse er knyttet til et krav om dannelse af foreninger. Efterfølgende undersøgte jeg om biavlere var bedre stillet end ikke-biavlere i samme område mht. til afgørende livskvalitetsdomæner, og om biavl var i stand til at udfylde indkomstgab forårsaget af variationer i landbrugsindkomsten. Jeg observerede at biavlere oplever større sikkerhed mht. adgangen til fødevarer end andre, de er også mere resiliente end andre og har flere landbrugs- og ikke-landbrugsaktiver. Jeg fandt også at indkomsten fra biavl var utilstrækkelig til effektivt at forhindre perioder uden indkomst hen over året. Endelig analyserede jeg sammenhængene mellem biavl og naturbeskyttelse ved at undersøge en række faktorer der bidrager til skovvenlig adfærd. Jeg fandt at biavl er knyttet til mere intensiv skovanvendelse, en mere positiv indstilling til skoven og en større anerkendelse af fordelene ved naturbeskyttelse. Disse observerede virkninger blev dog mildnet af biavleres engagement i skovens destruktive adfærd og deres utilstrækkelige indflydelse i deres lokalsamfund til at beskytte skovressourcerne. Disse observationer er vigtige, idet der gøres en betydelig indsats for at fremme biavl i udviklingslandene, herunder i forbindelse med REDD+-

programmet. Den valgte metode til denne forskning samt den korte tidsforbrug i studiefællesskaber udelukker dog bestemte konklusioner om forskelle mellem biavleres og ikke-biavleres trivsel og bevaringseffekt. I betragtning af hvor allestedsnærværende engagement i biavl i Tanzania er, kan det helt tænkes, at fordelene ved biavl på trivsel og bevaringsmotiveringer enten er meget større - men alligevel ikke fanget i de data, der er indsamlet til denne undersøgelse - eller at de tilbyder et let tilgængeligt supplement til lokale levebrød. Resultaterne af dette studie kan stadig pege på muligheder for bedre målrettede investeringer i biavl i forbindelse med sammenhængende bevarings- og udviklingsinterventioner ved at forbedre udvælgelsen af støttemodtagere og udformning af projektleveringsmekanismer, idet der kan indføres en række faktorer, der kan forbedre biavl fordele og identificere yderligere foranstaltninger, der potentielt er nødvendige for at opnå forbedrede levebrøds- og bevaringsmål.

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ABBREVIATIONS

ADAP	Association pour le Développement des Aires Protégées
AIC	Akaike Information Criterion
ALP	Alternative Livelihood Project
ANRC	African Natural Resources Centre of the African Development Bank
APFIC	Asia-Pacific Fishery Commission
ARC	African Rainforest Conservancy
BTC	Belgian Technical Cooperation
CBD	Convention on Biological Diversity
CBFM	Community-Based Forest Management
COP	Conference of the Parties
ESA CCI	European Space Agency Climate Change Initiative
FAO	Food and Agriculture Organization
GoCR	Government of Costa Rica
GoF	Government of France
HDI	Human Development Index
ICDP	Integrated Conservation and Development Programme
ICIPE	International Centre of Insect Physiology and Ecology
IFAD	International Fund for Agricultural Development
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
ITC	International Trade Centre
IUCN	International Union for Conservation of Nature
JFM	Joint Forest Management
LCDA	Linked conservation and development approach
MPAT	Multidimensional Poverty Assessment Tool
MNRP	Management of Natural Resources Programme
MNRT	Ministry of Natural Resources and Tourism
NGO	Non-Governmental Organisation

NORAD	Norwegian Agency for Development Cooperation
NTFP	Non-Timber Forest Product
ODK	Open Data Kit
OECD	Organisation for Economic Co-operation and Development
PEN	Poverty and Environment Network
PES	Payments for Ecosystem Services
PFM	Participatory Forest Management
REDD+	Reducing emissions from deforestation and forest degradation
SCBD	Secretariat of the Convention on Biological Diversity
SDT	Self-Determination Theory
SIDO	Small Industries Development Organization
SNV	Netherlands Development Organisation
SUA	Sokoine University of Agriculture
TASAF	Tanzania Social Action Fund
TBCS	Tabora Beekeeping Cooperative Society
TBH	Top-bar hive
TLU	Tropical Livestock Unit
TFF	Tanzania Forest Fund
TFS	Tanzania Forest Service
TPB	Theory of Planned Behaviour
TZS	Tanzanian Shilling
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-REDD	UN Programme on Reducing Emissions from Deforestation and Forest Degradation
USAID	United States Agency for International Development

AUTHORSHIP

All data chapters (Chapters 3-5) in this thesis have been prepared as manuscripts for peer reviewed publication. These are co-authored to reflect the role of my supervisors. The references and supplementary material can be found at the end of this thesis.

Chapter 3: Wagner, K., H. Meilby & P. Cross (2019) "Sticky business - Why do beekeepers keep bees and what makes them successful in Tanzania?", Journal of Rural Studies, 66, pp 52-66. https://doi.org/10.1016/j.jrurstud.2019.01.022

I designed the study with advice from Paul Cross and Henrik Meilby. I was responsible for data collection with field assistants. I conducted the statistical analysis with advice from Paul Cross and Henrik Meilby. I wrote the first version of the paper and all co-authors provided minor stylistic revisions.

Chapter 4: Wagner, K., H. Meilby & P. Cross (Manuscript with editor). The contribution of beekeeping to rural livelihoods and wellbeing in Central Tanzania

I designed the study with advice from Paul Cross and Henrik Meilby. I was responsible for data collection with field assistants. I conducted the statistical analysis with advice from Paul Cross and Henrik Meilby. I wrote the first version of the paper and all co-authors provided minor stylistic revisions.

Chapter 5: Wagner, K., H. Meilby & P. Cross (Manuscript in preparation). Guardians of the forest? Tanzanian beekeepers' forest use, attitudes, values and perceived control.

I designed the study with advice from Paul Cross and Henrik Meilby. I was responsible for data collection with field assistants. I conducted the statistical analysis with advice from Paul Cross and Henrik Meilby. I wrote the first version of the paper and all co-authors provided minor stylistic revisions.

1. INTRODUCTION

1.1. Research background and rationale

For the past four decades, beekeeping has been promoted by major development organisations and non-governmental organisations (NGOs) as a means to alleviate poverty and to provide an incentive for forest conservation (Drescher and Crane 1982, Munthali and Mughogho 1992, Brown 2001, FAO 2005, FAO 2011, Bees Abroad 2013, ICIPE 2013, FAO 2014b, World Bank 2015b, World Vision 2015, BTC 2016, SNV 2016b, UNDP 2016a, UNDP 2016b, World Vision 2016). The appeal of promoting beekeeping as a response to poverty and conservation concerns is evidenced by the coverage in the international news media (Jones 2010, Kalan 2014, Newsome 2014, Jeffrey 2015, Lageman 2016). Notwithstanding the popular media interest, there is a substantial lack of peer-reviewed empirical evidence to support the purported claims of beekeeping programmes to either alleviate poverty or contribute to natural resources conservation.

This thesis assesses the contribution of beekeeping to household wellbeing and forest conservation by identifying predictors for conservation behaviour linked to beekeeping.

The following sections explore the historical, theoretical, and methodical background to the study. I start by providing a background to approaches that link conservation and development and specifically to beekeeping projects as prominent examples of such efforts. I then explore the different means employed to measure the effectiveness of these efforts. Finally, each section refers also to the methods chosen for the present research and the justification of these choices based on the literature reviewed.

1.1.1. The global context of linking conservation and poverty alleviation approaches

Despite substantial and ongoing efforts by the world community, levels of extreme poverty (defined as a person living on less than US$1.90/day) (World Bank 2015a) remain undiminished in the developing world (Ravallion, Chen et al. 2009). The majority of the world's poor are rural dwellers (IFAD 2010). Rural poverty manifests itself not only in a lack

of income, but also in a lack of access to productive resources, infrastructure and services, in hunger, malnutrition and poor health, inadequate housing, increased insecurity, socio-economic disconnectedness as well as in an increased vulnerability to risks and shocks, as caused by e.g. natural disasters. (United Nations 1995, World Bank 2001).

According to the most recent Global Forest Resource Assessment, forest cover continues to decrease globally by approximately 6.5 million hectares per year[1] (FAO 2016b). Poverty and forest loss appear to be interlinked. A large proportion of the extremely poor live in rural, partly forested landscapes (Sunderlin, Angelsen et al. 2005, Banerjee and Duflo 2007, Fisher and Christopher 2007). While a simplistic two-way causal relationship of poverty and forest loss has been questioned (Angelsen and Wunder 2003), poverty is nonetheless considered one of several principal contributing factors to forest loss (Sunderlin, Angelsen et al. 2005, Mackenzie and Hartter 2013). For example, the single largest cause for deforestation across Africa continues to be the conversion of forest cover to agricultural lands for subsistence farming (Geist and Lambin 2002, Gibbs, Ruesch et al. 2010, Hosonuma, Herold et al. 2012, Rudel 2013, FAO 2016b, Curtis, Slay et al. 2018).

Deforestation and forest degradation have quantifiable impacts on biodiversity, habitat quality, water cycling, soil stability, and atmospheric carbon concentration (Dregne 1990, Falkenmark and Widstrand 1992, Polcher and Laval 1994, Alin, Cohen et al. 1999, IPCC 2000, Patz, Graczyk et al. 2000, Ramankutty, Gibbs et al. 2007). The impact of the decline of natural forests on livelihoods has also been widely recognised (Maruyama and Morioka 1998, Sunderlin, Angelsen et al. 2005, Arnold, Köhlin et al. 2006, Nasi, Taber et al. 2011). The Millennium Ecosystem Assessment highlighted that the ongoing global degradation of ecosystem services affects the rural poor disproportionately (Reid, Mooney et al. 2005). The level of forest dependence ranges from forests as the main source of livelihood and cash-income generation - through the sale and consumption of timber and non-timber forest products – to subsistence level dependency including reliance on forest provision for supplementary benefits such as gap-filler nutrition provision during lean agricultural seasons.

[1] When temporary land cover changes are taken into account (e.g. the felling of trees in a forest concession) this number increases to approximately 19 million hectares per year (Hansen, M. C., et al. (2013). "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science, 342: 6160, pp 850-853.)

The number of forest dependent people is estimated to be in the tens of millions (Angelsen and Wunder 2003, Newton, Miller et al. 2016).

The elimination of extreme poverty and the halt of forest degradation and loss are thus prominent development objectives as highlighted by the Sustainable Development Goals 1 and 15 (General Assembly resolution 70/1 2015). Given the scale of interdependencies, many governments and development agencies seek to address poverty and forest loss conjointly (World Bank 2004, Oberndorf, Durst et al. 2006, GoCR, GoF et al. 2013, UNDP 2013, World Bank 2013, USAID 2014, UNDP 2015, USAID 2015). The win-win benefits of biodiversity conservation and poverty reduction are recognised as: increased food security[2], health benefits in the form of traditional medicine, income generation based on natural resources, reduced exposure to natural hazards such as floods and droughts, and cultural and spiritual assets (Timmer and Juma 2005). Development that integrates natural resource management aspects is not a new idea and can take multiple forms. Sayer and Campbell (2004), provide a comprehensive overview of the diversity and similarity of integrative approaches applied by the global development community during the past five decades.

On the part of the conservation community the two principal responses to the demands of development are 'preservation' on the one hand or 'wise use' of natural resources on the other (Newsham and Bhagwat 2016). Traditional conservation, based on the assumption that rural livelihood aspirations conflict with biodiversity goals, aims to create parks and protected areas that exclude or strongly restrict any use of protected resources by local communities. This preservation approach of delinking conservation and local livelihoods and enforcing zoning and use restrictions faces several social challenges such as effective practical implementation particularly where capacity for control and enforcement is limited (Hough 1988, Brandon and Wells 1992, West, Igoe et al. 2006).

To overcome such challenges, a newer generation of conservation approaches aims to provide positive incentives for conservation by linking economic development and livelihoods of local communities either indirectly or directly with the protection of natural resources (Brandon and Wells 1992, Salafsky and Wollenberg 2000, Roe, Day et al. 2014). The term integrated conservation and development programmes (ICDPs) describes a range of

[2] Directly through consumption of natural foods and indirectly through soil stabilisation and fertility, nutrient cycling, natural pest control, fertilisation, and pollination.

approaches within this vision. Indirect ICDP approaches are characterised by 'distracting' local communities from natural resource exploitation by substituting their reliance on natural resources with alternatives, e.g. reducing dependence on bushmeat by introducing domesticated sources of meat (Milner-Gulland and Rowcliffe 2007).

Direct approaches attempt to give local communities an immediate stake in the preservation of natural resources by directly benefitting from biodiversity through biodiversity-based livelihood activities (UNDP 2000, Roe, Day et al. 2014). The underlying rationale is that income and subsistence derived from biodiversity provide an incentive to the community to protect and conserve natural resources (Salafsky and Wollenberg 2000, Roe, Day et al. 2014).

Linked conservation and development approaches have been appearing under different labels over the past three decades (Brocklesby 2002, Wright, Hill et al. 2016). Alternative livelihood projects (ALPs) represent a newer terminology, the use of which seems to have proliferated in the last decade (Roe, Day et al. 2014). As characteristic of many 'innovations' in the development and conservation domains, ALPs reuse the basic concept of earlier approaches and are based on reducing the dependence on environmentally damaging activities by substituting them completely or partially with alternative livelihood activities with a lower ecological impact while providing the same benefits (Redford, Padoch et al. 2013, Roe, Booker et al. 2015). Many so-called ALPs introduce new livelihood activities with the aim of providing a supplementary income source rather than to fully substitute present livelihood activities ('alternative' interpreted here as 'another' rather than 'replacement'). In order to avoid confusion, I thus use the more general term 'linked conservation and development approaches' (LCDA) in this study when referring to all types of practices which carry the dual goal of livelihood improvements and increased conservation behaviour.

In the 1990s, LCDAs were described as a 'win-win' solutions to the complex issues pertaining to conservation and development demands that spatially overlap in many rural areas in the developing world (Brandon and Wells 1992). Yet, with increasing experience in implementing these projects and programmes, it became apparent that successful conservation and development integration was rarely achieved. Some authors argue that the reason why indirect LCDAs have not led to a decrease in exploitation of natural resources by local communities is that they do not directly link economic development to conservation behaviour (Oates 1995, Salafsky and Wollenberg 2000, Sievanen, Crawford et al. 2005, Linkie,

Smith et al. 2008). Direct approaches on the other hand are argued to not always provide a sufficiently long-term benefit to the rural poor (Wunder 2001).

In general, LCDAs are thought to be based on untested assumptions about their impacts on ecosystems as well as on human behaviour (Brandon and Wells 1992, Barrett and Arcese 1995). In a recent review, Wright et al. (2016) specify flawed assumptions inherent in LCDAs in three areas. The first assumption relates specifically to ALPs and to the effectiveness of alternative livelihood strategies in reducing people's needs to exploit natural resources. In reality, the promoted alternative frequently becomes a supplementary income source while the exploitation of natural resources targeted by the project continues. The authors thus propose that it is important to understand why people engage in particular livelihood activities.

The second assumption refers to the homogeneity of the environmental impact of rural community members' diverse livelihood strategies. A large-scale global study found that wealthier community members exploited more natural resources than their less well-off peers (Angelsen, Jagger et al. 2014). To be effective, projects promoting new livelihood activities as opportunities to reduce or pre-empt expansion of other livelihood activities with undesirable natural resource exploitation impacts thus need to clearly identify how different parts of target communities use natural resources (Wright, Hill et al. 2016).

The third flawed assumption inherent in the design of LCDAs is that interventions addressed at an individual level can be scaled up to the scale of the community or even of larger populations. However, the complete shift to or the addition of new livelihood activity of an individual might enable other community members to increase their natural resource exploitation effort as the use of certain resources decreases and thus availability increases (St John, Keane et al. 2013).

Wright et al. (2016) thus summarise that interventions aiming to change people's livelihood strategies are inherently complex and need to be recognised as such by project planners (2016). Consequently, some authors are pessimistic about the capability of LCDAs to deliver integration of conservation and development in practice (Wunder 2001, Sayer and Campbell 2004, Barrett, Bulte et al. 2013, Agrawal, Chhatre et al. 2015).

Even without significant evidence of win-wins of LCDAs, conservation in general still needs to engage with local communities. Different approaches which centre around people's behaviours thus continue to be the mainstay in conservation (Redford, Padoch et al. 2013). Payments for ecosystem services (PES) have been posited as an improved strategy for combining local economic development with conservation (Bulte, Lipper et al. 2008, Wunder and Wertz-Kanounnikoff 2009). PES differ from LCDAs in that they are a) focused on a specific utility (e.g. watershed services) to local stakeholders rather than abstract notions of nature and biodiversity; and b) more flexible than predetermined investments in LCDAs, as PES compensations to ecosystem service sellers are renegotiable if costs and benefits change during the implementation process (Barrett, Bulte et al. 2013). However, the successful implementation of PES is contingent upon clear tenure and use rights, which is seldom present in rural areas of the developing world (Sunderlin, Larson et al. 2009). Furthermore, a sustainable source of financing for these schemes is seldom easily found (Milner-Gulland and Rowcliffe 2007). Additionally, PES do not address the common issue of leakage or shifting of destructive behaviour to areas not managed under the scheme (Barrett, Bulte et al. 2013). Lastly, practice has shown that direct cash payments have their own associated problems. As a result, there is growing interest in using in-kind incentives instead (Clements, John et al. 2010, Cranford and Mourato 2011).

These in-kind PES schemes frequently share similarities with LCDAs (Wright, Hill et al. 2016). LCDA rhetoric as well as PES concepts also form the basis (Bauch, Sills et al. 2014) of the UNFCCC Reducing Emissions from Deforestation and Forest Degradation (REDD+) scheme, thus meaning that these strategies remain prominent in international conservation efforts (Salafsky, Cauley et al. 2001, Brandon and Wells 2009, Blom, Sunderland et al. 2010, Sunderlin and Sills 2012).

Apart from providing the foundation for PES and REDD+, and despite their disputed effectiveness, LCDAs remain prominent development and conservation strategies in their own right (APFIC 2010, Triet 2010, SCBD 2011, Roe, Day et al. 2014, USAID 2016). So much so, that the International Union for the Conservation of Nature (IUCN) recently called for a critical review of LCDAs as evidence of their effectiveness has not grown at the same rate as their prominence (IUCN 2012). In a recent systematic review of LCDAs Roe et al. (2015) found that still only a small number of projects were able to produce concrete evidence of their

conservation impacts. Brooks (2017) confirms this lack of evidence. Nonetheless, he also confirms McShane *et al.* (2011) in their assessment that most LCDAs produce trade-offs rather than so-called win-wins. He draws a list of commonalities between projects, which achieve the elusive triple-bottom line of positive ecological, economic, and social outcomes (Brooks 2017).

1.1.2. Beekeeping in the context of linked conservation and development approaches

A prominent example of LCDAs is the promotion of commercialisation of non-timber forest products (NTFPs) by forest-dependent communities as a means to achieve both livelihood outcomes and generate incentives for conservation of natural resources (Brandon and Wells 1992, Salafsky and Wollenberg 2000, Roe, Day et al. 2014). It is assumed that if the benefits provided by the commercial extraction of NTFPs are larger than the benefits of expanding forest land use conversion f to subsistence agriculture, sufficient motivation is generated to maintain forest cover (Ticktin 2004, Kusters, Belcher et al. 2005).

Beekeeping has been widely promoted as a successful example of LCDAs with beekeeping products being a prominent example of an NTFP with considerable commercial potential (Drescher and Crane 1982, Munthali and Mughogho 1992, Brown 2001, FAO 2005, FAO 2011, Bees Abroad 2013, ICIPE 2013, FAO 2014b, World Bank 2015b, World Vision 2015, BTC 2016, SNV 2016, UNDP 2016a, UNDP 2016b, World Vision 2016). Such levels of promotion are due to the perceived low investment requirements in raw materials, equipment, capacity development, the low-scale of negative externalities, its potential to not only create additional income, but to simultaneously contribute to food security and deliver medicinal benefits to the rural poor, and finally its potential to incentivise the conservation of forest and tree resources (Drescher and Crane 1982, Bradbear, Fisher et al. 2002, FAO 2011).

In the context of REDD+, beekeeping is regarded as one of only a few land use and management practices (e.g. agroforestry) that contribute to a reduction of emissions from deforestation and forest degradation and that could therefore eventually be supported and promoted through REDD+ funds (UN-REDD 2012, URT 2013). Whilst this results-based financing approach is still under development it is worthwhile exploring the assumptions that

underpin the apparent incentives or motivational effects of beekeeping on forest conservation. Given how widely beekeeping is promoted in LCDA contexts, there is very little empirical evidence of its effectiveness in providing sustainable livelihoods while contributing to the conservation of biodiversity (Brooks, Franzen et al. 2006a, Roe, Day et al. 2014).

External investment by national governments, NGOs and donor organisations in beekeeping in an LCDA context is based on two assumptions, both of which lack an empirical evidence base: a) beekeeping positively contributes to the alleviation of poverty and b) because of this economic incentive, beekeepers refrain from practices that are destructive to the natural resource base.

Beekeeping project evaluations tend to focus on short-term economic measures of project outcomes for beneficiaries (FAO 2014b, Heyde and Lukumbuzya 2016, MNRT 2016, SNV 2016). Other aspects of wellbeing benefits, for which beekeeping is also promoted, such as health, nutrition, or resilience, are not usually considered. The second, often applied argument for beekeeping support, namely its incentive for conservation behaviour[3] is rarely assessed at all (FAO 2014b, Roe, Day et al. 2014, Heyde and Lukumbuzya 2016, MNRT 2016). Indeed, conservation benefits are often alluded to, but concrete conservation goals are not explicitly defined (Bees Abroad 2013, FAO 2014b, Agrawal, Chhatre et al. 2015).

1.2. Measuring success of linked conservation and development projects

In order to address the above discussed knowledge-gaps on the success measures of LCDAs that encourage beekeeping by poor rural communities, it is necessary to examine livelihood and conservation outcomes of beekeeping itself. As LCDAs ultimately seek to change the resource use behaviour of local communities (Brooks, Franzen et al. 2006, St John, Keane et al. 2013), it is important to examine motivations and values for conservation in the context of beekeeping. The following sections provide a brief overview of the scientific discourse on the measurement of livelihood, conservation, and behavioural indicators.

[3] What is meant here is conservation behaviour that goes beyond tree-planting activities, which are usually also funded as part of beekeeping support projects and are therefore not necessarily born from an intrinsic conservation intention by local communities themselves.

1.2.1. Measuring economic success and wellbeing

Brooks *et al.* (2006a) define economic success as "the consequences for material welfare of the communities affected". A closer look at how we currently define 'welfare' indicates that this necessarily means more than just material aspects.

Poverty has traditionally been defined in purely monetary income terms ("a dollar a day"). Since the 1960s, this narrow definition has undergone several phases of broadening and refinement, reflecting changes in development paradigms and the growing understanding of the causes of poverty (Angelsen and Wunder 2003). Monetary income (or the lack of) as a poverty definition was broadened to include the so-called 'hidden harvest', i.e. the non-monetary consumption of goods (Campbell and Luckert 2002). For rural communities, forest products often contribute more to non-monetary income than to cash income (Hickey, Pouliot et al. 2016). Development policy focus during the 1970s gradually shifted towards a 'welfare' concept, which included, along with income, an emphasis of basic needs, such as nutrition, health services and education (Angelsen and Wunder 2003). In the 1980s, growing criticism of the paradigm of economic growth as a panacea for all human needs resulted in further expansion of the poverty concept to include social and natural capital (Meadows, Meadows et al. 1972, Angelsen and Wunder 2003).

Building on these gradual extensions of the poverty definition, Chambers and Conway (1992) developed the 'livelihood concept' as an actor-centred approach to account for "[…] all assets (stores, claims, and access) and activities required for a means of living". The so-called 'sustainable livelihoods approach' was the first operationalisation of the sustainable livelihoods concept - formulated by Chambers, Scoones and other scholars of the Institute of Development Studies - in the British Department for International Development. It defines five capitals (natural, human, social, physical, and financial) that need to be taken into consideration when designing poverty interventions (Chambers and Conway 1992, Carney 1998, Scoones 1998, Scoones 2009).

However, the sustainable livelihoods or five-capitals approach draws criticism from a practical measurability and applicability perspective. Angelsen and Wunder (2003) contest that the different capital types lack comparability and that capital in itself, without ways to transform it in productive ways, does not guarantee welfare. They thus suggest a need to distinguish

between the analysis and the measurement of poverty. Their advice is to use the five-capital model to understand the causes of poverty, but to measure it through more practical quantitative indicators such as income and assets (Angelsen and Wunder 2003).

In addition to measuring welfare using objective indicators that quantify financial and other capitals, another approach is to use subjective wellbeing indicators identified and reported by the households or individuals themselves. The appeal of this method is that people are thought to be the best judges of their own poverty or wellbeing (Narayan, Chambers et al. 2000). McGillivray and Clarke (2006) describe the measurement of subjective wellbeing as "[…] a multidimensional evaluation of life, including cognitive judgments of life satisfaction and affective evaluations of emotions and moods". But the subjective wellbeing approach faces limitations in terms of comparability across different sites with different cultural norms and possible strategic bias in indicating poverty levels with the view on possible external development support (Angelsen and Wunder 2003).

The above described discourse informed the formulation of the research methods used in this thesis to assess the contribution of beekeeping to household wellbeing. As the notion of wellbeing is not solely dependent on economics and the value and comprehensiveness of the sustainable livelihoods approach is now well established in the development literature, I have opted to base my approach on the foundations of the five-capital approach. Another important factor in this decision was that beekeeping is promoted for providing more than just income to poor rural households. The suggestion by Angelsen and Wunder (2003) to measure household wellbeing through income and assets only, felt to be cutting short the understanding of the range of benefits beekeeping might offer to households.

The final research instrument was based on the template of the Multidimensional Poverty Assessment Tool (MPAT) developed by the International Fund for Agricultural Development (IFAD). MPAT is survey-based and collects information on ten dimensions of wellbeing. It includes food and nutrition security, domestic water supply, health and healthcare, sanitation and hygiene, housing and energy, education, agricultural assets, non-agricultural assets, exposure and resilience to shocks, and gender equality (Cohen 2009, Saisana and Saltelli 2010). An external validation and critical evaluation of MPAT by the European Commission found it to be internally consistent, well-balanced, and statistically robust (Saisana and Saltelli 2010). For the purpose of this research individual sub-components were adjusted to local

conditions at the sample field sites. In order to validate the five-capitals approach, the survey also included subjective wellbeing indicators.

Additionally, the wellbeing benefits of certain activities can be unequally distributed throughout the year. The use of NTFPs such as African honey and beeswax (Belcher and Vantomme 2003, FAO 2009) are often promoted due to the temporal distribution of their benefits in rural livelihoods and their ability to contribute to food security during lean periods (Arnold, Powell et al. 2011, Vinceti, Termote et al. 2013). While anecdotal evidence exists on beekeeping being able to support households through the shortage periods of the agricultural year, there appears to be a lack of supporting empirical evidence to this claim. An assessment of the temporal distribution of beekeeping benefits was thus included in the household wellbeing survey.

Lastly, access to markets for honey bee products may be a limiting factor in beekeeping adoption, dependence, and success and thus wellbeing based on beekeeping (Wainwright 2002). This is much in the same vein, as access to NTFP markets can be a limiting factor for commercial success in this sector, a topic which has been discussed at depth in rural livelihood literature (e.g. Belcher, Ruiz-Perez et al. 2005, Shepherd 2007). This limitation is due to the remoteness of producers, in this case beekeepers, from input and output markets, the usually small volumes produced and/or the lack of resources to package and market their products (Wainwright 2002).

An assessment of the limits of economic success of beekeepers due to limitations of honey bee product markets and value chains was beyond the scope of this study. Nevertheless, the issue of market access was broached by a) surveying beekeepers on problems experienced related to marketing and location of markets where bee products were sold as well as, b) by discussing marketing issues with beekeepers and ex-beekeepers during individual and group interviews, and lastly by c) modelling adoption, dependence and success rates through the households' distance to major roads as a proxy for physical ease of accessing non-local markets where bee products were marketed. Non-local markets were deemed to be more profitable than local marketing options by beekeepers interviewed during the scoping phase of the study.

1.2.2. Measuring conservation success

Brooks et al. (2006b) define ecological success of conservation strategies as "the consequences for one or a set of species (or habitats) designated as targets of the conservation project".

In reality, it is this designation of targets that often lacks precision in LCDA plans. Indeed, any desired conservation outcome is often only alluded to and frequently neither specifies a particular species nor defines which aspects of biodiversity or areas are to be targeted (Salafsky, Margoluis et al. 2002, Bees Abroad 2013, FAO 2014b, Agrawal, Chhatre et al. 2015, Kuboka and NKuba 2015, Roe, Booker et al. 2015, SNV 2016).

In addition to unclear characterisation of project conservation goals, the definition of well-conserved forests is in itself contested. Schwartzman *et al*. (2000) for example, argue that target forests should serve as carbon-sinks, have stable hydrology and soils, and provide a "productive home for forest-living peoples". By contrast, ecologists argue that well-conserved forests should provide functional populations of all species possible within the ecosystem, thus conserve all species, genes, and ecological relationships (Redford 1992). Drutschinin *et al.* (2015) assert that a narrow interpretation of conservation generally advocates protection, whereas broader interpretations of the concept allow the sustainable use of forest resources. Sustainable use is defined by the Convention on Biological Diversity as a level of use that allows natural regeneration and the potential to meet current and future human needs and aspirations and preventing their long-term decline (CBD 2004). This is most likely to be case and location specific and poses a range of complexities for its measurement. Newsham and Bhagwat (2016) argue that how nature is managed in practice is fundamentally political and depends on whose definition and uses predominate in the given context.

Measuring the conservation impacts of development projects can be challenging due to the time frames of natural system responses, potentially differing scales of intervention implementation and intervention results, inaccurately articulated conservation objectives, problems with attribution of any measurable change, lack of monitoring resources and ambiguity of monitoring targets and, importantly, a lack of baselines, controls and counterfactuals (Pullin, Sutherland et al. 2013, Roe, Booker et al. 2015).

External support in beekeeping with a conservation objective seeks to incentivise the avoidance of deforestation and degradation. Beekeeping projects tend to employ three different strategies in the aim to achieve the conservation impact of beekeeping: a) through (monetary) encouragement of planting of trees that are used by bees for forage; b) through environmental education and awareness raising for linkages between beekeeping and environmental conservation; and c) by creating a livelihood opportunity with reduced environmental impact to ease resource use pressure of forests (BTC 2016, SNV 2016b, UNDP 2016a) .

To assess the overall impact of beekeeping on avoided deforestation and degradation it is necessary to evaluate information about the forests planted and/or used by communities where beekeeping activities take place. In group discussions during the scoping phase of this project it became clear that many beekeepers tend to move their hives from one location to another throughout the year and between years due to shortages of bee fodder, security concerns or other reasons. These locations can be communal village land, forest reserves and private land. It was considered too complex to systematically analyse the actual physical impact of beekeeping on existing forest stands in the framework of the present project.

The strategy chosen was to assess environmental awareness as well as values and perceptions regarding the forest. The analyses of perceptions and knowledge of the forest as well as of values assigned to different forest ecosystem services may help to identify key predictors for conservation behaviour of beekeepers compared to other community-members who do not practice beekeeping.

1.2.3. Understanding conservation behaviour

Conservation interventions aim to change the behaviour of people and it is therefore important for conservationists to understand what shapes behaviour (Schultz 2011, St John, Keane et al. 2013). Conservation psychology, a relatively new and growing field of scientific inquiry, aims to address this by examining two main outcome areas: how humans value nature and how humans behave towards nature (Clayton 2015). Psychological constructs that touch upon the interface of human psychology and conservation include knowledge, behaviour, values, attitudes, norms, incentives, and barriers (Clayton 2015).

The most influential theory on what determines and predicts behaviour is Fishbein's theory of planned behaviour (TPB) (Fishbein and Ajzen 1975). According to Fishbein and Ajzen's (1975) model, behaviour is a function of intention, which in turn is a function of attitude towards the behaviour, subjective norms, and perceived behavioural control. Self-determination theory (SDT), another prominent construct aimed at explaining human behaviour uses a similar concept to intention, namely motivation as a predictor of behaviour (Deci 1985). While SDT makes a distinction between intrinsic and extrinsic motivation for a particular behaviour, TPB is primarily extrinsically focused (Leavell 2015).

LCDAs that promote beekeeping, ecotourism or other nature dependent livelihood activities aim to demonstrate that success in the respective livelihood activity is explicitly linked with healthy ecosystems, thus providing motivation for conservation (Roe, Booker et al. 2015). The underlying assumption here is that as income generation is linked to the sustainable use of a natural resource, in this case trees that are used by bees for fodder, local communities will be aware of the importance of sustainable management of the resource and will thus demonstrate positive attitudes and behaviours toward conservation (Hutton and Leader-Williams 2003, Brooks, Franzen et al. 2006). Souto et al. (2014) argue that unless conservation improves human wellbeing, it will not be a priority for local communities. Only when the benefits of conservation outweigh the costs of the avoidance of ecologically destructive human behaviours as well as any direct costs associated with activities to promote conservation (e.g. patrolling), will incentives change behaviour (Salafsky and Wollenberg 2000).

Agrawal et al. (2015) claim that the effects of such incentive-based programs on conservation motivations are poorly understood. Waylen et al. (2010) state that these types of projects are often marked by a lack of appreciation for the influence of social and cultural contexts on conservation outcomes. Sayer and Campbell (2004b) suggest that donors have failed "[…] to accept the reality that conserving the global environment is simply not a very high priority for poor people living in rural areas in developing countries […]". Spiteri and Nepal (2006) summarise that incentive-based conservation approaches regularly fall short of delivering on their stated objectives.

Agrawal et al. (2015) argue that incentive-based conservation approaches often hinge on an assumed relationship of economic and environmental motivations. Nilsson et al. (2016a)

compare the effect of intrinsic (e.g. intrinsic desire due to self-identification with the behaviour) and extrinsic (e.g. economic rewards or coercion) motivation on changes in conservation behaviour and find that extrinsic motivations generated through ecotourism income did not change behaviour towards forests. A combination of both types of motivations was found to have the greatest effect on behaviour change (Nilsson, Gramotnev et al. 2016). These findings are supported by the conclusions of a systematic review of motivational values and conservation success by Cetas and Yasué (2016), who suggest that projects that foster intrinsic motivations for conservation are more likely to succeed than those that foster extrinsic motivations.

The success of incentive-based projects appears to be contingent on the relative significance of income generated through the respective livelihood activity promoted, the individual capacity to engage in the activity and its cultural acceptability (Nilsson, Baxter et al. 2016). The source of motivation, together with the level of community participation, the integration of traditional ecological knowledge and the level of external involvement in implementation are used by Souto et al. (2014) to construct a model to predict the sustainability of the outcomes of conservation projects. They place conservation projects that aim to increase household income coupled with awareness raising for biodiversity, i.e. approaches that are typical of beekeeping projects, at an intermediate position in terms of expected long-term sustainability (Souto, Deichmann et al. 2014). In order to evaluate the effect of beekeeping on conservation behaviour it is thus worthwhile to explore any intrinsic conservation motivation of beekeepers, the significance of beekeeping income in individual households as well as individual capacity to engage in beekeeping.

Corresponding to the behavioural control aspect of TPB, the role of participation, empowerment, and decision-making power over conservation decisions in conservation success are highlighted by several authors (Salafsky and Wollenberg 2000, Wyckoff-Baird 2000, Salafsky, Cauley et al. 2001). Osbaldiston and Sheldon (2003) reported an increased frequency of environmental behaviour where autonomy over environmental decisions was perceived by an individual. To further the understanding of the contribution of beekeeping to conservation motivation it is thus meaningful to examine how empowered beekeepers feel compared to non-beekeepers over natural resource management decisions in their communities.

1.3. Thesis aim and research questions

The overall aim of this thesis is to inform better-targeted investment in beekeeping in the context of linked conservation and development interventions by providing empirical evidence of the role of beekeeping on household wellbeing and its incentive effect for forest conservation. The two objectives of the project are to:

1. Assess the socio-economic characteristics of beekeeping households in Central Tanzania
2. Gauge the effect of beekeeping on resource use values and behaviour

For this I have set myself the following research questions:

Research question 1: What are the circumstances that push/draw households to beekeeping?

Research question 2: What are the socio-economic predictors for different levels of beekeeping dependence and success?

Research question 3: Do beekeepers enjoy a higher quality of life than their non-beekeeping peers?

Research question 4: Does beekeeping contribute to a bridging of shortage periods, i.e. are beekeeping benefits received in times of biggest needs?

Research question 5: Do beekeepers differ in their forest perceptions and attitudes to non-beekeepers?

Research question 6: Do beekeepers value the forest for different ecosystem services than non-beekeepers?

Research question 7: How powerful are beekeepers within their communities in comparison with non-beekeepers in decision-making processes over the communities' natural resource base?

Research questions 1 – 4 correspond with the first objective of this study by identifying population groups more likely to incorporate beekeeping into their livelihood portfolio, assessing the influence of external assistance on beekeeping success and evaluating the

benefits beekeeping might provide to rural livelihoods. Only when these benefits are large enough, can they serve as a foundation to beekeeping providing incentives for forest conservation. Research questions 5 – 7 are aimed at exploring factors contributing to conservation behaviour, thus corresponding with the second study objective.

My hypotheses for this work were the following:

1. Beekeeping adoption is influenced by the availability of human capital, labour, individual de facto and/or de jure use rights over natural and planted forests, access to input, relative ease of physically accessing non-local honey and wax markets used by the local population and cultural proximity to beekeeping activities.
2. Households with a higher dependence on beekeeping for subsistence, i.e. who use their harvested honey to supplement their calorific need, differ in location, social situation, history in beekeeping and livelihood strategies from those who are more dependent on beekeeping for income than subsistence.
3. The more external training a beekeeper had received, the greater his/her honey harvest.
4. Beekeepers enjoy a higher level of fulfilment of their subsistence and fundamental needs, a more effective safety net in the form of higher resilience to shocks and stresses as well as more means to move towards prosperity through the possession of a larger asset base than their non-beekeeping peers.
5. Beekeeping benefits fill a gap in subsistence and income resources in particular months of the agricultural year.
6. Beekeepers are more motivated to conserve and protect forest resources than non-beekeepers.

1.4. Study context

1.4.1. Tanzanian forests

The size of Tanzania's forest and woodland cover is estimated to be 46.1 million ha (FAO 2016b). Of these, 2 million ha are found within protected areas, i.e. game reserves or national parks. Almost 90% of Tanzanian forests consist of miombo woodlands, which feature several

excellent bee fodder tree species and are regarded as particularly productive for beekeepers (Hausser and Mpuya 2004).

Mature miombo woodlands are characterised by a single-storey structure with tree height reaching 10-20m. Being situated on poor soils, their productivity is lower than that of many other forest types (Campbell, Angelsen et al. 2007). Miombo woodlands are not valued for a large number of timber species and are not particularly suitable for the conversion to plantations of exotic species (Chamshama and Vyamana 2010). Yet, due to the heavy reliance of local populations on woodland resources, exploitation and degradation of miombo woodlands is widespread resulting in increased occurrence of shrub as well as invasive species (Obiri, Healey et al. 2010). This occurs in particular where trees have been completely uprooted, as miombo species have an extraordinary regeneration capacity through coppicing and the development of sucker shoots from the stump and roots (Frost 1996). The rate of coppicing is affected by soil and climatic conditions, the species, the time since they were last coppiced as well as human activities (Chidumayo, Gambiza et al. 1996). In the case of clear felling, the woodland is susceptible to the invasion of woody weeds as miombo seeds are characterised by low dispersibility (Frost 1996).

Land in Tanzania is categorised as either 'reserved land' (28%), 'village land' (70%) supporting about 80% of the population and 'general land' (2%) (MNRT 2008, Blomley, Lukumbuzya et al. 2011). While village land is managed directly by village governments, reserved forests fall either under the authority of the central, local or village governments. They can serve as production forests or be under protection as water catchments or biodiversity conservation sites (Blomley, Lukumbuzya et al. 2008). Confusingly, general land is all land that is neither reserved nor village land but includes also 'unused' village land. This has led to varying interpretations by authorities at different levels over the extent of these two land categories (ANRC 2019, Blomley, Lukumbuzya et al. 2011).

Customary tenure, i.e. *de facto* rights based on local practices, frequently exists alongside statutory or *de jure* rights based on official laws in many developing countries. These different claims to the land can be contradicting and overlapping with each other (Sunderlin, Larson et al. 2009). While the villagisation process during the 1970s upended many of these customary uses, the Village Land Act 1999 was a step towards formalising communities' customary rights by assigning the 'village land' category (Wily 2003).

Reserved forests can have varying use restrictions. While district governments are responsible for community-owned forests, the Tanzania Forest Service (TFS) is responsible for government owned land, although there is some overlap in these responsibilities. The coordination between the different levels of governance is in practice weak and can lead to local land use conflicts (Luhula 2017).

Decentralization in forest management spread from Asia to Africa in the 1990s and Tanzania has led the implementation of Participatory Forest Management (PFM) schemes on the continent (Wily 1997, Lund and Nielsen 2006). PFM, which has become the central forest management strategy in Tanzania, allows local communities to either manage their forest resources alone or together with government authorities (Treue, Ngaga et al. 2014). Two types of PFM exist: Joint Forest Management (JFM), in which communities and the government enter into a management agreement sharing responsibilities as well as benefits, and Community-Based Forest Management (CBFM) – covering the largest forest area - whereby communities demarcate village land as reserved forest and set use and access rules with local government approval (URT 2006). PFM forests can be under complete protection, used as production forests or for mixed purposes (Kajembe, Silayo et al. 2015). CBFM forests are managed by village natural resource committees (Akida and Blomley 2008).

Despite the introduction of participatory policies, Tanzania has seen a larger percentage of annual forest area loss than most other countries and is among the top five countries with greatest annual net loss of forest cover with 372 000 ha/annum (Hansen, Potapov et al. 2013, FAO 2016). This is attributed to an annual population growth of 2.7% and the limited availability of employment options outside small-scale agriculture (Sungusia and Lund 2016). Parallel to this development, a growing percentage of Tanzania's surface area is being targeted by conservation efforts. Part of these ongoing conservation endeavours are linked conservation and development projects with the country ranking third globally in the number of implemented LCDAs according to recent systematic review (Roe, Booker et al. 2015).

1.4.2. Beekeeping practice and support in Tanzania

While recorded evidence of beekeeping in SE-Africa dates back only to the 16th century, it is assumed that it had been part of local populations' livelihood portfolios for much longer (Crane 1999). Traditional beekeeping is performed in the forest, using hives made from bark, logs or similar materials found in nature (Figure 1.1).

Figure 1. 1. - Traditional log hive

Hives are usually hung high in tree tops (Nel and Illgner 2004). In an effort to render traditional beekeeping systems more efficient and to improve the quality of harvested honey, external support organisations have promoted the use of non-local hives such as frame-hives and top bar-hives (Figure 1.2). The appropriateness of frame-hives in this context has been highly

disputed. This is due to their lower suitability for the behaviour of many African bee species, for the complexity of their design and lack of reproducibility in local contexts and due to the cost of producing them (Carroll, Davey et al. 2017, Amulen, D'Haese et al. 2019, Schouten and Lloyd 2019).

Figure 1. 2. - Traditional log hive, top-bar hives and frame hives hung in a tree

African beekeeping is an extensive land use activity with beekeepers sometimes owning hundreds of hives which they distribute throughout the forest and which rarely have full occupancy rates due to the absconding nature of African honeybee races (Nightingale 1976, Tesfaye, Begna et al. 2017). Approximately five percent of the Tanzanian population keeps bees (Hausser and Mpuya 2004). Honeybee products are used locally as food, fodder, traditional medicine, or beer-brewing ingredients and are thought to play an important role in the rural Tanzanian economy as subsistence and income sources (Nel and Illgner 2004). Beekeeping can be performed, albeit sometimes requiring permits, under a variety of land tenure arrangements existing in Tanzania today, except in National Parks (Hausser and Mpuya 2004).

Before the arrival of colonial powers, honey was used for different local purposes e.g. in consumption, in ceremonies as well as in the provisioning of caravans passing through the region. In contrast, beeswax had only limited uses locally (e.g. as a sealant) but was traded in limited amounts within the region to satisfy a demand by the Arab population of the area (Fisher 1997a).

The trade in honeybee products, in particular beeswax, received several boosts by German and British colonial powers (Hausser and Mpuya 2004). The German colonial era created new markets for beeswax through catholic missionaries, fuelled by the importance of it for the Catholic Church. Indeed, beeswax became one of the most important export products of the country under German colonial rule, with Arab and Asian middlemen and traders facilitating the movement of the product (Fisher 1997a). Wax trade was based exclusively on production using traditional beekeeping methods. The German colonial powers also sought to introduce frame hives to increase the production and trade of honey, but this remained very limited in comparison with the beeswax trade (Hausser and Mpuya 2004). Due to its weight and perishability, honey was not traded over longer distances until the second part of the 20th century when it gained importance as a substitute for sugar during the Second World War and when motorisation made its transportation beyond local markets possible (Fisher 1997a).

After the First World War, British colonial rulers in Tanganyika sought to introduce beekeeping techniques using new types of hives to improve the quality of wax produced for export (Fisher 1997a). In an effort to reduce the destructive exploitation of natural resources and to increase production and quality of beeswax and honey, the British colonial Government established a beekeeping section in the Agricultural Department at the end of the Second World War. Part of this effort was the foundation of the Beekeeping Research Institute (since renamed to Beekeeping Training Institute) in Tabora to help improve the quality of honey and wax destined for export. The Beekeeping Research Institute - in association with the Catholic Society of Missionaries in Africa - then created the Tanganyika Honey Organisation – the predecessor of today's Tabora Beekeeping Cooperative Society (TBCS) – with the aim of assisting beekeepers in the collective marketing of honey and to alleviate their poverty (Smith 1958). TBCS provides members with transport, containers, and collective marketing services. The Beekeeping Training Institute is still active in Tabora and offers short courses, diplomas, and technical certificates to eligible candidates.

After independence was regained, the Tanzanian government started to introduce beekeeping development programmes and promote technological innovation (Mpuya 2001). In 1998, a new Beekeeping Division was added to the existing Forestry Division within the Ministry of Natural Resources and Tourism (MNRT). The same year saw the adoption of the first formal Beekeeping Policy, which aimed at increasing the contribution of beekeeping to the sustainable development of the country as well as to the conservation of its forests (URT 1998, Hausser and Mpuya 2004). Three years later a National Beekeeping Program, designed to implement the Beekeeping Policy, was adopted. The Program focuses on stakeholders' participation and environmental conservation. Finally, the 2002 Beekeeping Act makes provisions for an "orderly conduct of beekeeping", for enhancing the quantity and quality of honeybee products, to combat bee diseases and pests and to enhance the collection of revenues (URT 2002).

The Tanzania Forest Service (TFS) is a semi-autonomous government executive agency in national forestry and beekeeping affairs. Its role is to ensure efficient and effective management of forest and bee resources (FAO 2016). The 1998 National Beekeeping Policy also introduced the concept of bee reserves, mirroring the provision of forest reserves defined in the National Forest Policy. The aim behind the establishment of bee reserves is the management and conservation of natural resources which are critical for beekeeping (Hausser and Mpuya 2004). A total of 506 forest reserves of over 69,000 ha have been set aside for beekeeping. As part of the Government of Tanzania's push for the modernisation of its beekeeping sector, TFS has supplied local beekeepers with more than 14,000 top bar hives in the period of 2012/2015 alone. The agency is also supporting beekeepers by establishing value chain linkages and creating demonstration apiaries to train farmers in beekeeping (FAO 2016).

Besides governmental efforts to promote beekeeping at a national level, innumerable NGOs, international development organisations as well as social entrepreneurs have implemented and are currently implementing beekeeping support projects and programmes in all regions of Tanzania (Traidcraft 2007, ARC 2010, UNDP 2010, ITC 2014, Kuboka and NKuba 2015, ILO 2016, USAID 2017, ADAP 2018).

The ultimate goals of beekeeping interventions vary but can be approximately categorised in to two groups: poverty alleviation and conservation interventions. Projects in the first group

are aimed at creating income generating activities and employment in contexts where these are otherwise difficult to find – be it in a rural or urban setting, for the general population or marginalised groups (UNDP 2016b, Worldbank 2015b). Coupled with the aim of increasing cash income for project beneficiaries can be such diverse goals as the empowerment of the disenfranchised or the generation of greater resilience to the effects of climate change and other risks through income diversification (Jeffrey 2015, USAID 2017, World Vision 2015).

Interventions aimed at increasing employment and income generation opportunities are most often implemented by focusing on either one of the following components or a combination of them: intensification and expansion of production as well as valorisation and marketing of bee products (BTC 2016, SNV 2016b, Zocchi, Volpato et al. 2020). Frequently, these types of projects aim to replace traditional beekeeping systems by introduced systems coupled with technical training and extension.

Interventions with a conservation aim are often coupled with socio-economic goals, which are intended to serve as incentives to local people to sustainably manage the natural resources beekeeping is reliant on. Beekeeping is used to increase the value of these resources and thus encourage those benefiting from beekeeping to protect them (Brocklesby 2002, ARC 2010, FAO 2014b, ICIPE 2014, UNDP 2016a). One form of this approach is the encouragement of the placement of hives in national parks and reserves to allow people to gain benefit from the area. One added benefit of this is that the yearly controlled burning of vegetation performed by beekeepers near their hives prevents the build-up of flammable material. Additionally, beekeepers can act as aids in the identification of poachers while they spend time in the protected area (FAO 2009). Another conservation approach through beekeeping in the context of protected areas and their associated wildlife presents itself in the form of bee hive fences deterring elephants from raiding crops of neighbouring farms and thus lowering the occurrence of human-wildlife conflicts (King, Lawrence et al. 2009).

Besides using beekeeping as a driver for conservation, it can also be promoted as a less-damaging forest activity than e.g. charcoal burning or hunting (FAO 2009). It can provide an additional income source and take the pressure off natural resources caused by more degrading activities (Brocklesby 2002). Similarly, in some conservation projects honey hunters are trained as beekeepers with the aim of deterring them from non-sustainable tree cutting and burning, which can form part of honey hunting practices (Dieteman, Walter et al. 2009).

In some instances, modern beekeeping methods are promoted as a means to reduce forest fires caused by traditional beekeeping methods (UNDP 2010). Lastly, as a more direct form of conservation through beekeeping promotion, forest land is reserved exclusively for beekeeping activities and thus protected from more damaging human forest resource use (BTC 2016).

The nature of beekeeping interventions that occurred in the communities included in this study is detailed below (Section 1.4.3.4.).

1.4.3. Case study sites

I conducted the study in the two central regions of Tanzania, Dodoma and Singida. These predominantly arid zones are known as areas where local communities are engaged in beekeeping. The study area experienced drought conditions for three consecutive years prior to data collection. This had detrimental consequences not only for the farmers and livestock keepers of the area, but also negatively impacted the abundance of floral resources for bees. The results of this study need to be viewed in light of this context.

The four study communities (Figure 1.3) were selected based on the known presence of large enough numbers of beekeepers and non-beekeepers, their proximity to forested land and having received outside beekeeping support in the past. To minimise compounding factors, I selected communities which were similar in terms of population size, distance to major roads and market towns. Table 1.1 provides an overview of the key attributes of each study community.

Table 1. 1-1 Key attributes of study communities

	Msemembo	**Sasilo**	**Kwa Mtoro**	**Paranga**
Region	Singida	Singida	Dodoma	Dodoma
District	Manyoni	Manyoni	Kondoa	Chemba
Population	5 978	11 987	9 785	12 297
Forest area (ha) per person	2.3	unknown (60 ha owned by community + small private forest areas of unknown size)	unknown (20 ha in general use + reserved forest of unknown size)	1.3
Participatory Forest Management in place	Planned: Joint Forest Management of 11 536 ha	Planned: PFM for 100 ha shared with neighbouring village	No	No
Distance to district market*	33 km	72 km	65 km	50 km
Reserved land for beekeeping (ha)	730	60, but not enforced	Yes, size unknown	No
Beekeeping projects in the past	2007: District Gov.; 2013/14: World Vision, TFS; SIDO and TFF (unknown year)	1999 – 2004: NORAD	TSF, TASAF, World Vision, CREDEP, District Government (years unknown)	2012: TASAF
Beekeeping group existent	1 functional group, 1 inactive group	Yes, but not functional	2 functional groups	Yes

* location of where a part of bee product harvest can be marketed

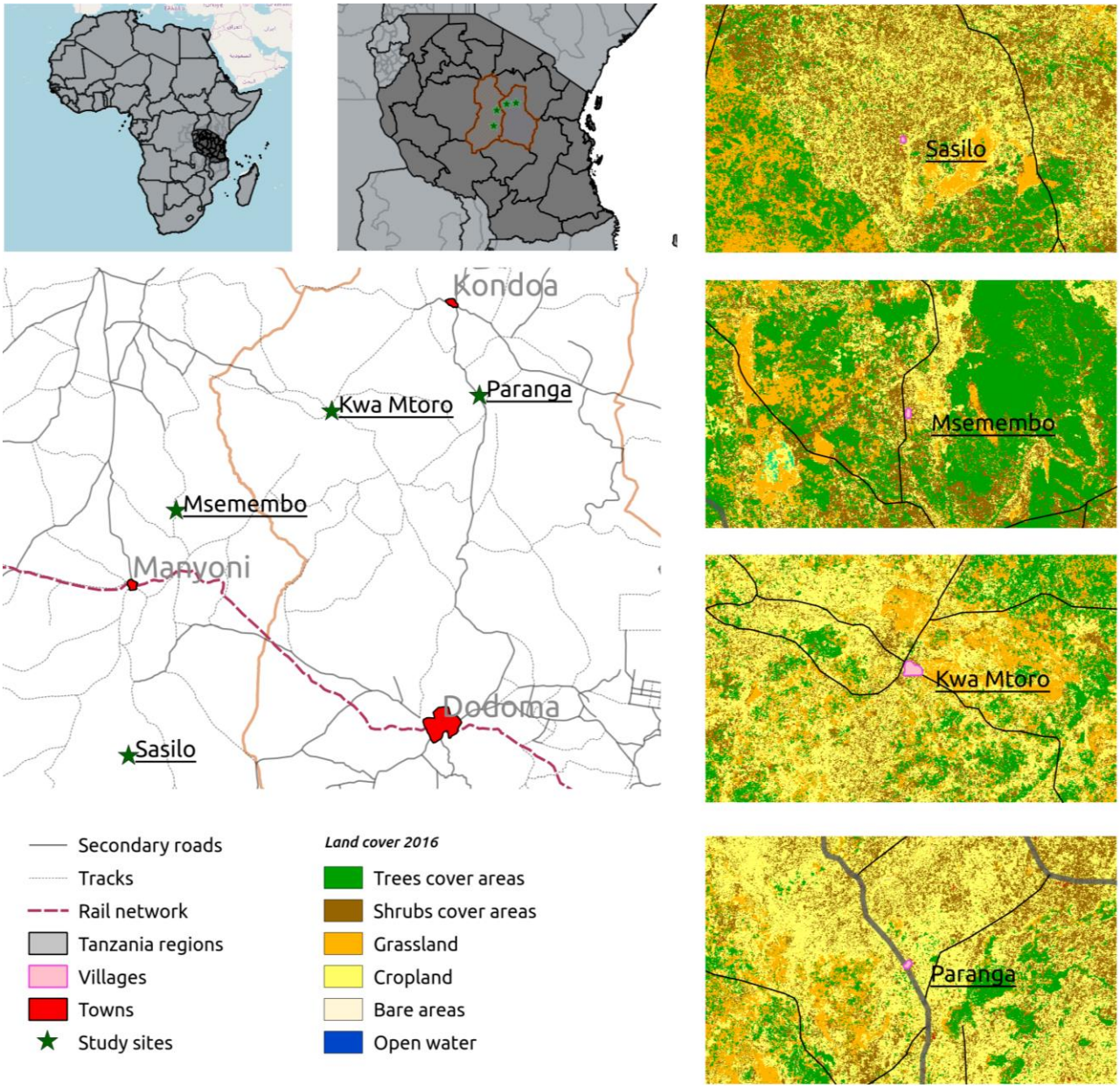


Figure 1. 3. - Study locations in Central Tanzania and their respective land covers in 2016. Source: ESA CCI Land Cover Map, 20m resolution

The following three sections provide an overview of key characteristics of the four study communities.

1.4.3.1. Livelihood context

In all four study communities the majority of livelihoods were based on farming of crops and vegetables for subsistence and cash income (maize, rice, sunflower, sesame, groundnuts, sorghum, cowpeas, tobacco, onions, tomatoes, beans, etc.) as well as on livestock keeping

(cows, goats, sheep, pigs, chicken, guinea fowl). Other livelihood options were limited, and encompassed services required by the local communities (e.g. carpentry, masonry, transportation, mechanic, small-scale trade, charcoal-making, beer-brewing). Based on a self-assessment of study community members, the extremely poor among them did not own land or only a very small area, were engaged in casual labour, could not afford to own an oxen to cultivate any agricultural land at their disposal, had poorer housing than other community members and could not procure sufficient food and clothing for their families or send their children to school throughout the year. Apart from farming and livestock keeping, local communities rely on the forest as a source of food, water, construction materials, medicine, dyes, gums, resins, oils, energy for cooking, fodder, beeswax, and honey.

The ethnic composition of the communities differed significantly. Msemembo was predominantly populated by Nyaturu people, Kwa Mtoro by Sandawe and Paranga by Rangi people. Sasilo stood out for being the most ethnically mixed among the study communities. Notably, the Sandawe in Kwa Mtoro pride themselves on having deep cultural roots in beekeeping.

1.4.3.2. Forest context

The forest resources available to the population of the study communities varied. The following sections provide a brief overview of the forest context of each community. The data was collected during group discussions with village leaders, village environment committee leaders, district officials and community members during the scoping phase and the main data collection phase of the study.

In Msemembo, the community had set aside 1800 acres of forested land for beekeeping. This was in response to a decrease in honey harvests due to the clearing of forests to accommodate a growing population. The area was selected as it was rich in nectar sources, was far from tobacco farming locations and the associated chemical pollution and had plenty of water available in an adjacent wetland. Besides beekeeping no other activities were allowed in the forest. Although illegal harvesting of fruits and mushrooms as well as firewood collection still occurs. A beekeeping group using this forested land was charged with its protection. Beekeepers are also allowed to place hives in other forested locations (see below) but were encouraged to use this reserved forest for siting their hives.

At the time of data collection for this study, Msemembo was in the process of obtaining a national forest reserve with a JFM arrangement established. Limited harvesting and collection of poles (with permit), fruits, mushrooms, and firewood (all without permit) was allowed prior to the establishment of the reserve. While new reserve use regulations were yet to be stipulated, district officials confirmed that beekeeping would be allowed, but restricted by the number of permitted beekeepers and hives. The community also had access to several unreserved village forests, where the most important products harvested, in order of the highest value in terms of cash or subsistence, were honey, timber and firewood. According to village leaders, the availability of all of these products had declined in the ten years preceding the study. The main reasons were forest clearing for agriculture, illegal timber harvesting as well as livestock overstocking and overgrazing.

According to village leaders, conflict between beekeepers and other forest users existed, but was rare. In one recent incident beekeepers came into conflict with pastoralists over the use of a particular area. Some hives were destroyed, the district council became involved, but failed to resolve the conflict. Finally, the beekeeper in question abandoned the location in question.

The community of Sasilo also demarcated a reserved area immediately adjacent to the village for beekeeping in 1999, although significantly smaller than in Msemembo (150 acres). A beekeeping group formed through an external beekeeping support organisation (see 1.4.3.4) was tasked with the management and protection of this forest. An open land use conflict between the beekeepers and pastoralist also interested in letting their livestock graze the area could not be mitigated by village and ward leadership. Owing to a lack of statutory protection, the vicinity of the main village and a lack of leadership of the beekeeping group, the area had been degraded to such an extent that beekeeping was no longer feasible. The area was hence abandoned by the beekeeping group originally put in charge of its protection.

The community of Sasilo had limited access to larger forests with the majority of forested land under customary use by the population. In search for more land, the village had been contesting the rights for a large forest area, for which a neighbouring village was holding statutory rights, but which was located closer to the community of Sasilo. A PFM arrangement was foreseen for 100 ha of this forested land, but contestation by the neighbouring village halted this process. The village is also adjacent to the Muhesi Game Reserve, which has

substantial use restrictions for the surrounding communities. Many of the beekeepers in Sasilo were resettled from this area when the status of the forest changed to become a reserve. This had negative consequences for the beekeepers, who lost access to a suitable area for beekeeping with a rich nectar source. Several beekeepers in Sasilo had since petitioned to be allowed to access the game reserve for beekeeping purposes, without success.

The most important products in order of the value they generate for beekeeping members were firewood, withies, and honey. The availability of all of these products had declined during the decade prior to this study. According to village leaders this was because of overuse due to population growth, poor harvesting techniques and climate change. There was practically no enforcement of the use and access regulations for the remaining forested areas, further contributing to the degrading of these resource. A village environment committee and a voluntary tree planting group existed but did not receive support from the authorities in their activities and were thus mostly non-operational.

Kwa Mtoro lies in direct proximity to the Swagaswaga Game Reserve. While it is legally accessed by a beekeeping group and some individual beekeepers in the village, some individual beekeepers reported to have experienced restrictions from accessing the game reserve, even being beaten by patrolling guards. As other use rights are severely restricted to the surrounding communities, conflict between the game reserve and neighbouring villages had been ongoing since it was established in 1997. This had escalated to the extent, that it was taken up by a newly established pilot district multi-stakeholder forum where the verification of game reserve boundaries and the identification of villagers eligible for compensations was decided (Luhula 2017).

There are three areas reserved for beekeeping in the vicinity of the community, the size of which could not be ascertained. These areas were in rocky terrain not suitable for farming. These bee reserves made up the majority of the village forest of Kwa Mtoro. Limited use for other purposes such as the collection of firewood, mushrooms, and other wild food as well as rocks for construction was allowed. The extent of other forest land used by the community could not be ascertained as the plots were numerous and small.

The community members of Paranga had access to a village forest of 300 acres for subsistence needs as well as 6000 acres of general land shared with neighbouring communities. When the settlement was established in 1968 the village was surrounded by thick forest. Over the past decades the forest frontier had receded significantly from the settlement boundaries. All uses were permitted on forests designated as general land with the exception of the cutting of larger trees in some zoned areas. Given the size of the area as well as its distance to the village, rules and regulations are rarely enforced. General land forest areas are used by the community for subsistence purposes as well as for small-scale commercial activities such as charcoal production and harvesting of firewood, poles, and timber. The most important forest products in order of the value they generate for the community are firewood, withies, honey, and charcoal.

The community also maintained one forest area for conservation purposes only, where no human activities were allowed. The condition of this reserved forest had improved since protection began. There were two designated areas for beekeeping in the village forest, but they were not protected. The establishment of a bee reserve in the district was planned. The aim for this was to create an area, which could sustain beekeeping in the long term and where only limited other activities, such as water fetching, dry fire wood and fodder collection would be permitted. Other activities, including NTFP harvesting, would not be allowed.

Among the four communities, Paranga seemed to have the least conflicts regarding access and use of resources, likely due to the availability of vast forest resources on general land. A village environment committee was founded in 1968 and is part of the village government. Notably, the chair of this committee is also the chair of the beekeeping group.

1.4.3.3. Beekeeping context

Beekeeping had been practiced in all communities traditionally even before it was promoted by NGOs and governmental organisations. While there is anecdotal evidence of beekeepers in Tanzania traditionally being older men (Fisher 1997), my data suggests that this is not the case in my study communities, where beekeeping study participants who had learned beekeeping as a family tradition (rather than through training provided by an external organisation) and were currently practicing it included also younger men and women. The beekeeping systems used by beekeepers in the study communities included a range of

different technologies: local technology such as log hives clearly dominating in numbers as well as a more limited number of top-bar hives (TBH) donated through past beekeeping projects. Hives were located at vastly varying distances from beekeepers' homesteads with some sited in direct vicinity of the home, others in forested areas nearby, while some were located at up to 60km distance from the community.

Beekeeping groups

Social organisation in groups according to specific common economic, social, or religious interests is a means to solve the "free rider" problem in communal resource use, lower transaction costs, decrease risk and build social capital is common throughout rural Tanzania (Aker 2007, De Weerdt 2001). Indeed, a share of beekeepers in all four study communities associated themselves in groups:

In Msemembo, two beekeeping groups existed. The formation of one of them was initiated through an external beekeeping support organisation (described below) with the aim of easing delivery of training and achieving economies of scale by pooling harvests and marketing them in bulk. Honey and wax harvested from TBHs owned collectively by external donation were sold in the group and the profits paid into a group account. Members also owned local hives, the harvest from which was sold individually by the respective beekeeper. The number of members had decreased over the years as the group did not manage to generate the expected profits due to unreliable harvest quantities.

The second group was formed later and had not received any outside support. Members of this newer group placed their (local) hives in one shared apiary in order to share supervision duties to prevent hive theft or damage, but every group member harvested and marketed separately. At the time of the data collection for this study, the group existed only in name as its members were not undertaking any beekeeping activities together or in coordination with each other. Group members were meant to receive some form of training through the group leader, who attended a beekeeping seminar outside of the community, but this did not materialise.

Similarly, an external support organisation facilitated the establishment of a beekeeping group in Sasilo with the aim of easing training delivery and access to external markets. Receipt of project benefits (see below) was tied to group membership, which itself was linked to an

entry fee, the requirement to contribute a small amount to the group capital as well as a regular contribution. These financial requirements were set by the group itself and not by the project implementer. All honey and wax harvested by group members from the hives donated through the project was meant to be sold to the supporting organisation. The group was given exclusive access to a bee reserve of 60 ha, but ongoing forest degradation and theft of hives from this location led to the eventual disintegration of the group.

In Kwa Mtoro, two officially registered beekeeping groups were active at the time of data collection, one of which was initiated through an external support organisation. The older of these two groups (Ching) was a women's only group, initiated by an external support organisation in 1999 and officially registered in 2003. To gain group membership an entry fee and the contribution of a local and a top-bar hive to the group asset base were required. Group members were also expected to add an unspecified number of additional hives to this each year. The group sought access to an apiary location belonging to a neighbouring village, as forest resources directly accessible in Kwa Mtoro were limited. Access to this more remote location had become problematic over the years as most group members were elderly women with limited capacities to travel larger distances from their homesteads.

The official group registration brought with it support by the TFS, which placed its own hives near the group apiary and provided regular patrolling of the joint apiary area. One part of the group harvest was divided among the members and one part was sold in bulk. The income received from this was either reinvested in maintenance of the apiary or kept as savings. The group had received marketing support through two external support organisations. This support has led to the establishment of marketing links to middlemen from outside the region, which the group has managed to maintain over the years.

A second beekeeping group (Vumilia) was formed by members of the first group as the latter grew in membership but lagged in growth of hive numbers and thus in profits for individual members. The group was given 30 top-bar hives by the district government once they were officially registered in 2015. Hive donation was linked to a compulsory basic beekeeping training. Through personal connections to the first beekeeping group and its marketing links, the Vumilia group has access to external middlemen in its marketing efforts as well (see details below).

In Paranga, access to external beekeeping support by TASAF was linked to the requirement of beneficiaries grouping together in an association. A beekeeping group was thus formed in 2012, including experienced beekeepers as well as non-beekeepers. Group members were given top-bar hives with the initial training, but a subsequent drought led to disappointing harvests from these 'modern' hives. This led to attrition and poor group cohesion. Besides having received the initial training together, the group had not implemented any common activities and did not share a common apiary location.

Marketing of bee products

In all four communities, some of the honey and to a more limited degree wax, was sold by individual beekeepers within the communities to neighbours and fellow community members on an *ad hoc* basis as well as at local village markets which took place usually once a month. A part of the produce was also sold to middlemen from within and outside the district or retailers in nearby market towns who collected honey and wax directly from the villages. They then further refined, packaged, and sold it on. In some instances, individual beekeepers with connections to middlemen and retailers bought honey from other beekeepers in their community and then sold it on. Marketing options for honey bee products differed slightly between the four communities:

In Msemembo, beekeepers associated in a group and sold their honey in bulk to middlemen coming from Manyoni, Arusha and Das es Salaam. Smaller quantities of honey were sold locally at a lower price to female beer brewers. Beeswax was also sold to middlemen coming from the wider Manyoni district or Arusha region.

In Sasilo, where the beekeeping group was defunct, honey (and wax in a more limited fashion), was sold by individual beekeepers to middlemen. The group initially had a link established with HoneyCare through a NORAD project, but the link became inactive after the project ended.

In Kwa Mtoro, past beekeeping projects encompassed also marketing capacity building aspects. The two beekeeping groups which resulted from these projects have established relatively stable marketing links for honey and wax outside of the district. In the case of one group (Ching), the project implementer World Vision buys these products in bulk. In the case

of the other group (Vumilia), the group members have managed to keep marketing links established through the project with bulk buyers in Kondoa and Dodoma.

In Paranga, while a beekeeping group and thus the potential to sell honey and wax in bulk existed, the group had not managed to establish lucrative links with bulk buyers outside the community. Honey was thus sold unprocessed and on an *ad hoc* basis in small quantities for low prices.

1.4.3.4. External beekeeping support

Beekeeping support projects took place in all four study communities at various times during the 15 years preceding this study. These projects were implemented by non-governmental or governmental institutions and encompassed in all cases some form of training in beekeeping techniques and the donation of equipment in the form of top-bar hives or protective gear and harvesting equipment as well as environmental awareness raising. In some instances, the projects targeted already established beekeepers, and in other instances, beekeepers as well as non-beekeepers. Due to a changeover of staff in the relevant organisations since the projects were undertaken, it was difficult to obtain project documents and other detailed information pertaining specifically to all the implemented projects. The material presented here is based on the limited number of project reports obtained as well as on interviews with representatives of the implementing organisations and with project beneficiaries in the study communities.

In Msemembo, the international NGO World Vision implemented a beekeeping support project as part of an ongoing effort to reduce poverty in rural Tanzania and to build a conducive environment for the conservation of forests. The support included a week-long training of beneficiaries who were already keeping bees and were associated in a group. Topics taught included hive siting, swarm catching, harvesting of honey and wax, marketing of bee products as well as awareness raising on the importance of forest conservation. The group also received a one-off donation of 75 top-bar hives. The initial training provided by World Vision was followed up by additional training provided by TFS to the leaders of the beekeeping group, who were then expected to pass on the information provided to the rest of the group.

Sasilo was one of three pilot villages of the Management of Natural Resources Programme (MNRP) beekeeping subcomponent of the Tanzanian Ministry of Natural Resources and Tourism (MNRT) financed by the Governments of Norway and Tanzania. The main objective of this programme was to increase benefits to rural communities based on sustainable natural resource management. Beekeepers as well as non-beekeepers were trained on topics including swarm catching, the construction of local and top-bar hives, local bee forage sources, the importance of preserving trees that provide bee forage or are suitable for hive siting, the protection of hives from pests, necessity of the planting of local trees and of the establishment of a management plan for the harvesting of trees for timber and for the construction of local hives, the disadvantages of shifting cultivation, the negative effects of tobacco cultivation on forests and on honey quality. Besides training, the project provided beekeeping equipment such as top-bar hives and buckets as well as marketing support through the linking up of the beekeeping group with the social enterprise 'HoneyCare'. In order to participate in the project, beekeepers were required to group together in informal associations with the aim of registering the group officially through the respective district government.

Msemembo and Sasilo belong to Manyoni District, where the TFS has established a bee reserve at approximately 60 km distance from Msemembo and Sasilo. The TFS maintains its own hives in this reserve, which is meant to serve as a demonstration site for 'modern' beekeeping techniques and conducts training of beekeepers in the district on the use of these.

In Kwa Mtoro, the Irish NGO CREDEP began a near decade long beekeeping focussed project by training both traditional beekeepers as well as non-beekeepers on hive siting, swarm catching, the prevention of absconding, providing additional food for bees in times of forage shortages, harvesting and processing, the beekeeping calendar, the identification of pests, quality control and marketing. Yearly follow up to this initial training was provided until 2010. CREDEP also assisted the beekeepers by purchasing part of their harvest every year. After the CREDEP support had ended World Vision implemented a livelihood project based on beekeeping in Kwa Mtoro. This was done in the same fashion as in Msemembo (see above). To this day, World Vision is also an important buyer of bee products produced by the group it supported.

In Paranga the Tanzanian Social Action Fund (TASAF), a state-run poverty alleviation programme, conducted a three-day training for beekeepers and non-beekeepers on beekeeping techniques including swarm catching, honey harvesting, colony multiplication as well as on the importance of preserving forest resources where hives are sited. TASAF also provided its training beneficiaries with top-bar hives and protective equipment. No follow up was provided to this intervention.

The selection of project beneficiaries in all four study communities was based on certain selection criteria set by the external support organisation – information on these criteria was not available - and the subsequent self-selection of beneficiaries during public village meetings. In all cases, both beekeepers and non-beekeepers, men and women, older and younger people were encouraged to participate.

1.5. Ethical standards

This study was approved by the Bangor University Research Ethics Committee (Ethical approval number: CNS2015kw1). The following potential ethical issues were addressed:

1.5.1. Stress on local communities

The questioning of community members by unknown outsiders on wellbeing and forest resource use practices might cause stress and tension in rural communities, especially in remote locations or in communities with existent resource conflicts. Through the local project partner, Sokoine University of Agriculture (SUA), local guides were engaged to facilitate introductions to study communities. I elicited the support of village leaders to introduce and discuss the project in each study community.

1.5.2. Informed consent

The research components that had the potential to be sensitive were the household survey (Appendix 1.1), the key informant interviews, and the group discussions. Household survey

questions have been adapted from the previously tested Poverty and Environment Network research project (PEN) as well as the Multidimensional Poverty Assessment Tool (MPAT) questionnaires. Per household, one questionnaire (duration approx. 1 hour) was administered. All participating households were compensated for their time (see below).

In order to mitigate any potential ethical risks, participation in any of these research components was voluntary. Informed consent was sought after potential participants had been informed of the purpose of the study, the composition and contact details of the research team, what data was to be collected, how the data was to be used and what their participation would require of them (i.e. the subjects to be covered and the time that would be required) (Appendix 1.2). Oral consent was sought from all research participants as asking for signatures on written consent forms might cause stress to not fully literate rural community members. The condition of anonymity and confidentiality was proposed to all participants. I engaged community leaders to reassure community members of low personal risk in case of study participation. I emphasised that there is no obligation for any community member to participate in any of the activities and that participation could be withdrawn at any point in the process.

1.5.3. Storage of sensitive/personal data

Names of household heads were recorded during the survey as I needed to return to a selected number of households to conduct semi-structured interviews. To avoid storing sensitive and personal data that could be linked to individuals, individual identifier codes were assigned to all research participants. Names of research participants do not appear in any published material. Data was archived on a personal university drive that is backed up regularly and only accessible with a password. Personal identifiers were stored separately from the data and will be destroyed upon completion of the work.

1.5.4. Compensation for study participation

Participants of the household survey, of the group discussions and interviews were compensated for their participation through small locally appropriate gifts (laundry soap bars) at the end of each session. I aimed to compensate the time given by the participants at a value that corresponded with average local payment rates for the time spent.

1.5.5. Questions on sensitive topics

Questions on the households' forest resource use might be sensitive, if forest use activities of the respective household are illegal (e.g. tree cutting for charcoal or timber production in protection forest reserves). Questions on household income streams might be sensitive for some participants. Both types of questions (on forest resource use and household income) were however important in order to understand and compare the wellbeing and resource use behaviour of beekeepers against that of non-beekeepers. This corresponds to key research questions of this project on the relative wellbeing of beekeepers and the conservation-related behaviour of beekeepers compared with their non-beekeeping peers. Participants were assured of the scientific purpose of the survey and of complete confidentiality. The survey and interviews were conducted privately – out of the hearing range of neighbours or local government officials. In order to protect the individuals involved, there were no photos taken of illegal tree cutting activities. I ensured adequate training, remuneration, supervision, and control of research assistants engaged for survey implementation. In case of external requests for my research data, I am able provide the data without personal identifiers to avoid incrimination of participants for potentially illegal activities.

1.6. Thesis synopsis

In this thesis I examine the contribution of beekeeping to household wellbeing and forest conservation by identifying predictors for conservation behaviour linked to beekeeping. The aim of this research is to gather evidence on the effects of beekeeping within the context of

LCDAs and to provide suggestions for future improvements to enhance their effectiveness both in poverty alleviation as well as forest conservation.

In Chapter 3 I examined the predictors of beekeeping adoption and levels of dependence on beekeeping. I also assessed whether the type and quantity of external assistance influences beekeeping success. I used a mixed-methods approach to identify beekeeper characteristics as well as key drivers and barriers to beekeeping. I found that hive theft and lack of land, capital and knowledge were the major inhibiting factors to beekeeping adoption. Further, external beekeeping training by governmental organisations did not lead to increased success in beekeeping. Lastly, the requirement to form associations in order to access beekeeping support project benefits may destabilise existing community dynamics. These results are important to understand how future beekeeping support projects could improve their targeting and delivery of capacity building efforts to improve more long-term beekeeping adoption and increase yields of beekeepers.

In Chapter 4 I evaluated the wellbeing benefits of beekeeping using a multidimensional, non-monetary assessment template. I distinguished between three possible effects of beekeeping: the fulfilment of basic needs, the provision of a safety net to protect against shocks and the contribution to move a household towards greater prosperity. I also assessed whether beekeeping benefits fill a gap in subsistence and cash income throughout the agricultural year. I found beekeeping gains in all basic needs, albeit modest. I also determined that beekeepers were more resilient than non-beekeepers, but that beekeeping did not sufficiently fill an income gap throughout the year. Lastly, beekeepers owned more assets and were thus potentially in a better position to move towards greater prosperity. These findings are important to emphasise the need to generate realistic expectations when promoting beekeeping in rural communities.

In Chapter 5 I assessed several factors contributing to pro-conservation behaviour of beekeepers. For this I analysed whether beekeepers differ in their forest use, perceptions, and attitudes towards the forest and in their valuation of different ecosystem services from non-beekeepers. I also assessed whether beekeepers perceived themselves to be more or less powerful than non-beekeepers in forest resource use decisions within their communities. I found that beekeepers were more frequent and more diversified forest users but also displayed a partial disassociation between beekeeping and forest use. I also found that

beekeepers exhibited a slightly more positive attitude towards the forest and valued it more from a conservation point of view than non-beekeepers. The differences between beekeepers and non-beekeepers in all examined factors were relatively small. These results are important to appraise if LCDAs promoting beekeeping as an additional, forest-friendly livelihood have the potential to achieve conservation successes.

2. METHODS

2.1. Methodology and study design

The aim of this study was to test pre-existing theories about wealth and conservation incentive effects of beekeeping as well as to explore factors contributing to these assumed impacts. The research questions set for this study (see section 1.3) do not sit comfortably within a wholly qualitative or quantitative research approach. To address the research questions a pragmatist or "what works" tactic was thus used, mixing methods from both approaches (Creswell 2009). The different methods were used in a sequential manner, with the results of each informing the development of the next. The core methods used included a household survey as well as individual and group interviews. The survey data was aimed to create empirical evidence to test the relationship between beekeeping and wellbeing and conservation effects, in other words to examine the outcomes of beekeeping. Interview data was used to explore the factors contributing to these effects, in other words to investigate the processes and reasons for the observed phenomena.

The research strategy was both deductive, i.e. testing existing hypotheses on the contribution of beekeeping to wellbeing and conservation motivations, and inductive, i.e. inducing new theory based on phenomena observed in the interview data. The analysis of the latter was undertaken in a hermeneutic-phenomenological tradition of seeing human action as based on individual interpretation of reality (i.e. social reality) and thus as meaningful and requiring interpretation from the actors' point of view (Bryman 2015).

The research is based on four case studies which serve to provide a cross-sectional view of the contribution of beekeeping to household wellbeing and conservation motivations in the Tanzanian Miombo.

2.2. Study area and selection of sites

Study participants were recruited from two known beekeeping zones in the central Tanzanian Regions of Dodoma (Kondoa and Chemba districts) and Singida (Manyoni District). Within these two predominantly arid regions, four rural communities were selected as study sites.

All communities were located at similar distances to major roads, large markets, and forests where beekeeping was undertaken. Study communities had similar population sizes, including the presence of at least 30 beekeepers and non-beekeepers, respectively, as well as a history of having received external beekeeping support (Table 1.1).

2.3. Definitions of key terminology

2.3.1. Beekeeper

During the pre-testing of the questionnaire it became evident that a simple self-identification as a beekeeper or non-beekeeper, as originally planned in the survey, presented potential for erroneous categorisation of participants. This was subsequently corrected while implementing the questionnaire by categorising people who owned bee hives as beekeepers or else non-beekeepers. While it is conceivable for someone to own hives and to never actually have used them, all survey participants who had indicated to own hives answered subsequent beekeeping related questions in a manner reflecting some level of practical beekeeping experience.

The possibility of survey participants giving misleading or untruthful answers to make it look like they were keeping bees, when in reality they were not, exists. But it is doubtful that a large number of participants would have done so, as no gains could be made from such assertions. Vice versa, the possibility of someone not owning hives yet being involved in beekeeping as a labourer e.g. exists as well. However, the categorisation of beekeepers based on hive ownership was deemed to be the least complex way to disaggregate the study sample. For the purpose of this study, 'beekeepers' are thus defined as those who indicated to own hives at the time the study was undertaken or else were considered as 'non-beekeepers'. This approach also follows the approach other authors have chosen in their comparison of beekeepers and non-beekeepers livelihoods (Lowore, Meaton et al. 2020, Amulen, D'Haese 2017).

2.3.2. Beehive

In the survey questionnaire all non-local beehives, i.e. frame-hives and TBHs are referred to as “modern hives” (mizinga ya kisasa) as this is the colloquial term used locally for both of these types of hives. In the study context the vast majority of local hives observed were log hives. Among the non-local hives only a few frame hives could be observed, with the majority of non-local hives being of the TBH type. This was the type of hive donated to the study communities through the external beekeeping support that information was still available on at the time of data collection (see Section 1.4.3.4).

The appropriateness of non-local hives, and in particular frame-hives in the African beekeeping context, has been questioned by a range of authors (Carroll, Davey et al. 2017, Amulen, D’Haese et al. 2019, Schouten and Lloyd 2019). While the use of different hive-types has implications for the beekeeping system used as well as on the quality and quantity of harvestable bee products, an assessment of the suitability of these different hive types was beyond the scope of this study. The discussion around the appropriateness of the promotion of certain hive types and beekeeping systems is of pertinence to beekeeping outcomes. However, the breadth of scope of this study was such that an analysis of the effects of different beekeeping systems on indicators of wellbeing and forest use behaviour could not have been performed to a satisfactory depth.

2.3.3. Beekeeping products

Besides honey and beeswax, bees produce a range of products of value for humans, including pollen, propolis, royal jelly, bee venom (FAO 2009). In the Tanzanian context and at the study locations beekeepers focussed their efforts on the harvesting of honey and wax (Fisher 1997a). Honey and wax are harvested as comb honey and then either consumed or sold in an unprocessed state or processed to various degrees depending on its use. If wax is marketed, which is not the case for every beekeeper in the study context, it is separated from the honey, cleaned, and pressed into a compact, transportable shape (Fisher 1997a)

According to scoping data derived from group discussions with beekeepers at the study sites as well as with district officials, when honey is destined to be sold to middlemen or retailers,

most beekeepers in the study communities partially process comb honey by straining the honey after harvest and pouring it into various types of containers. A further filtering out of wax and other impurities as well as packaging is then performed by middlemen or shop owners buying the semi-processed product. When honey is destined to be sold locally, it can be in the form of comb honey or semi-processed with impurities such as brood and pollen not necessarily removed as the protein is important for the fermentation process in the production of local honey beer (Fisher 1997a).

In the context of this study, no distinction was made between honey processed to different levels by individual beekeepers in order to avoid indicator categories with low representations in the statistical analysis. I intended to analyse the connection between selling wax as well as honey, i.e. selling wax and honey in separate forms, on the wellbeing of beekeepers. However, during the data analysis process it became apparent that 'processing honey' was interpreted not uniformly among beekeeping study participants. Any analysis that had the separation of honey from wax at its basis, had to thus be abandoned as survey data on this was not reliable. Any reference in this thesis to beekeepers at the study locations marketing 'wax and honey' includes the marketing of comb honey as well as the marketing of honey and wax separately in various levels of refinement.

2.4. Sampling, data collection and analysis

The scoping, piloting and data collection took place in the years 2015 and 2016. Both quantitative and qualitative data were collected. During the scoping phase, twelve group discussions were held separately in each community with beekeepers, non-beekeepers, and village leaders to allow the research team to construct a first impression of the study communities with respect to the research questions set for the study. Topics discussed during these initial conversations included historical and current beekeeping development and practice at the study locations, locally relevant push and pull factors of beekeeping, perceived wealth differences between beekeepers and non-beekeepers, other livelihood options, local forest resource quantity, type, access, and use.

Participants were purposefully selected to generate the widest possible, representative range of socio-economic characteristics within each community. Village leaders were asked to invite representatives of both sexes, younger and older generations, immigrants, and established village residents as well as representatives of all livelihood activities. The discussions were recorded, transcribed, and translated in situ from Swahili to English.

These initial group discussions informed the development of the household survey, which was pretested in a community not included in the study but displaying the same general characteristics of the study communities in terms of population size, climate, predominant vegetation, land uses, distances to major roads, larger markets and forests. The survey was coded by using the OpenDataKit (ODK) tool (Brunette, Sudar et al. 2014). A stratified random sampling approach was applied to select approximately equal numbers of beekeepers and non-beekeepers from each village in each community (Bryman 2015). Randomness was introduced by assigning random numbers to all households recorded in village registries and selecting a proportional number of beekeeping and non-beekeeping households from each sub-village of a village. The questionnaire elicited information on a range of socio-economic indicators, on beekeeping activities as well as on perceptions and attitudes towards forests and forest use behaviour.

Local research assistants trained in questionnaire administration, key beekeeping terminology and the use of the ODK tool implemented the survey (Angelsen, Larsen et al. 2011). Respondents' anonymity was maintained by assigning individual identifier codes to all research participants and storing questionnaire and interview responses under these codes. Sensitive and personal data could thus not be linked to individuals. All identifying information will be destroyed at the end of the study.

A total of 318 household questionnaires were completed (155 beekeepers and 163 non-beekeepers). Forty-five of these survey participants were invited to attend further, semi-structured interviews to gain a more in-depth understanding of topics touched upon in the questionnaire. These interview participants were selected to represent the largest possible diversity in terms of age, sex, beekeeping background and main livelihood activity. Lastly, ten semi-structured interviews were held with beekeeping support organisations active in the study communities and in Tanzania in general. Topics discussed included reasons for

promoting beekeeping, selection criteria for program/project beneficiaries as well as indicators of success.

Quantitative data was analysed using descriptive statistics as well as statistical tests, regression analysis as well as modelling. As the analytical approaches varied for each research question, the specific quantitative analytical methods used in each data chapter are detailed in the respective data chapter sections (3.3, 4.3 and 5.3).

To analyse the qualitative data, I coded the interview and group discussion transcripts both deductively and inductively in accordance with the research questions and extracted themes as they occurred (Ritchie, Lewis et al. 2013). I adjusted the coding framework continuously throughout this process as new themes emerged during the analysis. The purpose of the coding was to capture and interpret common sense and elicit and interpret substantive meanings in the survey data. The focus of this study is on the analysis of quantitative data. The results and implications of the qualitative data analysis are used to annotate the results and discussion sections of this study. Quotes from interviews and group discussions are inserted throughout the results sections and represent illustrations of major findings of this analysis.

Table 2.1. summarises the methodological approach, data and analysis used in this study.

Table 2. 1 Chapters and methods used within the thesis

Chapter	Topic	Research question	Methodological approach	Data used	Data analysis
Chapter 3	Determinants of beekeeping adoption, dependence, and success	1. What are the circumstances that push/draw households to beekeeping? 2. What are the socio-economic predictors for different levels of beekeeping dependence and success?	Group discussions, household questionnaire, semi-structured interviews	Survey data on selected socio-economic variables and responses relating to beekeeping motivation, background, technical capacities, participation in beekeeping support programs, problems experienced in beekeeping, beekeeping success measures	Ordinary binary logit regression modelling, two-part binary and fractional regression modelling, qualitative data analysis using framework approach
Chapter 4	Beekeeping benefits to rural communities	3. Do beekeepers enjoy a higher quality of life than their non-beekeeping peers? 4. Does beekeeping contribute to a bridging of shortage periods?	Group discussions, household questionnaire, semi-structured interviews	Socio-economic survey data; interview data	Ordinary binary logit regression modelling, qualitative data analysis using framework approach
Chapter 5	Factors contributing to beekeeping incentivising forest conservation	5. Do beekeepers differ in their forest perceptions and attitudes to non-beekeepers? 6. Do beekeepers value the forest for different ecosystem services than non-beekeepers? 7. How powerful are beekeepers within their communities?	Group discussions, household questionnaire, semi-structured interviews	Survey data on forest use behaviour, forest attitudes and values, perceived decision-making power; interview data	Ordinary linear modelling, ordered logistic regression modelling, logistic regression modelling, qualitative data analysis using framework approach

2.5. Data overview

An overview of the variables analysed for each research question is provided in Table 2.2.

Table 2. 2 Variables analysed for each research question

Research question	Analysed predictor variables	Sample	
RQ 1 – Factors influencing beekeeping adoption	• Age • Household size • Distance of homestead to forest • Distance of homestead to road • Forested area owned • Length of stay in community • Household head education • Engaged in honey hunting • Parental beekeeping • Engaged in livestock keeping	Beekeepers Non-beekeepers	Chapter 3
RQ 2a – Factors influencing dependence on beekeeping	• All variables analysed for RQ 1 + • Gender • Motivation for beekeeping uptake • Source of beekeeping training • Length of external training received • Length of beekeeping activity • Beekeeping group membership	Beekeepers	
RQ 2b – Factors influencing success in beekeeping	• All variables analysed for RQ 2a + • Self-assessed beekeeping training needs • Technical beekeeping knowledge	Beekeepers	
RQ 3 – Comparison of wellbeing of beekeepers and non-beekeepers	• Engaged in beekeeping • Age • Gender (Beekeepers only) • Number of hives owned (Beekeepers only) • Quantity of honey harvested (Beekeepers only) • Received any formalized training (Beekeepers only) • Location where bee products were marketed (Beekeepers only)	Beekeepers Non-beekeepers	Chapter 4
RQ 4 – Beekeeping as a gap filler	• Months of shortages • Months of high income • Months of high food security • Months of beekeeping benefits	Beekeepers Non-beekeepers	
RQ 5 – Forest perceptions and attitudes	• Forest planting and clearing • Reasons for forest planting • Frequency of forest visits • Number of different forest product types regularly harvested • Sentiments experienced in the forest • Preference for more or less forest near village	Beekeepers Non-beekeepers	Chapter 5
RQ 6 – Valuation of forest products and ecosystem services	• Values given to different forest products and ecosystem services		
RQ 7 – Decision-making power	• Self-assessment of influence over resource use decisions		

While factors influencing dependence on beekeeping for income and subsistence as well as factors influencing beekeeping success were only analysed for beekeepers, factors influencing beekeeping adoption were analysed for both, beekeepers and non-beekeepers. The same is true for the analyses of forest use, forest attitudes and values and decision-making power as these constituted direct comparisons between the two groups. For variables which necessitated the inclusion of both groups into the analysis, gender was excluded as a predictor variable. The reason for this was that non-beekeeping households were always represented by the household head, who was more often male. The comparison of wellbeing of beekeeping versus non-beekeeping households therefore did not include a gender indicator. Further analysis of differences in wellbeing between different types of beekeepers, however, included a disaggregation of the beekeeping sample into female and male beekeepers. Correspondingly, analyses of differences between different types of beekeepers regarding factors contributing to conservation behaviour included a differentiation between male and female beekeepers.

A wide range of socio-economic predictor variables encompassing variables for food security, domestic water supply, health, sanitation, housing and energy, education, farm assets, non-farm assets, resilience, as well as social capital were purposefully excluded from the analysis of beekeeping adoption, dependence on beekeeping and beekeeping success (Chapter 3). This was to preclude circularity in the analysis of wellbeing (Chapter 4), which was based on the exploration of the influence of the engagement in beekeeping on a range of socio-economic variables.

3. STICKY BUSINESS – WHY DO BEEKEEPERS KEEP BEES AND WHAT MAKES THEM SUCCESSFUL IN TANZANIA?[4]

Abstract

Development agencies promote beekeeping widely in developing nations to alleviate rural poverty and simultaneously provide an incentive for forest conservation. There is little robust evidence to suggest that beekeeping interventions target the most suitable beneficiaries, or that training length and content are adequate to sustainably promote beekeeping in sub-Saharan Africa. This study aimed to determine predictors of both beekeeping adoption and levels of dependence on beekeeping. I also assessed whether the type and quantity of external assistance appeared to influence beekeeping success. I applied a mixed methods approach to identify beekeeper characteristics and identify key drivers and barriers to beekeeping in four communities in central Tanzania. Income and food provision were the main drivers for beekeeping adoption, but the effects of these were moderated by both the respondents' cultural background, and the perceived human health risks posed by African bees. Land ownership, technical knowledge, initial capital inputs and hive theft were important constraints to adopting beekeeping. I found that formal beekeeping training did not result in increased yields and propose that training provided by the majority of development agencies is inadequate to address the technical capacity requirements of local beekeepers. I also propose that the requirement to form associations to access project benefits creates divisions in communities and needs to be handled with more care than is currently done.

[4] An adapted version of this chapter has been published as: Wagner, K., H. Meilby & P. Cross (2019) Sticky business - Why do beekeepers keep bees and what makes them successful in Tanzania? *Journal of Rural Studies*. 66, 52-66, 10.1016/j.jrurstud.2019.01.022.

3.1. Introduction

The elimination of extreme poverty and the reversal of forest degradation are prominent international development objectives (UN General Assembly resolution 70/1 2015). Given the scale of interdependencies between poverty and forest loss, many governments and development agencies seek to address the two issues conjointly (UNDP 2013, World Bank 2013, USAID 2014, UNDP 2015, USAID 2015). Current conservation approaches aim to incentivise local communities by linking economic development and livelihoods with the protection of natural resources (Brandon and Wells 1992, Salafsky and Wollenberg 2000, APFIC 2010, Roe, Day et al. 2014, USAID 2016).

These approaches can link livelihoods and conservation indirectly by substituting local communities' reliance on natural resources with alternatives, e.g. reducing dependence on bushmeat by introducing domesticated sources of meat. Or they can give local communities an immediate stake in the preservation of natural resources by directly benefitting from biodiversity through biodiversity-based livelihood activities using non-timber forest products for example. The underlying idea is that income and subsistence derived from biodiversity provide an incentive to the community to protect and conserve natural resources. (Brandon and Wells 1992, Salafsky and Wollenberg 2000, Roe, Day et al. 2014,).

Beekeeping has been widely promoted as a successful example of the linked conservation and development approach, with beekeeping products being important non-timber forest products due to their considerable commercial potential (Brown 2001, FAO 2011, ICIPE 2013). Beekeeping is considered a suitable development activity by many governments and development agencies owing to relatively low initial economic investment, limited equipment, and training needs, as well as minimal land requirements. The potential to generate additional income, whilst contributing to food security and delivering medicinal benefits to the rural poor, is thought to increase local resilience leading to incentives to conserve forest and tree resources (Drescher and Crane 1982, Bradbear, Fisher et al. 2002, FAO 2011).

The Miombo woodland ecoregion extends over several countries in Southeast Africa and sustains extensive beekeeping and honey-hunting activities. (Campbell 1996, Mickels-Kokwe 2006, Campbell, Angelsen et al. 2007). Tanzania is the second largest honey-producer in Africa

by volume (USAID 2012), harvesting an estimated 30 905 metric tons annually (FAO 2017). Increased globalization and the opening of niche markets for organic and Fair-Trade forest products has increased the potential for the expansion of the apiculture sector (Campbell, Angelsen et al. 2007, Shackleton 2007). Improved in-country communication technology has facilitated linkages between rural entrepreneurs and urban-centred markets (Aker and Mbiti 2010). This has the potential to connect beekeepers often living in remote locations with networks that could allow them to obtain cash income from their beekeeping products.

Despite these positive contributory factors, several authors have suggested that beehive product potential remains untapped across much of Southeast Africa (Kihwele 1985, Mickels-Kokwe 2006, Carroll and Kinsella 2013). While a potential yield gap in African beekeeping products has recently been contested (Bradbear 2018), the Tanzanian Government and Non-Governmental Organisations (NGOs) have developed a series of policy and technical training initiatives to improve production efficiency and gross production in the national beekeeping sector (URT 2002, Hausser and Mpuya 2004, MNRT 2016).

The majority of beekeeping interventions in sub-Saharan Africa comprise an admix of training, hive donation and occasionally protective equipment provision (Hausser and Mpuya 2004, Anand and Sisay 2011, Affognon, Kingori et al. 2015, Carroll, Davey et al. 2017). Several support organisations encourage the modernization of beekeeping through the distribution of frame hives (Carroll, Davey et al. 2017), which are thought to be less suitable for both the local honeybee sub-species and prevailing climatic conditions (FAO 2009, Carroll and Kinsella 2013). Beekeeping promoters aim to encourage existing beekeepers to intensify and modernize their honey production, whilst also incentivising non-beekeepers to adopt beekeeping as a supplementary livelihood activity (FAO 2014, World Vision 2015). However, attrition of participants following the implementation of such projects is substantial (Brown 2001, Carroll, Davey et al. 2017).

Beekeeping intervention beneficiaries are sometimes already beekeepers (BTC 2016, SNV 2016b). In other cases, project teams target non-beekeepers with particular characteristics usually based on the ultimate aim of the intervention (e.g. landless youth, honey hunters, widows) (Bees Abroad 2013, ILO 2016). Beekeeping projects tend to be delivered to groups of beekeepers rather than to individual (Anand and Sisay 2011, Affognon, Kingori et al. 2015, Carroll, Davey et al. 2017). This is done for several reasons including the sharing of knowledge,

resources as well as the creation of economies of scale (Wainwright 2002). It also reflects the paradigm of participatory, community-based development, which aims to reduce inefficiencies of centralised development, to democratise decision-making and create local agency to manage the terms local entrepreneurs operate under (Lyon 2003, Dasgupta and Beard 2007).

Carroll et al. (2017) found that training provision within beekeeping projects often did not reflect the complex and practical skill set required to manage Langstroth hives (frame hives). Beekeeping training within projects usually lasts only a few days and is often classroom based (Amulen, D'Haese et al. 2017), delivering techniques considered too advanced for the training time frame and lacking appropriate follow up extension services (Carroll, Davey et al. 2017). Whilst insufficient knowledge of beekeeping techniques appears to be a critical factor in explaining the honey yield gap in East Africa (Nel, Illgner et al. 2000, Carroll 2013, Affognon, Kingori et al. 2015, Carroll, Davey et al. 2017), there is a lack of robust studies measuring the actual effect of capacity building for beekeeping on skills (Amulen, D'Haese et al. 2017). Such information is critical to inform effective policy and technical delivery.

LCDAs, among which beekeeping projects feature prominently, remain pervasive conservation and development tools in the tropics despite criticism of their effectiveness (Agrawal and Redford 2006, Roe 2008). Wright *et al.* (2016) observe that these types of projects are based on flawed assumptions, weakening their chances of success. Salafsky *et al*. (2001) find that while LCDAs can lead to positive conservation outcomes, this never happens when they are implemented as the sole means by which conservation is to be achieved. McShane *et al*. (2011) conclude that so-called win-wins are rarely achieved and trade-offs between conservation and socio-economic outcomes being more often the case.

The International Union for the Conservation of Nature (IUCN) recently called for a critical review of LCDAs as evidence of their effectiveness has not grown at the same rate as their prominence (IUCN 2012). A subsequent systematic review concluded that we do not understand why most of LCDA project fail to achieve their goals (Roe, Booker et al. 2015). The lack of evidence is corroborated by Brooks (2017), who also confirms in his systematic review that trade-offs between the dual goals of these projects are necessary in the majority of cases. He argues that the acknowledgement of risks and costs as well as an open communication

with project beneficiaries on the necessary trade-offs is of fundamental importance in order to manage expectations and local buy-in (Brooks 2017).

This knowledge gap becomes even more significant as efforts towards reducing emissions from deforestation and forest degradation (REDD) once again bring conservation and development agendas to converge by making livelihood activities such as beekeeping fundable under the UNFCC REDD+ framework (Roe 2008, Blom, Sunderland et al. 2010, UN-REDD 2012, URT 2013). This study is a step towards answering some of the questions regarding effectiveness of beekeeping interventions, by examining how the targeting and delivery of capacity building efforts could be improved to further beekeeping adoption and to increase yields of beekeepers.

For this, I identified the predictors, motivations and barriers of beekeeping adoption and characterized the relative dependence on beekeeping for subsistence and income generation. I characterized beekeeping adopters and non-adopters to identify any rural Tanzanian groups more likely to incorporate beekeeping into their livelihood activities. I also hypothesised that households with a higher dependence on beekeeping for subsistence, i.e. who use their harvested honey to supplement their calorific need, differed in location, social situation, history in beekeeping and livelihood strategies to those who were more dependent on beekeeping for income than subsistence. It is important to discriminate between beekeeper typologies as these divergent motivations to harvest bee products may also have implications for the motivation to participate in beekeeping support programs and for how participants may benefit from them.

The study also assessed whether and what type of support and training influenced beekeeping success, defined here as the quantity of honey harvested in the preceding twelve months. Since the aim of most external beekeeping training is to increase production (URT 2002, Hausser and Mpuya 2004, MNRT 2016), I hypothesised that the more external training received, the greater the honey harvest. I hope that the results of this analysis can provide guidance for future LCDA project planners intending to promote beekeeping in Tanzania and the wider Miombo-region.

3.2. Data collection

The following section details the themes relevant for the analysis of this first data chapter as elicited through the data collection methods described in chapter 2.

In the separate group discussions held during the scoping phase of this study with beekeepers, non-beekeepers and village leaders (see sections 2.1 and 2.5) elicited themes of relevance for this first data chapter were those related to the motivation for or against beekeeping; perceived benefits of beekeeping; perceived changes over the past decade in forest and beekeeping resources; as well as any potential conflicts between community members in the context of beekeeping and other livelihood activities. Including non-beekeepers' perspectives on beekeeping was key to understanding potential barriers to the adoption of beekeeping.

The subsequently administered household survey included several sections eliciting socio-economic as well as beekeeping related responses concerning the motivation for or against beekeeping, family background in beekeeping, technical beekeeping capacities, participation in beekeeping support programs, problems experienced in beekeeping, beekeeping success measures and experiences as beekeepers. Beekeeping related questions to non-beekeepers concerned their family history, past experiences and possible external training received in beekeeping as well as reasons for non-adoption and conditions for potential adoption.

Semi-structured interviews, which were conducted after the administration of the household survey, gave the opportunity to obtain more detailed information on motivations for or against practicing beekeeping; status of beekeeping in the community; resource constraints; beekeeping-related conflicts; experiences in beekeeping groups as well as experiences with beekeeping training.

3.3. Data analysis

My analysis explored several potential predictors suggested in the relevant literature as determinants in the adoption of new agricultural technologies in least developed countries (Rahm and Huffman 1984, Feder and Umali 1993, Doss and Morris 2000, Abdulai and Huffman 2005). I hypothesised the following indicators to have significant associations with

beekeeping adoption: age and education levels (as proxies for human capital), household size (as a proxy for labour availability), forest area owned (individual de facto and/or de jure use rights over natural and planted forests), distance to forest and livestock keeping (as proxies for access to input), distance to road[5] (as a proxy for the relative ease of physically accessing non-local honey and wax markets used by the local population), length of residence (as a proxy for social capital), honey hunting activity and parental beekeeping (proxies for cultural proximity to beekeeping activities) (Table 3.1).

For the continuous variables I applied two-sample t-tests to determine if the two population means (for beekeepers and non-beekeepers) were significantly different. Further, I used Pearson's chi-squared tests to determine whether the proportions for categorical variables in the beekeeping and non-beekeeping groups were equal. Finally, factors, which were found to be significantly different between the two populations, were analysed using an ordinary binary logit model. The distribution of the residuals was used to validate the logit link function. An independence test between all variable combinations considered for the regression model was performed using standard Pearson's chi-squared test in order to exclude any moderated relationships. Model selection was based on the lowest Akaike Information Criterion (AIC) score. Model variables were tested for multicollinearity, random effects of sub-villages as well as interactions.

Lastly, barriers and conditions for beekeeping uptake were analysed using descriptive statistics. This analysis of predictors of beekeeping adoption was the only part of my study that included non-beekeepers. The analysis of predictors of levels of dependence and success in beekeeping only encompassed beekeepers' responses.

For the analysis of dependence on beekeeping for subsistence and for income I examined the same range of hypothesised predictor variables as for beekeeping adoption, as well as

[5]Beekeeping products in all four study communities were traded also to middlemen traveling to the communities to collect the products being sold. The assumption behind using the proxy of 'distance to road' as a proxy for the access to non-local markets was that beekeepers living closer to the road that middlemen would have to use to collect bee products would face fewer difficulties getting their products to said middlemen than beekeepers living in more remote locations. While distance to the road as a proxy for access to non-local markets does not fully reflect other aspects necessary to be able to trade at these markets (e.g. being able to establish a link to middlemen in the first place, maintaining this link for regular transactions to take place or having the necessary marketing skills to make full benefit of this access by controlling the price of the product), it was considered a valuable stand-in in lieu of a rather more complex set of variables explaining access.

variables representing the ex-ante motivation behind beekeeping adoption and the source of beekeeping training received (Table 3.3). The dependent variables for dependence on beekeeping for subsistence and income were expressed in percentage shares and were thus bounded from above and below, i.e. assuming values between 0-100. They also showed highly asymmetric distributions towards the lower boundary (0) and a large proportion of zeros. Two-part binary and fractional regression models were used to determine predictor variables. For both dependent variables, the discrete components (determining whether values were equal to 0 or not) were modelled as binary logit models and the continuous components (determining actual levels where values were not equal to 0) as fractional regression models. For this, percentage values were converted to fractional (0-1) values. The binary model component predicts the probability of the dependent variable being non-zero. The fractional component predicts the fractional value in case the dependent variable is a non-zero.

Lastly, for beekeeping success, defined here as litres of honey harvested in the 12 months prior to the survey in 2016 (obtained through recall and encompassing two honey flow seasons), I tested the same hypothesised predictor variables as for beekeeping adoption and dependence as well as additional variables representing technical capacity and individual training history (Table 3.6). While "litres harvested" is a relatively narrow definition of beekeeping success, other possible indicators such as the number of hives owned, the level of dependence on beekeeping or marketing success had their own limitations (African beekeeping is an extensive form of beekeeping, i.e. beekeepers own many hives, but not all of these are occupied all the time; level of dependence and marketing success can both also be a result of other circumstances and might not directly indicate 'success'). Litres harvested was felt to be an easily measurable proxy for how skilled a beekeeper was in beekeeping terms only.

External factors such as droughts, fires or pests were not considered for the model as these factors would have had an impact on all local beekeepers and would not have explained any difference in litres harvested over a given time period. Since harvest quantities showed a skewed distribution with a high proportion of zeros, I applied a two-part binary and fractional regression modelling approach here as well. For this, I divided the number of litres harvested by the maximum number of litres reported (600 litres) in order to get values between 0-1.

Variables tested as predictors for beekeeping adoption, dependence on beekeeping for subsistence and income as well as beekeeping success were selected based on previously assessed significant relationships or correlations (Appendix 3.1) or because they were theoretically hypothesised to have relationships with the respective dependent variables, i.e. beekeeping adoption, beekeeping dependence for subsistence, beekeeping dependence for income and beekeeping success. Problems beekeepers experienced, aspects training was received on, source of training as well as existing and desired beekeeping skills were also analysed using descriptive statistics.

3.4. Results

3.4.1. Determinants of beekeeping adoption

Beekeepers (n = 155) cited income from honey (89%), provision of food (74%) and income from wax (64%) as the main reasons for keeping bees (Figure 3.1a). Non-beekeepers (n = 163) identified a lack of capital (54%), knowledge (37%) and space, defined as a shortage of areas suitable for beekeeping, (26%) as the three most important reasons for not adopting beekeeping (Figure 3.1c). Respondents who had previously practiced beekeeping, but subsequently abandoned this activity (n = 39) indicated that theft of hives/honey (54%) and lack of space and capital (both 23%) were the primary causes of activity cessation (Figure 3.1b). The most frequently cited reasons for not adopting beekeeping by non-beekeeping respondents whose parents used to keep bees (n = 78), were lack of access to necessary resources (43%), fear of bees (18%) and theft of hives/honey (15%) (Figure 3.1d). The most frequently indicated conditions for beekeeping uptake among non-beekeepers were access to capital (64%), to land/space for beekeeping (38%) and provision of training and advisory support in beekeeping techniques (both 31%).

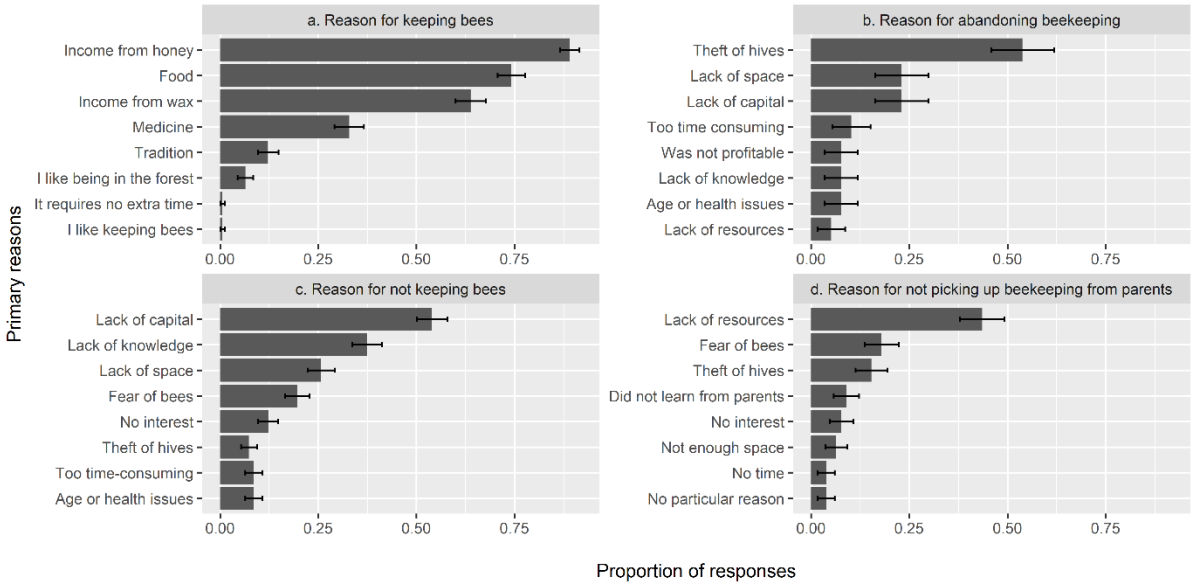


Figure 3. 1. - Proportion of reported primary reasons for (a) and against (c) beekeeping adoption, for abandoning beekeeping (b) and for not picking up beekeeping from parents (d).

In statistical tests, beekeepers came from a background of considerably higher forest ownership, percentage of honey hunters, parental beekeeping and livestock keeping than non-beekeepers (Table 3.1). Ease of access to more distant markets, as measured through the distance of a household to major roads did not have a significant relationship with beekeeping adoption.

Table 3. 1. - Continuous (t-test) and binary (chi-squared test) predictors of beekeeping adoption (Sample size: 155 beekeepers, 163 non-beekeepers)

Continuous predictors	**Beekeepers mean (± SE)**	**Non-beekeepers mean (± SE)**	**t value**
Age	49.03 (±1.7)	50.56 (±1.2)	0.90*
HH size (Adult equivalent[6])	2.79 (± 0.1)	2.50 (±0.1)	-2.35
Distance to forest (min walking)	77.97 (± 0.5)	88.04 (±0.5)	1.11
Distance to road (km)	1.10 (± 0.2)	1.17 (±0.2)	0.22
Forested area owned[7] (acres)	5.08 (± 1.4)	1.14 (±0.3)	-2.70**
Length of stay in community (years)	40.51 (± 1.3)	39.03 (±1.3)	-0.78
Dichotomous predictors	**Beekeepers % (± SE)**	**Non-beekeepers % (± SE)**	**χ^2 value**
HH head education (no formal education)	18.07 (± 0.34)	24.54 (± 0.40)	1.98
HH head education (secondary/techn. school)	3.65 (± 0.15)	10.00 (± 0.25)	2.39
Honeyhunter (yes)	32.90 (± 0.46)	10.43 (± 0.26)	23.87***
Parental beekeeping (yes)	72.26(± 0.68)	47.85 (± 0.55)	19.68***
Engaged in livestock keeping (y)	80.65(± 0.72)	53.99 (± 0.59)	25.53***

Using the OECD-modified scale: Household head = 1, each additional adult = 0.5, each child = 0.3 (http://www.oecd.org/eco/growth/OECD-Note-EquivalenceScales.pdf)
2 Comprises natural and planted forest areas as well as orchards
* significance at 5%, ** significance at 1%, *** significance at 0.1%

Stepwise backward binary logit regression identified significant relationships between beekeeping uptake and the size of forest area owned, engagement in honey hunting, parental beekeeping and engagement in livestock keeping (Table 3.2, Figure 3.2). The pseudo R^2 (1-residual deviance/null deviance) for the beekeeping adoption model was 0.248. The distribution of the residuals indicated that the logit link function was a suitable choice. Random effects for sub-village affiliation as well as 2nd degree interactions were also tested for the model, but did not improve the model fit, i.e. did not lower the AIC score by more than 2 points.

Table 3. 2. - Estimated parameters of a binary logit regression model of beekeeping adoption

	Coefficient	**SE**	**z value**
Intercept	-1.844	0.298	-9.199***
Forested area owned (acres)	0.082	0.031	2.686**
Honey hunter (yes)	1.182	0.331	3.573***
Parental beekeeping (yes)	0.968	0.260	3.726***
Livestock keeping (yes)	1.165	0.277	4.213***

* significance at 5%, ** significance at 1%, *** significance at 0.1%

[6] Using the OECD-modified scale: Household head = 1, each additional adult = 0.5, each child = 0.3 (http://www.oecd.org/eco/growth/OECD-Note-EquivalenceScales.pdf)
[7] Comprises natural and planted forest areas as well as orchards

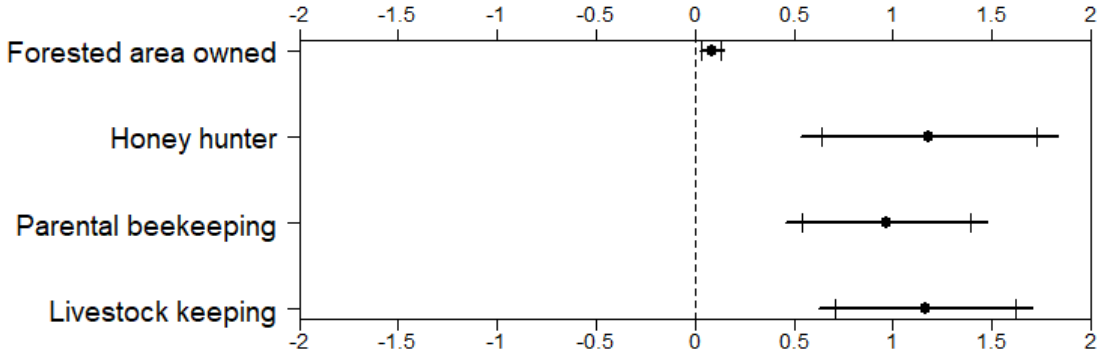


Figure 3. 2. - Estimated coefficients, standard errors, 90% and 95% confidence intervals of binary logit regression model of beekeeping adoption (Sample size: 155 beekeepers, 163 non-beekeepers).

Interviewed beekeepers and non-beekeepers also stated that tribal cultural tradition in beekeeping (or the lack of) was an important driver (or inhibitor) of beekeeping adoption:

> *"But here the Sandawe people used to be beekeepers for a long time, and they used to hunt bees from the trees. But I am Wagogo, we don't have this culture from our grandfather, [we are] not engaged in beekeeping." (male non-beekeeper, 60)*

While the reasons for a link between beekeeping adoption and livestock keeping or honey hunting respectively were not evident from my qualitative data, the inheritance of bee hives from parents and grandparents as a reason for beekeeping adoption was a recurrent theme in interviews conducted with beekeepers.

The link between size of forested land owned and beekeeping adoption is further supported by repeated mentions of shortage of land resources for beekeeping due to deforestation or lack of access rights:

> *"[…] there is no empty space where we can place beehives, we are supposed to go and look for a place and find who owns that place and have to request or rent for placing hives." (female beekeeper, 46),*

> *"[Beekeeping] is getting worse nowadays because the area where bees used to get flowers has reduced because of farming and livestock keeping […]. Nowadays the number of beekeepers has increased compared to five years ago, but harvest has gone*

down, because there are very few places where people can place their hives." (male beekeeper, 51),

"Working in a group is good because they have a shortage of land. So, working alone it is difficult to have places. But as group they can request for a place/piece of land." (male beekeeper, 49).

Lack of access to land suitable for beekeeping was also mentioned through the prism of safety from theft as well as distance from the settlement:

"Q: Why is this generation less likely to be involved in beekeeping? A: Previously people were living in the forest. Now people live closer to the 'town' where there are not enough forest resources." (female non-beekeeper, 36)

"In Changombe forest, people are not allowed to go there. Those who have hives there are getting more honey compared to me and other people who have hives in Uzogo. Q: Why do you not put your hives in the Changombe forest? A: Too far from where I live. Q: How far? A: 3 - 4 hours walking." (male ex-beekeeper, 37)

"Also, I am a woman, I cannot place the beehives far from where I live, as I cannot go to the forest." (female non-beekeeper, 66)

Lastly, many interview respondents also indicated courage as a necessary character attribute of a beekeeper.

On examination of interview data on possible causes for theft of honey and hives being such a pervasive problem and the predominant reason for giving up beekeeping, I found emerging themes regarding a general lack of resources, unclear tenure arrangements, preferential treatment of beekeeping groups as well as added security for modern hives.

Theft occurred of both honey and hives, although whether these were empty at the time could not be ascertained:

"So, I was a beekeeper for a long time, but then I was discouraged. There was theft. People go at night to harvest the honey and sometimes they take the hives as well. That was the most important factor." (female ex-beekeeper, 43)

According to numerous interviewees, the issue of honey theft seems to have grown in the recent years. A possible explanation for this observation is the growing value of honey:

> *"There is no competition, but there are more thieves, because people get money from honey."(male ex-beekeeper, 69)*

While the reasons behind the theft of hives were not directly linked by interview participants with the stated growing difficulty to obtain raw materials for hives, the accounts below make it clear that the availability of trees to be used for the production of hives has become an issue for beekeepers:

> *"Nowadays beekeeping has become a bit harder than ten years ago because of the shortage of trees. Back then there were many trees. If you wanted to make a hive, it was easy to find a tree around here. Within one day you could make even five hives. But now you need to travel a lot. First ask people where you can get a good tree, and they tell you that you need to travel a lot. You may find that you need to travel one day to go there and one day to make the hives and one day to come back. So, it has been difficult to make hives" (male beekeeper, 38)*

> *"I am interested in beekeeping, but I don't have the facility to make hives. And there are not enough trees that he can make hives from." (male non-beekeeper, 34)*

Several respondents stated that insecure tenure rights of forested areas on central government owned, unreserved land led to an increased occurrence of theft in general:

> *"I think that placing hives only to the forest is not safe, because I am not sure who owns that place even though it is community forest, but I am not sure of the security in that place. If I started beekeeping, I would put hives on my own land." (male non-beekeeper, 44)*

The large distances to land reserved for beekeeping activities, where some level of protection against theft is provided by the local authorities, was also stated as an inhibiting factor for some beekeepers.

Traditional hives were more likely to be stolen than modern hives (frequently donated by development organisations) as the latter were perceived to be 'official' and therefore more respected by the general public who were fearful of the authorities:

"For the modern hives, is good, because people here respect when they see a modern hive, they regard it as a government property, so they cannot touch it because they are afraid of getting caught." (male beekeeper, 77)

Several respondents also reported that beekeepers who were organised in official beekeeping associations and had received modern hives from support organisations were extended increased protection by law-enforcers. This has led to increased protection from theft as well as improved access to land reserved for beekeeping, where other forest activities are excluded.

3.4.2. Determinants of dependence on beekeeping for subsistence and income

Given the relatively limited nutritional value of honey, it is perhaps not surprising that only 10% percent of beekeepers indicated a dependence on beekeeping products for subsistence of 30% and more. More unexpected however was that almost half of all the beekeepers in the study (45%) indicated zero dependence on beekeeping for subsistence. I found significant associations between dependence on beekeeping for subsistence and several potential predictor variables (Table 3.6, Section 3.7), including length of engagement in beekeeping, honey hunting, motivation for beekeeping adoption as well as source of beekeeping training received. Only 23% of beekeepers indicated a dependence on beekeeping for income of 30% or more within their livelihood portfolios. Approximately the same number of beekeepers did not gain any income from beekeeping at all.

I found significant associations between dependence on beekeeping as an income source and several predictor variables, including length of engagement in beekeeping, motivation for beekeeping adoption and beekeeping group membership. Distance to major roads and thus ease of access to district markets did not have a significant association with levels of dependence on beekeeping for income or subsistence. Gender and age did not have a significant association with dependence on beekeeping either (see Table 3.6, Section 3.7).

I analysed the dependence on beekeeping for either subsistence and/or income in two separate models. The binary component of a fractional regression model for subsistence dependence determines if someone is to at least some degree (i.e. more than 0%) dependent

on beekeeping for subsistence (zero vs non-zero dependence proportion). I identified significant relationships between non-zero dependence for subsistence and several variables. These included engagement in honey hunting and income from wax as motivation for beekeeping uptake (negative relationship), food and medicine provision as motivations for beekeeping uptake, as well as being self-taught in beekeeping techniques (negative relationship) (Figure 3.3). The fractional model component explains the distribution of non-zero levels of beekeeping dependence for subsistence. It revealed significant relationships between level of dependence on beekeeping for subsistence and length of engagement in beekeeping as well as external training received in beekeeping technical knowledge by a government organisation (negative relationship) (Table 3.3, Figure 3.3).

Table 3. 3. - Estimated parameters of binary logit and fractional components of a two-part regression model for beekeeping dependence for subsistence

	Binary component Estimate	**SE**	**Fractional component Estimate**	**SE**
Intercept	-0.45	0.849	-1.178***	0.343
Length of beekeeping activity (years)	-0.001	0.019	0.013**	0.004
Honeyhunter (yes)	1.647**	0.605	0.034	0.111
Motivation for beekeeping uptake - income from wax	-2.705***	0.612	-0.052	0.109
Motivation for beekeeping uptake – food	1.653*	0.732	-0.582	0.303
Motivation for beekeeping uptake – medicine	3.642***	0.820	-0.026	0.104
Beekeeping learned from – self-taught	-2.929**	0.998	0.244	0.235
Beekeeping learned from –government training	-1.491	0.974	-0.524***	0.081
Forest area owned	0.043	0.029	0.002	0.001

* significance at 5%, ** significance at 1%, *** significance at 0.1

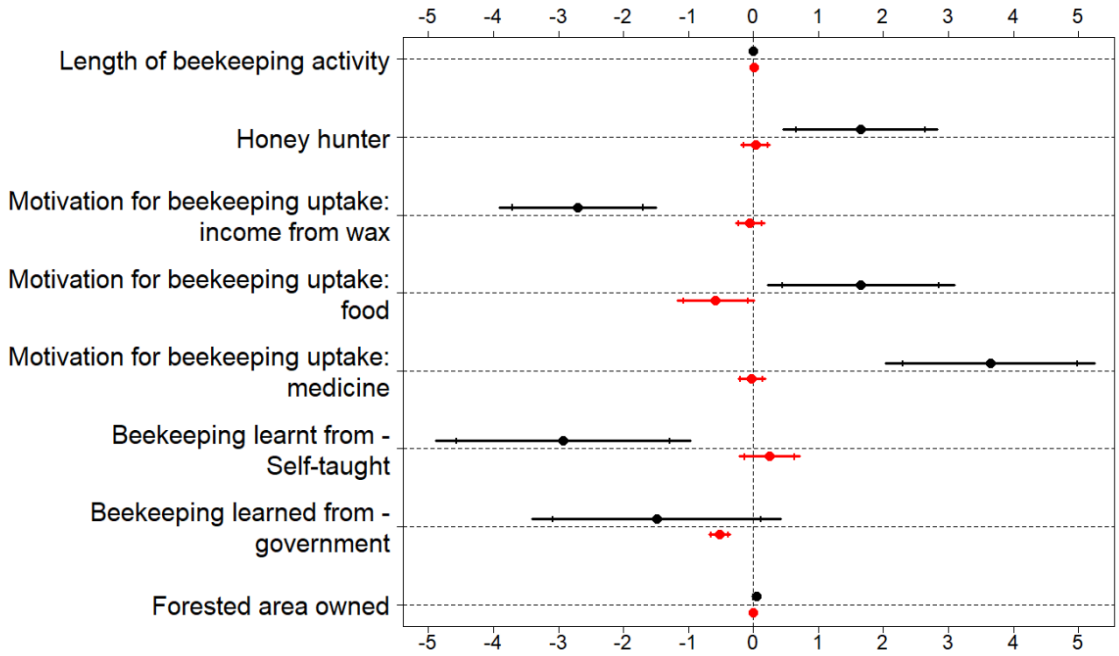


Figure 3. 3. - Estimated coefficients, standard errors, 90% and 95% confidence intervals of binary logit (black) and fractional (red) components of a two-part regression model for beekeeping dependence for subsistence (Sample size: 155 beekeepers).

Through fractional regression modelling of dependence on beekeeping as an income source, I identified significant relationships between non-zero dependence for income (binary model component) and the following variables: income from honey and wax being one of the motivations for beekeeping uptake, beekeepers living closer to the forest (negative estimate implying that beekeepers closer to the forest have a higher probability of non-zero dependence) as well as being members of a beekeeping group (Table 3.4, Figure 3.4). The fractional model component for the regression model of beekeeping dependence for income, which explains the variability of non-zero levels of dependence, showed significant relationships for increasing living distance from a major road and thus access to more distant markets, with provision of medicine as a beekeeping uptake motivation (negative) as well as the length of engagement in beekeeping (Table 3.4, Figure 3.4).

Table 3. 4. - Estimated parameters of binary logit and fractional components of a two-part regression model for beekeeping dependence for income

	Binary component Estimate	**SE**	**Fractional component Estimate**	**SE**
Intercept	-1.674	0.966	-1.264***	0.340
Length of beekeeping activity (years)	0.035	0.021	0.010*	0.005
Distance to forest (minutes walking)	-0.012**	0.004	0.001	0.001
Distance to road (km)	0.129	0.087	0.062*	0.026
Forest area owned (acres)	0.013	0.026	-0.005	0.004
Parental beekeeping (yes)	0.378	0.548	0.097	0.159
External training received (yes)	0.027	1.020	0.013	0.283
Motivation for beekeeping uptake - income from honey	2.204***	0.677	-0.001	0.302
Motivation for beekeeping uptake - income from wax	0.918	0.504	0.183	0.159
Motivation for beekeeping uptake – food	0.281	0.668	-0.288	0.223
Motivation for beekeeping uptake – medicine	-0.277	0.573	-0.394*	0.163
Motivation for beekeeping uptake – tradition	-0.220	0.759	-0.081	0.289
Beekeeping learned from –government training	-1.439	1.290	-0.191	0.311
Member of beekeeping group	2.100**	0.828	0.276	0.190

* significance at 5%, ** significance at 1%, *** significance at 0.1%

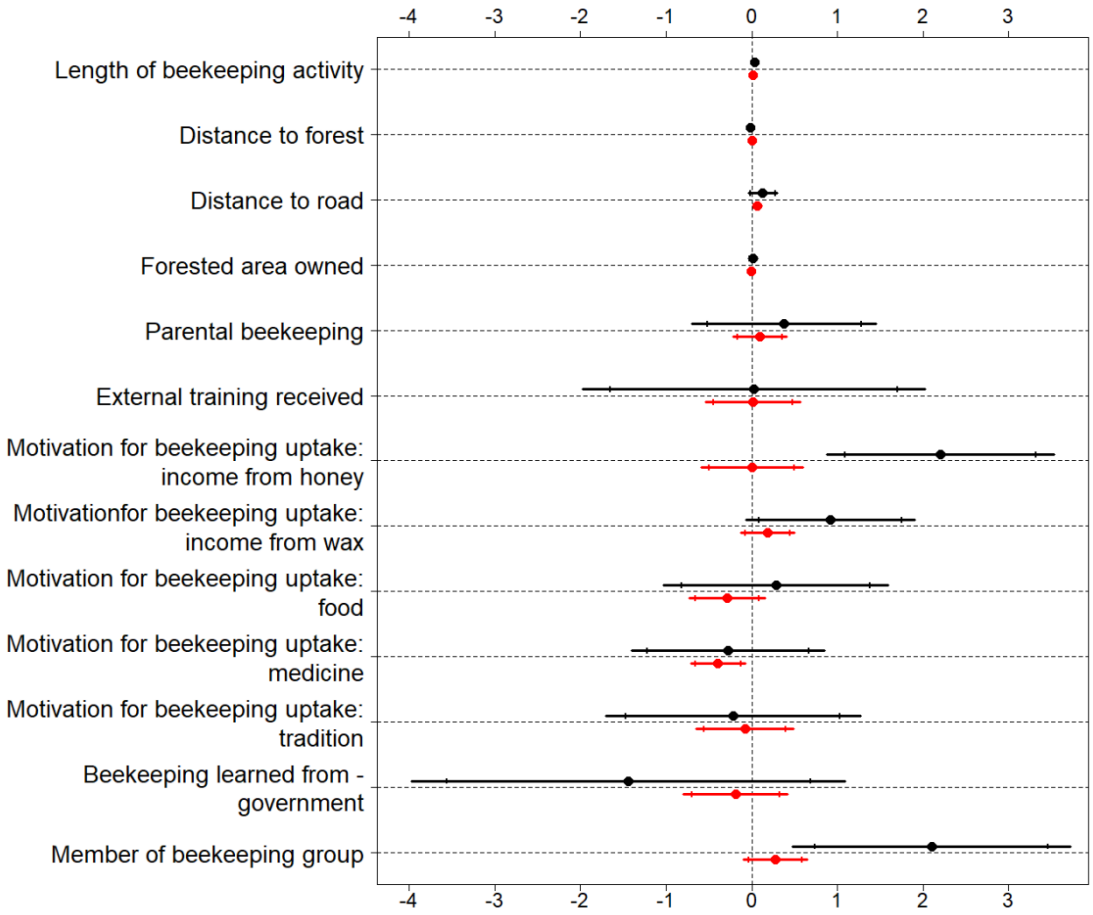


Figure 3. 4. - Estimated coefficients, standard errors, 90% and 95% confidence intervals of binary logit (black) and fractional (red) components of a two-part regression model for beekeeping dependence for income (Sample size: 155 beekeepers).

3.4.3. Determinants of beekeeping success

Beekeepers (n = 155) cited drought (66%), theft (53%) and pests (44%) as the three most frequent problems affecting success in their beekeeping activities. A limited access to markets was mentioned as a problem by only 3% of surveyed beekeepers. Some interview participants indicated however that a lack of marketing opportunities due to the relatively small quantities of honey and wax produced by them was problematic. Access to middlemen and thus more distant and more profitable markets was deemed only possible when produce was available for sale in bulk – something reserved to individual beekeepers with large enough harvests and those who pooled their harvests for sale through a beekeeping group.

Interview respondents indicated that harvest levels were generally very low compared to the period preceding the drought. They pointed out that many recently trained beekeepers had abandoned beekeeping due to very low honey production during the preceding drought years. In contrast, more experienced beekeepers were more aware of climate-induced harvest fluctuations and were more likely to continue with beekeeping activities despite temporary setbacks (Fisher 1996).

> "*Q: Why did you stop beekeeping? A: [Because of] climate change: nowadays you can go to hives and you find no bees enter the hive. Q: And that is because the climate has changed? A: Nowadays there are no more bees and sometime when I go there is brood but no honey, so that discouraged me from beekeeping." (male ex-beekeeper, 31)*

Regardless of these climate-induced harvest fluctuations, the majority of beekeepers had indicated that floral resources had declined during the decade preceding this study.

> *"In previous years there were so many bees around and the forest areas were dense. People harvested more in that period. […] But nowadays the harvest from the bees is very small. In the forest most of the areas have been cut off, less trees than before."(male beekeeper, 77)*

> *"There are many bees here, but the problem is with flowers. There are no more flowers that can sustain the lives of bees throughout the year." (male beekeeper, 40)*

> *"Q: Do you think there are enough resources for more beekeepers and their bees? Are there enough flowers and trees? A: Now there is very few or none. Q: Would this be a problem then if there were more beekeepers? A: Yes, that would be a problem." (male beekeeper, 48)*

Correlation tests for a recall of harvest quantity (litres) per household in the preceding 12 months, used here as a variable for success in beekeeping, and predictor variables revealed several significant associations including gender, source of training received, and indication of no training required (Table 3.7, Section 3.7).

I identified a significant negative relationship (fractional regression modelling) between non-zero harvest quantities and the beekeeper having been trained in beekeeping by a governmental organisation. While beekeepers taught by a governmental organisation had been active beekeepers for about half of the time than those taught by family/community

members, the length of engagement in beekeeping was not a significant predictor of beekeeping success. I also found a significant negative relationship with the beekeeper indicating that they do not require further training (Table 3.5, Figure 3.5). The variation of harvest quantities larger than zero was significantly positively affected by gender, area of forests owned and engagement in livestock keeping (Table 3.5, Figure 3.5)

Table 3. 5. - Estimated parameters of binary logit and fractional components of a two-part regression model for beekeeping success

	Binary component Estimate	**SE**	**Fractional component Estimate**	**SE**
Intercept	-0.280	1.149	-5.563***	0.718
Gender	-0.221	0.734	1.181**	0.377
Distance to road (km)	0.191	0.147	0.051	0.041
Forest area owned (acres)	0.041	0.031	0.013***	0.003
Livestock keeping (yes)	0.375	0.519	0.609*	0.289
Beekeeping learned from –government training	-2.082*	1.038	-0.310	0.253
Does not require training	-2.094*	0.986	-0.328	0.287
Knowledge in hive placement (yes)	-0.184	0.714	0.288	0.260
Knowledge in local hive construction (yes)	1.217	0.672	-0.261	0.269
External training received (yes)	0.789	0.669	0.042	0.282
Knowledge in colony multiplication (yes)	1.466	1.070	-0.439	0.296

* significance at 5%, ** significance at 1%, *** significance at 0.1%

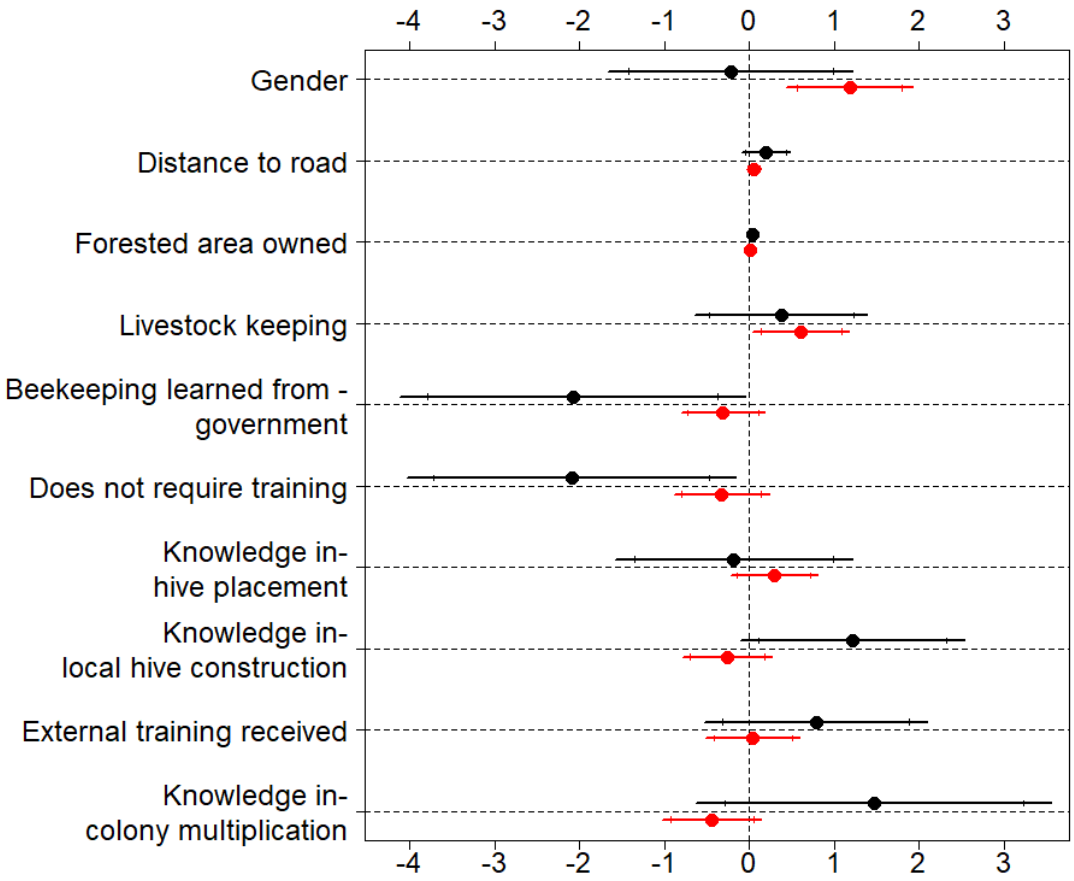


Figure 3. 5. - Estimated coefficients, standard errors and 95% confidence intervals of binary logit (black) and fractional (red) components of a two-part regression model for beekeeping success (Sample size: 155 beekeepers).

3.4.4. Existing technical capacities and needs

Farmers currently engaged in beekeeping recalled having received external technical beekeeping training from a governmental or non-governmental organisation mainly on the topics of honey harvesting and processing (93%), hive placement (48%), construction of modern hives, proper hive inspection and other beehive product processing (all 21%). Most active beekeepers learned beekeeping from a family member (68%) followed by a neighbour or other village member (19%) or were self-taught (12%). Only a small proportion of beekeepers learned beekeeping through governmental or non-governmental capacity building organisations (6% and 3% respectively).

Most respondents who were engaged in beekeeping in the past, but have since given up, learned beekeeping from their family members (67%). This training included hive placement (86%), honey harvesting and processing (83%) and construction of traditional hives (79%). Beekeepers most frequently named hive placement (88%), traditional hive construction and honey harvesting and processing (both 81%) as the aspects of beekeeping they possess knowledge over. Technical knowledge aspects, which were cited as desired but not yet owned by beekeepers were mainly honey harvesting and processing (61%), modern hive construction (54%) and pest and disease control (48%).

3.4.5. Beekeeping associations

While I did not specifically set out to examine the dynamics of beekeeping associations, through inductive analysis of my interview data I found evidence of continued group cohesion after support ended in only one case, namely in Kwa Mtoro (see 1.4.3.3). This was where yearly follow-up visits by the project team were carried out over several years. Only about a third of the surveyed beekeepers were members of a beekeeping group at the time the study was undertaken. Survey results indicate that the prospect of pooling of resources, of knowledge sharing, of access to external training and hive donations as well as of economies of scale were the most important motivations for joining a beekeeping group (Figure 3.6).

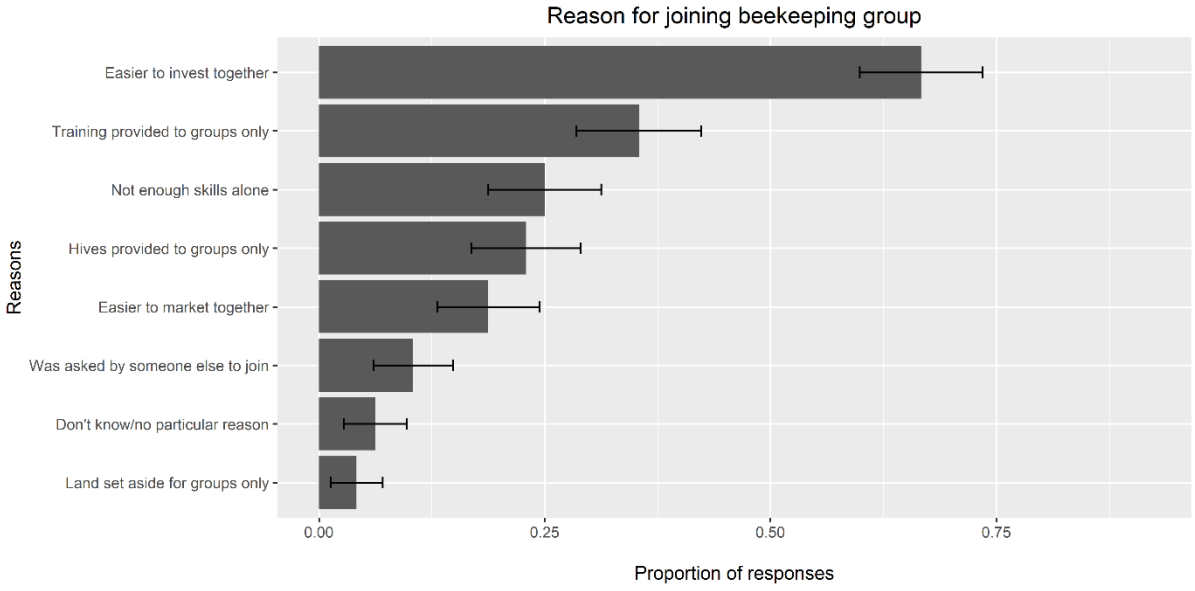


Figure 3. 6. - Proportion of reported reasons for joining a beekeeping group (n=48)

Many interview respondents saw advantages in joining beekeeping associations in principle (i.e. improved market access; security; knowledge sharing; pooling of resources):

"A: Good to work in group as it is easy to make supervision, in case anything happens there (e.g. destruction of hives) it is easier to deal with the destructors in a group than alone. Q: Why is it easier? A: The good thing is that if I am busy and cannot go there, others can go there. And if there is a problem it is easier to find a solution than alone." (female beekeeper, 43)

"For the leader of a certain group it is easier [to find a market for honey]. Because if you go there as a group, people they value that. So, they can go to a company and saying the he is representing a group from Sasilo and that they have honey. So, if people see that this is the group of people producing honey, probably they will be interested because they get more honey from a group than from an individual person." (male beekeeper, 40)

"In a group it is easier to get training, get equipment from donors who want to support beekeeping activities. Also, the bylaw operates more for the beekeeping groups than for individuals. So e.g. if they have hives in a group and someone goes and destroys them or steals the honey, if he is caught and sent to the government, the law is more acted on than if the person had destroyed an individual persons property. Also, in a group, if there are several people, if he e.g. does not have time, it is possible that someone from the group can go and patrol. They can set up a timetable of who patrols when and that is good for security of the hives." (male beekeeper, 41)

Numerous interviewees indicated also that beekeeping group members had sole access rights to forest reserves with protection provided by the government, albeit with an additional bureaucratic burden:

"Q: Can you tell me more about Ndoroboni forest? You said that no-one has permission to enter, not even beekeepers? A: That forest only allowed for groups. And those groups have to follow a certain procedure. Before you are allowed to go you have to write a letter, send it to the TFS. Then after following all the procedures they want […], then afterwards you are allowed to go. Then during the harvesting of the honey, they give you their own 'askari', like a policeman to supervise you while you are harvesting."(male beekeeper, 48)

But several beekeepers also indicated that beekeeping groups face a multitude of internal problems related to lack of transparency, leadership, market knowledge, capacity to produce economies of scale and member buy-in to the associations' goals. Indeed, many beekeeping group members perceived little to no benefit from collective action.

> *"There is bad leadership, because the group was given responsibility of that forest to ensure no cows go there to graze, but other villagers they used to give money to the group leader and the leader allowed them to send their cattle to graze in the forest. It created a lot of conflict and the group collapsed." (male beekeeper, 51)*

> *"Formerly they were 45 group members, but me and others [left the group] and we don't know how many remained. But the good thing about being alone is that in a group when it comes to decisions it is very difficult because everyone talks this way and that way, and they were conflicts and sometimes very difficult to come to an agreement. So now it is good, because if I decide to do something, I can do it. But the problem alone comes with honey market. There is no market for the honey." (male beekeeper, 50)*

Furthermore, several interviewees indicated that access to these associations is made difficult for those who are not able to pay the requested entry fee.

> *"There is also another beekeeping group, where you are supposed to make a payment for entry fee, but I didn't have the money to pay for it and you are supposed to have capital to start to have beehives, so I didn't manage to have that capital." (female beekeeper, 48)*

While several interview respondents indicated that participants for beekeeping training were self-selected during village meetings, several other respondents reported instances of elite capture of project benefits as less well-connected community members or people living on the geographical edges of community boundaries were overlooked when invitations were issued to participate in the project and to join associations. They were subsequently precluded from access to training and possible equipment distribution.

> *"Q: Are you a beekeeping group member? A: No, because of the selfishness of the people to select themselves for the group. If someone wants to form a group, he needs to find the people, like his friends and they all then represent the same interest and they don't want other people in the group." (male beekeeper, 25)*

"Q: […] Why did you not participate in that training? A: I was not involved, because I stay far from the centre of the village. When they came to train, they only took people who were around the centre of the village. But people like me were not called." (male beekeeper, 77)

"I heard that there was beekeeping training, but I was not involved. Because here, when something like this happens the leaders call their own friends. Because sometimes you can get something else (i.e. equipment for example) from the training. So, I was not part of the friends of the leaders." (male beekeeper, 38)

Noteworthy is also that in one of the communities, the chair of the beekeeping group was also a member of the village government and the chair of the village environment committee.

Lastly, some study participants retold instances where the division of beekeeping equipment donated to a beekeeping group was not perceived as transparent and fair.

"Q: What about the hives? Were these given to the group together or did you take ownership of some of these hives? A: They were distributed to the group, but I didn't get any hives. Q: How is it possible that you are member of a group with 45 members and you receive 300 modern hives and you don't get a single one? A: I don't know why those leaders [were] so greedy. The donors gave the hives for free, but when it came here, the leaders they have their own people and only give things to them." (male beekeeper, 50)

3.5. Discussion

Given how widely beekeeping is promoted in LCDA contexts, there is very little empirical evidence of the effectiveness of these interventions aiming to integrate conservation and development goals (Brooks, Franzen et al. 2006, Roe, Day et al. 2014). Blom *et al*. (2010) find that these projects often fail as the complexity of rural communities is ignored. This study is an attempt to begin to close the knowledge gap on how the targeting and delivery of beekeeping interventions need to be designed in order to take account of local circumstances and the reality of rural beekeepers in Tanzania. I identified key drivers influencing beekeeping uptake, dependence, and success, which may be critical to the design of future beekeeping technical assistance programs. The appropriate targeting of beneficiaries and the nature of

capacity building for beekeeping influence the long-term outcome of interventions as they become relevant to local communities and correspond to their motivations and needs.

3.5.1. Adoption and abandonment of beekeeping as a livelihood activity

3.5.1.1. Key factors influencing adoption of beekeeping

Beekeeping adoption was contingent upon whether parents had previously kept bees as a livelihood activity. While the inheritance of hives from parents is a logical explanation for this, another conceivable explanation might be that through parental beekeeping younger generations can acquire beekeeping skills from a young age (Fisher 2000). This also suggests that tradition is an important factor in the uptake of beekeeping – a point which was supported by the qualitative data analysis. Support organisations may wish to consider this when deciding on beneficiary selection criteria for beekeeping projects to avoid working against cultural preferences.

Adoption was also more likely if the respondent simultaneously practiced honey hunting i.e. the collection of honey from wild bees. The reason for this might be that honeyhunters are familiar with bees as well as the use of honeybee products. Whether an individual was a beekeeper or not was also contingent on them keeping livestock. An explanation for this phenomenon could be that livestock keepers spend more time in the forest while grazing their herds than farmers. This gives them the opportunity to locate and plunder wild bee nests, thus becoming more familiar with bees and aware of the benefits of honeybee products. Given that honey hunting and livestock keeping seem to be conducive to the adoption of beekeeping, selecting participants with these backgrounds for beekeeping promoting interventions could reduce project attrition and enhance adoption of beekeeping.

Lastly, beekeeping adoption was also predicted by the size of forested land owned, suggesting that beekeeping is not necessarily an activity that is without land requirements as purported by some authors (Jacobs, Simoens et al. 2006, FAO 2011). A variety of reasons were given with statements about a lack of access to suitable areas for beekeeping. This included deforestation and the resulting increase in distance between the settlement and undisturbed forest areas, perceived security of hives against theft in locations closer to settlement as well

as lack of access rights to undisturbed forests, especially for beekeepers not associated in groups. While these issues could be unique to the study area, planning beekeeping interventions in locations with limited access to forested land for participants could undermine project outcomes.

When asked about their individual motivation to become a beekeeper, the most important reasons were the expectation of income from honey sales, followed by supplementary food provision. This information may help guide NGOs and government organisations to target and promote the benefits of beekeeping to beneficiary communities more effectively.

3.5.1.2. Key factors influencing rejection of beekeeping

Some respondents were dissuaded from adopting beekeeping due to a lack of capital, available land, and relevant knowledge, indicating that the initial investment, space, and technical knowledge requirements of beekeeping are non-trivial contrary to some authors' suggestions (Nel and Illgner 2004). The expectation that modern hive donation leads to trickle-down benefits, i.e. the adoption of modern hive technology by other community members over time, needs to be carefully managed, as a lack of capital to purchase modern hives can be inhibitive (Carroll, Davey, et al. 2017, Tesfaye, Begna et al. 2017)

Land availability and access is critical to increasing beekeeping uptake (Jayne, Chamberlin et al. 2014), as hives located away from homesteads are often damaged or stolen. The consideration of respondent land access and tenure as a critical component of participant recruitment may reduce beekeeping project attrition. Access could for example be improved through the designation of beekeeping reserves, which are accessible to all beekeepers in the community. Finally, there was awareness among respondents of the significant challenges posed to successful beekeeping if the supporting technical assistance was absent. While some new activities might be adopted through a 'learning by doing' approach, my results indicate that this is not the case for beekeeping. This suggests that beekeeping project participants may benefit from a greater emphasis on building technical capacities appropriate to the specific context of each project location.

Fear of bees was one of the most frequently cited reasons for not adopting beekeeping by non-beekeeping respondents whose parents were beekeepers. Managing *Apis mellifera scutellata* (the most widely spread sub-species in Central and Eastern Africa) is challenging

due to its highly defensive behaviour (Hepburn and Radloff 2008). Even when there is a family history in beekeeping, some offspring are unwilling to adopt the activity to boost their income. Interview data confirms beekeeping as a potentially perilous activity, particularly as African beekeeping is still largely practiced in forested environments, which can pose significant dangers to humans through contact with wildlife and insect transmitted diseases (Lawton 1982). Successfully overcoming the apprehension of bees may be contingent on the level of training and protective equipment provided.

3.5.1.3. Reasons for abandoning beekeeping

Theft of honey and hives was cited as the most common cause of beekeeping abandonment, due in part to the increasing value of honey as a commercial product and the growing difficulty in obtaining raw materials for the construction of hives. For example, obtaining whole tree stems necessary for the construction of traditional log hives is becoming more and more difficult due to increasing restrictions on forest resource use, as well as increasing levels of deforestation, according to several interviewed beekeepers. There have been accounts of the theft of bee hives and honey in other parts of Tanzania as well (Mtengeti, Maseki et al. 2013). While according to some interview participants theft of local hives was more likely to occur than that of modern hives, the opposite has been reported in other settings (Wambua 2015). There appears to be a spatial determinant of the occurrence of theft as hives in forested locations in the vicinity of the village are more likely to be stolen or robbed, than hives positioned deep in the forest or in immediate vicinity of beekeepers' homesteads (Lowore 2020, Fisher 1997a).

Theft is rarely addressed by beekeeping support organisations yet appears to be a significant concern of beekeepers. If organisations continue to ignore this aspect of beekeeping development, then there is the possibility that they will undermine their own project outcomes and fail to augment recruits to their programs. Secure access to forested areas for the sourcing of hive materials and increased protection of these areas by local authorities for beekeeping use could prove to be helpful in tackling the issue of theft.

3.5.2. Factors influencing dependence on beekeeping for subsistence and as an income source

I hypothesised that individuals with a higher dependence on beekeeping for subsistence differed in location, social situation, history in beekeeping and livelihood strategies from those who were more dependent on beekeeping as an income generating activity.

3.5.2.1. Motivation for adopting beekeeping

The initial adoption of beekeeping was motivated by different factors for those more dependent on beekeeping for subsistence than for those more dependent on beekeeping as an income generating activity. Farmers who used beekeeping as an income generating activity were more likely to indicate income from honey and wax as a motivation, rather than for the provision of traditional medicine. Conversely, subsistence dependence demonstrated a significant negative relationship with income from beehive products as ex-ante adoption motivation and an increased tendency to engage in honey hunting. While recollection may limit the accuracy of the stated ex-ante motivation, this suggests that households that were more dependent on honey as a calorie source regarded the procurement and use of honey with a less commercial sense than households that were more dependent on honey as an income source.

Further, I observed a negative relationship between the level of dependence on beekeeping for subsistence and having received initial training in beekeeping from a governmental organisation. This suggests that those individuals who received formal training were more inclined to treat beekeeping as an income rather than a food source. I suggest that if typologies of divergent motivations to harvest bee products are taken into account during participant selection for beekeeping support programs a higher continuation rate of newly trained beekeepers could be achieved. Furthermore, honey harvesting techniques with the aim of commercialization of the end product might be more complex to those aimed for home consumption. Training participants, who do not intend to sell their harvest, in these more complex techniques may be of little use to them. All in all, more precise targeting of beekeeping interventions according to participants needs and wishes could improve the overall outcome.

3.5.2.2. Access to resources

Proximity to forests influenced the dependence on beekeeping as an income generating activity, as access to resources such as bee forage is an important factor in any beekeeping production system. The majority of beekeepers participating in the study bore witness to diminishing resources necessary for beekeeping such as trees suitable for hive production and providing abundant nectar. The discussion on access to land suitable for beekeeping (Section 3.5.1.1.) further supports this point. So do Mwakatobe *et al.* (2006) who found an "increased loss of beekeeping areas" to be one of several major constraints of the beekeeping industry in Tanzania. When beekeeping is promoted by support organisations for income generation, the consideration of the question of sustainable access of project beneficiaries to forest resources may help ensure the necessary input factors.

3.5.2.3. Membership in a beekeeping association

Most external capacity building efforts require farmers to form informal collectives before receiving training and equipment provision (Affognon, Kingori et al. 2015, Carroll, Davey et al. 2017). This may be done for one or more of the following reasons: to enable more efficient delivery of training and information, to allow knowledge sharing, to create economies of scale through marketing as a group as well as to share responsibilities around the apiaries, to empower group members to negotiate their terms of trade and finally to provide a sense of collective sharing of experiences (Fisher 1997). Beekeeping group membership was an important determinant of whether a respondent used beekeeping as an income generating activity. Membership was not a significant determinant of dependence on beekeeping for subsistence.

My interview data suggests a mismatch between expectations towards beekeeping associations and the reality they deliver. Evidence of long-term group cohesion was found only in the case where continued and regular follow-up support was provided from the intervening organisation – in itself a phenomenon rarely observed in beekeeping projects (Carroll, Davey et al. 2017). Noteworthy is also that the observed case of group-cohesion occurred in the study community composed to a large majority of an ethnic group with strong cultural links to beekeeping. This reiterates the point on cultural proximity being a useful

indicator of where beekeeping support efforts might fall onto more fertile ground than elsewhere.

Elite capture of project benefits through better connected, more centrally living and financially more flexible community members has left several community members missing out on the opportunity to receive training and equipment donations (Platteau 2004). Further, a lack of transparency within beekeeping groups has left several community members questioning the fairness of how benefits were distributed. The commonly applied project requirement of grouping together project beneficiaries in associations thus needs to be handled with care by beekeeping support organisations: transparency, members' buy-in and inclusiveness of groups might be enhanced by establishing clearly defined outcome indicators for both, participants and support organisations as well as advertising the possibility of training and access to a beekeeping group more thoroughly within communities; the promise of improved market access through economies of scale and value-added products requires an increased access to honey processing equipment as well as more thorough baseline studies of bee forage availability and thus potential to produce the quantities of bee products needed for larger markets; regular follow-up through more investment in local extension service providers may ensure overall group success and cohesion.

In this context further research is needed to estimate the relative benefits of investing a part of project budgets into organisations that can provide extension services versus investing in the donation of more hives to beneficiaries. In summary, there is a large body of literature available on producer organisations and determinants of their sustainability (Markelova, Meinzen-Dick et al. 2009, Shiferaw, Hellin et al. 2011, Fischer and Qaim 2014), but my results suggest that the application of this knowledge by practitioners in the beekeeping sector is thus far lacking.

3.5.2.4. Length of engagement in beekeeping

The level of dependence for both subsistence and income-motivated beekeepers was related to the number of years spent beekeeping, suggesting that experience is critical to an individual's intensity of engagement in beekeeping. If the goal is to promote the engagement in beekeeping, longer-term educational support provided over extended timescales may be beneficial (Carroll, Davey et al. 2017). Beekeeping demands the knowledge of a range of

different techniques throughout a beekeeping season. Conditions for beekeeping can vary significantly between seasons contingent upon regional weather patterns. Extension services tailored to the technical knowledge needs of beekeepers throughout several beekeeping seasons could thus contribute to the increased sustainability of interventions by adapting to both the beekeepers needs and the contingencies of unpredictable weather conditions. This type of capacity building support could engage locally successful and experienced beekeepers as champions and trainers. These trainers could provide valuable knowledge of local conditions and are likely to enjoy acceptance and trust by local community members. The logistics of employing locally present personnel is also more cost-effective than externally sourced beekeeping experts.

3.5.3. Success as a beekeeper

The three years preceding this study were marked by severe drought conditions in the study region, which had negative consequences on honey harvests. During interviews, drought was also the most frequently cited challenge faced by beekeepers, in some cases even leading to giving up beekeeping altogether among less experienced beekeepers. This draws attention to the necessity of taking seasonal changes in local climate into consideration when designing beekeeping capacity building and support interventions in order to manage expectations of success of project participants (Fisher 1996). An analysis of most frequently recalled topics taught in the context of such external interventions shows that only the very basic technical knowledge of hive placement and harvesting was passed on to the majority of training beneficiaries. Most of the respondents in receipt of formal training (i.e. not by family or community members) had received a maximum of three days training. The brevity of such training fails to reflect the complex skillset required for a successful beekeeper (Amulen, D'Haese et al. 2017, Carroll, Davey et al. 2017).

Whether a beekeeper managed to harvest any honey at all in the twelve months preceding the study, was negatively related to the individual having received beekeeping training by a government organisation. This negative relationship suggests either that a) the quality of training provided was so low that it was insufficient to generate any harvest, b) the targeting of project participants was ineffective, c) the training - in conjunction with the distribution of

non-local hives - was conducted on beekeeping systems which are not appropriate for the local context or d) a combination of these. While the hives donated in the study context in the recent years all seemed to belong to the TBH type, using moveable comb top-bar hives still differs significantly enough from local beekeeping systems using log hives to create challenges for local beekeepers (Amulen, D'Haese et al. 2017, Carroll, Davey et al. 2017). Training provided locally by family or community members on the other hand was focused on beekeeping techniques using log hives, which have a long tradition in the miombo, are adapted to local beekeeping systems and bees, can be constructed from locally more easily available materials and for which local expertise is readily available, if need be (FAO 2009).

I propose that capacity building efforts by governmental organisations need to be more precisely targeted towards individuals whose livelihood strategies, proximity to the forest and family history are most conducive to beekeeping. I also suggest that beekeeping training is improved, in order to render the beneficiaries of such trainings capable of achieving at least the same beekeeping results as their family/community-trained peers. As discussed above, these improvements might entail: more intensive training on locally appropriate beekeeping systems and construction of hives based on locally available resources, subsequent extension services to provide follow-up support throughout several beekeeping seasons, training provided by locally successful and experienced beekeepers, while the need for protective equipment and land access of project beneficiaries are kept in consideration.

In the study communities, size of forested area owned was also an important predicting factor of beekeeping success. This supports my claim that beekeeping is not necessarily a suitable activity to be promoted as a solution to landless rural populations (Nel and Illgner 2004).

Male beekeepers harvested more bee products than female beekeepers in the study context. This is linked to male beekeeping study participants owning more hives. My results confirm the notion of beekeeping traditionally being a predominantly male occupation in Tanzania. This is due to diverse set of socio-cultural barriers women face in their efforts to engage in the activity (Fisher 1997, Hecklé, Smith et al. 2018). Traditional beekeeping, which most often takes place in undisturbed forested areas, requires the beekeeper to travel large distances from their homesteads to access their apiaries, to climb trees to access the hives and to handle hives, which can have a substantial weight right before harvest. External beekeeping support organisations seeking to make beekeeping more gender inclusive thus encourage the

transition to apiaries stationed closer to beneficiaries' homesteads and closer to the ground and using systems which do not require the movement of hives. Women possessing fewer hives than men might also be due to the former being more likely to be responsible for a larger variety of chores in and around the household, e.g. child rearing and food preparation, compared to their male counterparts, thus leaving less time to engage with more intensity in activities which take them away from the homestead.

My results regarding the difference in bee product quantities harvested by female and male study participants suggest that even if more women are engaged in beekeeping than in the past - in part also due to the efforts of external beekeeping support organisations - their level of engagement is still limited compared to their male counterparts. Fisher (2002) notes that besides traditional gender roles, access of women to resources enabling them to successfully practice beekeeping such as technical knowledge, capital, and labour input as well as social and political capital are important aspects to consider when external beekeeping projects are aimed at greater gender inclusiveness.

Whilst the suitability of modern beehives for African bee species is disputed (Ingram and Njikeu 2011), a majority of surveyed beekeepers indicated a desire to learn how to construct such hives. I conclude that at least the promotion of this type of hives by governmental and non-governmental organisations among the rural populations of Central Tanzania has been successful. Whether or not the expectations of higher yields and better-quality hive products raised in this way are justified, particularly without appropriate training support, remains to be determined.

3.5.4. Access to marketing opportunities

A lack of access to marketing opportunities for forest products such as honey and beeswax is not uncommon in the developing world (Angelsen and Wunder 2003, Belcher 2005, Wainwright 2002, Lowore 2020). I found a statistically significant, albeit weak association between the extent to which a study participant was dependent on beekeeping for income generation and their ability to access more distant markets. This suggests that access to marketing opportunities plays a small role in the relative importance beekeeping is given in

the livelihood portfolio of a household. My data further suggests that individual beekeepers who do not produce large quantities of honey and beeswax, who do not pool their harvests with other beekeepers and/or who have not been supported by an external organisation in obtaining sustained marketing connections outside their village boundaries are facing problems in obtaining better prices by selling their products at more profitable, more distant markets.

Furthermore, the inability to produce economies of scale by some beekeeping groups in the study communities, as described in my results, renders these groups unable to access more profitable markets. The survey and interview data suggest that this inability to produce larger harvests stems at least in part from a lack of access to sufficient bee forage in the form of undisturbed forest resources. I propose that it can also be the result of a lack of sufficient training and/or the use of inappropriate hive types (FAO 2009, Carroll and Kinsella 2013, Amulen, D'Haese et al. 2017).

While some of the support organisations active in the study communities in the past made efforts to connect producers with marketing opportunities outside of the community, I only saw one example where this connection was maintained after the project had ended (Kwa Mtoro). I suggest that the yearly follow up provided by the CREDEP over a timeframe that extended well beyond the normal project cycle, i.e. 3 years, was instrumental in establishing this sustainable marketing link. I thus concur with Lowore (2020) that if local beekeepers have reliable access to trading companies buying their honey and beeswax in bulk, a higher beekeeping income might ensue.

3.6. Conclusion

In analysing predictors of beekeeping uptake, dependence and success I have identified a range of factors that need to be considered during the planning of beekeeping interventions: 1. Beneficiary selection needs to be culturally sensitive in order to target those population groups that are most likely to incorporate beekeeping into their portfolio of livelihood activities. 2. Access to land, technical knowledge, and capital to purchase hives determine farmers' decisions to adopt beekeeping. The consideration of these points may thus need to

form the cornerstones of beekeeping projects. 3. The noticeable shift from beekeeping for food procurement to an income generating activity, with implications for the macro-economic output of beekeeping, is partly fuelled by beekeeping training projects. This may have implications for the selection of future project sites and alignment with national beekeeping policy goals. 4. The distribution of hives by NGOs and the Government may be less critical to adoption than the provision of protective equipment. 4. The widespread theft of honey and hives is an issue that could undermine project outcomes, but for which no straightforward solution can be suggested. 5. The often-required group membership of projects tends to create division in project communities and needs to be handled with more care. 6. The ability to achieve better prices for honey and beeswax is linked with having reliable access to marketing opportunities outside village boundaries. 7. Women are still less likely to be as intensively engaged in beekeeping as their male counterparts. Lastly, more comprehensive training on locally appropriate beekeeping systems using locally available materials and equipment, delivered by locally experienced beekeepers and regular technical follow-up support are needed to equip future beekeepers with the necessary skills to continue their beekeeping activities in the face of arising challenges.

This study attempted to start closing the knowledge gap around how beekeeping interventions need to be targeted and delivered in order to achieve better long-term adoption of locally appropriate beekeeping techniques. I believe that this will determine the overall livelihood and conservation outcomes of LCDA projects, in which beekeeping seems to be playing a key role.

As beekeeping is widely promoted as a livelihood activity that provides potential conservation incentives to the rural poor, future research should investigate the impacts of beekeeping on poverty alleviation as well as conservation behaviour in beekeeping communities.

3.7. Additional tables

Table 3. 6. - Table of [1] correlation coefficients for possible continuous predictors (Pearson's r), [2] correlation coefficients for possible ordinal predictors (Spearman's rho), [3] variation of means of possible categorical predictors as well as [4] two-sample t-tests for possible dichotomous predictors of proportion of beekeeping dependence for subsistence and income

(dependent variables; measured as % of the contribution of beekeeping to individual households' subsistence and income)

[1] Continuous predictors	**Beekeeping dependence for subsistence (r)**	**t-value**	**p value**	**Beekeeping dependence for income (r)**	**t-value**	**p value**
Age	0.008	0.097	0.923	0.017	0.210	0.834
HH size (Adult equivalent)	-0.076	-0.941	0.349	0.078	0.964	0.337
Distance to forest (min walking)	-0.111	-1.383	0.169	0.076	0.944	0.347
Distance to road (km)	-0.089	-1.111	0.268	0.140	1.746	0.083
Forested area owned (acres)	0.130	1.615	0.108	0.048	0.528	0.598
Length of stay in community (years)	0.017	0.215	0.830	0.077	0.923	0.358
Length of beekeeping activity (years)	0.215	2.702	0.008	0.198	2.485	0.014
[2] Ordinal predictor	**rho**	**S-value**	**p-value**	**rho**	**S-value**	**p-value**
Length of beekeeping training received	-0.1364	705270	0.0906	0.0585	584320	0.4697
[3] Categorical predictors	**Mean Sq**	**F-value**	**p-value**	**Mean Sq**	**F-value**	**p-value**
Village	223.25	1.803	0.1491	69.48	0.1934	0.9008
Subvillage	152.77	1.2526	0.2259	381.76	1.0918	0.3661
[4] Dichotomous predictors	**μ Yes (No)**	**t-value**	**p value**	**μ Yes (No)**	**t-value**	**p value**
Gender (male)	10.351 (8.571)	-0.735	0.469	21.642 (15.952)	-1.297	0.206
Household head has no formal education	10.714 (9.976)	-0.323	0.749	22.857 (20.433)	-0.522	0.605
Household head has secondary/ technical school education	7.500 (10.179)	0.550	0.618	33.750 (20.530)	-0.946	0.413
Honeyhunter	14.215 (8.096)	-3.427	<0.001	18.628 (21.971)	1.100	0.274
Parental beekeeping	10.777 (8.372)	-1.232	0.221	22.366 (16.977)	-1.781	0.078
Engaged in livestock keeping	9.496 (12.667)	1.125	0.268	20.760 (21.333)	0.146	0.885

External training received	7.069 (10.810)	1.902	0.063	23.448 (20.278)	-0.788	0.435
Motivation for beekeeping uptake – income from honey	10.558 (6.471)	-1.493	0.1504	22.210 (10.000)	-3.003	0.007
Motivation for beekeeping uptake – income from wax	7.546 (14.643)	4.124	<0.001	24.091 (15.179)	-3.127	0.002
Motivation for beekeeping uptake – food	12.409 (3.500)	-4.612	<0.001	18.565 (27.500)	2.256	0.028
Motivation for beekeeping uptake – like being in the forest	13.000 (9.910)	-0.983	0.3471	18.000 (21.069)	0.584	0.571
Motivation for beekeeping uptake – medicine	16.706 (6.875)	-5.814	<0.001	16.471 (23.029)	2.364	0.020
Motivation for beekeeping uptake – tradition	5.263 (10.787)	1.814	0.0834	23.684 (20.478)	-0.630	0.5351
Beekeeping learned from – family member	11.876 (6.400)	-3.131	0.002	21.667 (19.200)	-0.767	0.445
Beekeeping learned from – village member	12.400 (9.560)	-1.415	0.163	17.833 (21.600)	1.088	0.281
Beekeeping learned from – self-taught	4.211 (10.939)	2.945	0.007	18.684 (21.177)	0.535	0.598
Beekeeping learned from – government training	3.000 (10.600)	4.232	<0.001	17.500 (21.104)	0.707	0.494
Member of beekeeping group	10.313 (10.019)	-0.149	0.882	26.146 (18.505)	-2.412	0.018

Table 3. 7. – Table of [1] correlation coefficients (Pearson's r) for possible continuous predictors of beekeeping success measure (litres of honey harvested in the preceding 12 months) and [2] two-sample t-test of mean values of beekeeping success measure for its possible dichotomous predictors

[1] Continuous predictors	**Harvest quantities (r)**	**t-value**	**p value**
Age	-0.139	-1.620	0.108
Household size (Adult equivalent)	0.019	0.220	0.826
Distance to forest (min walking)	0.019	0.220	0.826
Distance to road (km)	0.191	2.261	0.025
Forested area owned (acres)	0.187	2.216	0.371
Length of stay in community (years)	-0.046	-0.537	0.593
Length of beekeeping activity	0.078	0.897	0.371
Length of beekeeping training received	-0.059	-0.686	0.494
[2] Dichotomous predictors (y/n)	**Yes (mean litres harvested)**	**No (mean litres harvested)**	**p-value**
Gender (male)	32.000	11.263	0.030
Household head has no formal education	26.060	46.048	0.494
Household head has secondary and technical school	29.179	26.667	0.902
Honeyhunter	27.710	32.114	0.603
Parental beekeeping	25.529	30.311	0.577
Engaged in livestock keeping	11.960	32.955	0.002
External training received	30.455	23.704	0.444
Motivation for beekeeping uptake – income from honey	20.000	29.399	0.567
Motivation for beekeeping uptake – income from wax	26.364	30.430	0.617
Motivation for beekeeping uptake – food	19.462	32.969	0.082
Motivation for beekeeping uptake – like being in the forest	29.648	21.667	0.342
Motivation for beekeeping uptake – medicine	29.652	28.044	0.850
Motivation for beekeeping uptake – tradition	30.636	19.737	0.157
Beekeeping learned from – family member	19.325	33.165	0.083
Beekeeping learned from – village member	30.523	23.679	0.399
Beekeeping learned from – self-taught	29.355	26.923	0.792
Beekeeping learned from – government training	30.612	5.125	0.001
Member of beekeeping group	30.879	25.652	0.539
Received modern hives	30.342	18.429	0.197
Requires training in modern hive construction	32.475	26.590	0.596
Requires training in hive placement	28.408	31.294	0.736
Requires training in capturing swarms	30.461	26.646	0.659
Requires training in pest management	22.443	36.105	0.175
Requires training in harvesting process	28.434	29.560	0.926
Requires training in hive inspection	28.496	32.083	0.695
Requires training in colony multiplication	24.942	42.303	0.356
Does not require training	30.574	5.750	0.002
Requires training in forage calendar	32.772	18.889	0.063
Requires training in feeding	29.651	27.071	0.742
Requires training in other processes	31.370	23.054	0.291
Received training in hive placement	29.887	21.846	0.392
Received training in harvesting process	29.946	25.440	0.619
Knowledge in marketing	29.365	26.364	0.762

Knowledge in local hive construction	19.360	31.304	0.220
Knowledge in hive placement	14.353	31.217	0.032
Knowledge in harvesting process	22.429	30.844	0.286
Knowledge in hive inspection	26.320	36.703	0.529
Knowledge in colony multiplication	28.825	32.546	0.783
Knowledge in feeding	29.630	22.700	0.472
Knowledge in pest control	30.025	21.800	0.333
Knowledge in capturing swarms	30.439	22.609	0.307

4. THE CONTRIBUTION OF BEEKEEPING TO RURAL LIVELIHOODS AND WELLBEING IN CENTRAL TANZANIA

Abstract

Despite considerable development efforts during the past decades significant poverty is still widespread in Tanzania. Beekeeping is frequently promoted in Tanzania and other African countries to alleviate poverty and fill rural income gaps. Assessments of beekeeping projects tend to focus on short-term monetary benefits to the exclusion of aspects such as wellbeing. Additionally, robust evidence is absent on the timing of beekeeping benefits throughout the agricultural year. This study used a multidimensional assessment template to evaluate non-monetary household benefits of beekeeping in four rural communities in Central Tanzania. In a stratified sample of 155 beekeeping and 163 non-beekeeping households, I measured ten life domains, complemented by qualitative interview data. I found a positive effect on food security for larger scale beekeepers. I observed positive life domain effects for those beekeepers able to market their products to markets outside their village boundaries. Beekeepers were more resilient and relatively more prosperous than non-beekeeping peers, although it was not entirely possible to attribute this to beekeeping. Benefits did not fully mitigated shortage periods during the agricultural year. My results highlight the need to set in place a range of factors which can improve beekeeping benefits when promoting beekeeping in rural communities. Increased emphasis in beekeeping projects on linking local beekeepers with more profitable markets as well as on strategies to use beekeeping income to overcome dearth periods might lead to improved livelihood outcomes.

4.1. Introduction

Despite substantial development efforts, significant poverty persists in Tanzania, with 70% of the population living on less than $2 per day (World Bank 2017). The country ranks 154th out of 189 countries based on the Human Development Index (UNDP 2018). As is the case with much of the developing world, poverty in Tanzania is most prevalent in rural areas, with over 80% of poor and extremely poor residing outside of urban centres (IFAD 2016). Rural poverty does not only mean a lack of income, but also deprivation in terms of access to productive resources like land, infrastructure, and services such as financial services, subsistence and health care, adequate housing, and safety from the effects of natural disasters or conflict. Poverty can also manifest itself in a lack of social and economic connectedness to decision making processes, markets, and value chains as well as an increased vulnerability to risks and shocks (United Nations 1995, World Bank 2001).

A large proportion of the extremely poor live in rural, partly forested landscapes (Sunderlin, Angelsen et al. 2005, Banerjee and Duflo 2007, Fisher and Christopher 2007). The forest and livelihood literature characterises the role of forests as supporting livelihoods through the provision of subsistence and safety nets, protecting people from falling into deeper poverty and helping to move households towards prosperity (Angelsen and Wunder 2003, Cheng, Ahlroth et al. 2017). Forests can provide subsistence through consumption of forest products for food, fodder, medicine, and energy as well as raw materials for tools and building construction. They can also offer income generation opportunities through the sale of forest products.

The diversity of forest products can provide an supplementary subsistence and income source to agricultural products and thus act as a 'natural insurance' against the effects of shocks and disasters (Cheng, Ahlroth et al. 2017). Barrett et al. (2001) found a positive association between non-farm income and household wellbeing, with higher levels of diversification leading to an increase in nutritional and monetary wealth. Several case studies suggest that due to the relative ease of access to forest resources even for the poorest households, forests can lead to an increase in assets and thus move a household gradually towards increased prosperity (Cheng, Ahlroth et al. 2017). Confirming these findings, other studies show that forest products using households tend to have more savings than others (Shackleton and

Shackleton 2004). The counterargument to the forest safety-net perspective, suggests that forests can become poverty traps as forest products offer a lower potential for value creation than agricultural products (Angelsen, Jagger et al. 2014), or that the use of forest products in a shock occurrence is more limited than assumed (Babigumira, Angelsen et al. 2014, Wunder, Börner et al. 2014).

Whilst the contribution of forests to rural livelihoods remains contested, donor and government organisations devote significant resources to LCDAs, to enable rural communities to derive value from their forest resources (APFIC 2010, Roe, Day et al. 2014). Such projects often have the dual objectives of alleviating poverty and incentivising forest conservation, by providing opportunities for communities to develop biodiversity-based livelihood activities (Salafsky and Wollenberg 2000, Roe, Day et al. 2014).

Beekeeping is frequently integral to LCDAs and is widely promoted by major development organisations, governments in the developing world and non-governmental organisations (URT 1998, FAO 2011, World Bank 2015, UNDP 2016a). The arguments raised in support of beekeeping activities relate to the perceived potential to augment rural income opportunities, particularly during periods of food scarcity, and to diversify rural livelihoods to counter agricultural risks. Additional benefits attributed to beekeeping include the relatively low entry barriers, minimum time investment requirement, reduced negative externalities and the ability to contribute to food security and health (Drescher and Crane 1982, Bradbear, Fisher et al. 2002, FAO 2011). A recent systematic review by Roe et al. (2015) found that Tanzania ranked globally third highest in the number of LCDAs implemented.

Beekeeping in the Miombo woodlands of Tanzania has a long history, and the commitment to promote beekeeping by the Tanzanian Government is evidenced in the existence of a dedicated beekeeping policy and beekeeping Act aimed at promoting and expanding beekeeping activities nationally (URT 1998, URT 2002). External investment in beekeeping support, which in the majority of cases consists of a combination of training and donation of beekeeping equipment, is based on the assumption that beekeeping contributes positively to household wellbeing in poor rural communities (FAO 2011, World Bank 2015b). Further, it is suggested that beekeeping is particularly useful in bridging shortage periods and thus contributes to household resilience (Brown 2001). Some authors argue that beekeeping income in the Miombo region fills a critical income gap in November and June, when farmers

need to purchase inputs such as seeds and fertilizers (Husselman, Moeliono and Paumgarten 2010).

But beekeeping project assessments tend to focus on monetary measures of project outcomes for beneficiaries (FAO 2014a, Heyde and Lukumbuzya 2016, MNRT 2016, SNV 2016b). Other aspects of wellbeing benefits, for which beekeeping is also promoted, such as health, nutrition, or resilience, are not usually evaluated. Whilst anecdotal evidence exists for beekeeping being able to support households through the shortage periods of the agricultural year, there appears to be a lack of documented, empirical evidence supporting this notion. Given how widely beekeeping is promoted within linked conservation and development interventions, the lack of empirical research on its benefits to local communities is surprising (Wagner, Meilby and Cross 2019).

Measuring wellbeing is a complex task. The definition of poverty (or its absence) and hence the approach to measure it have undergone a significant evolution since the 1960s. The traditional definition in monetary terms has been gradually widened to include non-monetary consumption of goods and a focus on the wider welfare benefits (Campbell and Luckert 2002). Contemporary composite indices typically include an assessment of peoples' basic needs, such as food security, access to health services and education as well as income (Ravallion 2011). The most prominent global indicator consisting of a series of welfare domains has been the Human Development Index (HDI) (Hopkins 1991). The HDI has been criticized for its selection of indicator variables as well as of the arbitrary weights assigned to them in the composite index calculation (Ravallion 1997).

A growing recognition in the 1970s and 80s of pure economic growth not being able to cater to all human needs led to the development of the 'Sustainable Livelihoods' approach, which stresses the need to assess all factors contributing to the quality of the daily lives of the poor (Chambers and Conway 1992, Scoones 1998). While this conceptualization of wellbeing is more encompassing and refined than traditional measures of the HDI, some critics suggest that the 'Sustainable Livelihoods' approach suffers from a diminished practical measurability, comparability and tangibility (Angelsen and Wunder 2003). Despite this criticism, multidimensional poverty or wellbeing indices remain ubiquitous tools for measuring the quality of life. Questions regarding their composition and the weights given to individual components remain difficult and unresolved (Ravallion 2011). There is a growing recognition,

however, that weights should reflect the utility that people gain from the components measured and should be validated wherever possible by the local populations in question (Ravallion 2011, Woodhouse, Homewood et al. 2015). There is also general agreement in the literature, as well as at a policy level, that a multidimensional measure should encompass basic human needs such as food security, health, housing, energy, sanitation, access to education, social connectedness as well as a subjective component (Woodhouse, Homewood et al. 2015).

This paper evaluates the benefits of beekeeping for rural communities using a range of non-monetized criteria. My approach is also based on a multidimensional assessment template. I assess whether beekeepers enjoy a higher quality of life in a range of wellbeing domains compared to their non-beekeeping counterparts in rural communities in Central Tanzania. Based on the rationale behind the significant efforts to promote beekeeping, as well as the forest and livelihood literature, I hypothesise that beekeepers enjoy a higher level of fulfilment of their subsistence and fundamental needs, a more effective safety net in the form of higher resilience to shocks and stresses as well as more means to move towards prosperity through the possession of a larger asset base than their non-beekeeping peers. I further hypothesise that beekeeping benefits fill a gap in subsistence and income resources in particular months of the agricultural year.

4.2. Data collection

Through the semi-structured interviews with community leaders conducted during the project scoping phase I established locally relevant markers of household wellbeing to be used as indicators in the subsequent development of a multidimensional socio-economic assessment tool. Further, I elicited accounts of any perceived differences in the socio-economic status of beekeepers and their non-beekeeping counterparts through the group discussions with beekeepers and non-beekeepers in each community during the scoping phase of the study.

I then constructed a socio-economic survey based on the template of the Multidimensional Poverty Assessment Tool (MPAT) (Cohen 2009), which I shortened and adjusted by using the

wellbeing indicators derived through interviews with community leaders. I chose the MPAT template for four reasons: it comprises a two-fold structure of basic needs indicators (food security, domestic water supply, health, sanitation, housing and energy, education) and other indicators thought to be of importance for poverty assessment in the study context (farm and non-farm assets, resilience, social capital); it provides ample documentation of how indicators and weights for individual variables were derived; it can be adjusted to suit individual research needs; and it has been critically assessed for internal consistency and statistical robustness by the European Commission Joint Research Centre (Saisana and Saltelli 2010, Cohen and Saisana 2014). The MPAT is not designed to produce one composite index, but rather separate indices for individual life domains, allowing us to explore potential differences in a range of key life domains affected by beekeeping.

All survey responses were scaled 1-10 and then aggregated for each subcomponent using the weighted arithmetic average. Values and weights for these were derived where possible from the MPAT template. Subcomponents were then aggregated using the weighted geometric average to form life domains while avoiding full compensability (Cohen 2009). The weights for these were also derived, where possible, from the MPAT framework. My adjustments of the MPAT template comprised the removal or alteration of individual questions as well as response options to questions. Where I removed MPAT questions or subcomponents I assigned equal weights to the remaining questions and subcomponents to avoid introducing ad hoc weighting. Where my response options differed to the MPAT, I derived values by using the arithmetic means of existing MPAT response options related to my actual responses. I then scaled the resulting values to a range of 1-10 using the Min-Max normalization approach: $y = 1 + (x-xmin)*(10-1)/(xmax-xmin)$ (see Appendix 4.1).

Lastly, the semi-structured interviews with selected survey participants gave opportunity to elicit individual accounts of perceived beekeeping benefits.

4.3. Data analysis

I analysed differences between beekeepers and non-beekeepers in ten life domains: food security, domestic water supply, health, sanitation, housing and energy, education, farm

assets, non-farm assets, resilience, and social capital[8]. While the distinction between those who do and those who do not keep bees is binary, there is considerable variation in the level of engagement in the activity among beekeepers themselves. I thus conducted the analysis by using not only beekeeping per se as a dependent variable, but also disaggregated beekeepers into different categories according to gender, age, the number of hives owned, quantity of honey harvested in the 12 months preceding the study, whether or not the beekeeper had received any formalised training, and the location where bee products were marketed.

When analysing mean scores for the ten life domains I used two-sample Wilcoxon rank sum tests in cases where a comparison was made between levels for a categorical variable with only two levels (beekeeping vs non-beekeeping, more or less than 20 hives owned, marketing honey and/or wax at only local markets or at more distant markets as well). For categorical variables with more than two levels (litres of honey harvested, number or formal training days participated in) I used Kruskal-Wallis tests and post-hoc Bonferroni tests to determine statistically significant differences in the mean scores between the different groups. I further analysed the relationship between life domain scores and my classification of the sample into beekeepers and non-beekeepers using an ordinary binary logit model. The variables representing the ten life domains were tested for multicollinearity. A correlation matrix was used to identify any moderated relationships between model variables.

To determine if beekeeping was filling a gap in income and subsistence resources, I compared the months mentioned by beekeepers and non-beekeepers as periods when they experienced high cash income and food security or shortages with the months in which beekeepers stated to reap the most benefits of their beekeeping activity.

4.4. Results

Beekeepers owned more farm and non-farm assets and were more resilient than non-beekeepers (Table 4.1, Figure 4.1).

[8] The inclusion of social capital as a potential outcome of engagement beekeeping is based on the hypothesis that beekeeping alleviates poverty, which can be a determinant of social capital (Cleaver 2005, Eckhard 2018). Social capital forms an important part of wellbeing as it can enable access to economic opportunities and support (Chantarat and Barrett 2012).

Table 4. 1. - Mean life domain scores (standard errors in brackets). Beekeepers and non-beekeepers are compared using Wilcoxon rank sum tests (test statistic: W)

Life domains	Beekeepers mean (± SE)	Non-beekeepers mean (± SE)	W value
Food security	5.423 (0.319)	4.748 (0.301)	13792
Dom. water supply	3.148 (0.255)	3.112 (0.250)	12702
Health	5.810 (0.148)	6.002 (0.161)	11904
Sanitation	7.779 (0.054)	7.840 (0.077)	12182
Housing and energy	4.353 (0.118)	4.277 (0.099)	12628
Education	3.432 (0.302)	3.150 (0.297)	5001
Farm assets	5.188 (0.197)	3.675 (0.159)	17110***
Non-farm assets	3.508 (0.146)	2.844 (0.119)	15999***
Resilience	3.759 (0.095)	3.369 (0.086)	11208***
Social capital	5.567 (0.129)	5.311 (0.143)	13517

** significance at 1%, *** significance at 0.1%

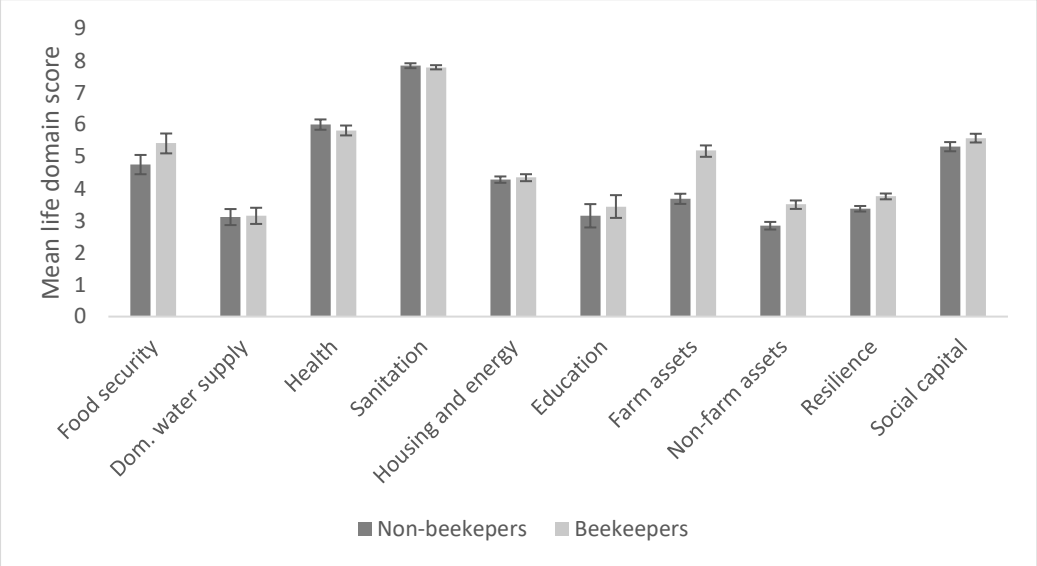


Figure 4. 1 Two-sample comparisons of the mean life domain scores for beekeepers and non-beekeepers

However, the number of hives owned per beekeeper, did not have any effect on any of the ten life domains (Table 4.2).

Table 4. 2. - Mean life domain scores (standard errors in brackets). Beekeepers owning fewer than 20 or 20 or more hives are compared using Wilcoxon rank sum tests (test statistic: W)

Life domains	**< 20 hives, mean (± SE)**	**≥ 20 hives, mean (± SE)**	**W value**
Food security	5.208 (0.379)	6.000 (0.590)	2108
Dom. water supply	3.230 (0.303)	2.929 (0.476)	2478
Health	5.819 (0.168)	5.786 (0.310)	2403
Sanitation	7.770 (0.072)	7.804 (0.054)	2380
Housing and energy	4.339 (0.142)	4.390 (0.216)	2267
Education	3.296 (0.357)	3.795 (0.571)	1096
Farm assets	4.992 (0.230)	5.715 (0.377)	1987
Non-farm assets	3.381 (0.167)	3.847 (0.290)	1896
Resilience	3.822 (0.107)	3.557 (0.207)	1869
Social capital	5.660 (0.157)	5.317 (0.220)	2631

Beekeepers who harvested more than 45 litres of honey in the 12 months preceding the study owned significantly more farm assets than beekeepers who harvested no honey during the same period (Table 4.3).

Table 4. 3. - Mean life domain scores (standard errors in brackets). Beekeepers who harvested 0 litres, 45 litres or less and or more than 45 litres in the 12 months preceding the study are compared using Kruskal-Wallis tests (test statistic $\chi 2$) with Bonferroni correction

Life domains	**0 litres (± SE)**	**≤ 45 litres (± SE)**	**> 45 litres**	**X^2 value**
Food security	5.622 (0.633)	5.395 (0.482)	5.828 (0.743)	0.510
Dom. water supply	3.000 (0.476)	2.851 (0.386)	4.026 (0.634)	2.854
Health	5.756 (0.268)	5.890 (0.233)	5.798 (0.371)	0.274
Sanitation	7.700 (0.168)	7.786 (0.036)	7.905 (0.108)	1.350
Housing and energy	4.358 (0.239)	4.429 (0.184)	4.275 (0.260)	0.290
Education	4.228 (0.604)	4.828 (0.518)	5.921 (0.797)	2.786
Farm assets	4.516 (0.308)	5.276 (0.317)	6.380 (0.452)	9.133**
Non-farm assets	3.700 (0.298)	3.515 (0.228)	3.832 (0.328)	1.425
Resilience	3.852 (0.141)	3.892 (0.168)	3.688 (0.230)	0.633
Social capital	5.393 (0.249)	5.614 (0.196)	5.567 (0.322)	0.909
Bonferroni correction of p-values for 'Farm assets'- life domain – before p-adjustment				
	0 litres	**≤ 45 litres**	**> 45 litres**	
≤ 45 litres	0.1473	-	-	
> 45 litres	0.0044	0.0821	-	
Bonferroni correction of p-values for 'Farm assets'- life domain – p-adjusted				
	0 litres	**≤ 45 litres**	**> 45 litres**	
≤ 45 litres	0.442	-	-	
> 45 litres	0.013	0.246	-	

There was no statistically significant difference between life domain scores between the different age groups (Table 4.4).

Table 4. 4. - Mean life domain scores and Kruskal-Wallis χ2 test statistic for beekeepers' age groups 20 – 70

Life domains	20 Mean score (± SE)	30 Mean score (± SE)	40 Mean score (± SE)	50 Mean score (± SE)	60 Mean score (± SE)	70 Mean score (± SE)	X^2 value	p-value
Food security	5.917 (1.06)	5.935 (0.701)	5 (0.624)	5.583 (0.663)	5.75 (1.101)	5.233 (1.074)	6.389	0.27
Dom. water supply	3.812 (1.003)	3.177 (0.576)	2.768 (0.463)	3.5 (0.565)	3.953 (0.865)	1.9 (0.613)	0.512	0.774
Health	5.952 (0.697)	5.73 (0.305)	5.627 (0.29)	5.966 (0.314)	6.132 (0.415)	5.838 (0.442)	36.793	0.257
Sanitation	7.75 (0)	7.823 (0.073)	7.857 (0.075)	7.875 (0.087)	7.328 (0.422)	7.75 (0)	1.482	0.477
Housing and energy	3.854 (0.35)	4.218 (0.236)	4.218 (0.182)	4.635 (0.279)	4.957 (0.483)	4.127 (0.371)	23.977	0.12
Education	7.233 (0.949)	6.768 (0.635)	4.142 (0.513)	4.939 (0.586)	3.425 (0.794)	5.511 (1.009)	2.973	0.562
Farm assets	4.997 (0.76)	5.272 (0.435)	5.46 (0.371)	5.31 (0.385)	5.262 (0.736)	4.17 (0.629)	91.761	0.575
Non-farm assets	3.275 (0.393)	3.375 (0.265)	3.958 (0.337)	3.564 (0.334)	3.8 (0.418)	2.575 (0.157)	75.064	0.26
Resilience	3.79 (0.31)	3.871 (0.209)	3.775 (0.17)	3.854 (0.205)	3.374 (0.296)	3.711 (0.181)	56.234	0.744
Social capital	5.822 (0.463)	5.575 (0.19)	5.261 (0.291)	5.781 (0.286)	5.101 (0.35)	6.247 (0.401)	4.513	0.921

Differences between beekeepers and non-beekeepers varied for male and female study participants. While female beekeepers had more non-farm assets than female non-beekeepers, differences in other life domain scores were not statistically significant (Table 4.5).

Table 4. 5. - Mean life domain scores and Wilcoxon rank-sum test statistic for female beekeepers and non-beekeepers

	Female NBK Mean score (± SE)	Female BK Mean score (± SE)	W value	p-value
Food security	3.864 (0.426)	3.571 (0.827)	612	0.404
Dom. water supply	2.943 (0.379)	3.679 (0.77)	767	0.364
Health	6.038 (0.239)	5.221 (0.4)	505	0.062
Sanitation	7.92 (0.14)	7.964 (0.148)	684.5	0.89
Housing and energy	4.323 (0.172)	4.69 (0.403)	739	0.649
Education	4.534 (0.418)	2.664 (0.498)	208.5	0.053
Farm assets	2.905 (0.148)	4.306 (0.546)	876	0.07
Non-farm assets	2.543 (0.168)	3.686 (0.418)	972.5	0.006
Resilience	3.609 (0.13)	3.644 (0.265)	509	0.671
Social capital	5.201 (0.218)	5.442 (0.335)	716	0.821

Male beekeepers, on the other hand, were better off than their male non-beekeeping peers in three life domains, ownership of farm and non-farm assets as well as resilience (Table 4.6).

Table 4. 6. - Mean life domain scores and Wilcoxon rank-sum test statistic for male beekeepers and non-beekeepers

	Male NBK Mean score (± SE)	Male BK Mean score (± SE)	W value	p-value
Food security	5.49 (0.401)	5.807 (0.337)	7145.5	0.557
Dom. water supply	3.228 (0.328)	3.119 (0.269)	6743.5	0.801
Health	6.037 (0.214)	5.902 (0.157)	6632	0.676
Sanitation	7.784 (0.085)	7.75 (0.057)	6743.5	0.577
Housing and energy	4.253 (0.117)	4.328 (0.123)	6806.5	0.933
Education	5.709 (0.375)	5.464 (0.305)	2382.5	0.533
Farm assets	4.192 (0.228)	5.385 (0.209)	8760	0
Non-farm assets	3.015 (0.158)	3.51 (0.159)	8142.5	0.013
Resilience	3.157 (0.092)	3.65 (0.085)	6451.5	0
Social capital	5.4 (0.189)	5.557 (0.138)	7226.5	0.465

There were no significant differences in the means for most life domain scores of beekeepers only selling honey and/or wax at local markets and those selling to more distant locations with the exception of domestic water supply and non-farm assets with the latter group scoring higher (Table 4.7).

Table 4. 7. - Mean life domain scores (standard errors in brackets). Beekeepers selling honey only at local markets and beekeepers also selling honey at more distant markets are compared using Wilcoxon rank sum tests (test statistic: W)

Life domains	Local markets (± SE)	More distant markets (± SE)	W value
Food security	5.683 (0.355)	4.885 (1.182)	850
Dom. water supply	2.884 (0.277)	5.673 (0.899)	471***
Health	5.802 (0.168)	5.851 (0.422)	807
Sanitation	7.768 (0.066)	7.923 (0.173)	758
Housing and energy	4.347 (0.130)	4.785 (0.506)	711
Education	3.345 (0.329)	3.523 (1.019)	369
Farm assets	5.164 (0.217)	5.784 (0.716)	676
Non-farm assets	3.554 (0.165)	4.495 (0.517)	508*
Resilience	3.800 (0.105)	4.054 (0.376)	460
Social capital	5.572 (0.137)	5.154 (0.137)	896

* significance at 5%, ** significance at 1%, *** significance at 0.1%

I did not detect any significant differences between the pairs of life domain means for beekeepers having received different amounts of formal beekeeping training (no training, 1-2 days of training, more than 3 days of training) (Table 4.8).

Table 4. 8. - Mean life domain scores (standard errors in brackets). Beekeepers who have received one to two days of formal beekeeping training, beekeepers who have received three or more days of training and beekeepers who have not received any formal training are compared using Kruskal-Wallis tests (test statistic χ^2) with Bonferroni correction

Life domains	1-2 days (± SE)	3+ days (± SE)	Not trained	X^2 value
Food security	5.346 (1.179)	6.750 (0.980)	5.262 (0.352)	2.138
Dom. water supply	4.635 (0.971)	4.375 (0.871)	2.839 (0.271)	6.442*
Health	6.161 (0.361)	5.535 (0.360)	5.809 (0.173)	1.147
Sanitation	7.923 (0.173)	7.891 (0.141)	7.750 (0.062)	1.777
Housing and energy	4.338 (0.443)	4.845 (0.390)	4.292 (0.129)	2.344
Education	4.722 (1.327)	5.518 (1.024)	5.044 (0.386)	0.080
Farm assets	4.926 (0.728)	4.973 (0.597)	5.242 (0.220)	0.181
Non-farm assets	4.035 (0.729)	4.0 (0.433)	3.391 (0.153)	2.903
Resilience	3.888 (0.316)	3.787 (0.267)	3.742 (0.108)	0.287
Social capital	5.765 (0.461)	5.461 (0.449)	5.561 (0.142)	0.200
Bonferroni correction of p-values for 'Domestic water supply'- life domain – before p-adjustment				
	1-2 days	**3+ days**		
3+ days	0.827	-		
Not trained	0.052	0.068		

Bonferroni correction of p-values for 'Domestic water supply'- life domain – p-adjusted

	1-2 days	3+ days
3+ days	1.00	-
Not trained	0.16	0.20

* significance at 5%, ** significance at 1%, *** significance at 0.1%

Using a binary logit regression model, I found significant associations between beekeeping and increased food security, increased ownership of farm assets and non-farm assets, a higher resilience, and a lower education score (Table 4.9, Figure 4.2).

Table 4. 9. - Estimated parameters of a binary logit regression model describing associations between life domains and of engagement in beekeeping

	Coefficient	SE	z value
Intercept	-3.412	1.671	-2.041
Food security	0.110	0.040	2.775**
Dom. water supply	0.055	0.044	1.237
Health	-0.104	0.075	-1.389
Sanitation	-0.162	0.184	-0.882
Housing and energy	-0.008	0.105	-0.073
Education	-0.088	0.041	-2.170*
Farm assets	0.325	0.066	4.971***
Non-farm assets	0.229	0.094	2.421*
Resilience	0.547	0.148	3.698***
Social capital	0.145	0.082	1.783

* significance at 5%, ** significance at 1%, *** significance at 0.1%

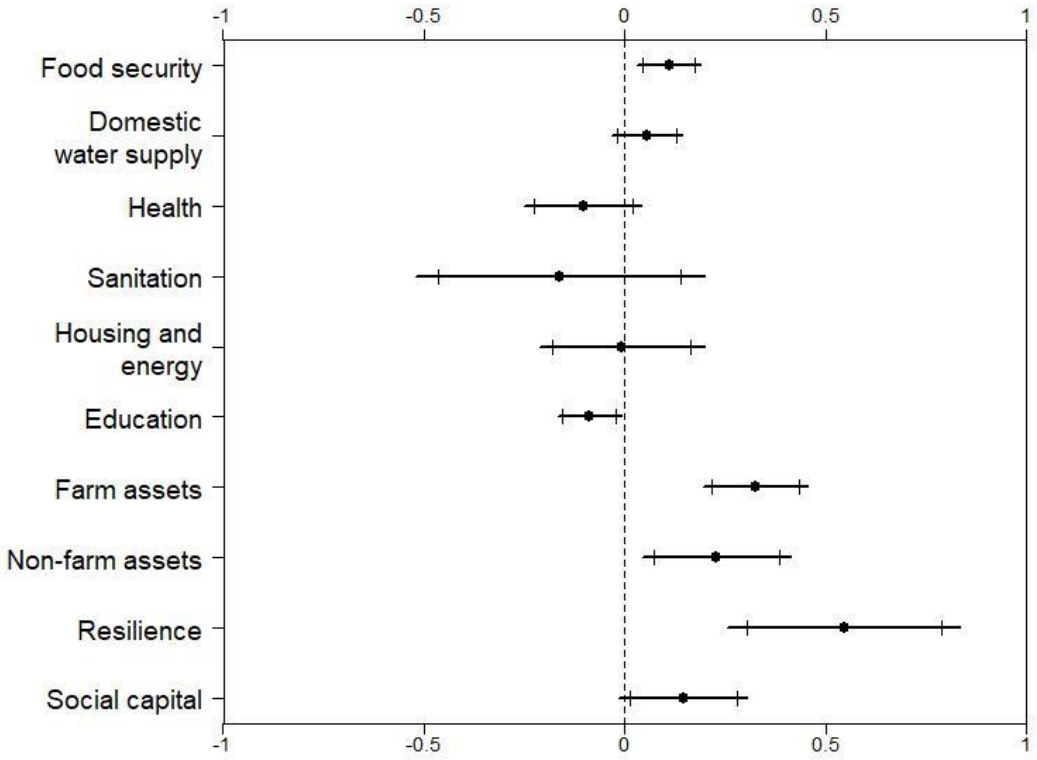


Figure 4. 2. - Estimated coefficients, 90% and 95% confidence intervals for a binary logit regression model describing associations between life domains and of engagement in beekeeping

Except for the education score, all significant model parameters are positive, meaning that beekeepers score better in these domain variables than non-beekeepers. This finding is also reflected in my qualitative data, where beekeepers repeatedly explained that they were able to afford livestock, better housing, and other assets through the sale of honey bee products. They also described themselves to be more resilient through the diversification of livelihood activities:

> *"When beekeepers harvest honey, they sell them and can build a house, schooling children and for other development. […] So those who selling honey have cattle, and when you want to get cattle easily [it] is through honey. When you want to get anything nowadays [it] is through honey business. […]" (Beekeeper from Msememb*o)

> *"We saw it's true that beekeeping is more beneficial than agriculture, because you may harvest large amount of honey than the agricultural products. So, we saw it's more*

beneficial because when honey is sold, it provides us with money. […]" (Beekeeper from Paranga)

My qualitative data also suggests that honey plays a role in providing food during lean periods:

"There was a hunger period, so honey was the main source of food. Out of seven days, you could eat ugali [maize porridge] *on only two times. The rest of the time you eat honey". (Beekeeper from Paranga)*

The regression results on the negative association between beekeeping and education is contradicted by interview data where beekeepers repeatedly mentioned that income from beekeeping helped beekeepers afford to pay for school fees and supplies of their children:

"I'm benefited from [beekeeping] *as I get income that help us for schooling children." (Beekeeper from Msemembo)*

I found no multicollinearity among the ten domain variables. I observed weak correlations between multiple variables, notably between resilience and food security (negative relationship); education and farm assets; education and food security; non-farm assets and housing (Figure 4.3).

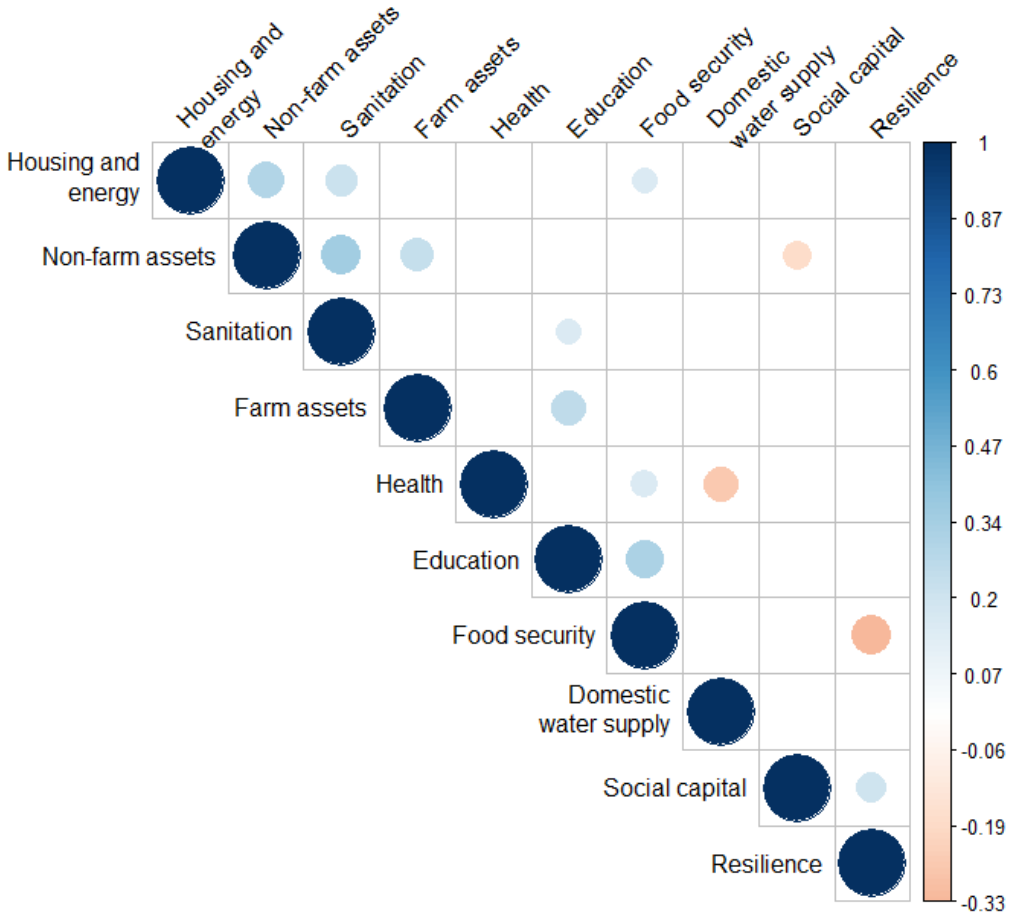


Figure 4. 3. - Correlation matrix of ten life domains (farm assets, education, health, food security, social capital, resilience, domestic water supply, sanitation, non-farm assets, housing, and energy). Correlations with P > 0.05 are left blank; colour intensity and size of circles are proportional to the correlation coefficient; blue = positive correlation, red = negative correlation (dark blue circles represent self-correlation).

More beekeepers than non-beekeepers mentioned January, June, July, August, September, and October as the months in which they receive high cash income, whereas more non-beekeepers cited April and May. The differences for when food security was perceived high were not significant, except for the month of August (Figures 4.4 and 4.5).

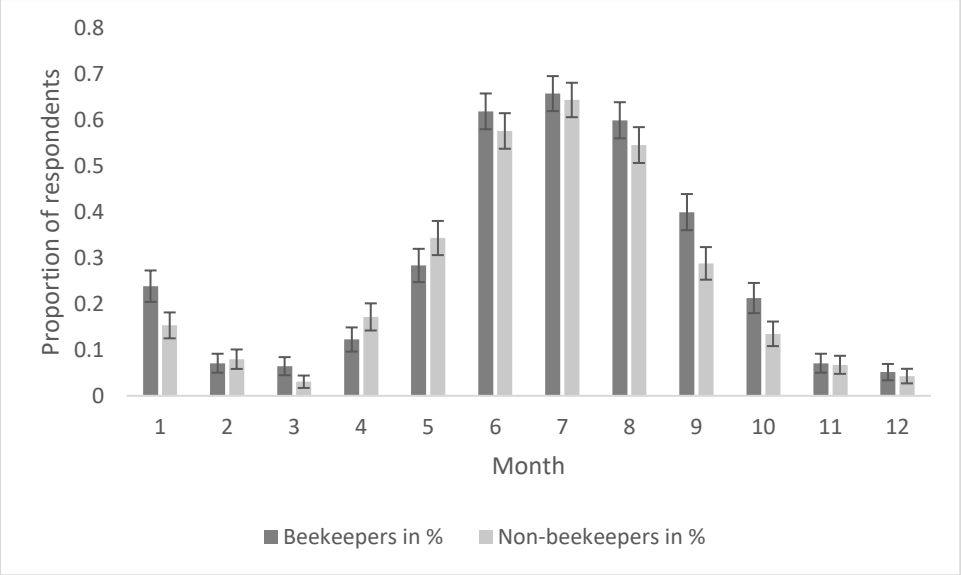


Figure 4. 4. - Occurrence of months (1-12) mentioned as times when highest cash income is experienced by beekeepers and non-beekeepers

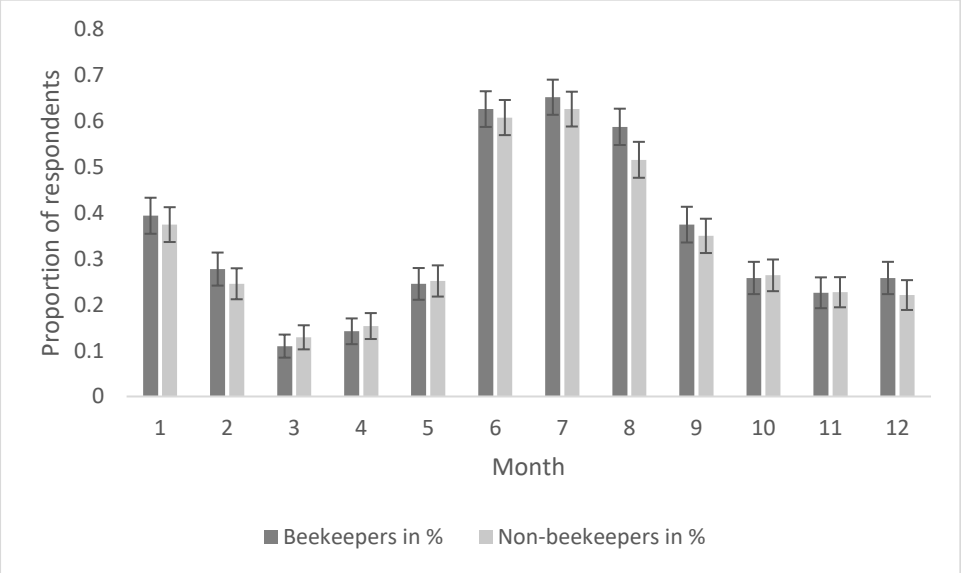


Figure 4. 5. - Occurrence of months (1-12) mentioned as times when highest subsistence income is experienced by beekeepers and non-beekeepers

January, June, July, and August were most often mentioned by beekeepers as well as non-beekeepers as more food-secure months. Beekeepers stated that they gained benefits from their beekeeping activities in all months of the year except November. May, June, and July were named by most beekeepers as high benefit months, which corresponds with months were both groups experienced the smallest shortages. Some beekeepers also reported

benefitting from beekeeping in the months January to May, but more beekeepers reported shortages in a large part of this period (January to March) than non-beekeepers (Figure 4.6).

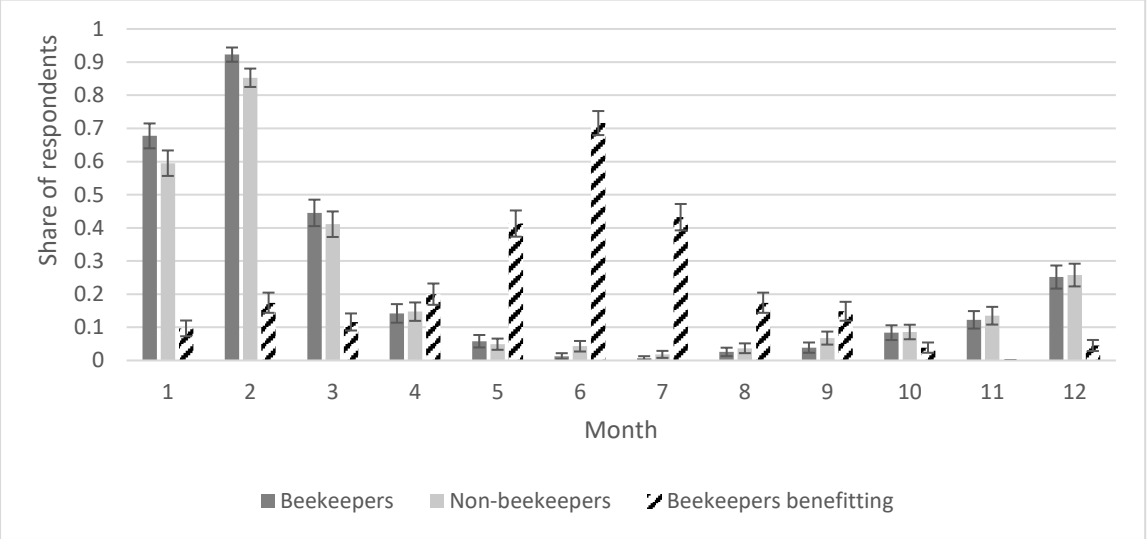


Figure 4. 6. - Occurrence of months (1-12) mentioned as times when shortages are experienced by beekeepers and non-beekeepers and when beekeeping benefits are received

The findings from this quantitative analysis are not directly supported by the qualitative data I analysed. Both beekeepers and non-beekeepers stated that beekeepers are better off during the two honey harvest seasons than non-beekeepers:

> *"I see beekeepers are better off because for example, there is a period hunger. During this period, people with no beehives face problems due to lacking food. While beekeepers harvest honey and selling them to get money for buying some food. Therefore, beehives owners are better off than non-beekeepers." (Beekeeper from Msemembo)*

> *"I see there is difference as said before, because it comes time, for example in February, September that the season of harvesting honey. Honestly, they [beekeepers] get honey. For that season of harvest, they become different from non-beekeepers even though that honey is not much valuable, but beekeeper can sell even two buckets and get TZS 80,000 but non-beekeeper you lack TZS 80,000. Therefore, there is a difference in the season of harvesting honey. They become better off; their income grows due to the selling of honey. So, we [non-beekeepers and beekeepers] differ in that way." (Non-beekeeper from Msemembo)*

4.5. Discussion

There is an evidence gap on the livelihood benefits of beekeeping as well as the timing of these throughout the agricultural year. This is of particular importance as beekeeping is extensively promoted by development organisations with the aim of increasing food security and cash income, providing a safety net for rural households during times of agricultural shortages and creating a means to help rural populations move towards prosperity. Without evidence of the effects of beekeeping on people's lives, beekeeping promoting organisations risk creating unrealistic expectations in project beneficiaries as well as funding bodies. An unrealistic expectation of potential benefits might lead to valuable time and material inputs of support organisations and beekeeping support beneficiaries not being used to the latter's full advantage leading to possible discontent and project attrition. Failure to deliver promised gains can ultimately lead to an erosion of trust between rural communities and the government or non-governmental bodies that aim to support them.

This study is an attempt to provide evidence of the benefits of beekeeping for rural communities using a range of non-monetized criteria. I document in which life domains beekeepers score higher than non-beekeepers, indicating the possible effects of beekeeping on different aspects of wellbeing. I also provide evidence of the seasons when beekeeping profits are perceived to be highest. This information is important for targeting future external beekeeping support as it indicates which aspects of people's wellbeing beekeeping might impact and whether the returns of beekeeping are received when most needed by the beneficiaries.

A better understanding of how farmers might gain from beekeeping helps to keep expectations among donors and beneficiaries realistic and helps to avoid disenchantment and attrition. The following sections provide a discourse on the relationship between beekeeping and different livelihood aspects. I divided these into a) the fulfilment of fundamental needs, b) the existence of a safety net structure and c) the means that may enable farmers to prosper.

One of the caveats with potential implications for the study results is the extended drought in the three years preceding this study and its effects on wellbeing domains discussed below. It is conceivable that the drought impacted the answers on a range of socio-economic survey

questions on which wellbeing domains are based differently for beekeepers and non-beekeepers. This cannot be ascertained from the data collected for this study. It is also possible that the potential of beekeeping benefits to fill an income and subsistence gap during the agricultural year was reduced compared to non-drought conditions. While the questions on this topic were formulated so that participants' answers could reflect their experiences over a longer time period, the data collected cannot provide a definitive answer on this.

Another caveat touches on the effect of marketing options for beekeepers. It is possible that beekeepers who processed their harvest by separating honey from wax and who were thus able to market these two products separately were able to achieve better wellbeing results than beekeepers who sold unprocessed honey comb. Whether such a tendency exists or not cannot be inferred from data collected for this study.

4.5.1. Subsistence and fundamental needs

I found that beekeeping presented some advantages in life domains that relate to peoples' fundamental needs, i.e. food security, domestic water supply, sanitation, health, and housing and energy (Cohen 2009, Shackleton, Delang et al. 2011). The qualitative and quantitative data suggests that beekeepers, especially those owning more than 20 hives, were more food secure than non-beekeepers. According to interviewee responses, this weak effect is due to the consumption of honey during times of food shortages and the use of income from bee product sales for the acquisition of food. This concords with one of the main justifications of donor organisations to promote and support beekeeping (FAO 2011, World Bank 2015b). The finding is also supported by literature on the provision of food being one of the main motivators behind farmers adopting beekeeping in Tanzania (Wagner, Meilby et al. 2019).

The negative association between engagement in beekeeping and education score, which in this case consists of an indication of how often the respondent households could afford school fees and school supplies for their children, is not confirmed by the beekeepers and non-beekeepers I interviewed, who stated that beekeeping income helped them send their children to school. This inconsistency in my findings might be due to beekeepers either not always being able to afford their children's schooling due to an irregular cash flow from

beekeeping or choosing to use their beekeeping income on more urgent expenses (Buchmann 2000, Schafer 2006). Another possible reason might be that when asked about their ability to pay for school fees, beekeepers may be sufficiently poor that they frequently indicate that they are not able to do so, but they may still believe they would be considerably worse off if they had not been able to sell honey bee products. Lastly, as I observed significant collinearity between education and farm assets, I cannot exclude this as the reason for inconsistencies between my quantitative and qualitative results.

Associations between beekeeping and other life domains were discernible when the beekeeping sample was divided into various categories characterizing the extent of the beekeepers' engagement in beekeeping. My assumption that individuals capable of marketing their bee products to more distant markets in addition to local markets were socio-economically better positioned, was validated by respondents scoring higher in the domestic water supply and non-farm assets domains.

4.5.2. Resilience, safety net and gap filling

The resilience and social capital domains represent variables I consider critical in the appraisal of the existence of a safety net to protect rural populations from the negative effects of shocks and disasters, such as illness or crop failure (Cohen 2009, Aldrich and Meyer 2015). I found that beekeepers were more resilient than non-beekeepers and thus appear better protected from shocks by the diversity of income streams and coping mechanisms than non-beekeepers. These results are supported by the farmers I interviewed who indicated that diversification with the aim of risk reduction was one of their main motivations to keep bees. This seems to be a successful strategy as higher income diversification is known to be linked with higher welfare in terms of subsistence as well as cash income (Barrett, Reardon and Webb 2001, Block and Webb 2001).

Entry barriers to beekeeping adoption (Wagner, Meilby et al. 2019) and more generally to high-return activities in rural non-farm environments (Block and Webb 2001) make the assigning of cause and effect of the above observed phenomenon (i.e. higher diversification and resilience characterizing beekeepers) problematic (Vedeld, Angelsen et al. 2007). It is

worth noting, that only male beekeepers were more resilient than their non-beekeeping male counterparts. My results thus suggest that beekeeping was not sufficient to reverse the general trend of gender inequality in resilience in rural Tanzania and that differences in women's and men's ability to engage in beekeeping persist (Nelson and Stathers 2009, Mason, Ndlovu et al. 2015).

Beekeepers and non-beekeepers repeatedly mentioned the same months of the year as periods of high food security and cash income, with only small differences between groups in the distribution of months mentioned. This suggests that the two groups are similar in their economic status and experience the same yearly fluctuations of higher and lower food security and cash income. The higher number of mentions of the months of January, September, and October as periods of high cash income by beekeepers is consistent with the presence of the two honey flow seasons during the year and consequently the concentration of perceived beekeeping benefits in those two periods. The timing of these benefits occurs when both beekeepers and non-beekeepers indicated the least shortages. This suggests that the perceived beekeeping benefits do not imply a significant difference between how severely beekeepers and non-beekeepers experience these annual shortages. While both groups mentioned the first three months of the year as the hardest in terms of low food security and cash income, a greater proportion of beekeepers indicated hardship during this time. And this, despite this period corresponding with when beekeeping benefits were perceived to be relatively high.

While an exploration of what level of 'gap-filling' could be considered as sufficient is complex and based on individual needs and perceptions, my results suggest that beekeeping benefits are insufficient to fully mitigate shortage periods throughout the year. I contend that while beekeeping contributes to some additional cash income during distinct periods of the year, it does not act as a completely effective gap-filler during the seasons of scarcity as suggested by other authors (Husselman, Moeliono and Paumgarten 2010). However, the aim of engagement in beekeeping and of external LCDA interventions using beekeeping is not to fully fill income gaps during the agricultural year, but rather to augment alternative income and subsistence sources and thus contribute an additional element to rural people's resilience. Results of this study show that beekeeping achieves that to some degree. The wide-spread

engagement in Tanzania reflects the point of beekeeping providing a relatively easily accessible and necessary supplement to local people's livelihood portfolios.

4.5.3. Path towards prosperity

The scientific discussion regarding the role of forests in rural populations' livelihoods has tended to focus on the fulfilment of immediate subsistence needs to prevent the already poor moving further into poverty. It is only in the past decade that this discourse started to examine the importance of forest income, such as beekeeping income, in moving people out of poverty on a 'path towards prosperity' (Angelsen and Wunder 2003, Vedeld, Angelsen et al. 2007).

I based the analysis of the connection between beekeeping and poverty alleviation on accumulated assets, both farm-related and others (Cheng, Ahlroth et al. 2017). The quantitative and qualitative results show that beekeepers had significantly more farm and non-farm assets than non-beekeepers. The more honey a beekeeper harvested the more farm assets they owned, perhaps indicating that large-scale beekeepers were more likely to invest beekeeping income in extending their farm activities than in growing their non-farm asset base.

This may partly explain why beekeepers often also kept livestock (Wagner, Meilby et al. 2019). The investment of cash income generated through beekeeping into livestock can also be attributed to the fact that livestock is regularly used as a way to convert cash into savings in low-income settings where access to financial services is absent (Upton 2004). Indeed, in the context of this study, where other rural income generating opportunities were scarce, beekeeping income was one of only a few means available to local people to acquire livestock. Conversely, the reverse may also be true, i.e. that livestock investment promotes beekeeping as it offers more time spent in the forest and thus increases the opportunity to engage in beekeeping activities.

Land possession (*de facto* and *de jure*) was an equally important component of the 'farm assets' wellbeing domain as livestock ownership (Appendix 4.1). It is thus also conceivable that beekeepers were investing their income to expand their land ownership in order to

secure essential inputs for their beekeeping activities, such as material for the construction of hives as well as trees which provide a good nectar source.

Interestingly, only male beekeepers were able to command over a larger farm asset base compared to their male non-beekeeping counterparts. My results suggest that while female beekeepers followed the general trend of the study population in having accumulated more non-farm assets than non-beekeeping women, they did not mirror the general trend regarding farm assets. This is likely explained by women in Tanzania being less likely to acquire livestock and owning a significantly lower number of livestock than men due to locally prevailing cultural norms and a lower access to other, smaller assets (e.g. domestic assets and farm implements), the accumulation of which could facilitate livestock ownership (Mkenda-Mugittu 2003, Njuki and Mburu 2013, Daley, Lanz et al. 2018).

This study has not been able to explicitly identify beekeeping as the causal factor of asset accumulation. However, the interview data suggests that beekeeping income was perceived by both beekeepers and non-beekeepers as a direct contributor to a larger asset base. I propose that beekeeping positively impacts household prosperity. Whether or not this move towards prosperity is sustainable will arguably be determined by several factors including a reliable access to profitable markets as well as a dependable supply of bee forage (Amulen, D'Haese et al. 2017, Bradbear 2018, Wagner, Meilby et al. 2019).

4.6. Conclusion

I analysed associations between Tanzanian farmers' engagement in beekeeping and their household wellbeing. I distinguished between the fulfilment of basic needs, the strength of an existing safety net to protect households against the effects of shocks and the means for households to move towards prosperity.

Regarding the fulfilment of basic needs, I found an association between beekeeping and food security and an uncertain connection with education. Beekeepers who were able to market their bee products also to non-local markets, were better-off in a wider range of basic life domains. Support organisations need to be aware of the relationship between beekeeping, subsistence, and basic needs coverage. I propose that beekeeping projects need to ensure

that long-term connections are established between beekeepers and more profitable value chains for bee products.

In the analysis of the role of beekeeping as a safety net protecting against the effects of shocks, I found that beekeepers were overall more resilient due to a more diverse portfolio of livelihood activities and coping mechanisms. I found that beekeeping contributes to some additional cash income during distinct periods of the year, it does not act as a completely effective gap-filler during the seasons of scarcity. While external beekeeping support would not normally aim to offer a means to completely overcome times of shortages solely through beekeeping benefits, I suggest that future beekeeping project planners promote and support strategies to make beekeeping harvests help overcome periods of dearth.

Lastly, beekeepers owned more farm and non-farm assets. This presents the potential to move farmers engaged in beekeeping towards greater prosperity by using their assets productively. How this potential can be achieved is contingent upon the overall local economic and ecological sustainability of beekeeping as a business option.

Overall, I found the relationship between engagement in beekeeping and higher resilience as well as a larger asset base to be gendered. I thus suggest that local gender norms and gendered barriers to resource access need to be considered in the design of external beekeeping support projects aimed at improving the wellbeing of rural women in Tanzania.

5. GUARDIANS OF THE FOREST? TANZANIAN BEEKEEPERS' FOREST USE, ATTITUDES, VALUES AND PERCEIVED CONTROL

Abstract

Tanzania currently ranks globally among the top five of countries with highest annual forest loss. Poverty is one of the biggest contributors to forest loss in Africa. Conservation organisations consider beekeepers as guardians of the forests their apiaries are placed in. Beekeeping is thus a frequent component of linked conservation and development projects aimed to address poverty and forest loss conjointly by modifying the forest use behaviour of rural communities. While there is growing evidence on the effects of beekeeping on livelihoods, there is lack of evidence of its effectiveness to attain conservation goals. In this study I compare forest use, attitudes, and values as well as perceived control over natural resource use decisions of beekeepers and non-beekeepers as factors contributing to pro-conservation behaviour. For this I applied a mixed method approach involving 318 participants in four Central Tanzanian communities. I found beekeepers' forest use slightly more intensive. Beekeepers are, however, also increasingly using non-forested land for their beekeeping activities. Beekeepers were found to have more positive attitudes towards the forest and higher recognition of its conservation values. Pro-conservation motivation was mitigated by other livelihood needs for forest resources as well as limited influence within their communities' decision-making processes over the use of forest resources. I suggest that additional conservation measures need to accompany beekeeping support in order to attain conservation goals.

5.1. Introduction

Despite significant global efforts to halt deforestation, forest cover continues to decrease by approximately 6.5 million hectares per year (FAO 2016b). Tanzania has reported the fifth greatest annual net loss of forest area for any country between 2010–2015 (FAO 2016b). Poverty is considered one of the main contributors to forest loss (Sunderlin, Angelsen et al. 2005, Mackenzie and Hartter 2013). This is especially the case in Africa, where the primary reason for deforestation is the conversion of forest to subsistence agriculture (Geist and Lambin 2002, Gibbs, Ruesch et al. 2010, Hosonuma, Herold et al. 2012, Rudel 2013, FAO 2016b). Many governments and development agencies thus seek to address the problems of poverty and forest loss conjointly (World Bank 2004, Oberndorf, Mahanty et al. 2006, GoCR, GoF et al. 2013, UNDP 2013, World Bank 2013, USAID 2014, UNDP 2015, USAID 2015).

The two main approaches in response to development are 'preservation' and 'wise use' of natural resources (Newsham and Bhagwat 2016). The former assumes that the pursuit of rural livelihoods stands in conflict with conservation goals and thus seeks to restrict the use of protected resources by adjacent communities. The limitations associated with the preservation approach have been widely debated (e.g. Hough 1988, Brandon and Wells 1992, West, Igoe et al. 2006). The latter 'wise use' approach is based on the intention of providing incentives for conservation by linking development indirectly (e.g. through the substitution of an exploited natural resource with an alternative) or directly with natural resource protection (Salafsky and Wollenberg 2000). Direct LCDAs attempt to give local communities an immediate stake in the preservation of natural resources by directly benefitting from biodiversity through biodiversity-based livelihood activities (UNDP 2000, Roe 2008).

The basic idea of LCDAs is that subsistence and cash income derived from biodiversity-based livelihoods provide motivation to local communities to protect and conserve natural resources (Salafsky and Wollenberg 2000). However, the ability of these conservation- based approaches to provide lasting benefits to the rural poor is not always evident (Wunder 2001). Abbot *et al.* (2001) found the relationship between livelihood generation and conservation to be unpredictable. The shifting of destructive behaviour (leakage) to areas outside of project scope and other negative feedbacks between conservation activities and human behaviour are not uncommon issues in the context of LCDAs (St John, Keane et al. 2013).

Several authors sum up that incentive-based conservation interventions like LCDAs are based on untested notions about their impact on natural resources and on human behaviour (Brandon and Wells 1992, Barrett and Arcese 1995). Wright *et al.* (2016) identify three flawed assumptions underpinning LCDAs. These relate to the effectiveness of LCDAs in reducing the necessity to exploit natural resources by local communities, to a uniform impact of diverse community members' livelihood activities on natural resources and to the potential of scaling up interventions aimed at an individual level to the community and beyond (Wright et al. 2016).

Despite criticism of their effectiveness, LCDAs remain frequently used to simultaneously confront both poverty and deforestation (APFIC 2010, Roe, Day et al. 2014). Non-timber forest products (NTFPs) play a prominent role in incentive-based conservation interventions (Brandon and Wells 1992, Salafsky and Wollenberg 2000, Lowore, Meaton et al. 2018). Beekeeping is often promoted in LCDAs with a poverty alleviation and conservation aim (e.g. Munthali and Mughogho 1992, Brown 2001, FAO 2011, ICIPE 2013, World Bank 2015b, BTC 2016, SNV 2016, UNDP 2016a). Lowore *et al.* (2018) even make the case for forest beekeeping being a "near-perfect" NTFP as it embodies several factors known to contribute to the success of using NTFPs in a combined development and conservation approach, while avoiding many of the challenges other NTFPs are beset with.

Narratives used in beekeeping project justification frequently invoke the assumption that beekeepers gaining an income from healthy forests act as stewards of their communities' forest resources (World Bank 2015b, UNDP 2016). This assumption is so firmly established that beekeeping is listed as a land practice that contributes to the reduction of CO2 emissions and is thus promoted for REDD+ funding (UN-REDD 2012, URT 2013). While the effect of beekeeping on poverty alleviation is beginning to gain scientific attention (Amulen, D'Haese et al. 2017), its influence on conservation motivations lacks empirical evidence (Brooks, Franzen et al. 2006b, Roe, Day et al. 2014). Although the conservation benefits of beekeeping are often alluded to in project documents, concrete conservation goals are usually not explicitly defined and thus not measured (Bees Abroad 2013a, FAO 2014b, Agrawal, Chhatre et al. 2015).

Lowore *et al*. (2018) provide a comprehensive overview of the manners in which beekeepers have been documented to perform forest enhancing and protecting actions in order to

advance the safety and productivity of their hives. These include controlled burning, protection and promotion of specific tree species that serve as nectar sources, hive siting places or raw material for new hives, protection of entire forest tracts from timber cutting, planting of trees used by bees for fodder, lobbying and even financially contributing to forest management associations.

In beekeeping interventions conservation impact is usually sought through either one or a combination of a) the instigation of tree planting, b) environmental education and c) the creation of an additional livelihood opportunity reducing the pressure on forests by more damaging livelihood activities such as charcoal burning (BTC 2016, SNV 2016, UNDP 2016a). Lowore *et al.* (2018) however recap several sources questioning the evidence for how beekeeping and forest management are linked or how strong this relationship is in reality. Souto *et al.* (2014) determine that beekeeping projects, typically aimed at the generation of higher household income combined with environmental awareness raising in beneficiary communities place at an intermediate position in terms of expected long-term sustainability.

Measuring the conservation impact of external interventions is fraught with challenges. This starts with the contestation of the definition of a well-conserved forest (Schwartzman et al. 2000). Further, concrete conservation goals, against which conservation success could be measured, are rarely precisely defined in LCDA plans (Salafsky, Margoluis et al. 2002, Bees Abroad 2013, Agrawal, Chhatre et al. 2015, Kuboka and NKuba 2015, Roe, Booker et al. 2015, SNV 2016). Lastly, the measurement of conservation impacts is made problematic by attribution questions, temporal lags in the response of natural systems to interventions and the frequent lack of baseline information on the state of the resource sought to be protected prior to the intervention (Pullin, Sutherland et al. 2013, Roe, Booker et al. 2015). The miombo ecosystem, in which this study is based, presents particular challenges for the setting of management goals and the attribution of agents of change. This is due to miombo landscapes being formed through an intricate web of interactions of a complex fire regime, extensive herbivory and grazing as well as regeneration through coppicing (Valkonen 2007).

LCDAs, and conservation interventions in general, aim to change the environmental behaviour of local people (Schultz 2011). In order to understand the effects of interventions on forest conservation behaviour it is important to recognise what shapes behaviour (St John, Edwards-Jones et al. 2010). Conservation psychology aims to assess environmental behaviour

by investigating how humans value nature and their behaviour towards it (Clayton 2015). The theory of reasoned action (Fishbein and Ajzen 1975) and the theory of planned behaviour (TPB) (Ajzen 1991) are commonly applied to conservation projects. The theory of planned behaviour is premised on behaviour as a function of attitude towards a particular action, perceived subjective norms over the action and perceived behavioural control. By understanding which of these factors, i.e. attitude as well as perceived subjective norms and behavioural control, is most important for forming a specific behaviour, interventions can be designed to target any of these factors specifically (Ajzen 1991). To be able to apply TPB, it is necessary to define an explicit behaviour to be targeted through the intervention and the TPB investigation. In conservation projects based on beekeeping income incentives target behaviours are rarely defined, thus making the use of TPB to investigate conservation behaviour outcomes impossible.

Several conservation studies have shown that general pro-conservation attitudes alone do not necessarily translate into pro-conservation behaviours and actual behaviour may even contradict attitudes (Holmes 2003, St John, Keane et al. 2013). Waylen, Fischer et al. (2010) suggest that planners of incentive-based conservation interventions need to appreciate the influence of existing institutions, social and cultural contexts on project outcomes.

Another prominent approach to assessing what shapes behaviour is the so-called self-determination theory (SDT), which distinguishes between intrinsic (e.g. intrinsic desire due to self-identification with the behaviour) and extrinsic motivations (e.g. economic rewards or coercion) for specific behaviours (Ryan and Deci 2000). In the conservation context, when the effects of intrinsic and extrinsic motivations on change in environmental behaviour are compared, extrinsic motivations (e.g. such as income generated through ecotourism) alone did not result in behaviour change (Nilsson, Baxter et al. 2016). Indeed, the greatest effect is achieved when the creation of extrinsic motivations is coupled with efforts to foster intrinsic motivations for conservation (Cetas and Yasué 2016, Nilsson, Gramotnev et al. 2016).

Incentive-based conservation approaches, such as LCDAs promoting beekeeping as a livelihood activity with a conservation aim, hinge on an assumed direct relationship between economic and environmental motivations (Agrawal, Chhatre et al. 2015). In reality, the success of these projects is determined by the relative significance of income generated through the respective livelihood activity, the individual capacity to engage in the activity and

its cultural acceptability as well as any intrinsic conservation motivations pre-existing in the community (Barrett, Reardon et al. 2001, Souto, Deichmann et al. 2014, Wisely, Alexander et al. 2018). To evaluate the effect of beekeeping on conservation behaviour it is thus critical to assess the significance of beekeeping income in individual households, individual capacity to engage in beekeeping as well as any intrinsic conservation motivation of beekeepers. While the first two aspects have begun to be unpacked by the scientific community (Amulen, D'Haese et al. 2017, Wagner, Meilby et al. 2019), the motivational aspect has so far received little attention.

Analogous to the behavioural control aspect of TPB, the importance of local communities' participation and power in natural resource management decisions in conservation success is well established (Salafsky and Wollenberg 2000, Wyckoff-Baird 2000, Salafsky, Cauley et al. 2001). When an individual perceives to possess autonomy over environmental decisions, pro-conservation behaviour is more frequently observed (Osbaldiston and Sheldon 2003). Therefore, to further the understanding of the contribution of beekeeping to conservation motivations, it is important to also assess the perceived empowerment of beekeepers over natural resource management decisions in their communities.

This study aimed to assess factors contributing to pro-conservation behaviours of beekeepers to identify any potential incentives beekeeping projects might deliver. For this, I explore the following questions:

1. Do beekeepers differ in their forest use compared to non-beekeepers?
2. Do beekeepers and non-beekeepers differ in their perceptions and attitudes towards the forest?
3. Do beekeepers' valuation of different forest ecosystem services differ from that of non-beekeepers?
4. How powerful do beekeepers perceive themselves to be in comparison with non-beekeepers in decision-making processes regarding the community natural resource base?

While answers to the first three questions aim to inform about potential conservation motivations, the last question is an assessment of individual ability to act on the latter.

5.2. Data collection

In the semi-structured interviews conducted with village leaders during the study scoping phase I assessed the extent and uses of the communities' forest resources as well as the existence of local bylaws regarding forest access and use. In the separate group discussions with beekeepers and non-beekeepers during this scoping phase I then identified emerging themes regarding the forest use behaviour of both groups.

The results of these discussions informed the development of sections of the household survey exploring the intensity and nature of beekeeping activities, self-reported forest use behaviour, feelings experienced by the participants while spending time in the forest, the value of different forest products and ecosystem services as well as perceived power in local natural resource management decisions.

The subsequent interviews with selected survey participants allowed for deeper exploration of the reasons behind forest use decisions, perceptions and values held in relation to forests, the development of the forest condition, forest use conflicts as well as perceived differences between the influence of beekeepers and non-beekeepers in forest management decisions.

5.3. Data and analysis

I analysed several factors that are considered to contribute to pro-conservation behaviour for both beekeepers and non-beekeepers (Osbaldiston and Sheldon 2003, Souto, Deichmann et al. 2014, Nilsson, Baxter et al. 2016).

As a proxy for actual forest use behaviour I assessed the number of different forest products regularly collected by households, the frequency of forest visits in the 12 months preceding the study and whether or not the household had planted or cleared any trees or woodlots in the five years preceding the study. I also identified the top three reasons for planting trees or woodlots. I applied a Chi-square test to determine if the distribution of count data for the two populations (beekeepers and non-beekeepers) were significantly different for categorical variables with only two levels (trees planted and cleared) and a two-sample Wilcoxon rank-sum test for the interval-scale variable of number of different forest products collected. To assess the differences in the distribution of counts for the frequency of forest visits, I used a

Kruskal-Wallis test. To determine the relationships between actual forest use behaviour variables and beekeeping I fitted different regression models: an ordinary linear model for the number of collected forest products, ordered logistic regression for the frequency of forest visits (with and without assumed proportional odds) and logistic regression for woodlots/trees planted and cleared. I also tested if the amount of land owned by the household and planting/clearing done in the five years preceding the study had any effect on whether any forest was cleared or planted by the household.

As a proxy for attitudes towards the forest, I analysed whether the sentiments participants experienced while spending time in the forest, the importance they assigned to different forest products and services and the preference they expressed for more or less forest near the community differed between beekeepers and non-beekeepers. To assess whether there were significant associations between individual feelings as well as between individual products or services and whether the participant kept bees or not, I applied Wilcoxon rank-sum tests. I then grouped positive and negative sentiments and tested for significant differences between beekeepers' and non-beekeepers' responses using the same type of tests. I assessed whether there was a significant difference in how beekeepers valued diverse types of products and services compared to non-beekeepers also by applying Wilcoxon rank-sum tests. I then grouped different forest products and services according to what type of ecosystem service they would fall under, i.e. regulating, provisioning or cultural types. To reveal the nature of any association between beekeeping and the valuing of forest products/services I used the same type of tests again. I assessed the relationship between beekeeping and the preference for more or less forest near the community by using a logistic regression model.

As a proxy for perceived control of conservation behaviour I compared the degree to which beekeepers and non-beekeepers differed in their perceived influence over resource use decisions in the community. I applied Wilcoxon rank-sum tests to determine if there were statistically significant differences in how beekeepers and non-beekeepers agreed to diverse statements about natural resource management decision power. I used Wilcoxon rank-sum tests to assess potential associations between beekeeping and combined positive and negative power statements.

To estimate if the intensity of involvement in beekeeping showed any indication of an effect on pro-conservation behaviour factors, I performed the above-mentioned tests and regression analyses on two different beekeeping categories, i.e. beekeepers owning more or less than 20 hives. As the number of hives owned by beekeepers can also serve as a proxy for their relative wealth, this analysis also identified any potential associations between beekeepers' socio-economic status and factors contributing to pro-conservation behaviour (Lowore 2018). I performed the above-mentioned statistical tests only for variables where the number of observations was large enough to produce statistically valid results. This was only the case for the number of different forest products collected, the preference for more or less forest near the community as well as for whether trees/woodlots were cleared or planted in the five years preceding the study.

In order to further differentiate beekeepers, I also tested if gender or age (below or above 50 years) of beekeepers had any effect on factors contributing to pro-conservation behaviour. However, the number of observations for some of the levels of predictor variables for these different beekeeping classes were low ($n < 10$). The reliability of the results is thus lower than for the results of the entire sample (beekeepers and non-beekeepers).

As access and use rights to forest resources differed between study communities I also tested if beekeepers differed significantly in their attitudes, values, and perceived decision-making power in the four communities. As observation numbers at each level of a variable were low, I grouped positive and negative statements on sentiments and decision-making power together. For the same reason I grouped the valuation of ecosystem services and products into the categories 'provisioning', 'regulating' and 'cultural'.

To analyse the qualitative data, I coded the interview and group transcripts both deductively and inductively in accordance with my research questions and extracted themes as they occurred (Ritchie, Lewis et al. 2013). I adjusted my coding framework continuously throughout this process as new themes emerged during the analysis. The purpose of the coding was to elicit and interpret substantive meanings in the data regarding forest use behaviour, perceptions of forest change due to beekeeping as well as power relations and potential conflicts among different livelihood groups regarding forest use and natural resource management decisions. The results and implications of this qualitative data analysis are used to annotate the results and discussion sections of this study.

5.4. Results

The following sub-sections are structured according to the four research questions (i.e. forest use, forest perceptions and attitudes, valuation of forest products and services, perceived influence in forest use decisions), with forest perception and valuation combined under one heading.

5.4.1. Forest use behaviour

While beekeepers did not harvest a larger number of different forest product types on average than non-beekeepers, they were more likely to collect five or more products than non-beekeepers (Table 5.1). Older beekeepers were however more likely to collect less than five types of forest products than their younger peers (Chi-square test: p-value = 0.04). This age-related phenomenon was also observed in the main sample including beekeepers and non-beekeepers. The number of different product types harvested was statistically not significantly different for male and female beekeepers, nor for beekeepers belonging to different wealth classes (based on number of hives owned).

Table 5. 1. - Estimated parameters of the ordinary linear regression model for the number of different forest products harvested and logistic regression model for the likelihood of harvesting more than five different forest product types (standard errors in brackets)

	Number of different product types harvested - linear model	**More or less than five products harvested – logistic model**
Intercept	3.51 (0.22)***	-1.53 (0.20)***
Beekeeping y/n	0.20 (0.32)	0.54 (0.27)*

Levels of significance: * 5%, *** 0.1%

In the 12 months preceding the study, beekeepers visited the forest significantly more often than non-beekeepers (Kruskal-Wallis test, p-value = 0.02) (Figure 5.1).

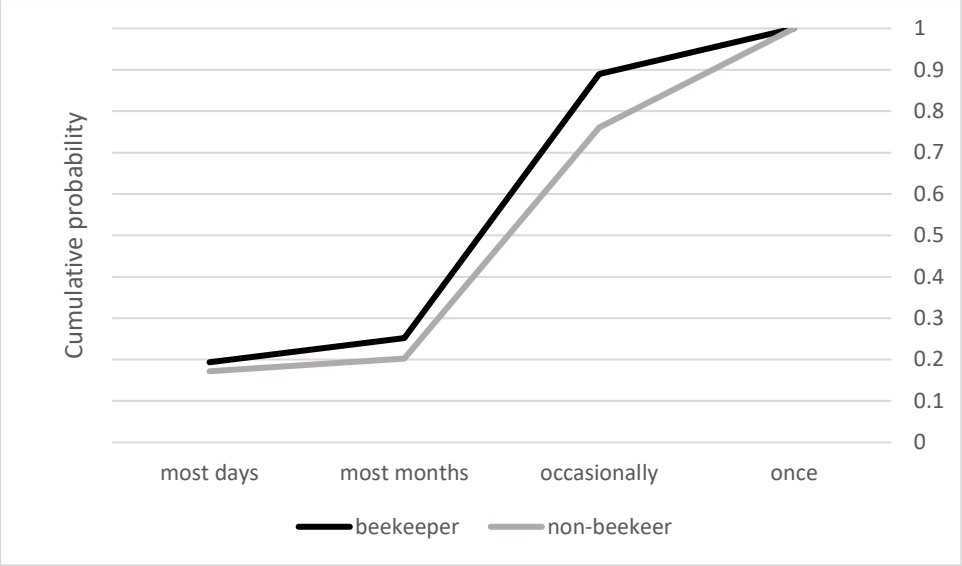


Figure 5. 1. - Cumulative probability of forest visit frequency in the 12 months preceding the study (data was recorded numerically: 1=once, 2=occasionally, 3=most months, 4= most days)

Compared to non-beekepers the odds of visiting the forest more than once rose by a factor of 2.55 (odds ratio of visiting more than once obtained through logistic regression) if the study participant kept bees (Table 5.2). Many of the beekeepers interviewed indicated that they no longer used the forest to site their hives, preferring to place them in trees around their farms for both security and convenience.

> *"I keep bees on my farm, on the boundary there are trees, that's where I placed the hives. […] I have two places; one is near my cropland. The other place is called 'nzizi', where people keep cows. It's like bushes and trees. I chose the big trees to put the hives there." (Beekeeper from Sasilo)*

Some beekeepers also argued that bee forage was more consistently available near farmland as opposed to forests. Other beekeepers rejected the idea that beekeeping was possible outside of the forest. The opinions were also divided on the impact of forest fragmentation and degradation on beekeeping. Some beekeepers indicated to have moved their hives away from forests after its degradation became too intense. Others said that there was enough forage left in these forests and thus had left their hives there.

No statistical indication of an influence of relative wealth, gender, or age of beekeepers on the frequency of their forest visits could be detected.

Table 5. 2. - Estimated parameters of ordered logistic regression with and without assumption of proportional odds for the association between the frequency of forest visits and beekeeping

	Intercept			Slope		
	Coefficient	**SE**	**z value**	**Coefficient**	**SE**	**z value**
Proportional odds assumed						
Visiting more than most months	-1.794	0.192	0.001***	0.536	0.224	2.391*
Visiting more than occasionally	-1.521	0.183	0.001***	0.536	0.224	2.391*
Visiting more than once	1.296	0.175	0.001***	0.536	0.224	2.391*
Proportional odds not assumed						
Visiting more than most months	-1.573	0.208	-7.575***	0.146	0.291	0.502
Visiting more than occasionally	-1.371	0.110	-7.034***	1.182	0.331	1.045
Visiting more than once	1.157	0.184	6.301***	1.165	0.277	2.967**

Levels of significance: * 5%, ** 1%, *** 0.1%

Beekeepers were significantly more likely to plant trees and woodlots than non-beekeepers (Table 5.3). While beekeepers owned more land than non-beekeepers, the area of land owned by a farmer did not determine whether they had planted any trees or woodlots in the five years preceding the study (Logistic regression: p-value = 0.405).

Table 5. 3. - Estimated parameters of logistic regression describing the association between beekeeping and the probability of planting woodlots and trees in the five years preceding the study

	Coefficient	**SE**	**z value**
Intercept	-0.934	0.174	-5.364***
Beekeeping y/n	0.817	0.237	3.448***

Levels of significance: *** 0.1%

Compared to non-beekeepers, beekeepers did not indicate significantly different reasons for planting trees and woodlots (Chi-square test: p-value = 0.433). The three most important reasons for planting were the establishment of trees for domestic use, the increase of land value and the provision of firewood, fodder, timber, and poles for domestic use (Figure 5.2).

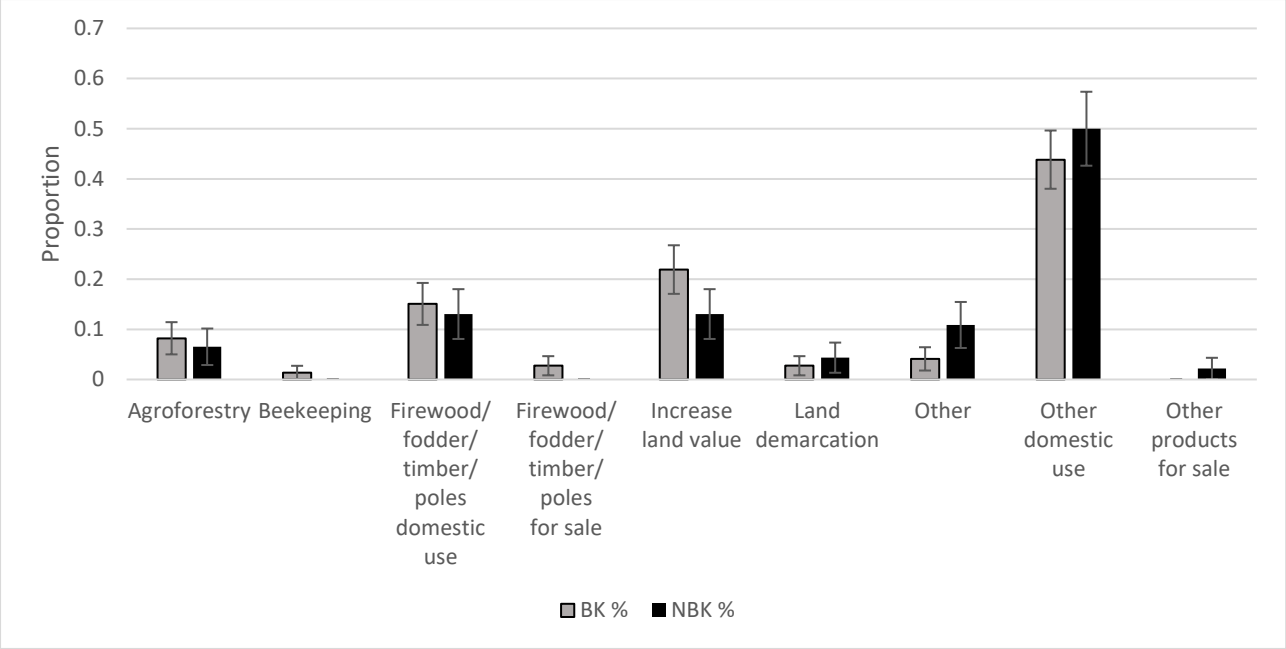


Figure 5. 2. - Proportion of beekeepers and non-beekeepers who planted trees disaggregated by primary reasons for planting woodlots/trees in the five years preceding the study , error bars indicate standard errors (199 of 318 respondents did not plant trees during this period).

Significantly more beekeepers than non-beekeepers indicated to have cleared forests in the five years preceding the study (Table 5.4). The area of land owned did not seem to influence whether someone had cleared land in the past or not. No statistical indication of an influence of relative wealth, gender or age of beekeepers could be detected on whether beekeepers had planted or cleared forested land in the past or on the reasons behind the of planting trees or woodlots.

Table 5. 4. - Estimated parameters of logistic regression describing the association between beekeeping and the probability of having cleared woodlots and trees in the five years preceding the study

	Coefficient	**SE**	**z value**
Intercept	-1.225	0.187	-6.553***
Beekeeping y/n	0.683	0.250	2.729**

Levels of significance: ** 1%, *** 0.1%

Interview data suggests that illegal forest use such as cutting fresh branches to be used as firewood is widely performed out of necessity by non-beekeepers and beekeepers alike. Individuals in both interviewed groups indicated that trees with hives in them were left

untouched. This was explained to be due to respect towards hives marking some form of investment or ownership of the tree by someone as well as due to a fear of the bees. Many interview respondents indicated that trees in a certain radius around trees with hives in them were generally also left untouched. The radius mentioned varied between respondents.

> *"They are aware that tree belongs to the person who put his hives there. So, another person can never touch that. […] Those trees which are very close to the hive are not touched. If they want to cut those trees, they have to seek permission from the person who owns the hive. Trees that are very far from hive are allowed to be cut without permission." (Beekeeper from Kwa Mtoro)*

However, not everyone viewed the security of hive trees in the same way:

> *"In general, some of the pastoralists and farmers don't value beekeeping activities. They regard beekeeping as an activity that has no value, so when they see a hive in a tree, they can cut the tree down, even if the hives break, they don't care. If the owner of that hive seeks advice from the government officials, they found no response has been taken, no penalty for the person who did it." (Non-beekeeper from Sasilo)*

Forests which were used as bee reserves, i.e. protected from most uses other than beekeeping had seen an improvement in forest condition in the ten years preceding the study according to all interview participants. These reserves were mostly used by organised beekeeping groups using modern hives, usually donated by external beekeeping support organisations.

> *"In those areas where they used to put the modern hives the group people [beekeeping group members], there is some improvement in the forest. Now there are so many beehives there and people do not go there to do anything, so the forest is a little bit improved." (Beekeeper from Msemembo)*

Most interviewed beekeepers and non-beekeepers indicated that the state of forests on general land without use and access restrictions had degraded during the same time period due to more intense use by the communities. Beekeepers, mostly working as individuals, who had placed their hives in these forests were being pushed out to give way to other, more dominant uses such as farming and grazing.

Lastly, honey hunters indicated that to obtain honey, they regularly engaged in potentially destructive forest behaviour by setting fires under trees to smoke out the bees or even cutting down entire trees to access the honey stores.

5.4.2. Attitudes towards the forest

Significantly more beekeepers than non-beekeepers experienced overall positive feelings (average of level of agreement with 'close to nature', 'relaxed', 'happy', 'uplifted', 'in touch with the past' and 'secure' statements) when spending time in the forest (Wilcoxon rank-sum test: p - value = <0.001) (Table 5.5).

Table 5. 5. - Means and two-sample Wilcoxon rank-sum tests of levels of agreement (1 = strongly disagree, 5 = strongly agree; standard errors in brackets) with statements about sentiments experienced in the forest by beekeepers and non-beekeepers

	Beekeepers μ (SE)	**Non-beekeepers μ (SE)**	**W value**
Worried	3.31 (0.135)	3.58 (0.131)	11360
Claustrophobic	3.19 (0.132)	3.58 (0.112)	11242
Bored	3.31 (0.117)	3.23 (0.122)	12834
Close to nature	3.88 (0.095)	3.64 (0.100)	13990
Relaxed	3.44 (0.118)	3.05 (0.122)	14295*
Afraid of trespassing	4.35 (0.086)	4.48 (0.070)	12190
Afraid of wildlife	4.02 (0.106)	3.97 (0.108)	12760
Happy	3.18 (0.121)	2.43 (0.117)	16019***
Vulnerable	3.80 (0.121)	3.78 (0.120)	12614
Uneasy	3.79 (0.110)	3.84 (0.108)	12372
Uplifted/revived	3.57 (0.106)	2.91 (0.110)	15998***
In touch with the past	3.35 (0.111)	3.10 (0.107)	13956
Secure	2.25 (0.124)	2.21 (0.122)	12891

Levels of significance: * 5%, ** 1%, *** 0.1%

There was no significant difference in overall negative sentiments (average of level of agreement with 'afraid of trespassing', 'afraid of wildlife', 'bored', 'claustrophobic', 'uneasy', 'vulnerable', 'worried when alone' statements) experienced. When looking at differences in individual sentiments beekeepers felt happier, more uplifted, and more relaxed than non-

beekeepers when spending time in the forest, whereas the two groups felt equally close to nature, in touch with the past and secure (Figure 5.3).

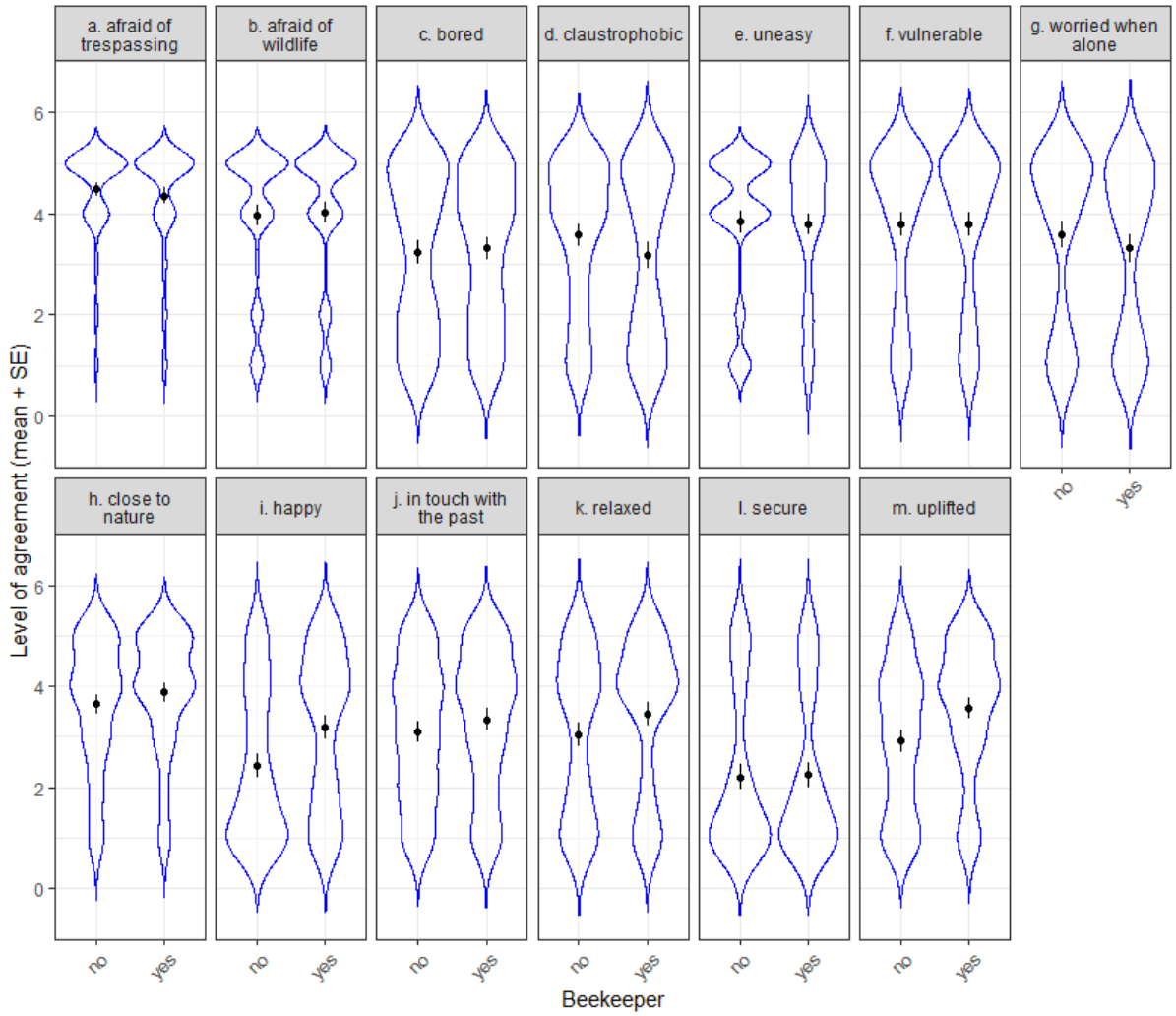


Figure 5. 3. - Distribution, probability density (rotated kernel density plot on each side), means and standard errors of levels of agreement (1 = strongly disagree, 5 = strongly agree) to statements about sentiments experienced in the forest by beekeepers and non-beekeepers (top row = negative sentiments, bottom row = positive sentiments).

No statistical indication could be detected of an influence of beekeepers' relative wealth, gender or age on their sentiments experienced in the forest. A statistically significant difference in positive feelings experienced was observed between the beekeepers of Kwa Mtoro and Sasilo (p-value = 0.032), with the latter scoring lowest and the former scoring highest among the four communities. There was no statistical difference between overall negative sentiments experienced by beekeepers in the four villages.

There were significant differences in how beekeepers and non-beekeepers valued the importance of the following products and services forests can provide: honey, fodder, medicine, charcoal, scenic beauty, and conservation (Table 5.6, Figure 5.4).No product or service was valued significantly higher by non-beekeepers.

Table 5. 6. - Means and two-sample Wilcoxon rank-sum tests of importance values (standard error in brackets) given to forest products and services (1 = not very important, 5 = very important) by beekeepers and non-beekeepers

	Beekeepers μ (SE)	**Non-beekeepers μ (SE)**	**W value**
Biodiversity	4.52 (0.050)	4.48 (0.053)	12859
Fodder	4.26 (0.077)	4.05 (0.083)	14076*
Tradition	4.02 (0.087)	3.80 (0.095)	13820
Climate	4.45 (0.055	4.50 (0.048)	12269
Conservation	4.68 (0.039)	4.50 (0.050)	14408**
Honey	4.83 (0.030)	4.58 (0.055)	14880***
Relaxation	4.25 (0.740)	4.30 (0.057)	12714
Fruits	4.21 (0.075)	4.21 (0.076)	12430
Bushmeat	2.89 (0.119)	2.93 (0.117)	12432
Scenic beauty	4.46 (0.060)	4.20 (0.076)	14398**
Medicine	4.15 (0.085)	3.89 (0.095)	14189*
Water	4.75 (0.036)	4.77 (0.037)	12272
Firewood	4.72 (0.039)	4.74 (0.038)	12292
Spirituality	3.39 (0.116)	3.20 (0.115)	13637
Charcoal	3.86 (0.101)	4.11 (0.090)	11058*
Timber	4.16 (0.094)	4.09 (0.098)	12918

Levels of significance: * 5%, ** 1%, *** 0.1%

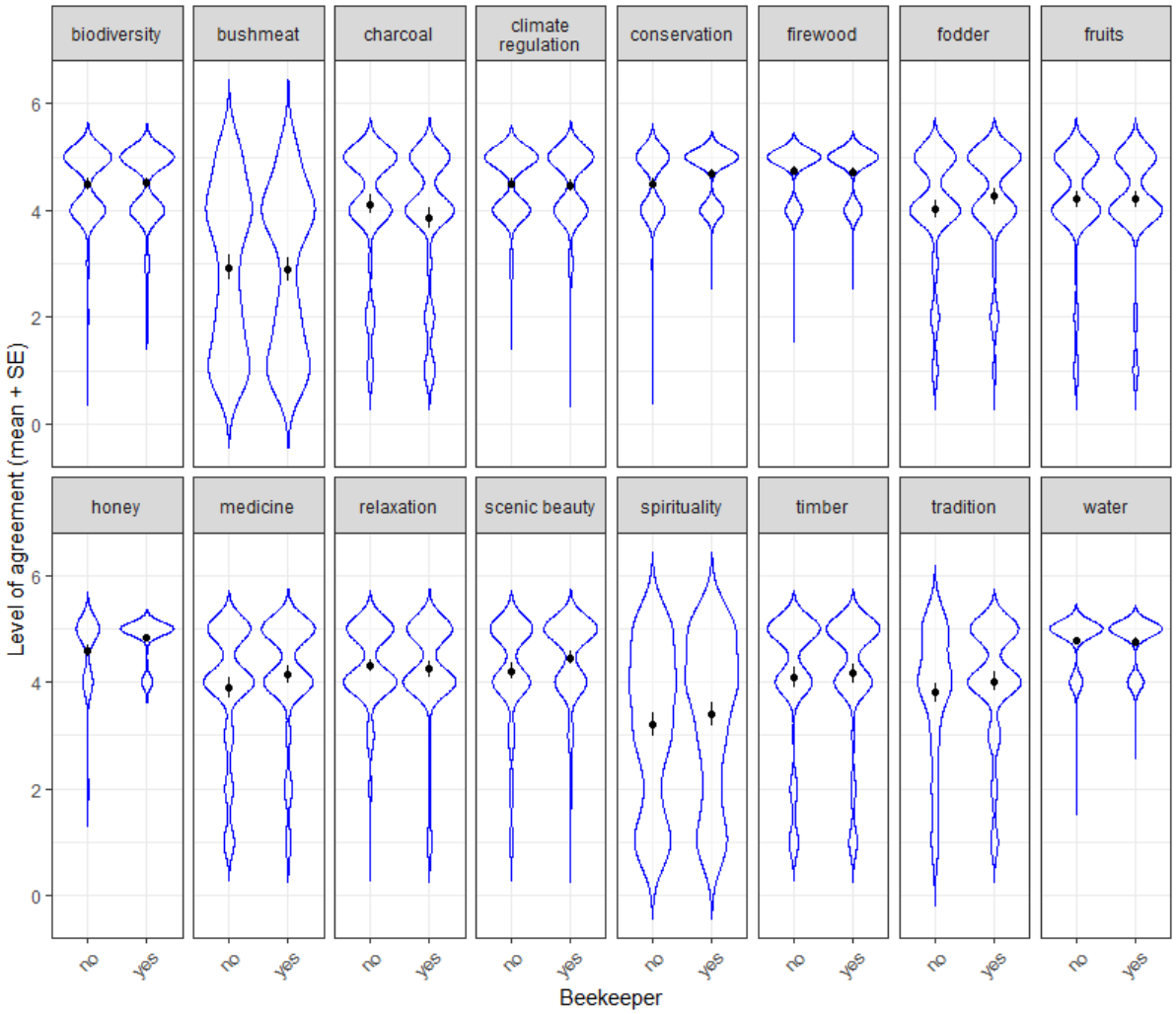


Figure 5. 4. - Distribution, probability density (rotated kernel density plot on each side), means and standard errors of levels of importance (1 = not important at all, 5 = very important) given to different forest products and services by beekeepers and non-beekeepers.

Male beekeepers were more likely to value the climate regulating ecosystem service of forests (p-value = 0.018) as well as the provision of fodder (p-value = 0.012) higher than female beekeepers. Both of these differences for female and male participants' valuation of fodder and the climate regulating service of forests were also observed in the main sample including beekeepers and non-beekeepers. There was no statistically significant difference in the valuation of other forest products or ecosystem services between the genders. Age and relative wealth of beekeepers did not influence the valuation of forest products and services.

Some interview participants thought that beekeepers were particularly drawn to pro-conservation behaviour as their livelihood depended on trees:

"Because honey cannot be found if there are no trees. So, cutting of trees is a challenge. So, the beekeepers are the first in the conservation of the forest. I feel bad when I see trees being cut down because honey provision depends on trees." (Beekeeper from Kwa Mtoro)

In support of this point, one interviewee reported that a beekeeping group which he was a member of, was involved in efforts to educate others to not cut down trees where beekeepers placed hives. While some interviewed non-beekeepers also indicated to be in favour of protecting forest resources, they also stated to engage in activities which were forbidden in forests reserved for beekeeping.

"It [reserving forest areas for beekeeping use only] *is good because I will not be completely restricted from using that forest, but I can go there to collect dry firewood and sometimes can go and take medicine, it is fine.* […] *In the case of village forest, it is correct that it is restricted. But we still used to go there illegally and take medicine, cutting some few trees for construction. But it was allocated to beekeeping, we were just using the back door." (Non-beekeeper from Sasilo)*

Both groups indicated a preference for more forested areas in close proximity to the community. Regression analysis revealed that a higher proportion of beekeepers than non-beekeepers preferred more forests nearby (Table 5.7). The intensity to which a beekeeper was involved in beekeeping, i.e. the number of hives they possessed, did not appear to make any difference to whether they preferred to have more or less forest close by. Neither did their age, gender, or village association.

Table 5. 7. - Estimated parameters of logistic regression describing the association between beekeeping and preference for more (rather than less) forested areas close to the community

	Coefficient	**SE**	**z value**
Intercept	1.261	0.189	6.677***
Beekeeping y/n	0.769	0.314	2.450*

Levels of significance: * 5%, *** 0.1%

5.4.3. Perceived control over natural resource management decisions

My survey data suggests that the majority of beekeepers thought that the current management of forests available to the community is beneficial for beekeeping activities (Table 5.8, Figure 5.5a).

Table 5. 8. - Means and two-sample Wilcoxon rank-sum tests of levels of agreement (1 = strongly disagree, 5 = strongly agree) with statements about perceived decision-making power in natural resource management questions

	Beekeepers μ (SE)	**Non-beekeepers μ (SE)**	**W value**
The current management/way of use of the forest is good for beekeeping. (Only beekeepers were presented with this statement.)	3.85 (0.126)	NA	NA
I am happy with the way my community in general manages and uses the forest I have access to and can use.	4.33 (0.104)	4.22 (0.101)	13535
My opinions on the management of the village land are respected by my community.	4.19 (0.095)	4.00 (0.103)	13350
I often feel frustrated with the way my community uses its land resources.	3.50 (0.125)	3.49 (0.123)	12702
I don't have a lot of power when it comes to decisions over the use of village land.	3.97 (0.109)	4.23 (0.097)	11238
What I personally think about how our village land should be used is not important in my community.	1.55 (0.073)	1.71 (0.086)	12036

Most beekeepers and non-beekeepers were happy with how the community forest was managed. In contradiction with this finding, most respondents of both groups also expressed some level of frustration over how the community used its land resources. There were no significant differences in respondents' perceptions of how much their opinions on village land management questions were respected, how much decision-making power they held over land use decisions or how important their thoughts about land use decisions were within their communities (Table 5.8, Figure 5.5b-f). When averaging positive and negative power statements separately (Wilcoxon rank-sum tests), there was no significant difference between the two groups. This was also the case when beekeepers were compared across villages.

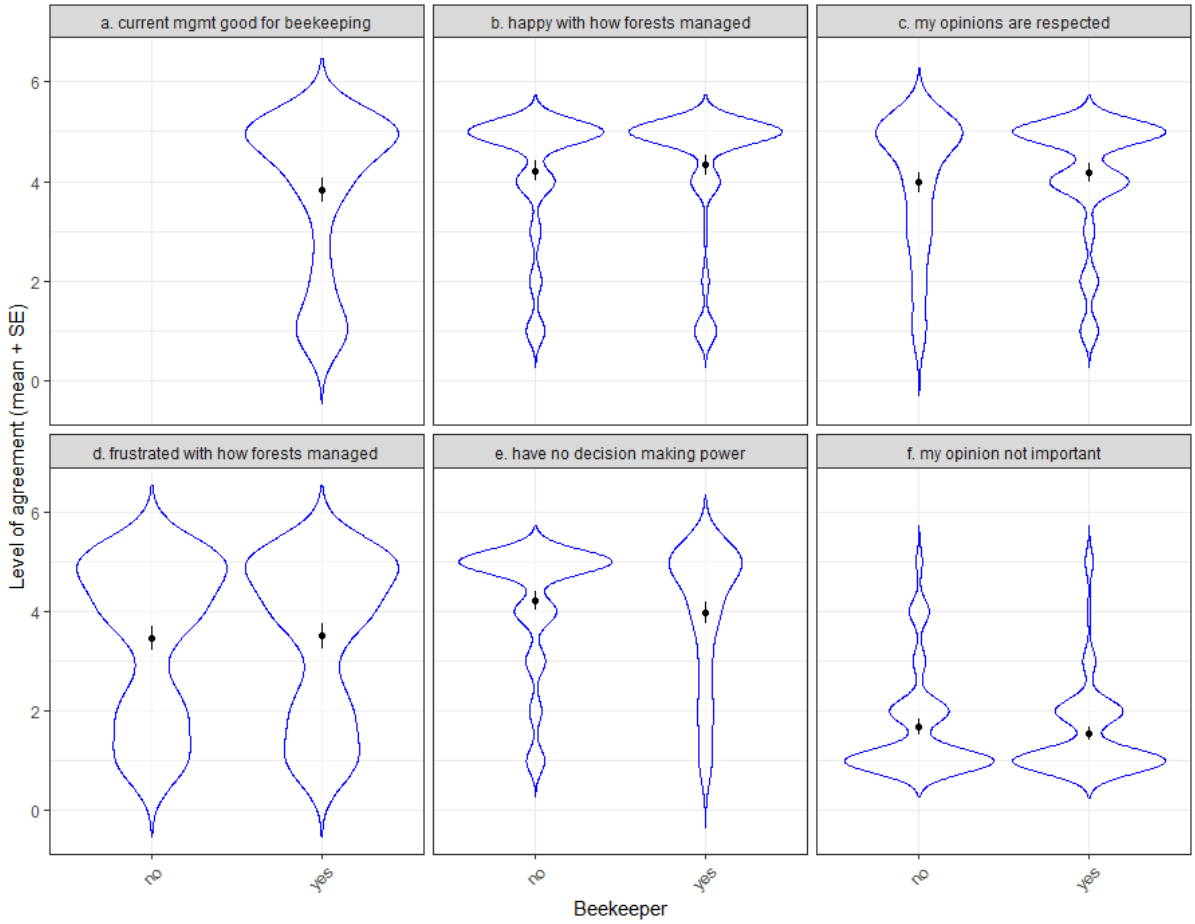


Figure 5. 5. - Distribution, probability density, means and standard errors of levels of agreement (1 = strongly disagree, 5 = strongly agree) to different statements about perceived natural resource decision making power by beekeepers and non-beekeepers.

Differences in perceived decision-making power were not statistically different for the beekeeping sample subdivided according to gender, age, and relative wealth. This was with the exception of age and the level of agreement to one specific power-related statement: fewer of the older beekeepers felt that their opinion on forest use decisions was important compared to their younger peers (p-value = 0.006). This age-related phenomenon was not repeated in the main sample including both beekeepers and non-beekeepers.

In interviews, beekeepers as well as non-beekeepers stated that beekeepers were often less powerful in staking a claim on space and use of forest resources compared to more dominant uses such as agriculture and livestock keeping. Other interviewees gave an opposing account of beekeepers' influence in their communities:

"When it comes to village decision, beekeepers are sometimes more active, and they have power in decision making." (Beekeeper from Msemembo)

Interview data also suggests that some non-beekeepers were unhappy with forests being reserved for beekeeping to the exclusion of non-beekeepers and their forest resource needs:

"There are conflicts, because at the place where hives were placed in the reserved forest, it used to be places/farms of people. After law was set that place needed to be reserved it created conflict with those people who were owners of that forest areas." (Non-beekeeper from Msemembo).

Comparing the qualitative data on occurrences of land use conflicts involving beekeepers, the two communities with the least available forest resources, Sasilo and Kwa Mtoro, stood out as the sites where most study participants reported clashes, some of them involving physical harm to hives and even to beekeepers. In the case of Sasilo, beekeepers were not able to protect a forest reserve allocated to them from grazing and had to subsequently abandon beekeeping on this land altogether (see 1.4.3.2). In Kwa Mtoro beekeeping had a larger influence on how available forest resources were managed as it was one of only very few uses allowed. While beekeepers in Kwa Mtoro, at least those associated in beekeeping groups, were able to gain official access to adjacent game reserves, this was not the case for beekeepers in Sasilo (see 1.4.3.2.).

5.5. Discussion

Beekeeping is an often-used component of many linked conservation and development projects, promoted with the aim of poverty alleviation coupled with forest conservation (FAO 2011, World Bank 2015a). There is a growing amount of data on the effects of beekeeping on livelihoods (Amulen, D'Haese et al. 2017, Wagner, Meilby et al. 2019). While the narrative of the beekeeper as the steward of the forest is well established in LCDA project documents, there is a lack of scientific evidence of the effects of beekeeping on conservation goals. This is of particular significance as beekeeping is promoted as a sustainable land use type eligible for REDD+ funding (UN-REDD 2012, URT 2013).

In order to understand the associations between beekeeping and conservation behaviour, it is critical to understand what influences this behaviour. This paper is an attempt to bridge the evidence gap on environmental behaviour of beekeepers by exploring the association between beekeeping and conservation motivations as well as the perceived empowerment of beekeepers over natural resource management decisions in their communities. While I do not establish a direct causal relationship between actual conservation behaviour and beekeeping, the results of this study inform about critical aspects of the link beekeepers have with the forest and about the patterns of influence of beekeepers over natural resource management decisions. Both factors can play a significant role in the success of conservation projects, which rely on beekeeping as a forest-friendly livelihood activity.

5.5.1. The beekeeper as a forest user

My results on the forest use of beekeepers give mixed indications of any existing basis for conservation motivations:

While I found that beekeepers and non-beekeepers harvested a similar number of different types of forest products, beekeepers were more likely to harvest five or more products than non-beekeepers. This means that the overall forest use intensity for forest product collection is very similar for the two groups, but the collection behaviour of beekeepers tended to be more diversified. This could indicate a more diversified knowledge of the forest and the diverse products it can offer (Whiteman and Cooper 2000). While greater ecological

knowledge is not necessarily a direct determinant of conservation motivation, it can contribute to it (Schultz 2011). As the observation of older beekeepers harvesting less different types of forest products was repeated in the main sample, i.e. older beekeeping as well as non-beekeeping study participants harvested less different types of products, I cannot link this observation with engagement in beekeeping. The differences between age groups could be linked to several of the products study participants could list being used in house construction[9].

The fact that African hives are often placed in the forest would be a logical explanation for why beekeepers in the study tended to visit the forest more often than non-beekeepers (Nightingale 1976). My interview data suggests however that beekeepers do not necessarily practice beekeeping in forests anymore. Wagner *et al*. (2019) found that the threat of hive theft in forests forced many beekeepers to keep their bees on agricultural land. The slightly higher frequency of forest visits observed for beekeepers might thus be also explained by their more diversified forest product harvesting habits. In poor countries, such as Tanzania, where annual hours worked per capita tend to be higher than in developed countries, i.e. where time spent is more precious, time investment in a particular location, in our case the forest, can indicate a larger livelihood dependence on the respective location. An increased dependence on forests could also imply a greater propensity for its conservation (Persha, Agrawal et al. 2011, Ramcilovic-Suominen, Matero et al. 2013).

When looking at stated conservation behaviour by the study participants I found that beekeepers were more likely to both plant and clear forests, thus likely cancelling out any potential positive conservation impacts of forest planting. My supposition that this could be explained by beekeepers owning more land than non-beekeepers, thus having greater use rights in forests, was not validated by my models. Consequently, I cannot find an association between beekeeping and direct, stated conservation behaviour.

I need to place a caveat on these findings, however, as asking people about their forest clearing activity can be a sensitive topic where clearing is illegal and there is thus potential for participants to hide their real activities (Fisher 1993). Further, due to the location of study

[9] This is an activity that older community members are less likely to be engaged in than younger generations whose housing is more frequently of lower quality and thus potentially requiring more repairs and improvements (Tusting, Bisanzio et al. 2019).

communities in a miombo context, local community members did not necessarily have to plant trees in order to obtain a range of forest products. This is because of the vigorous regeneration capacity through coppicing associated with miombo species.

I did not observe a significant difference in the reasons given by beekeepers and non-beekeepers for planting trees either. While the most important reason named was 'other domestic use', through triangulation with the other choice possibilities in the questionnaire and relevant literature I deduced that most likely 'other domestic use' referred to the planting of fruit trees for home consumption (Warner 1997, Aalbaek 2001). The similarity of reasons for planting suggests that overall forest or tree use requirements are very similar between the two groups. Similar tree use needs might indicate no difference in the basis for conservation motivation between beekeepers and non-beekeepers.

The above observations give a mixed picture of beekeepers' stake in forests and thus their potential reasons to display conservation behaviour. When the risk of theft drives beekeepers to site hives outside of forests, the direct link between forests and beekeeping and thus potential forest conservation incentives of beekeeping is severed. The introduction of modern beekeeping systems through external beekeeping interventions has also been found to play a role in the delinking of beekeepers from the forest (Zocchi, Volpato et al. 2020), thus undermining the cultural links beekeepers might hold with forest conservation. I suggest that livelihood projects promoting beekeeping with a conservation aim need to consider that the engagement in beekeeping alone might not necessarily be associated with pro-conservation motivations and that additional measures, such as awareness raising, or formal protection might need to be put in place to achieve project conservation goals (Brocklesby 2002).

My interview data suggests that illegal forest activities, such as cutting down parts of or even entire trees to be used as firewood were pursued by non-beekeepers and beekeepers alike. This confirms the proposition by Waylen *et al.* (2010) that local context matters when it comes to conservation behaviour. I propose that LCDA projects using beekeeping as a means to discourage forest degrading behaviour will only provide conservation success, if the chosen location and context allows for local communities to avoid forest destructive behaviour.

Further, and contrary to the prevailing narrative of the beekeeper as a forest steward, Wagner *et al.* (2019) found that beekeepers were also likely to be honeyhunters. This suggests that

domestic beekeeping may not preclude potentially harmful forest resource use practices such as the smoking out and destroying of wild bee colonies, damaging trees, and increasing forest fire risk during the collection of wild honey (Okoye and Agwu 2008, Dietemann, Pirk et al. 2009). Wagner et al. (2019) also found that whether an individual was a beekeeper or not was also to some extent contingent on them keeping livestock. Beekeepers are thus often also engaged in livestock keeping, which has been claimed by several interviewed beekeepers to have adverse effects on beekeeping due to its impact on forest resources and disturbances created by livestock grazing near apiaries. Sievanen et al. (2005) found that when new livelihood activities are introduced to a community, people may just add the activity to their portfolio without dropping environmentally damaging activities. When beekeeping is promoted as a livelihood activity with a view towards incentivising conservation, I suggest that beekeeping is often just one part of rural livelihood portfolios, which does not necessarily produce desired conservation outcomes.

Lastly, my qualitative data points to an interesting phenomenon, which St John et al. (2010) call a "happy consequence of taboo, and not the result of an innate desire to conserve biodiversity": the protection by the local communities of trees located adjacent to forest apiaries. It suggests an indirect impact of beekeeping on forest resources, which is not linked to any benefits obtained from beekeeping by the beekeeper him/herself. The study did not allow for an in-depth analysis of the impacts of this phenomenon on the forests at study sites. However, this tree protection mechanism, i.e. the sparing of trees carrying hives from felling was reported at all four sites, suggesting that it is a systematic occurrence. I thus suggest that its impacts on forest resources deserve further scientific exploration.

5.5.2. Forest attitudes and values

I compared beekeepers' and non-beekeepers' values and attitudes towards the forest, as these influence forest use behaviour (Ramcilovic-Suominen, Matero et al. 2013). Newhouse (1990) refers to attitude as "positive/negative feelings about a person/object/issue". In the study both groups experienced negative sentiments to similar degrees while spending time in the forest. This is perhaps a reflection of the nature of Tanzanian forests and the dangers they can pose to humans due to contact with wildlife and insect transmitted diseases (Lawton

1982). But a larger proportion of beekeepers also experienced positive feelings (happy, relaxed, uplifted) when spending time in the forest, thus displaying generally more positive attitudes toward the forest. In comparing beekeepers across the four study sites, the biggest and statistically significant difference in positive feelings experienced was between beekeepers in Kwa Mtoro and those in Sasilo. This is perhaps a reflection of the long tradition that links the Sandawe people, the ethnic majority of Kwa Mtoro, to beekeeping and thus time spent in the forest. One could thus surmise that supporting forest beekeeping, as a means to incentivise conservation behaviour, might be best directed at beneficiaries who have cultural links to spending time in the forest (Wagner, Meilby et al. 2019).

Despite the dangers Tanzanian forests and woodlands can pose to local communities, the majority of both groups – beekeepers and non-beekeepers – preferred to have more forested areas in close proximity to the community for ease of access. A larger proportion of beekeepers than non-beekeepers declared a preference for more forests close to the community, thus exhibiting a slightly higher tendency of affinity with the forest.

While beekeepers valued some products and services higher than non-beekeepers, none were valued significantly higher by non-beekeepers than beekeepers, suggesting a higher appreciation of the benefits of forests in general by the latter group. Conservation as well as scenic beauty were valued higher by beekeepers than non-beekeepers, possibly pointing to beekeepers being more likely to possess an intrinsic conservation motivation compared to non-beekeepers. It could also be due to having previously participated in a beekeeping support project in the framework of which awareness raising for the importance of forest conservation might have taken place. Chervier *et al.* (2019) suggest that a closer relatedness with nature influences individual environmental behaviours. While an appreciation of the scenic beauty of forests could be representative of a feeling of nature relatedness, other services that could fall in this category (i.e. spirituality, tradition, relaxation) were not valued higher by beekeepers than non-beekeepers.

My observation of male beekeepers valuing the forest for the provision of fodder higher than female beekeepers could be explained by the fact that while women are more often responsible for the collection of fodder, men more often take on the marketing of this product (Kiptot, Franzel et al. 2014). As this gender related phenomenon was observed also in the

general sample including beekeepers as well as non-beekeepers, it is not possible to link it to the engagement in beekeeping.

A gendered access to environmental knowledge though rural extension services, training and awareness raising, such as often conducted as part of beekeeping support projects (Nightingale 2006) could explain why male beekeepers valued the climate regulating forest ecosystem service higher than their female peers. However, proportionally more female beekeepers had received beekeeping training than male beekeepers in the study communities. Information on other types of awareness raising measures - with potentially higher male participation - at the study sites was not available. Furthermore, this gender related difference in the valuation of forests' climate regulating service was mirrored in the general sample, including beekeepers and non-beekeepers, and could thus not be linked with an engagement in beekeeping.

The above observations point towards a slightly higher existing intrinsic motivation for conservation by beekeepers. This confirms the notion of beekeepers being more inclined to act as stewards of forest resources. My findings show only small differences between beekeepers' and non-beekeepers' forest values and attitudes and thus in their potential intrinsic conservation motivations. If intrinsic conservation motivations exist, there is a risk of crowding these out by introducing economic incentives for conservation, such as through the commercialisation of beekeeping products (Rode, Gómez-Baggethun et al. 2015). Wunder (2003) proposes that economic incentives for conservation can contribute the most to the latter where collective, intrinsic conservation values are weak. I suggest that before beekeeping projects aimed at incentivising conservation are implemented, baseline assessments of existing conservation motivations are conducted to exclude a potential crowding-out of intrinsic motivations.

While attitudes and values can influence behaviour, measures of attitude and behaviour match more directly when they correspond in terms of the context, target, action, and time dimension (Cialdini, Petty et al. 1981). Nevertheless, the same authors have also found that general conservation attitudes, which were not matched with specific actions, can in some instances predict conservation behaviours. Beekeeping projects aiming at incentivising forest conservation generally lack concrete definitions of the conservation actions they are intended to target. I was thus limited to measuring general attitudes of beekeepers toward the forest

and therefore cannot link specific conservation behaviour to beekeeping. I concur with St John *et al.* (2010) in recommending defined targeted behaviour outcomes of conservation projects by describing the objective, context, and time scale in order to better understand the predictors of the respective behaviour. Once a specific behaviour to be targeted by the conservation intervention is defined, further factors influencing this behaviour such as subjective norms as well as local facilitating factors can and should be assessed (St John, Edwards-Jones et al. 2010).

My findings give support to the recommendation of Lowore *et al*. (2018) to be judicious in stating the potential of beekeeping benefits to deter local communities from forest destructive practices. Lowore *et al*. (2018) also point out however that evidence of beekeepers acting as stewards of the forests they use for beekeeping purposes exists. The results of this study also reflect a predisposition of beekeepers towards conservation practices. More work is necessary to assess under which conditions these pro-conservation dispositions of beekeepers translate into pro-conservation behaviour. Brocklesby (2002) points out that the analysis of resource use behaviour should be founded on an understanding of the values placed on different products and livelihood activities locally. She further concludes that self-selection for inclusion of beneficiaries in a beekeeping intervention ignores this necessary analysis and is thus not appropriate for guaranteeing the integration of conservation and development objectives (Brocklesby 2002).

5.5.3. Perceived power over forest use decisions

The influence of beekeepers over forest resource use was inconclusive. The quantitative data indicated no difference between how powerful beekeepers and non-beekeepers perceived themselves to be. Noteworthy is that both groups felt that while they did not have de facto decision-making power within their communities their opinion on natural resource management decisions was, in their own view, not unimportant. My qualitative results suggest a more mixed picture with some participants ascribing more power to beekeepers and others more to non-beekeepers in land use conflict situations. This could indicate that forest access and power in natural resource management decision-making processes are individualised and not tied to beekeeping as an activity. As an illustration, some beekeepers

are able to access bee reserves which offer better protected land with higher availability of bee forage than open forests and where non-beekeepers do not have use rights. But there is also evidence that only beekeepers who have integrated themselves into organised groups and have received official recognition as an association have access to these reserved forests (Wagner, Meilby et al. 2019).

My observation that older beekeepers perceived themselves to be more excluded in decision making processes than younger beekeepers or their non-beekeeping age cohort was rendered less conclusive by the fact that other statements on perceived decision-making power did not show differences for different age groups. The result could however reflect a stronger marginalisation of older beekeepers compared to younger beekeepers in their communities. While anecdotal evidence for this exists (J. Msuya, personal communication, 14th July 2015), a more detailed examination of this tendency could provide useful insights into the ability of beekeepers to influence resource use decisions within their communities.

Evidence of beekeepers' influence in land use decisions within their communities provides us with a mixed picture. In locations with abundant forest resources (Msemembo and Paranga) study participants reported fewer incidences of conflict around forest access and use than participants in the two communities with more limited resource availability (Sasilo and Kwa Mtoro). The latter two communities differed significantly in their ethnic composition and thus cultural links to beekeeping. Where these traditional ties exist, beekeepers seem to have more rights to the protection of forest resources that their beekeeping activities depend on, as well as more access to otherwise strictly reserved forested land, at least when they are associated in an official beekeeping group.

Conservation success of LCDAs is ultimately determined by a range of local and external factors. Elliott and Sumba (2011) sum up that long-term positive changes in conservation outcomes are likely to be "negotiated, agreed and contracted". In connection with this the authors point out the significance of enabling community institutions to plan, govern, manage, and monitor conservation actions effectively (Elliott and Sumba 2011). In a recent review of 136 LCDA-type projects for common features of interventions that produced win-win outcomes, Brooks (2017) confirmed the importance of local participation.

Mickels-Kokwe (2006) rightly points out that beekeepers are only one type of forest users among many others and their potential willingness to conserve forest resources might not be matched with actual power to do so. I thus suggest that unless there is some form of official protection, such as the establishment of a bee reserve provided for forested land, there is no guarantee that the promotion of beekeeping alone will contribute much to the conservation of forests. Interventions that focus only on behaviour change cannot be sustainable, where such institutional support is absent, leaving participants powerless in their conservation will (St John, Keane et al. 2013).

5.6. Conclusion

I evaluated factors contributing to pro-conservation behaviours in order to gauge whether LCDA projects promoting beekeeping have the potential to deliver conservation results. For this I explored the association between beekeeping and conservation motivations by examining beekeepers' forest use behaviours as well as their forest values and attitudes. As an important additional factor influencing actual behaviour, I assessed the perceived empowerment of beekeepers over natural resource management decisions in their communities.

I found that beekeepers' forest use was more diverse and more frequent compared to non-beekeepers', indicating larger ecological knowledge and dependence on the forest. But I also discovered beekeeping partially disassociated with forest use as well as an engagement in forest degrading activities by beekeepers and non-beekeepers alike. I suggest that additional conservation measures such as awareness raising, or formal protection might be necessary in the context of LCDA projects to achieve conservation success. I recommend taking into consideration local contexts of where projects are planned to ensure local communities are able to engage in conservation behaviour without having to compromise on the procurement of their daily needs. Finally, in the context of the actual forest use behaviour I encountered, I suggest that the protection of hive trees and trees in the vicinity of tree apiaries merits further scientific enquiry.

My study revealed beekeepers to have more positive attitudes towards the forest and to value it more for the conservation benefits it provides, suggesting an augmented intrinsic

conservation motivation of beekeepers. The differences in beekeepers' forest attitudes and values compared to non-beekeepers' were however modest. I recommend that baseline assessments of conservation motivations before beekeeping based LCDA projects are implemented are carried out. This is necessary to establish the level of pre-existing intrinsic motivations within the community and to preclude crowding-out of these by introducing extrinsic motivations, such as income through beekeeping. Furthermore, a more specific definition of the conservation behaviour these projects aim to influence is needed to better understand which factors might influence the specific behaviour. This would also allow for a more precise evaluation of the conservation success of these projects.

Finally, I found that any potential willingness of beekeepers to conserve and protect forest resources might not correspond with their actual power to do so. I thus conclude that instead of only focusing on changing forest use behaviour, the establishment of institutional support for conservation action needs to form part of LCDA project objectives.

6. DISCUSSION

Beekeeping is widely promoted in Tanzania and other developing countries as a forest-friendly livelihood activity (ICIPE 2013, BTC 2016, FAO 2016a, UNDP 2016a). This support is based on the assumption that beekeeping contributes positively to household wellbeing and thus provides an incentive to local communities for forest conservation. Despite the many projects aiming to support beekeeping development in Africa over the past 50 years, beekeeping has not developed as anticipated. Many projects fail to generate widespread tangible livelihood or conservation benefits. Overall, there is a lack of evidence on the contribution of beekeeping to poverty alleviation and conservation. Beekeeping seems to offer enough benefits for approximately five percent of the Tanzanian population to choose to be engaged in the activity (Hausser and Mpuya 2004). While the reliability of such an estimate is debatable - especially in light of the previously discussed potential to misidentify someone as 'beekeeper' or 'non-beekeeper' (see Section 2.3.1 of this thesis) - it still merits questions on how significant these benefits are and whether spending on beekeeping development represented was a worthy investment.

This study is an attempt at filling an evidence gap regarding wellbeing and conservation incentive assumptions in the context of beekeeping. For this, I applied a mixed-methods approach using group discussions, a household survey as well as semi-structured interviews. Data was analysed by means of descriptive statistics, regression modelling and qualitative data analysis methods. The overall aim of this study was to evaluate the efficacy of beekeeping interventions as a means that links livelihood and forest conservation.

In this chapter I present my key findings and their potential application in future LCDAs promoting beekeeping as a forest-friendly livelihood activity, limitations of the study as well as suggestions for further research on the topic.

6.1. Key findings

6.1.1. Socio-economic characteristics of beekeeping households in Central Tanzania

Numerous development agencies support beekeeping to alleviate rural poverty and fill income gaps in the agricultural year by providing training and beekeeping equipment to selected beneficiaries. There is a lack of robust evidence on the overall effects of beekeeping on household wellbeing and on whether the targeting and delivery of these interventions are adequate to promote beekeeping as a sustainable activity.

In Chapter 3 I identified predictors of beekeeping adoption, dependence and success using regression analysis of household survey data as well as qualitative analysis of group and interview data. I found that the main motivation behind beekeeping adoption was the provision of subsistence and cash income. Lack of land, capital and beekeeping knowledge were inhibiting factors for adoption. I also found that beekeeping training by governmental organisations did not have the intended effect of increased honey yields. Additionally, as training and equipment donations are usually linked with the requirement of forming beekeeping associations, elite capture and the creation of ensuing ill feelings within communities are a possibility. Lastly, male beekeepers were more successful than their female counterparts.

In Chapter 4 I assessed whether beekeepers were enjoying a higher quality of life than other non-beekeeping community members. I also assessed whether beekeeping was effective in bridging shortage periods in the agricultural year. I did this by repeating the methodology applied in Chapter 3 on a different set of variables. I found an association between beekeeping and improvements in food security and domestic water supply, higher resilience as well as larger value of farm- and non-farm assets. The effects I observed were skewed towards the benefit of male study participants. I found that the seasonal distribution of beekeeping benefits did not allow beekeepers to fully bridge an income and subsistence gap during the agricultural year.

Beekeeping in the context of this study takes the form of an additional income and subsistence source for a rural population that otherwise faces a scarcity of income generation

opportunities. The positive association beekeeping had with food security and domestic water supply are of particular relevance where food insecurity and lack of access to clean water are prevalent. Beekeepers' availing of a larger asset base was a positive indication of its contribution to rural wellbeing.

The findings of Chapter 3 and 4 are useful in providing guidance on how the selection of beneficiaries and project implementation need to be designed to accommodate local specificities and the needs of local communities. They can further help in creating realistic expectations as to what kind of wellbeing benefits beekeeping can potentially deliver to project beneficiaries. My findings offer a clear indication of demonstratable reasons why a not insignificant number of Tanzanians is involved in beekeeping activities: cultural and familial tradition in beekeeping, limited alternative income generation potential in rural settings, limited alternative productive uses of prevalent ecological zones such as miombo, increased food security as well as better access to key basic services and the acquisition of household assets afforded through the sale of bee products.

6.1.2. Effect of beekeeping on resource use values and behaviour

The narrative of the beekeeper as a conservative forest user is well established in LCDA project documents and other project justifications yet lacks substantive evidence. This lack of substantiation has important implications as beekeeping is listed as one of a handful of land uses which are eligible for funding through REDD+.

In Chapter 5 I assessed the associations between beekeeping and forest conservation by testing and modelling factors contributing to conservation behaviour, such as habitual forest use, perceptions, attitudes, values, and perceived behavioural control. I found that beekeeping was linked to more intensive use of the forest, more positive attitudes toward the forest as well as a stronger appreciation of conservation benefits. Further, tradition and cultural proximity to beekeeping might imply a more conservation positive inclination. The difference between beekeepers and non-beekeepers in all these aspects were generally modest. I found that even if beekeepers were more inclined to have pro-conservation attitudes, their ability to conserve and or protect forests from harmful uses were mitigated

by their limited power within their communities' decision-making processes over the use of forest resources.

Limited and mostly anecdotal evidence of beekeepers acting as stewards of forest resources was partially confirmed in this study through the higher affinity of beekeepers towards forest conservation. This finding comes with caveats including a diminishing link between beekeeping and the forest due to deforestation, forest degradation and a tendency of establishing apiaries closer to villages to e.g. avoid theft; the potential investment of beekeeping gains into livestock and thus contribution to increasing grazing pressure on forests as well as the engagement in honey hunting and other potentially forest degrading, extractive activities.

These findings are critical in furthering understanding of what additional measures need to be put in place, if LCDAs using beekeeping are to have a positive impact on conservation behaviour within target communities.

Lastly, I discovered a conservation-relevant phenomenon of trees being spared from being cut down, if they carried beehives in their crowns or were in the direct vicinity of hive-carrying trees. This observation could not be further analysed within the scope of this research. While it does not necessarily lead to forest conservation at a landscape scale, the origin, extent, and implications of this phenomenon merit scientific attention.

6.2. Lessons learned and their application in linked conservation and development interventions using beekeeping

The appeal of beekeeping as a poverty alleviation and conservation tool is evidenced in the number of LCDAs in the context of which it is promoted by development and conservation organisations (ICIPE 2013, BTC 2016, SNV 2016b, UNDP 2016b). Yet the complexity of interventions aimed at modifying peoples' livelihood strategies and forest use behaviour (Wright, Hill et al. 2016) as well as a lack of substantive evidence of livelihood and conservation impacts of LCDAs (Roe, Booker et al. 2015) raises questions regarding the effectiveness of promoting beekeeping in these linked interventions.

I have found some evidence of associations between improved livelihoods or positive conservation motivation with beekeeping in the context of this study. But I also point out key lessons learned and several areas of possible improvements to the manner in which beekeeping is typically promoted in the Tanzanian context. They are summarised as follows.

6.2.1. Availability of beekeeping resources to ensure sustainability

Access to suitable land, its availability, proximity, use rights and implications are discussed from different angles throughout the study: as a determinant of adoption, abandoning and rejection of and dependence on beekeeping. I also examined if beekeeping had an effect on land ownership or vice versa. While the results of this study indicate that beekeepers tended to own more land than non-beekeepers, causality for this observation could not be established. Contrary to the suggestions of some authors (Nel, Illgner et al. 2000), I found that access to land suitable for beekeeping purposes, was a determinant of involvement and success in beekeeping from the following perspectives: availability of bee fodder and hive material, security of hives from theft, legal access rights and distance required to travel to pursuit beekeeping. While these observations could be limited to conditions at the case study sites, they provide an important indication of potential prerequisites for successful beekeeping interventions in the Tanzanian context.

I propose that the sustainability of beekeeping promotion could be further improved by ensuring long-term access to land suitable for beekeeping for project beneficiaries. This could be in the form of designated beekeeping forests and reserves, such as is already practiced in selected locations in Tanzania. As I observed conflict over preferential treatment of externally trained, formally associated beekeepers in being granted access to reserved forest resources, it is critical to allow reserve access to all beekeepers in the community. User rules which are established in a transparent manner and are followed up on by local authorities could prevent potential conflicts between individual reserve users and beekeepers associated in a group.

Equally important is the availability of resources for hive making. I saw beekeepers struggling to access suitable trees for the construction of locally prevalent log hives and having to invest more time than previously in obtaining these materials. External beekeeping interventions aiming to promote locally prevalent techniques of beekeeping need to be purposefully

planned around the availability of resources, rather than assumptions that such materials are readily available and free.

The observed difficulties in obtaining hive construction material coincides with several accounts of diminishing floral resources for bee fodder. While this was to some extent attributed to drought conditions prior to the study, deforestation and forest degradation also seemed to play a substantial role in this. An assessment of the bee carrying capacity of the area beekeeping interventions are implemented in could play an important role in developing a realistic understanding of the extent to which rural populations could benefit from beekeeping. One of the frequently mentioned arguments for grouping together beekeepers is an assumed improvement in market access through economies of scale (Carroll, Davey et al. 2017). But my results suggest that without baseline studies of the availability of sufficient bee forage to be able to produce the yields necessary to access more profitable markets, this assumption creates only false hope.

Protected areas for beekeeping could counter the observed issue of hive theft as it would allow for easier monitoring of hives as well as pre-empt the necessity to steal hives from other beekeepers by providing secure access to forest resources for hive construction. Evidence from this study suggests that hives placed in such designated areas are less likely to be stolen.

6.2.2. Improved targeting and delivery of beekeeping support to minimise attrition

Abandonment of beekeeping activities after having received external beekeeping training being a relatively frequent phenomenon among beekeeping support project beneficiaries, the question of appropriate targeting of beneficiaries is important (Carroll, Davey et al. 2017). In Chapter 3 I found that tribal and familial tradition in beekeeping as well as engagement in honey hunting and livestock keeping were important factors in determining beekeeping uptake. Cultural proximity and tradition in beekeeping seemed to also influence intrinsic conservation motivations positively. Self-selection of project beneficiaries was common at all study locations. This does not necessarily ensure that the most appropriate candidates are targeted from the perspective of maximising wellbeing and conservation outcomes of the

intervention. I thus suggest that projects aimed at community members whose cultural background and livelihood strategies are conducive to beekeeping adoption are more likely to succeed in the long term. In order to achieve development and conservation goals, beneficiary selection should be founded on an awareness of how local community members value different products and livelihood activities.

If beekeeping is to be used as a conservation enhancing activity, conservation targets as well as desired conservation behaviours need to be more concretely defined than is currently the case in the majority of LCDAs relying on beekeeping (St John, Edwards-Jones et al. 2010). This should include the timing, objective, and context of individual conservation actions.

Clearly defined outcome indicators of beekeeping promoting projects would help project teams as well as participant beneficiaries to monitor project achievements and manage expectations. Concrete targeting of desired outcomes and moderation of all involved stakeholders' expectations of intervention outcomes could counter project attrition and foster participation.

Like most rural capacity building efforts, beekeeping projects require beneficiaries to form associations before receiving training or equipment (Affognon, Kingori et al. 2015, Carroll, Davey et al. 2017). I found a mismatch between beneficiaries' expectations towards the advantages of beekeeping group membership such as e.g. the creation of economies of scale as well as the sharing of responsibilities around apiaries and the benefits they deliver. Additionally, as evidenced by my data, the process of selecting beneficiaries to become group members has the potential to create envy and feelings of exclusion among other community members. I thus propose that a more thorough advertisement of project participation and transparent beneficiary selection within the community is necessary in order to minimise destabilisation of existing community dynamics.

The association of beekeepers into groups is often encouraged as it purportedly assists individual beekeepers in pooling together their harvests and market their products in bulk. With economies of scale and access to markets outside village boundaries, where higher prices can be achieved, beekeepers are given the prospect of achieving marketing benefits by collective cooperation. However, I found that the beekeeping groups in the study communities rarely managed to establish these wider marketing links and were mostly reliant

on intervening organisations to establish and maintain these connections. To render beekeeping more profitable I propose that projects should be aimed at establishing long-term connections between beekeepers and more profitable value chains for bee products that can continue to exist once the project team leaves.

6.2.3. Expanded capacity building of appropriate techniques for better livelihood outcomes

Most beekeeping interventions are based on training in beekeeping techniques (Amulen, D'Haese et al. 2017). The hypothesis that more beekeeping training equalled higher levels of wellbeing could not be confirmed by my data. Given that lack of beekeeping knowledge was one of the limiting factors for beekeeping adoption, it is evident that the technical capacity requirements for beekeeping adoption and success are not trivial. While there are a small number of organisations implementing beekeeping interventions in consideration of locally appropriate systems and training local trainers to achieve sustainable knowledge transfer and follow up, they are in the minority.

In Chapter 3 I found training delivered by government organisations particularly ineffective in building beekeeping capacities to increase yields and conclude that beekeeping training by most development organisations needs to be improved, expanded, and designed to be appropriate for the local context. Regardless of its duration and content, external beekeeping training did not lead to improved harvests or increased wellbeing compared to beekeeping apprenticeships and local knowledge transfer within the family and community. The reasons for this could be that most external training was conducted within short time frames, with little practical content and without any follow up training. By contrast, local training facilitated the asking and answering of technical questions as and when they arose during the beekeeping seasons (Hecklé, Smith et al. 2018). Most beekeepers who had received external training were trained for a maximum of three days and recalled only the most basic techniques.

Another important reason could be that the techniques taught were not appropriate for the local setting (Amulen, D'Haese et al. 2017). While I could not find evidence of fixed-frame

hives being distributed through external beekeeping interventions in the study communities in the recent years prior to the study, several beekeepers had received training on the management of moveable comb-hives, which were also distributed in conjunction with the training. The management of these and the beekeeping system, equipment, and expenses they entail differ significantly from local systems involving log or other types of fixed-comb hives. They are therefore not always appropriate in the setting they are promoted in (Carroll, Davey et al. 2017).

In order to be of use for local communities, training should be tailored to complement pre-existing, traditional beekeeping knowledge and match locally given specificities of climate, terrain, and vegetation. I also propose that capacity building should not just be a one-off event but be given regular follow-up at least during the first year of a newly trained beekeeper's activity. In order to increase community acceptance and to reduce costs of follow-up, training could be conducted in cooperation with locally successful beekeeping champions rather than just external organisations' staff members.

The donation of modern hives is also done with the aim of generating a trickle-down effect from project beneficiaries to their respective wider communities in the form of more local beekeepers adopting modern hive technology over time (Carroll, Davey et al. 2017). However, I found the lack of capital to purchase hives or hive materials an inhibiting factor for beekeepers. I suggest that the potential of scaling up technological benefits from beekeeping intervention which are based on modern hives is thus limited. Capacity building in hive construction from freely available materials could enhance the scaling up.

While the donation of modern hives can be problematic, I propose that providing local beekeepers with access to complementary assets such as adequate honey storage equipment as well as protective equipment could support beekeepers in storing their harvests until their sale could coincide with and counter agricultural shortage periods and improve beekeeping uptake where fear or bees is the main constraint.

6.2.4. Baseline assessments and institutional support for enhanced conservation effects

In Chapter 4 I examined several determinants of conservation behaviour among beekeepers. The results suggest that engagement in beekeeping might not necessarily be associated with pro-conservation behaviour. This can be due to several factors: a. a lack of association between forests and beekeeping, b. out of necessity to perform natural resource degrading activities to meet basic household needs, c. because of the performance of other chosen livelihood activities that are resource degrading and/or d. because of the lack of power over natural resource use decisions in the community. I suggest that additional measures might be needed in order to advance conservation goals of LCDAs relying on beekeeping. These could take the form of awareness raising campaigns or the establishment of formal protection for certain forests. This corresponds with the conclusion of St John *et al.* (2013) that targeting behavioural change alone might not lead to achieving the desired conservation outcomes. Institutional development allowing local communities to partake in conservation decisions and to act on pro-conservation motivations should be pursued in parallel. I also conclude, in concurrence with Waylen *et al.* (2010), that when designing livelihood interventions, a thorough understanding of the local context, local people's prevalent livelihood strategies as well as availability of sufficient resources for them to meet their basic needs should be the basis for planning.

Lastly, the introduction of economic incentives for conservation, such as income from beekeeping, might crowd out existing intrinsic conservation motivations in rural communities. Care needs to be taken to assess any pre-existing motivations before new incentives are initiated. Rode *et al.* (2015) find that guidance and methods to carry out such scoping studies are yet to be developed by the conservation community.

6.3. Limitations of the study

6.3.1. Methodological approach

It is surprising that differences between beekeepers' and non-beekeepers' livelihoods and conservation behaviour observed in this study were relatively small, given the portrayal of

the benefits of beekeeping in anecdotal evidence and grey literature. The following section provides a reflective assessment of how these comparatively modest effects are likely to be linked to the methodology chosen in this study.

The majority of data was collected through a standardised household survey. While surveys can provide a useful snapshot of quantifiable indicators of a large sample of study participants at a given moment in time and thus may represent characteristics of a larger population, they also have drawbacks. These pose limitations to interpreting the data obtained in this study. In situations where the researcher does not share the cultural background of the study community, as was the case in this study, key terms and concepts used in a survey may lead to misinterpretation of meaning between the researcher and the individual participants. Relying on native speakers to act as enumerators, as I did, can exacerbate miscommunication by introducing a third person with their own particular perceptions and interpretations into the data collection process. Indeed, we encountered several instances were survey participants interpreted key questions on their affiliation as beekeepers or non-beekeepers differently to our expectations. Since this may be critical to the analysis of differences between the two groups, false association can potentially distort results.

Surveys can also provide a false sense of precision, in particular where unique stories and experiences are forced into numbers. Constructing quantitative indicators on complex social phenomena - such as the 'sense of empowerment', as done in this study to gauge the decision-making power of study participants - is likely to capture a partial picture. Establishing a binary beekeeper/non-beekeeper category may fail to capture the complex reality in rural Tanzania as community members can be engaged in different levels of beekeeping activity, thus impacting the study result validity.

The short period in which the enumerator interacted with a survey participant – about one hour in the case of this study – probably curtailed the scope of information collected due to a lack of opportunity for respondents to express a more nuanced representation of their reality.

Furthermore, survey participants may have felt that they need to answer certain questions in a particular way or omit information in order to potentially gain benefits or avoid sanctions (e.g. for illegal behaviour). Throughout the data collection process our research team was

compelled to reiterate our independence and the nature of our questions as some study participants mistook us for representatives of governmental bodies, donor agencies or NGOs. While we attempted to correct false perceptions of our roles as researchers, the possibility that survey participants omitted certain information or provided answers that were inconsistent with their actual behaviour is a possibility. This is especially the case where questions touched on potentially illegal behaviour or the ownership of certain assets that might be subject to government licences.

Data collection took place over a relatively brief period of time with approximately four weeks spent in each study community. This prohibited *in-situ* observation of individual households who were instead interviewed at a central location in the village. During visits to individual homes much richer data on their socio-economic condition may have been gathered, thus providing an opportunity to triangulate survey data and develop a more nuanced understanding of community characteristics, processes, institutions and social norms which limit or enable behaviour motivation.

Through the analysis of qualitative data gathered through interviews and group discussions an attempt was made to triangulate survey data and to capture more facets of phenomena relating to the research questions. While these tools can provide an opportunity to collect rich data on individual experiences, perceptions and values they also have their drawbacks related to subjectivity, replicability and problems of generalisation. They also provide only fleeting contact with study participants, thus prohibiting a deeper understanding of individual experiences, to shine a light on particular matters which are taken for granted by study participants or to encounter phenomena not previously expected and thus included in the question catalogue. Particularly in group discussion settings participants might be more reticent to provide input (e.g. in our group discussions younger community members were particularly shy to contribute to the conversation) or to express views which are culturally unacceptable. Particularly outspoken group members may also inhibit the surfacing of dissenting opinions.

Lastly, conducting interviews using simultaneous translation introduced the potential for distortion or omission. While I was aware of this happening during the earlier phase of the field work, my ability to identify these instances and clarify what the interviewee had said, improved only gradually with my language skills growing during my stay in the communities.

Nevertheless, without being fluent in locally spoken languages there remained a substantial risk for misrepresentation and misinterpretation during the translation process.

Overall, the results of this study need to be read in conjunction with the above-described caveats based on the limitations of the study methodology. It is conceivable that the benefits of beekeeping on wellbeing and conservation motivations are much larger, yet not captured in the data collected for this study. It is also possible that engagement in beekeeping provides a relatively easily available supplement to local livelihood portfolios where alternative means of income generation and subsistence provision are limited. The large number of Tanzanians engaged in beekeeping speak for significant individually perceived benefits, thus supporting the assumption that the study methodology was not fully adequate in capturing these.

The above listed methodological shortcomings for this study could have been avoided by using an approach with more intense immersion in the social setting of the study communities. In the evaluation of the results of this study in has become clear that data collection through participant observation over an extended period of time would have allowed for a more nuanced understanding of the complexity of local people's approaches to beekeeping, the benefits gained from it, their attitudes towards conservation and their actual forest use behaviour. Observing actual behaviour of community members would have also allowed to capture phenomena, which are taken for granted by local people and thus perhaps not expressed in an interview setting. Spending more prolonged periods of time in the study communities would have allowed me to develop a deeper appreciation of the context of people's behaviour, of how key terminology was interpreted in the local setting and would have permitted me to identify key informants within the communities. The latter could then have been invited to be interviewed on issues not easily observable. Through an ongoing interaction of with community members, key informants could have also developed an appreciation of the research questions under examination and directed me to the discovery of further relevant sources of information advancing the investigation.

In hindsight, participant observation and key informant interviews before the development of the household survey would have perhaps allowed for the development of a more salient questionnaire tailored to the reality of community members. This would have permitted a more refined analysis of differences between socio-economic and behavioural determinants of people engaged in different ways in beekeeping. Further, by spending more prolonged time

in the communities and conducting interviews in person, without having to rely on translation, may have avoided some of the issues concerning cultural and context-specific misconceptions and misinterpretations. Nevertheless, limitations regarding the simplification of phenomena through the use of a quantitative approach may have remained.

Lastly, a comparative study design examining two contrasting cases using identical methods (e.g. beekeeping communities in different vegetation zones) could have helped to better understand the processes that lay behind the adoption of beekeeping as an additional livelihood activity, its socio-economic consequences and resulting forest use behaviours.

6.3.2. Sampling approach

In order to minimise compounding factors of specific conditions at study locations, I selected communities that were as similar as possible in terms of populations size, distance to major roads and markets as well as access to forest resources. Yet, no two communities ever display the exact same characteristics, as is also the case in this study (Table 1.1). Besides the differences I attempted to control for, differences in history, ethnic composition, background of village leadership personnel are among the factors I could not control for, but which could influence community members' experiences, attitudes, decisions, and behaviours.

At the community level I attempted to minimise social bias with a stratified random sampling approach using village registries as the basis. While these registries were kept regularly up to date, the latest information on community-members living on the physical boundaries of the village may have been not always accurate. Ethical standards allowed only household heads over 18 years of age to participate in the study. In reality, there might be younger household heads, who were omitted from the sample. The implication might be that poorer households of the communities were not included in the study.

For the purpose of this study a distinction needed to be made between participants who could be classified as beekeepers or as non-beekeepers. I based the definition of these two groups on the ownership of hives at the time of data collection. This was to be able reduce the complexity of the phenomenon of 'engagement in beekeeping' to a level appropriate for statistical analysis. In reality, it is conceivable, that some participants who had indicated to

own hives, had in reality never used them for beekeeping. However, responses to beekeeping related survey questions by all participants who were categorised as beekeepers indicated a greater than zero level of practical beekeeping experience. The opposite, namely a participant indicating to not own hives yet being involved in beekeeping as a labourer for example, was also possible. The implication of this definition decision is that both samples could have included a number of false affiliations. While the number of these was estimated to be small, it is impossible to verify *ex-post* the real incidence rate of divergent interpretation of these terms. It is therefore conceivable that the lack of observed difference between 'beekeepers' and 'non-beekeepers' is due to this 'watering down' of the samples. It is thus indeed possible that bigger differences exist between the wellbeing and conservation behaviour of beekeepers and non-beekeepers.

6.3.3. Establishing causality between beekeeping and livelihood benefits and conservation impacts

While I could assess correlation between engagement in beekeeping and different livelihood aspects, establishing causality was not possible. This would have involved assessing a baseline before participants began with their beekeeping activities and re-assessing the same indicators at a later time. The time limitations of a PhD research did not allow for such a before and after study set up. Where possible I triangulated survey data with qualitative data to learn about the livelihood benefits participants themselves attributed to beekeeping. In order to assess the exact contribution of beekeeping to household wealth, more time would have been needed to set up a panel survey recording all household input and outputs at regular intervals.

Similarly, a panel survey of forest resource use by beekeeping and non-beekeeping households, like the Poverty and Environment Network (PEN) survey, would have allowed for a more detailed understanding of differences associated with beekeeping. I was not able to assess the direct impacts of engagement in beekeeping on forest conservation either. For this a baseline assessment of forest condition before and once beekeeping activities were established would have been necessary. As beekeepers tended to move their hives in and out of different forests within their communities, it was not possible to identify a forest previously untouched by beekeeping activity. As beekeeping promoting LCDAs do not usually identify

concrete conservation goals or concrete target behaviours, the assessment of factors contributing to forest use behaviour had to be kept at a general level. If more concrete target behaviours were known, the application of the TPB approach could have yielded a more detailed picture of beekeepers' potential pro-conservation behaviour.

6.3.4. Impact evaluation of past beekeeping projects

All studied communities had a history of having received external beekeeping support in the two decades preceding the study. I was not able to find information on activities carried out through these projects other than what former participants recalled of them. Neither did I have access to any baseline assessments that former project teams may have compiled on beneficiary livelihoods or forest conditions. It was thus not feasible to conduct an impact evaluation of these past projects from a livelihood and conservation perspective. For this to be possible, baseline studies before and after project implementation at the actual project site as well as at a control site would have been necessary. Due to the limited timeframe of the PhD research and the longer timeframe of most beekeeping promoting projects, this was not within the scope of this study.

6.3.5. Effect of drought conditions on study results

As described in the introduction to this thesis, the study region suffered severe drought in the three years prior to data collection. This affected negatively not only agricultural outputs, but also beekeepers' harvests due to a lack of floral resources. The analysis of factors contributing to beekeeping success was based on the quantity of hive products beekeepers had harvested in the twelve months preceding the study. The results of this analysis thus need to be viewed in the context of severe drought conditions and with the understanding that they represent the success of beekeepers within one year, rather than over a longer period of time. While prolonged drought does not characterise the typical conditions beekeepers in the study region have to operate in, the climate crisis is predicted to make the reoccurrence of extreme climate events more frequent. In light of the promotion of beekeeping as a means to bridge shortages during the agricultural year, an analysis of how beekeeping benefits are obtained and used in contrast with income and subsistence derived through other rural livelihood

activities in the context of prolonged droughts could yield important insights. Unfortunately, this type of analysis was beyond the scope of this study.

6.3.6. Study location in an intermediary beekeeping zone

The study took place in two regions of Tanzania where beekeeping is practiced by a relatively large proportion of the local population, but still not to the same extent as in other regions of Tanzania (e.g. Tabora Region), where beekeeping is more widespread and pursued with much greater intensity. The maximum number of hives a beekeeper owned in the study communities was below 100, in Tabora this can often be a four-digit number (Fisher 1997a). This has implications for the level of dependence on beekeeping as well as the benefits beekeeping can provide. It also has implications in the motivation to conserve forest resources as well as on power relations between beekeepers and their fellow community members.

The study location was selected purposefully to provide an illustration of the association of beekeeping with wellbeing and conservation aspects, in a type of location that receives external beekeeping interventions. The aim was to provide an overview of beekeeping in a situation where it competes with other dominant land uses.

6.4. Further research

Based on my findings as well as the above identified limitations of this study, several areas for further research on the topic of beekeeping as a development and conservation tool present themselves. I have summarised these below.

The past four decades have seen a vast number of beekeeping projects implemented all over the developing world. A systematic review of their effectiveness to raise wellbeing and to contribute to conservation efforts could shed light of how useful these efforts have been and provide important lessons for future LCDAs promoting beekeeping.

Widespread beekeeping support is also based on the notion of an untapped potential of Tanzanian and African beekeeping, as mentioned by numerous authors (Kihwele 1985,

Mickels-Kokwe 2006, Carroll and Kinsella 2013). There is a lack of substantive evidence of the availability of sufficient bee forage necessary to produce the estimated potential yields. Indeed, the planning of beekeeping support projects would significantly benefit from conducting baseline studies indicating how many bee colonies the project area might be able to support. Studies of the melliferous potential of different plant compositions exist in developed countries (Porter 1978, Jablonski and Koltowski 2005, Jarić, Mačukanović-Jocić et al. 2013), but detailed studies of the honey yield potential of miombo species and compositions are thus far lacking.

Many beekeeping support projects foresee the donation of beehives to project beneficiaries. This and other studies (Amulen, D'Haese et al. 2017, Carroll, Davey et al. 2017) find that insufficient technical knowledge is being transferred through the capacity development which accompanies these donations. In parallel, I found formal extension services for beekeeping to be ineffective. Further studies could estimate the benefits of investing a part of project budgets into organisations that can provide extension services versus investing in the donation of more hives to beneficiaries. Additionally, assessment of beekeeping skills when trained externally versus locally through family or community members could be conducted. The results could indicate how extension services could improve their capacity building strategies. To optimise capacity building efforts generally, randomised control trials of beekeeping success with different training lengths, modes, content, follow-up, and hive donation strategies would be useful.

Commonly, Tanzanian beekeeping support is aimed at modernising beekeeping at a large scale. The suitability of modern beekeeping systems to local honeybee races, vegetation and climate has not been explored sufficiently. Further studies could assess the sustainability, productivity, harvest quality, costs, marketability of honey bee products originating from traditional versus modern beekeeping systems.

Panel surveys of household inputs and outputs as well as forest resource use recorded at regular intervals over a longer time period could provide more detail on the contribution of beekeeping to household wealth as well as forest impact than this study has been able to do.

In the context of conservation, it would also be worthwhile to further explore the phenomenon of the protection of hive carrying trees as well as trees in their immediate

vicinity through spatial analysis for example. Lastly, an assessment of opportunity costs to communities presented by the establishment of bee reserves could reveal potentially unwanted impacts of this conservation practice.

My results suggest that women and men benefit differently from beekeeping. A full gender analysis of beekeeping practice and its impacts on women's wellbeing and forest resource use was outside of the scope of this study. A more detailed examination of women's access, participation, perceptions, attitudes, values, and benefits in the context of beekeeping as a development and conservation tool merits further exploration.

Lastly, my results indicate that tenure influenced beekeepers' decisions around hive siting locations and led to unequal forest access for different types of beekeepers. A full analysis of governance arrangements regarding forest tenure was outside of the scope of this study. The influence of tenure security and land use rights distribution and enforcement play an important role in local people's forest use decision. These merit a more detailed assessment in the context of beekeeping and external support where forest conservation is at least one of the aims of the intervention.

7. CONCLUSION

The integration of rural development and conservation remains a pressing issue globally. Over the past decades numerous approaches to integrate these two aspirations have been tried all over the developing world. In part based on the lessons learned from past efforts, new approaches continue to emerge and capture the attention and funding of development agencies and organisations. The idea of promoting rural livelihood activities, which are hypothetically less damaging to the natural environment than some other forest-based activities, and which rely on the sustainable provision of forest resources thus providing incentives for forest conservation is not new. Despite a lack of evidence regarding the effectiveness of this approach, it continues to be the basis for a significant number of development and conservation projects. Among these, beekeeping is one of the most frequently promoted linked conservation and development activities.

In this thesis I examined the associations of beekeeping with livelihood improvements and with conservation motivations in Central Tanzania, while socio-economically characterising beekeepers and assessing the effects of past beekeeping support projects. The results suggest that beekeepers are somewhat better off than their non-beekeeping peers. I found differences to the advantage of beekeepers in the fulfilment of basic household needs, the level of resilience to shocks and the potential to move towards prosperity. These findings reflect important reasons for which a large portion of the Tanzanian population is engaged in beekeeping activities. As a conservation tool, beekeeping has modest associations with higher motivation to protect and conserve forest resources, but the findings of this study also show the limitations of beekeepers to act out on these motivations. Lastly, official training seems to be less effective in building technical beekeeping capacities than training provided by local community members. The methodology chosen for this study and the limited extent of time spent in the study communities during the research process preclude drawing definite conclusions on differences between beekeepers' wellbeing and conservation impact.

A large amount of attention and resources are currently being invested in beekeeping as a livelihood and conservation tool. Given the apparent complexities in targeting conservation behaviour through livelihood interventions, the evidence from this study suggests that investment in beekeeping as a livelihood activity aimed at improving wellbeing and

encouraging forest conservation needs to be very specifically targeted. Additionally, it needs to be delivered in a transparent and equitable manner with focus on capacity development and access to auxiliary equipment and markets, and based on an enabling environment, which includes access to resources, community participation as well as additional conservation measures.

8. APPENDICES

Appendix 1.1 – Household survey

Household survey

Bangor University/UK , Sokoine University of Agriculture/Morogoro

PhD Researcher: Kata Wagner

Research assistants: Jacqueline Kajembe, Saida Hussein, Juhudi Mfaume

Date:	**Time:**	**Enumerator:**
Village:	**Sub-village:**	**Device ID:**
Consent given: **Yes:** ☐ **No** ☐		**Household ID:**
Reschedule date:		**Household GPS coordinates:** Latitude: Longitude:
Household not found where indicated: ☐		**Was the survey conducted at the household?** (Y/N)

--READ CONSENT FORM--

1. **Respondent**

Name of the respondent

a. Household head or beekeeper Household head: ☐ Beekeeper: ☐ [*Note for enumerator: If interview is in a non-beekeeping household only the household head can be interviewed. If interview is in a beekeeping household only one of the beekeepers can be interviewed*.]	

Age [*Note for enumerator: Only adults 18 years of age or older can participate in the interview.*]	Sex (M/F)

2. Household composition

a. How many adults (age 15 and older) live and sleep in your home?	
Female adults	(Number)
Male adults	(Number)
Don't know	(999)
b. How many children (age 14 and younger) live and sleep in your home?	
Age <5	(Number)
Age 5-14	(Number)
Don't know	(999)
c. Does the household head belong to the largest ethnic group in the village?	(Y/N)
Which ethnic group does the household head belong to?	

d. What is the main occupation of the household head? (## select one)			
Farmer	☐	Casual labourer	☐
Livestock keeper	☐	Craftsman/mechanic	☐

Beekeeper ☐		Teacher ☐	
Business/shop owner ☐		Other, please specify:	
e. Since when do you live in this village? *[Note to enumerator: please record the year.]*	(Year)		

3. Education and specialized skills

a. What is the highest level of schooling of the household head?				
No formal education ☐		Secondary advanced level school [until age 19] ☐		
Primary school [until age 13] ☐		Technical or vocational training ☐		
Secondary ordinary level school [until age 17] ☐		University education ☐		
b. What is the highest level of schooling the children in your household will LIKELY complete? (## select one) (SKIP IF NO CHILDREN IN HH)				
No formal education ☐		Secondary advanced level school [until age 19] ☐		
Primary school [until age 13] ☐		Technical or vocational training ☐		
Secondary ordinary level school [until age 17] ☐		University education ☐		
c. Can your household afford your children's school fees and school supplies? (## select one) (SKIP IF NO CHILDREN IN HH)				
Never ☐	Rarely ☐	Sometimes ☐	Mostly ☐	Always ☐

4. Cash and subsistence income

a. Where does the food for your household come from? (## select multiple and insert appropriate number, see instructions below)	

Food products from own farm ☐ →	(Number)	Food products from own livestock ☐ →	(Number)	Food products from own trees or woodlots [excluding beekeeping] ☐ →	(Number)	
Food products from communal forest [excluding beekeeping] ☐ →	(Number)	Food products from government forest [excluding beekeeping] ☐ →	(Number)	Food products from beekeeping ☐ →	(Number)	
Purchased food ☐ →	(Number)	Other, specify: →	(Number)			

b. We would like to understand how important each food source you mentioned is for your household. For this we would like you to show us with the help of these ten peas [or beans/other food item] how much each food source contributes to your household's available food. Imagine the ten peas [or beans/other food item] represent all the food everyone in your household consumes in one year. Roughly guessing, how many of these peas [or beans/other food item] come from the different food sources you mentioned above? Please select a number of peas [or beans/other food item] for each of your food sources so that all peas [or beans/other food item] are used up in the end. *[Note: Enumerator to give participant ten peas [or beans/other food item] as question is explained and to record how many peas [or beans/other food item] the participant assigned to which food source. Please insert the numbers in the appropriate boxes above. The sum of all numbers added up must be exactly 10.]*

c. Where does your household get money from? (## select multiple and insert appropriate number, see instructions below)
[*Note to enumerator: It is very important to make a distinction here between honey/wax harvested from wild bees who live in their own nests (=honey/wax as NTFP) and honey/wax harvested from hives (=beekeeping)*.]

Crop sales ☐ →	(Number)	Livestock sales ☐ →	(Number)	Sale of wild harvested honey or wax ☐ →	(Number)	Sale of firewood ☐ →	(Number)

Sale of charcoal ☐ →	(Number)	Sale of mushrooms, medicinal plants or fruits ☐ →	(Number)	Sale of bush meat ☐ →	(Number)	Sale of beekeeping products (honey or wax) ☐ →	(Number)	
Sale of timber ☐ →	(Number)	Sale of poles ☐ →	(Number)	Sale of sawn wood ☐ →	(Number)	Sale of withies ☐ →	(Number)	
Sale of fodder from forest ☐ →	(Number)	Casual labour ☐ →	(Number)	Off farm employment [hint: small business, civil service, teaching, politics] ☐ →	(Number)	Other sources, please specify: →	(Number)	

d. We would like to understand how important each income source is for your household. This question is very similar to the question we asked you earlier about your food sources. This time we would like you to show us, with the help of these 20 beans, how much each income source contributes to your household's cash income. Imagine the beans represent all the cash income everyone in your household has in one year. Roughly guessing, how many beans come from the different income sources you mentioned above? Please select the appropriate number of coins for each of your income sources so that all coins are used up in the end. *[Note: Enumerator to give participant ten coins and to record how many coins the participant assigned to which income source. Please insert the numbers in the appropriate boxes above. Sum of all numbers added up must be exactly 20.]*

e. What is the average annual cash income of your household? *[Note for enumerator: Enumerator to remind respondent that all responses are anonymous]*	(TZS)

f. During the last 12 months, has anyone in your household managed/run their own business (other than selling agricultural products) or provided others with a skilled service (e.g. equipment repair, tailoring, construction work, etc.) for money or barter? (## select one)

No ☐	Yes 1-2 months ☐	Yes 3-4 months ☐	Yes 5-6 months ☐	Yes 7+ months ☐

g. In which months does your household have the highest cash income? [Note: Enumerator to record the numbers of months mentioned, i.e. 1 for January, 2 for February, 3 for March, etc.] (##multiples possible, please separate with commas)	

h. In which months does your household have the highest subsistence income? Subsistence income means: the value of products being consumed directly by the household or given away to friends and relatives. [*Note: Enumerator to record the numbers of months mentioned, i.e. 1 for January, 2 for February, 3 for March, etc*.] (## multiples possible, please separate with commas)	
i. In which months does your household have the highest expenses? *[Note: Enumerator to record the numbers of months mentioned, i.e. 1 for January, 2 for February, 3 for March, etc.]* (## multiples possible, please separate with commas)	
j. In which months do you usually experience shortages, in which months is it the hardest time to live? *[Note: Enumerator to record the numbers of months mentioned, i.e. 1 for January, 2 for February, 3 for March, etc.]* (## 1-12, multiples possible, please separate with commas)	

5. Housing and energy

a. Do you own the house you live in?	(Y/N)

b. *[Note: Information to be collected by enumerator while in the household. Ask only if unable to determine answer visually.]* What is the primary construction material of the main housing unit's exterior walls? (## select one)

Metal sheeting ☐	Wood (logs or boards) ☐	Mud brick ☐	Burnt brick ☐	Concrete ☐
Mud/Soil ☐	Reeds/Thatch/Straw/Grass/Fibers ☐	Plastic/Fabric ☐	Other, specify:	

c. *[Note: Information to be collected by enumerator while in the household. Ask only if unable to determine answer visually.]* What is the primary construction material of the main housing unit's roof? (## select one)

Roofing shingles or tiles ☐	Metal sheeting ☐	Cement or concrete ☐	Wood ☐
Plastic/Fabric ☐	Thatch/Straw/Reeds ☐	Other, specify:	

d. What is the primary fuel source your household uses for cooking? [Note: Enumerator to let participant answer first and then tick appropriate answer.] (## select multiple)

Liquid fuel (petrol, kerosene) or gas (from	Charcoal	Electricity from grid (legal connection)/generator/solar	Vegetable- or animal-based fats or oils	Firewood

tank or biogas) or coal ☐	☐	cells/wind turbine/small dam ☐	☐	☐
Sawdust, grass or other natural material ☐	Other, specify:			

e. What is the primary fuel source your household uses for lighting? [Note: Enumerator to let participant answer first and then tick appropriate answer.] (## select one)

Kerosene ☐	Electricity from grid (legal connection)/generator/solar cells/wind turbine/small dam ☐	Candles ☐	Flashlight ☐	Other, specify: ☐

6. Food access and nutrition

a. During the last 12 months, did the household eat fewer meals, or smaller portions, than usual because there was not enough food? If 'Yes', for approximately how long? (## select one)

Never ☐	Yes, once or twice ☐	Yes, for about 1 week ☐	Yes, for about 1 month ☐
Yes, for more than 1 month ☐	Yes, most days in the past 12 months ☐	Don't know ☐	

7. Domestic water supply

a. What is the primary source of the water your household uses for drinking and cooking inside the home? What we mean here is the source that water comes from immediately before being used. [Note: Enumerator to let participant answer first and then tick appropriate answer.] *[Note: If the household uses different water sources for drinking and cooking, only record drinking water source.]* (## select one)

Piped water ☐	Communal well ☐	Private well ☐	Natural spring/River/Lake/Dam ☐
Rainwater harvesting container ☐	Water vender (with truck or cart) ☐	Other, specify:	

8. Sanitation and hygiene

a. What type of toilet facilities does your household usually use? (## select one) [*Note for enumerator: 'Communal' means the facility is shared by 3 or more households. 'Private' means the facility is used by 1-2 households.]*		
None, open defecation ☐	Communal pit ☐	Private pit ☐
Communal pour-flush toilet ☐	Private pour-flush toilet ☐	Other, specify:

9. Health and healthcare

a. In the last 12 months, how often have members of your household been seriously ill (meaning they were so ill that they stayed in bed, or lying down, for 2 or more days)? (## select one)		
Never ☐	Rarely ☐	Sometimes ☐
Often ☐	Always ☐	Don't know ☐
b. To help people say how good or bad a health state is, we have drawn a scale, on which the best state you can imagine is marked 100 and the worst state you can imagine is marked 0. We would like you to indicate on this scale how good or bad your own health is today, in your opinion, by pointing at the appropriate point on the scale. *[Note: Show the card with the thermometer. Enumerator to record the number the participant pointed at.]*		(Number)

10. Household assets and savings

a. What is the distance from your home to the nearest all-season road in km?	(km)

b. How much land does your household have for agriculture, orchards, livestock or aquaculture (meaning fish-farming) in acres (this includes land that is currently fallow)?

	Owned	Rented	Rented out
Agriculture			
Orchards			
Livestock			
Aquaculture			
Forest/woodland, natural			
Forest/woodland, plantation			

c. Does your household engage in crop farming? (## If no, SKIP to 10 g.)	(Y/N)

d. During the last 2 years, was your household able to afford enough seed for each growing season? (## select one)

No ☐	Rarely ☐	Sometimes ☐	Often ☐
Always ☐	Not necessary because household saved seed ☐	Other, specify:	

e. Does your household ever use an oxen or a tractor to plough the fields? (Y/N) (## If no, skip to 10 g.)	(Y/N)
f. Do you own an oxen or a tractor?	(Y/N)

g. Does your household rear livestock? If yes: Please indicate numbers. (## If no, SKIP to 10i.)			
No (999)	Yes, cows (Number)	Yes, goats (Number)	Yes, sheep (Number)
Yes, poultry (Number)	Yes, pigs (Number)	Other, specify (Number)	

h. Over the past 12 months, has your household managed to maintain its stock of animals at the same level?	(Y/N/Not applicable)

i. If your household wanted to borrow money from a bank or other financial service provider (not including friends or relatives), would your household be able to borrow money? [*Note: Enumerator to remind respondent that all responses are anonymous*]				
Definitely no ☐	Probably not ☐	Probably yes ☐	Definitely yes ☐	Don't know ☐

j. Is your household currently in debt? If yes, how much?	(amount)

k. Do you ever lend other people money? (## select one)		
Never ☐	Rarely ☐	Regularly ☐

l. How many bicycles does your household own?	(Number)
m. How many motorcycles does your household own?	(Number)

11. Exposure and resilience to shocks

a. Has your household faced any major income shortfalls or unexpectedly large expenditures during the past 12 months? *[Note: Enumerator to let participant answer and then tick appropriate answers. If the participant is unsure about the question, give hints from the below list.]* (## select multiple) (IF NONE, SKIP TO 12a)

None ☐	Serious crop failure/livestock loss ☐	Serious illness in family ☐ [*Note for enumerator: adult (>17) unable to work for more than one month during past 12 months, due to illness, or to taking care of ill person; or high medical costs*]	Death of adult (>17) ☐

Land loss (expropriation, etc.) ☐	Other major asset loss (fire, theft, flood, etc.) ☐	Lost wage employment ☐	Wedding or other costly social events ☐	Other, specify:

b. If yes, how did you cope with the income loss or costs? *[Note: Enumerator to let participant answer and then tick appropriate answers. If the participant is unsure about the question, give hints from the below list.]* (## select multiple)

Harvest more forest products ☐	Harvest more agricultural products ☐	Sell honey or wax ☐	Spend cash savings or postpone paying back an existing loan ☐	Sell assets (land, livestock, etc.) ☐
Do extra casual labour work ☐	Assistance from friends and relatives ☐	Assistance from NGO, community org., religious org. or similar ☐	Get loan from money lender, credit association, bank etc. ☐	Reduced number of meals taken ☐
Borrowed against future earnings ☐	Did nothing in particular ☐	Others, please specify:		

12. Forest resource base

a. How far is it from the house to the edge of the nearest natural or managed forest that you have access to and can use? Measured in terms of time (minutes of walking)? *[Note: Enumerator to record number of minutes.]*	(Minutes)

b. Which forest products does your household collect? *[Note: Enumerator to let participant answer and then tick appropriate answers.]* (## select multiple)				
Charcoal ☐	Firewood ☐	Mushrooms ☐	Timber ☐	Poles ☐
Honey ☐	Water ☐	Fruits and nuts ☐	Medicine ☐	Saps ☐
Bush meat ☐	Insects ☐	Fodder ☐	Grasses/reeds/etc. ☐	Ropes and withies ☐
Rocks/stones ☐	None ☐	Others, please specify:		

c. Has your household planted any woodlots or trees on farms over the past 5 years? (## If no, skip to 13a)	(Y/N)

d. What are the main purposes of the trees planted? (## select multiple)				
Firewood/fodder/timber/poles for domestic use ☐	Firewood/fodder/timber/poles for sale ☐	Beekeeping ☐	Other domestic use ☐	Other products for sale ☐
Agroforestry purposes (improve fertilization or protection of crops) ☐	Land demarcation ☐	To increase the value of my land ☐	To allow my children and/or grandchildren to see these trees ☐	Other, specify: ☐
e. What was the most important reason for planting trees?				

13. Forest clearing

a. Did your household clear any forest during the past 12 months? (## If no, SKIP to 13 d.)	(Y/N)
b. How much forest was cleared (in acres)?	(acres)

c. What was the cleared forest (land) used for? *[Note: Enumerator to let participant answer first and then tick appropriate answer.]* (## select multiple)		
Cropping ☐	Tree plantation ☐	Pasture ☐
Non-agricultural uses, such as roads, buildings, etc. ☐	Nothing special, we just needed the trees on the land ☐	Other, please specify:
d. Has the household over the last 5 years cleared forest? (## If no, SKIP to 13 f.)		(Y/N)
e. How much forest (approx.) has been cleared over the last 5 years (in acres)?	(acres)	
f. Are you planning to clear any forests or woodlot in the next 12 months?		(Y/N)

14. Wellbeing and happiness

a. All things considered together, how satisfied are you with your life over the past 12 months? Please give us a number between 0 and 100, where 0 means 'very unsatisfied' to 100 means 'very satisfied'. *[Note: Enumerator to use the scale card again and record the number participants point at.]*	(Number)

b. Please tell us whether the following things happened in the past 7 days never, rarely, sometimes or often. *[Note: Enumerator to make sure that each statement is answered with one of the 4 possibilities]*

	Never	Rarely	Sometimes	Often
I felt dissatisfied with my life.				
I felt happy.				
I felt cheerless.				
I felt pleased with the way I am.				
I felt that life was enjoyable.				
I felt that life was meaningless.				

c. Compared with other households in the village, how well-off is your household?

Worse-off ☐	About average ☐	Better-off ☐
d. How well-off is your household today compared with the situation 5 years ago?		
less well-off now ☐	about the same ☐	better off now ☐
e. Do you consider your village to be a good place to live?		
No ☐	Partly ☐	Yes ☐
f. Do you in general trust people in the village?		
No ☐	Partly, trust some and not others ☐	Yes ☐

g. If you are in need, for example you need extra money because someone in your family is sick where can you get help from? *[Note: Enumerator to let participant answer and then tick appropriate answers.]* (## select multiple)

My household ☐	My relatives ☐	My neighbours ☐	My community ☐
Neighbouring communities ☐	External organisation ☐	All ☐	None ☐

15. Membership in local groups/organisations

a. Are you a member of any groups or associations? (## If no, SKIP to 15 c.)	(Y/N)

b. If yes, which ones *[Note for enumerator: Do not read out the list, wait for answer and if necessary, give hints.]* (## select multiple)

Farmer group ☐	Pastoralist group ☐	Business group ☐	Village environment committee ☐	Village land committee ☐
Village economic development committee ☐	Social defence committee (polisi jamii) ☐	Village community bank (VICOBA) ☐	Burial group (kamati ya maafa) ☐	Health group ☐
Beekeeping group ☐	Fisheries group ☐	NGO ☐	Political party ☐	Religious group ☐
Youth group ☐	Women's group ☐	Sporting group ☐	Neighbourhood responsibility ☐	Other, please specify:

c. Why are you not member of any group?	(reason)

d. Does anyone in the household have a specific role in the community?

[Note for enumerator: Do not read out the list, wait for answer and if necessary, give hints.] (## select multiple)

Ward chairperson/secretary/ treasurer ☐	Village chairperson/secretary/ treasurer ☐	Sub-village chairperson/secretary/ Treasurer ☐	Village environment committee leader ☐	Village land committee leader ☐
Village economic development committee leader ☐	Polisi jamii chairperson/secretary/ treasurer ☐	VICOBA chairperson/secretary / Treasurer ☐	Farmer group chairperson/secretary/ Treasurer ☐	Pastoralist group chairperson/secretary/treasurer ☐
Business group chairperson/secretary/ treasurer ☐	Burial group chairperson/secretary/ treasurer ☐	Health group chairperson/secretary/ treasurer☐	Beekeeping group chairperson/secretary/ Treasurer ☐	Fisheries group chairperson/secretary/ treasurer ☐
NGO chairperson/secretary/ Treasurer ☐	Political party chairperson/secretary/ treasurer ☐	Pastor/Church group chairperson ☐	Youth group chairperson/secretary / Treasurer ☐	Women's group chairperson/secretary/treasure r ☐
Sporting group chairperson/secretary/treasure r ☐	Other, please specify:			

16. Beekeeping

a. Do you collect honey from wild bees?	(Y/N)

b. Are or have your parents or grandparents been beekeepers?			(Y/N)	
c. Are you a beekeeper? (## If yes SKIP to 16 l.)	(Y/N)			
d. Why did you not pick up beekeeping from your parents or grandparents? (## select multiple) (ONLY ASK THIS QUESTION, IF RESPONDENT ANSWERED 16b. YES and 16c. NO)				
I was forbidden to do it ☐	I don't like bees ☐	It doesn't make enough money ☐	I don't have access to enough resources ☐	Other, specify:
e. Have you been a beekeeper before and stopped now? (If no, SKIP to 16 g.)	(Y/N)			
f. Why did you stop? (## select multiple)				
Limited knowledge ☐	No interest ☐	Fear of bees ☐	No capital to purchase equipment ☐	Limited space for beekeeping ☐
No market for products ☐	I didn't make money with it ☐	Too time-consuming ☐	Theft of hives ☐	Others, specify:
g. How interested are you in beekeeping? Please answer with a number between 1 and 5, where 1 means 'I am not interested at all' and 5 means 'I am very interested'.				(Number)
h. Have you ever received any training on beekeeping from anyone? (## select multiple) (## If 'No-one' SKIP to 16 j.)				
Family member ☐	Village member/neighbour/friend ☐		NGO ☐	Government extension service ☐
No-one ☐	Other, please specify:			
i. What aspects of beekeeping have you received training on? *[Note to enumerator: Let participant answer first and then select any of the below options.]* (## select multiple)				
Local hive construction ☐	Modern hive construction ☐	Hive placement ☐	Bee biology and behaviour ☐	Capturing swarms ☐

Pest and disease control ☐	Honey harvesting and processing ☐	Other product processing ☐	Bee forage calendar ☐	Proper hive inspection ☐
Colony multiplication techniques ☐	Feeding ☐	Other, please specify:		

j. What are your reasons for not keeping bees? *[Note for enumerator: Do not read out the list, wait for answer and if necessary, give hints.]* (## select multiple)

Limited knowledge ☐	No interest ☐	Fear of bees ☐	No capital ☐	Limited space for beekeeping ☐
No market for products ☐	I don't think it can make money ☐	Too time-consuming ☐	Others, specify:	

k. Under what conditions would you consider starting beekeeping? Choose 3 from the following:

Training on beekeeping ☐	Market availability ☐	Land (space) ☐	Capital ☐	Advisory support ☐
Time availability ☐	Security ☐	None, would never become a beekeeper ☐	Other, specify:	

Skip to 17a.

l. Why do you keep bees? (## select multiple)

Income from honey ☐	Income from wax ☐	Food ☐	Medicine ☐	Tradition ☐
I like being in the forest ☐	Other, please specify:			

m. How many hives do you own?	(Number)		
n. What type of hives do you own? (## select one)	Traditional only ☐	Modern only ☐	Mix of traditional and modern ☐

o. How far are your hives from your house? *[Note for enumerator: If hives are in different locations, ask how far the furthest hives are.]*	
(Distance in km)	Don't know ☐
p. Which year did you start beekeeping?	(Year)

q. Who taught you how to keep bees?

Family member ☐	Village member/neighbour/friend ☐	NGO ☐	Government extension service ☐
No-one ☐	Other, please specify:		

r. Have you ever received any training in beekeeping from an NGO or the government? (## If no, skip to 16 u.)

No ☐	Yes, 1 day ☐	Yes, 2 days ☐	Yes, 3 days ☐	Yes, more than 3 days ☐

s. What aspects of beekeeping have you received training on? *[Note to enumerator: Let participant answer first and then select any of the below options.]* (## select multiple)

Local hive construction ☐	Modern hive construction ☐	Hive placement ☐	Bee biology and behaviour ☐	Capturing swarms ☐
Pest and disease control ☐	Honey harvesting and processing ☐	Other product processing ☐	Bee forage calendar ☐	Proper hive inspection ☐
Colony multiplication techniques ☐	Feeding ☐	Other, please specify:		

t. Which organisation did you receive training in beekeeping from?				
u. Have you ever received any equipment from an NGO or the government? (## select multiple)				
No ☐	Yes, modern hives ☐	Yes, traditional hives ☐	Yes, protective equipment ☐	
Yes, smoker ☐	Yes, other, please specify:			
v. Which organisation did you receive equipment for beekeeping from?				
w. Who or what attracted you to beekeeping? *[Note: Enumerator to let participant answer first and then tick appropriate answers.]* (## select multiple)				
My parents ☐	Training ☐	Personal interest ☐	Income ☐	NGO's ☐
Friends ☐	Others, please specify:			
x. Are you member of a beekeeping group? (## If no, skip to 16 z.)	(Y/N)			
y. Why are you in a beekeeping group? *[Note to enumerator: Let participant answer first and then select any of the below options.]*				
Easier to invest together ☐	Hives provided to groups only ☐	Training provided to groups only ☐	Land set aside for groups only ☐	
Was asked by someone else to join ☐	Easier to market together ☐	Not enough skills alone ☐	Don't know/no particular reason ☐	
z. On a scale of 0 to 100, where 0 is worst beekeeper and 100 is the best, how do you rate yourself compared to other beekeepers in your community?	(Number)			
aa. On which aspects of beekeeping do you think you require training on? *[Note to enumerator: Let participant answer first and then select any of the below options*.] (## select multiple)				
Local hive construction ☐	Modern hive construction ☐	Hive placement ☐	Capturing swarms ☐	Pest and disease control ☐

Honey harvesting and processing ☐	Other product processing ☐	Bee forage calendar ☐	Proper hive inspection ☐	Colony multiplication techniques ☐
Feeding ☐	Marketing ☐	None ☐	Other, please specify:	
bb. Which aspects of beekeeping do you know? [*Note to enumerator: Read each answer individually.*] (## select multiple)				
Local hive construction ☐	Modern hive construction ☐	Hive placement ☐	Capturing swarms ☐	Pest and disease control ☐
Honey harvesting and processing ☐	Other product processing ☐	Bee forage calendar ☐	Proper hive inspection ☐	Colony multiplication techniques ☐
Feeding ☐	Marketing ☐			
cc. Do you inspect your bee colonies?				
Once a week ☐	Once a month ☐	Once every 3 months ☐	Once a year ☐	Never/at harvest ☐

dd. What problems do you face in beekeeping? *[Note to enumerator: Let participant answer first and then select any of the below options.]* (## select multiple)				
Aggressiveness of bees ☐	Bush fires ☐	Theft of hives and product ☐	Drought ☐	Limited forest resources ☐
Deforestation ☐	Limited knowledge ☐	Pest and diseases ☐	Limited space ☐	Limited market for our products ☐
Other, specify:				

ee. How many litres of honey did you harvest in the past 12 months?	(Litres)
ff. Do you sell honey? (## If no, skip to 16 jj.)	(Y/N)
gg. What is the price for 1 litre? (## pre-test on what is the most common measuring unit).	(Unit)
hh. How many litres of honey did you sell in the past 12 months?	(Y/N)

ii. Where do you sell the MAJORITY of your honey? *[Note to enumerator: Let participant answer first and then select one of the below options.]* (## select one)				
Neighbours/other village members ☐	Local shop ☐	Local market ☐	More distant market ☐	Other beekeeper in the village ☐
Middleman ☐	Beekeeping group ☐	Government (TFS or other) ☐	Processing company ☐	Other, specify: ☐

jj. Do you sell wax? (## If no, skip to 16 mm.)	(Y/N)
kk. How much wax (kg) did you sell in the past 12 months?	(kg)

ll. Where do you sell the MAJORITY of your wax? *[Note to enumerator: Let participant answer first and then select any of the below options.]*

Neighbours/other village members ☐	Local shop ☐	Local market ☐	More distant market ☐	Other beekeeper in the village ☐
Middleman ☐	Beekeeping group ☐	Government (TFS or other) ☐	Processing company ☐	Other, specify: ☐

mm. In which months do you benefit most from beekeeping (income and/or food)? *[Note: Enumerator to record the numbers of months mentioned, i.e. 1 for January, 2 for February, 3 for March, etc.]* (## 1-12, multiples possible, separate numbers with a comma)	(Months 1-12)
nn. Do you ever buy honey? (## If no, skip to 16 pp.)	(Y/N)
oo. Do you ever sell the honey you bought to someone else?	(Y/N)
pp. Do you buy wax? (## If no, skip to 16 rr.)	(Y/N)
qq. Do you ever sell the wax you bought from someone else?	(Y/N)
rr. How much do you agree or disagree to the following statement: If I was not allowed to keep bees, the wellbeing of my household would be significantly lower? Please answer with a number between 1 and 5, where 1 means 'I strongly disagree' and 5 means 'I strongly agree'.	(Number 1-5)

17. Perceptions and attitudes towards the forest

a. How much would you agree that the following expressions describe your feelings in general when you are/have been in the forest? Please respond to each statement ranging from 'I strongly disagree' to 'I strongly agree'.

[Note to enumerator: If the scale is not clear to the participant, please explain that the choices are: Disagree strongly, Disagree, Neutral, Agree, Disagree strongly]

	I strongly disagree	I disagree	Neutral	Agree	Agree strongly
Worried when alone					
Afraid of trespassing					
Vulnerable					
Secure					
Uneasy					
Happy					
Afraid of wildlife					
Close to nature					
Uplifted/revived					
In touch with the past					
Relaxed					
Bored					
Hemmed in/claustrophobic					

b. How important are various things that forests can offer? Please respond to each statement with a number between 1 and 5, where 1 means 'not very important' and 5 means 'very important'. *[Note: Please insert number 1-5 in each box]*

Timber	Charcoal	Spirituality	Firewood
Water	Medicine	Scenic beauty	Bush meat

Fruits, nuts and mushrooms	Relaxation/peace and quiet	Honey	Nature conservation
Fodder/Forage for livestock grazing	Climate-regulation	Tradition	Biodiversity
c. Do you want to have more or less forest close to your village?		(More/Less)	
d. How often did you go into the forest during the past 12 months? (## select one)			
Never ☐	Once ☐	Occasionally ☐	Most months ☐
Most weeks ☐	Most days ☐	Everyday ☐	

18. Decision-making power:

a. How much do you agree or disagree with the following statement? Please respond to each statement ranging from 'I strongly disagree' to 'I strongly agree'.

[Note to enumerator: If the scale is not clear to the participant, please explain that the choices are: Disagree strongly, Disagree, Neutral, Agree, Disagree strongly]

	I strongly disagree	I disagree	Neutral	Agree	Agree strongly
I am happy with the way my community in general manages and uses the forest I have access to and can use.					
What I personally think about how our village land should be used is not important in my community.					
I don't have a lot of power when it comes to decisions over the use of village land.					
My opinions on the management of the village land are respected by my community.					
I often feel frustrated with the way my community uses its land resources.					
The current management/way of use of the forest is good for beekeeping. (## ASK THIS ONLY IN BK HH)					

b. If a village forest management plan exists, did you participate in the decision-making process regarding management rules?

Plan does not exist. ☐	I don't know whether a plan exists. ☐	Yes ☐	No ☐

c. Individual people have different positions of power within their communities. Among all people in your village how would you rate your influence in decisions regarding your community? Please answer with a number between 1 and 5, where 1 means 'I have no influence at all' and 5 means 'I have as much influence as my village leader'.	(Number 1-5)

19. Enumerator assessment of the household [Note: This is to be completed by the enumerator after the interview.]

a. During the interview, did the respondent smile or laugh? (## select one)

Neither laughed nor smiled (sombre) ☐	Only smiled ☐	Smiled and laughed ☐	Laughed openly and frequently ☐

b. Based on your impression and what you have seen (house, assets, etc.), how well-off do you consider this household to be compared with other households in the village? (## select one) (SKIP THIS IF INTERVIEW WAS NOT CONDUCTED AT HOUSEHOLD)

Worse-off ☐	About average ☐	Better-off ☐

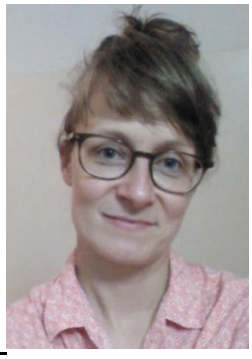
c. How reliable is the information GENERALLY provided by this household? (## select one)

Poor/not very reliable	Reasonably reliable	Very reliable

d. Did the participant get tired or lose interest during the interview?	(Y/N)
e. Were there other people present during the interview? (## If not, end of survey.)	(Y/N)
f. Did you feel that the presence of these other people had an influence on the answers given by the participant?	(Y/N)

- END OF SURVEY -

Appendix 1.2 – Information sheet for survey participants



INFORMATION SHEET FOR SURVEY PARTICIPANTS

PhD research project of Kata Wagner

Tel: +255 68411 7998, +44 747 989 3734; Email: afp48b@bangor.ac.uk

Research assistants:

Saida Hussein Juhudi Mfaume Jacqueline Kajembe

We are researchers working with Sokoine University of Agriculture in Morogoro and Bangor University in the UK working on PhD research project of Kata Wagner. This research is about 3 things that are related to each other: livelihoods, forests and beekeeping. We are interested to find out about the role of beekeeping for the people in this village and about the role of beekeeping for the forests of this village. This is a 3-year project. We selected your village as one of approximately 6 villages, because we have heard that there are many beekeepers here and because there are also many people here who don't keep bees. We will visit the other villages in the coming weeks as well. We hope that the results of the survey give us a better picture of the local livelihoods, the local forests and the role of beekeeping.

For this research, we would like to ask you some questions about your household and the community that you live in. The selection of your household, and approximately 60 others in your village, was done by the research team by randomly picking households from a list of all households in the village. The survey should take approximately 1 ½ hours. The district, ward

and village authorities have provided permission for the research to take place. Your participation in the survey is completely voluntary. Your participation in this research is very valuable to us. All information you provide during this interview will remain confidential and will only be used for the purpose of this research. We will never store the answers you provide together with your name. Every household or person who participates in the survey will be given a number. This number will then become your identity for the purpose of this project. The answers you give us will never be given to anyone else.

Appendix 3.1 – Overview of statistical analysis undertaken for each dependent variable

Dependent variable	Statistical tests	Regression model
Beekeeping adoption (i.e. beekeeper vs non-beekeeper)	Two-sample t-test of the means for possible continuous predictors Two-sample chi-squared test of the means for possible dichotomous predictors	Binary logit regression
Dependence on beekeeping for subsistence (measured as % of the contribution of beekeeping to individual households' subsistence)	Pearson's r correlation coefficients for possible continuous predictors Spearman's rho correlation coefficients for possible ordinal predictors Variation of means of possible categorical predictors Two-sample t-tests for possible dichotomous predictors	Two-part fractional model
Dependence on beekeeping for income (measured as % of the contribution of beekeeping to individual households' income)	Pearson's r correlation coefficients for possible continuous predictors Spearman's rho correlation coefficients for possible ordinal predictors Variation of means of possible categorical predictors Two-sample t-tests for possible dichotomous predictors	Two-part fractional model
Beekeeping success (measured as litres of honey harvested in the 12 months preceding the study)	Pearson's r correlation coefficients for possible continuous predictors Two-sample t-test of the mean for possible dichotomous predictors	Two-part fractional model

Appendix 4.1 - Composition of the key life domain variables

Note: Weights assigned to individual questions and subcomponents are shown in brackets.

1. Food security

During the last 12 months, did the household eat fewer meals, or smaller portions, than usual because there was not enough food? If 'Yes', for approximately how long? (100%)					
Never = 10	Yes, once or twice = 8	1 week = 6.5	1 month = 3.5	more than a month = 2	most days = 1

2. Domestic water supply

What is the primary source of the water your household uses for drinking and cooking inside the home? (100%)				
Private well = 10	Natural spring = 7.75	Rainwater = 7.75	Water vendor = 7.75	Communal well = 1

3. Health

In the last 12 months, how often have members of your household been seriously ill (meaning they were so ill that they stayed in bed, or lying down, for 2 or more days)? (50 %)				
Never = 10	Rarely = 7.5	Sometimes = 5	Often = 2	Always = 1

All things considered together, how satisfied are you with your life over the past 12 months? (50 %) (Woodhouse et al. 2015)
Values = y = 1 + (x-xmin)*(10-1)/(xmax-xmin), with x = actual value given (0-100), xmin = 0, xmax 100

4. Sanitation

What type of toilet facilities does your household usually use? (100%)				
Private pour-flush = 10	Private pit = 7.75	Communal pour-flush = 6.625	Communal pit = 3.25	None = 1

5. Housing and energy

What is the primary construction material of the main housing unit's exterior walls? (50 %)							
Concrete = 10	Burnt brick = 8	Metal sheeting = 7	Wood = 7	Mud brick = 4	Reeds/thatch = 2	Mud/soil = 2	Plastic/Fabric = 1

What is the primary fuel source your household uses for cooking? (25 %)				
Charcoal and liquid fuel = 10	Wood = 2.6	Wood and sawdust = 2.6	Charcoal and wood = 1.8	Charcoal = 1

What is the primary fuel source your household uses for lighting? (25 %)				
Electricity = 10	Kerosene = 8.2	Flashlight = 4.6	Candles = 4.6	None = 1

6. Education

Can your household afford your children's school fees and school supplies? (100 %)				
Always = 10	Mostly = 8.1	Sometimes = 3.6	Rarely = 2.3	Never = 1

7. Farm assets

How much land does your household have for agriculture, orchards, livestock or aquaculture in acres? (33.3 %)							
0 ha = 1	0-0.2 ha = 3	0.21-0.5 ha = 4	0.51 – 1 ha = 5.5	1.1 – 2 ha = 6.5	2.1 – 4 ha = 7.5	4.1 – 6 ha = 8.5	6+ ha = 10

During the last 2 years, was your household able to afford enough seed for each growing season? (16.65 %)					
Always = 10	Often = 8	Not necessary because household saved seed = 7.5	Sometimes = 5	Rarely = 2	No = 1

Do you own an ox or a tractor? (16.65 %)	
Yes = 10	No = 1

What is the value of your livestock? (33.3 %)
Value: Tropical livestock units[10] converted to scale from 10 – 1 (Range divided into 10 classes, with highest mentioned TLU taking value of 10.)

8. Non-farm assets

During the last 12 months, has anyone in your household managed/run their own business (other than selling agricultural products) or provided others with a skilled service (e.g. equipment repair, tailoring, construction work, etc.) for money or barter? (33.3 %)				
Yes, 7+ months = 10	Yes, 5-6 months = 7	Yes, 3-4 months = 6	Yes, 1-2 months = 5	No = 1

If your household wanted to borrow money from a bank or other financial service provider (not including friends or relatives), would your household be able to borrow money? (33.3 %)				
Definitely yes = 10	Probably yes = 6.5	Don't know = 4	Probably not = 3	No = 1

How many bicycles does your household own? (8.325 %)		
2 or more = 10	1 bicycle = 5.5	no bicycle = 1

What is the primary construction material of the main housing unit's roof? (8.325 %)				
Roofing shingles/tiles = 10	Cement/concrete = 9	Metal sheeting = 7.5	Wood = 5	Thatch/Straw/Reeds = 1

How many motorcycles does your household own? (8.325 %)		
2 motorbikes = 10	1 motorbike = 5.5	No motorbike = 1

Do you ever lend other people money? (8.325 %)		
Regularly = 10	Rarely = 5.5	Never = 1

9. Resilience to shocks

How many different sources does your household receive income from? (50 %)						
7 sources = 10	6 sources = 8.5	5 sources = 7	4 sources = 5.5	3 sources = 4	2 sources = 2.5	1 source = 1

[10] TLU weights derived from Jahnke and Jahnke (1982)

How did you cope with major income shortfalls or unexpectedly large expenditures in the past 12 months? (25 %)						
Did nothing in particular = 10	Start a business = 9.5	Do extra casual labour work = 8.5	Seek technical assistance = 8	Assistance from friends and relatives = 7.5	Reduced number of meals taken = 7	Assistance from NGO, community org., religious org. or similar = 6.5
Spend cash savings or postpone paying back an existing loan = 6	Get loan from money lender, credit association, bank etc. = 5.5	Sell honey or wax = 3.5	Harvest more agricultural products = 3	Harvest more forest products = 2.5 (Wunder et al., 2014)	Sell assets (land, livestock, etc.) = 2	Borrowed against future earnings = 1

Number of coping strategies named above (25%)					
6 strategies = 10	5 strategies = 8.2	4 strategies = 6.4	3 strategies = 4.6	2 strategies = 2.8	1 strategy = 1

10. Social capital

If you are in need, for example you need extra money because someone in your family is sick how many sources can you get help from? (50 %)				
4 sources = 10	3 sources = 7.75	2 sources = 5.5	1 source = 3.25	none = 1

Do you in general trust people in the village? (50 %)		
Yes = 10	Partly = 5.5	No =1

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