Original Research Article

The potentials of Beekeeping activities in enhancing local livelihoods and climate change adaptation in Semi-arid areas of Tanzania

ABSTRACT

Beekeeping also referred to as apiculture activities in semi-arid areas of Tanzania has been playing a significant role in enhancing rural livelihoods and climate change adaptation. Beekeeping groups have been established to mobilize resources and ensure high quality bee products and reliable markets. However, information on the enhancement of rural livelihoods and climate change adaptation in arid areas is scarce. Thus, this study was undertaken to assess the potential of bee keeping activities and climate change adaptation issues in semi-arid areas. A stratified sampling design was employed to select 90 respondents from beekeeping groups. Data were collected using questionnaires. Data was analysed using descriptive statistics, Gross Margin Return on Investment (GMROI), Capacity Performance Index (CPI) and Livelihood Index (LI). The study revealed that there is a high return to capital invested due to capacity performance of the smallholder beekeeper's groups. The groups' capacity resulted in strengthened climate change adaptation strategies and enhanced livelihoods. The study concludes that the beekeeping activities are perceived to have high return to capital invested. This also facilitates adaptation to climate change in the area through environmental conservation and local livelihoods support. Therefore, government and other stakeholders should continue capacitating beekeeping groups.

Keywords: *Beekeeping; apiculture; semi-arid areas; local livelihoods; return on investment; profits*

1.0 Introduction

Beekeeping is a science and art of rearing bees for various products and services. It is important to keep bees to produce honey, beeswax, *propolis*, pollen (bee bread), royal jelly and bee venom, for food and medicine as well as services like pollination and environmental conservation. Beekeeping involves the manipulation of bee colonies, processing, and value addition of the accrued bee products for profit maximization. Most such bees are honey bees in the genus *Apis*, but other honey-producing bees such as *Melipona* stingless bees are also kept (Sommeijer, 2015). Beekeeping is a source of food (e.g., honey, pollen and brood), raw materials for various industries (e.g., beeswax candles, lubricants), medicine (honey, *propolis*, beeswax, bee venom) and source of income and livelihoods for beekeepers (Mugo, 2015).

The European honeybees that were introduced in many countries such as eastern Asia, Australia, North and South America while African bees that were introduced into Central and South America currently form the basis of successful beekeeping industries. In the Amazon Forest, beekeeping has improved income, and medicinal benefits, even though some of them cannot be fully quantified. Beekeeping helps people to become less vulnerable, strengthens their ability to plan for the future and reduces their vulnerability to slip into poverty in a time of crisis, for example, if a family member becomes ill or crops fail (Bradbear, 2003; Green and Ginn, 2014;

Kohsaka and Rogel, 2019). In the events of droughts and famine due to climate change, bee products can become safety-nets to local communities (Lupala et al., 2015). However, it is observed that the European bee populations are declining either due to ingestion of pollen that is contaminated with pesticides or genetically modified organisms (GMO) plants (Fairbrother *et al.,* 2014; Tirado *et al.,* 2013).

In developing countries, beekeeping is a traditional honey-hunting (Guyo *et al.,* 2015) and rural-based activity. It is mostly practiced by local communities (Mpinga, 2016; Nyatsande *et al.,* 2014; MNRT, 1998) using local means in which hive management is critical. In Kenya, the Turkana pastoralists, for example, have long used risk-spreading strategies like moving livestock to access the best pasture and water available, maintaining species-specific herds to benefit from the heterogeneity of their disequilibrium environment, and diversifying economic strategies to include beekeeping, among other things (Opiyo *et al.,* 2015).

Tanzania is endowed with favourable environment for beekeeping activities to produce honey, beeswax and other bee products. It is the second largest honey producer in Africa (Sambua, 2015). Beekeeping potential is far below the potential that exists in Tanzania. It is estimated that Tanzania had a potential of producing 138,000MT of honey and nearly 10,000MT of beeswax (Sambua, 2015). Tanzanian production per hive is low because most honey producers use the "let alone method". That is, nobody checks on or assists the bees (Tutuba and Vanhaverbeke, 2018). While traditional production is about 7 kilograms of honey per year per colony, modern hives can yield about 15 kilograms per hive (Namwata *et al.,* 2013). Currently there is hardly enough honey to satisfy internal demand, much less the export market.

The country generates 1.7 million US dollars from the beekeeping activities. About 2 million Tanzanians directly or indirectly benefit from the beekeeping activities (ref? if possible). The biggest producers are small-scale beekeepers who use traditional extraction. Indeed, 95 percent of hives are traditional, and 99 percent of the production methods are equally old. The bee-keeping areas of the country include the Southern (Lindi) Western Highlands (Katavi and Tabora) and central (Dodoma and Singida) and northern (Manyara) Zones of Tanzania. Though initially a pastime in the forested areas, settled locations including Manyara and Singida districts have also become commercial honey centers.

The government of Tanzania and other NGOs such as Singida Youth Entrepreneurs and Consultants Cooperative Society (SYECCOS) has motivated beekeepers to form beekeeping groups. This maximizes beekeeping practices and facilitates participatory forest management. Beekeeping activities increases diversification of income sources. Diversification is suitable for smallholder farmers as it involves low investment costs and promising high returns. Moreover, formal beekeeper's groups develop strategies to counter various challenges (Mpinga, 2016). Some of these challenges are caused by climate change, food insecurity, and unreliable income streams. In these circumstances beekeeping activities have the potential for climate change adaptation (Lupala *et al.,* 2015). The groups also provide a forum for knowledge sharing and technology demonstration, initiating diversification into beekeeping enterprise and the development of beekeeping cooperatives in the region. The groups are expected extend partnership, for example, develop market linkages and provide capacity building services around bee hive management and harvest quality to beekeeping entrepreneurs in the region. Members of

beekeepers' groups can achieve business success in beekeeping, better educational opportunities. In addition, members benefit from greater exposure to training seminars through the partnership, allowing them to learn, share experiences and establish strong institutional networks (Atela *et al.*, 2018) leading to increased resilience to climate change (FAO, 2014).

The semi-arid areas of Tanzania face various challenges including effects of climate change and low economic opportunities. Beekeeping activities have not evolved to adopt more efficient methods of apiculture to enhance greater yields. In this regard, there are ongoing Government efforts of initiating strategies of promoting beekeeping for improving household income. However, the potential of beekeeping activities in Singida region, Tanzania particularly concerning smallholder beekeepers, is little known (URT, 2013). The contribution of beekeeping as a diversifying and strategic economic activity to enhance household livelihoods and climate change adaptation is still undocumented. Therefore, this paper is set to establish the performance status of the beekeeping groups in enhancing beekeepers' livelihoods and climate change adaptation in the region. The paper specifically assessed the perception of honey producers towards their beekeeping groups in promoting beekeeping activities, analysed the profitability of the activities and examined the performance of beekeeping groups and the contribution to their livelihood as well as climate change adaptation.

2.0 Methodology

2.1 Location of the Study Area and Study Design

This study was conducted at Singida region located at the central zone of Tanzania. The region is borders Manyara, Mbeya, Tabora and Dodoma. The people of Singida are mainly smallholder farmers, producing millet, groundnuts, maize, and potatoes. However, Singida region, unlike most other regions is covered by Miombo woodland forest with dense floral vegetation that creates a favourable environment for beekeeping. There are about 1,000 beekeepers in the region. Traditional hives account for approximately 90% implying that only a small fraction use improved hives in subsistence apiaries. The region contributes about 21% of Tanzania's honey produced annually. One of the most important aspects of beekeeping in the region is the pollination of sunflower and wild plants and grasses. Other economic activities include livestock, trading of agricultural products and beekeeping. The study used cross sectional research design whereby information was collected once at a specific time. The study sampling frame was the beekeepers in the study area. The study also involved the beekeeping cooperative and group's leaders.

2.2 Sampling Size and Sampling Techniques

The study randomly sampled 5 out of 16 beekeeping groups. Beekeepers were selected using stratified sampling whereby the beekeepers were obtained from the five strata (groups) found in the study area. Group leaders provided member registers where a random selection of 18 members were selected from each stratum (group). The sample size of the study was 90 beekeepers. The study also used purposive sampling to select the three leaders from each group.

2.3 Method of Data Collection

Data were collected using self administered questionnaire and interview guide. The questionnaire was administered to smallholder beekeepers selected from the beekeeping groups, whereby perception related to the beekeeping groups, costs, harvest (output) quantity sold, and prices of

the various honey products, and the livelihood assets (human, physical, personal, social, and financial) were included in the questionnaire. In addition, issues of climate change adaptation were also examined. Group leaders were specifically interviewed with regard to the general status of their group performance such as accountability, professional capacity, income potential, production management, marketing, participation of members, advocacy and the potential of beekeeping activities to climate change adaption.

2.4 Data Analysis Techniques

Data collected were entered into Statistical Package for Social Science (SPSS) version 20, and thereafter analyzed using descriptive statistics such as frequency, and percentage to describe the respondent's perception on beekeeping potential and climate change adaptation issues and other ranged on Likert type scale. The Likert scale was defined as: 1 = strongly disagree 2 = disagree 3 = undecided, 4 = agree and 5 = strongly agree. The capacity of the beekeeping groups was analysed using capacity performance index (CPI) as suggested by AGRA (Fig 1). The function of CPI is that CPI = f(Ac, PC, IP, PM, M, PaM, and Ad); where: Ac = Accountability, PC = Professional capacity, IP = Income potential, PM = Production management, M = Marketing, PaM = Participation of members, Ad = Advocacy.

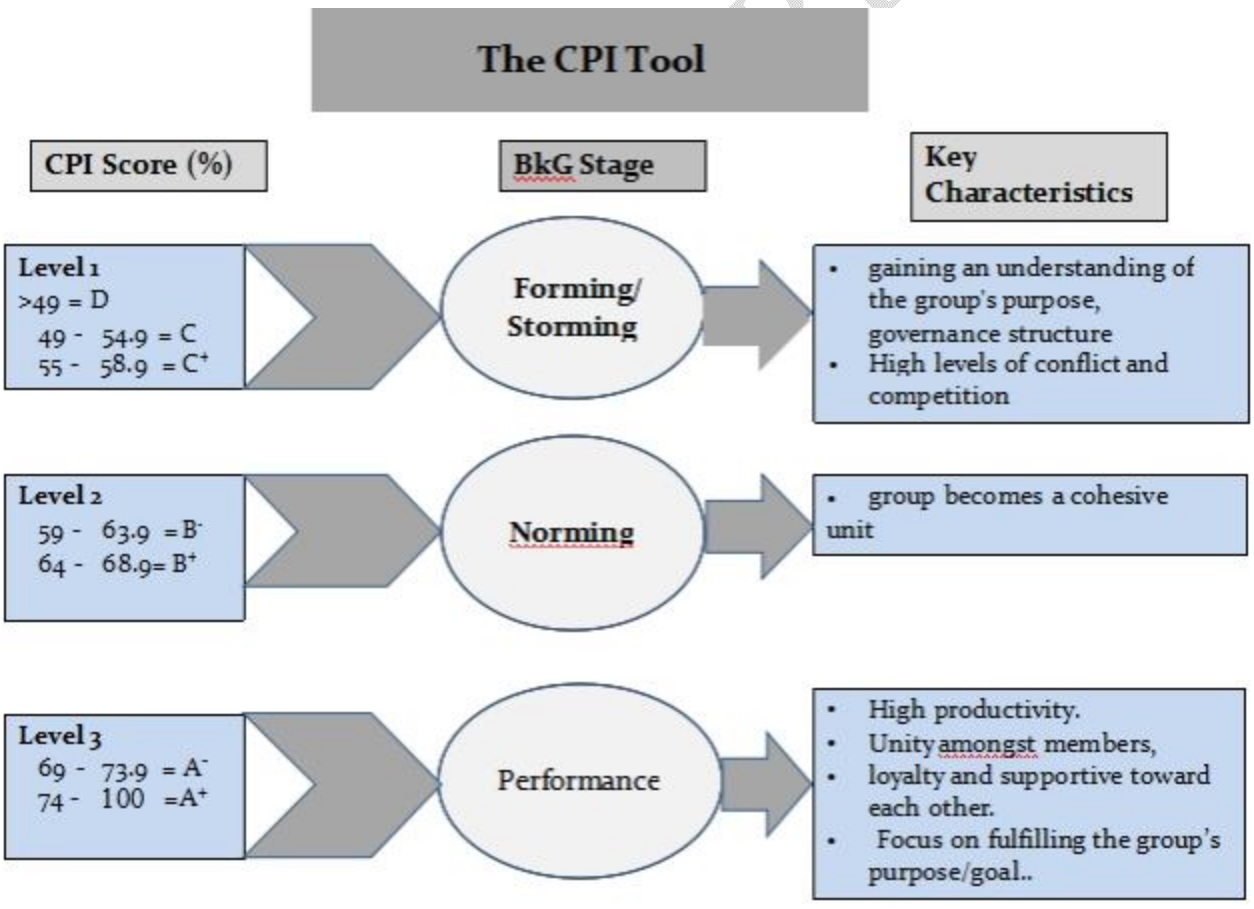

Figure 1: Capacity Performance Index
Adopted from Alliance for a Green revolution for Africa (AGRA)

The profitability of honey products was assessed using the profit function P(x) which is the difference between the revenue function R(x) and the total cost function C(x)
Thus P(x) = R(x) – C(x). The function can be specified as:

$$PM_{ij} = \frac{1}{n}\sum_{i=1}^{n}(P_{ij}\,V_{ij} - VC_{ij})$$

Where: PM_{ij} = Average profit (net) margin earned by beekeepers i=1...n earned by i^{th} beekeepers for jth honey products' output in TZS/Ltr,

P_{ij} = Unit producer price of i^{th} beekeeper for j^{th} honey output, (in TZS/Ltr)
V_{ij} = Volume marketed by i^{th} beekeepers for j^{th} honey output given k^{th} (in Ltr)
VC_{ij} = Total variable costs incurred by i^{th} beekeepers for j^{th} honey output (in TZS/Ltr)
n = Number of beekeepers dealing with j^{th} honey output

The contribution of the sub-sector in the beekeeping livelihoods was analysed using livelihood index based on the five capital assets of livelihoods. Therefore Livelihood Index = f(NA, HA, PA, SA, and FA).

Where: *NA = Natural Assets, HA = Human Assets, PA = Physical Assets, SA = Social Assets, and FA = Financial Assets.*
The index is specified as LI for an assets =

$$Human\_Asset = \frac{W_S S + W_K K + W_H H + W_M M}{W_{Sk} + W_K + W_H + W_M}$$

Where: S=Skills, K=Knowledge, H=Good health and Strength, M=Marketing expertise

$$Physical\_Asset = \frac{W_T T + W_{Eq} Eq + W_{Tr} Tr + W_{CW} CW + W_{En} En + W_B B}{W_T + W_{Eq} + W_{Tr} + W_{cw} + W_{En} + W_B}$$

Where: T = Tools, Eq = Equipment, Tr = Transport, CW = Clean water, En = Energy, B = Building

$$Natural\_Asset = \frac{W_{Be} Be + W_{Hi} Hi + W_{Bio} Bio + W_{ER} ER}{W_{Be} + W_{Hi} + W_{Bio} + W_{ER}}$$

Where: Be = Bees, Hi = Hives (a place to keep bees), Bio = Biodiversity, ER = Environmental Resources

$$Social\_Asset = \frac{W_{Hff} Hff + W_{Hfn} Hfn + W_{Mg} Mg + W_{MI} MI}{W_{Hff} + W_{Hfn} + W_{Mg} + W_{MI}}$$

Where: Hff = help from families, Hfn = Help from friends and networks, Mg = membership of groups,
MI = market information

$$Financial\_Asset = \frac{W_C C + W_S S + W_{Ac} AC}{W_C + W_S + W_{AC}}$$

Where: C = Cash, S = Savings, AC = Access to credit or grants, W = Weight of the indicator

3.0 Results and Discussion

3.1 Sample Characteristics

The results show that most of the sampled population was male (57.8%). The respondents' age groups were divided into two groups, namely; youth and matured. Among these, 88.9% were

youth aged 18 - 35 ages (Table 1) meaning that youth dominate in the subsector, may be due to their readiness of being early adopters of various technologies (Tucker, 2011). The findings also indicate that 90% of the respondents (sampled beekeepers) attained formal education. This suggests that it was easy the extension workers to introduce, and train the beekeepers on the beekeeping techniques to such beekeepers who inturn imparted the skills to the rest 10% who did not attend formal education.

Table 1: Respondents distribution

Characteristic	Category	Frequency	Percent
Sex	Male	52	57.8%
	Female	38	42.2%
Age Groups	18-35	80	88.9%
	36-60years	10	11.1%
Marital	Married	50	55.6
	Single	34	37.8
	Separation	6	6.7
Level of education	Primary	36	40.0
	Secondary	30	33.3
	Tertiary	12	13.3
	Degree level	12	13.3
Occupation	Employed	20	22.2
	Self employed	70	77.8

Table 1 also shows that 55.6% of the respondents were married, 37.8% were single and 6.7% were separated. The findings imply that the sampled married couples yield more honey than others, as they had combined labour power hence yielding income that facilitated them to have more hives, or invest in modern hives. The results presented in reveal that the majority of the respondents were married.

3.2 Performance of beekeeping production groups

The beekeeper's groups have several roles to the improvement of their members' livelihoods. The CPI was used to assess the capacity and performance of the groups. The index has seven indicators, namely: accountability, professional capacity, income potential, production management, marketing, participation of members and advocacy. Each of these indicators were assigned weights as per their respectively sub-indicators. The five groups which were involved in the study included Masega Asali, Mwankoko Women, Uhamaka Women, Unyianga Young and Tupendane Women groups. These beekeepers' groups are engaged in beekeeping activities for honey production. Hence results below show the capacity and performance of each beekeepers group.

Mwankoko Women and Unyianga Youth groups scored CPI of 85% and 74%, respectively; with A^{+} graded (Table 2). Moreover, Uhamaka Women group scored a CPI of 69%. The group is under level 3 and graded A^{-}. The three groups' scores are at performance stage with key characteristics such as high productivity, unity among members, loyalty and supportive toward each other. These groups focus more to fulfilling their respective group's purpose or goal; these are vivid indicators that the groups are performing well.

Table 2 shows that Tupendane Women and Masega Asali groups scored a CPI of 67% and 64%, respectively. According to AGRA the groups are in level 2 and are graded at B+ (Figure 1). The scores and levels of the two groups are at norming stage, with key characteristics of the groups becoming cohesive unit in delivering the service (Figure 1).

Table 2: Group Performance by mean score

S/N	Name of the Group	CPI	Level	CPI Grade
1.	Mwankoko women	85%	3	A^+
2.	Unyianga youth	75%	3	A^+
3.	Uhamaka women	69%	3	A^-
4.	Masega asali	64%	2	B^+
5.	Tupendane women	67%	2	B^+

3.3 The profitability of beekeeping production groups

Table 3 shows that the total cost per litre of honey is TZS 11,390/= while the Total Revenue per litre was TZS 13,348.08/=. Therefore, the gross profit of one litre TZS 1,959/=.

Table 3: Profitability of honey activity per litre

(i) Average cost	**Value in TZS**	**Value in USD**
a) Price of Beehive	112,000	48.70
b) Cost of bee hive for one kg	10,182	4.43
c) Security safety for the beehives	116	0.05
d) Harvesting + Transportation per liter	110	0.047
e) Package per kg	982	0.43
Average Total Cost (*a+b+c+d+e*)	11,390	5
(ii) Revenue		
d)Average price per kg	9,888	4.30
e)Quantity in kg per litre	1.35	NA
Average Total Revenue (d*e)	13,348.80	5.80
Gross profit = ATR-ATC	1,959	0.85
ROI = (Total profit/Total cost * 100)	17.2%	17.2%

NB: *i) One bee hive can produce 25 lb (11 kg)*
ii) One kg in stingless bee honey measure equals = into 0.74 litre)
iii) Exchange Rate during data collection: 1 USD =2312 TZS.

3.3 Contribution of beekeeping to local livelihoods and climate change adaptation

Result revealed that the beekeeping activities has contributed much to human assets (HA) of the beekeeper's livelihood as the assets score being 0.79 which is equal to 79%. This contribution also has been supporting climate change adaptation in dry lands of Tanzania. Thus, the beekeepers have gained skills and more knowledge in beekeeping, they have access of health facilities and marketing expertise on honey products.

In terms of natural asset (NA), the honey sub-sector has also improved the beekeepers as the sampled population scored a value of 0.76 which is equal to 76%. This signifies that the beekeepers have positive perception to the sub sector, have been motivated to be involved in beekeeping, and have high self-esteem. The sub sector has contributed to the social asset (SA) of the sampled population. Fig 2 shows that the asset has an average score of 0.74. The scores were

on the following subcomponent connectedness, interaction on the various matters which pertains to the community, family, households, friendship, among the community members; implying that the beekeepers are well involved and created a rapport social asset.
Another contribution was on physical asset (PA) which has a mean score value of 0.68 (68%) which were score from how the activity of honey has assisted the beekeepers to access child care, shelter, clean an affordable energy, information (mobile phone, television, radio), basic consumers' needs for example shops, market, groceries hence improving livelihood.

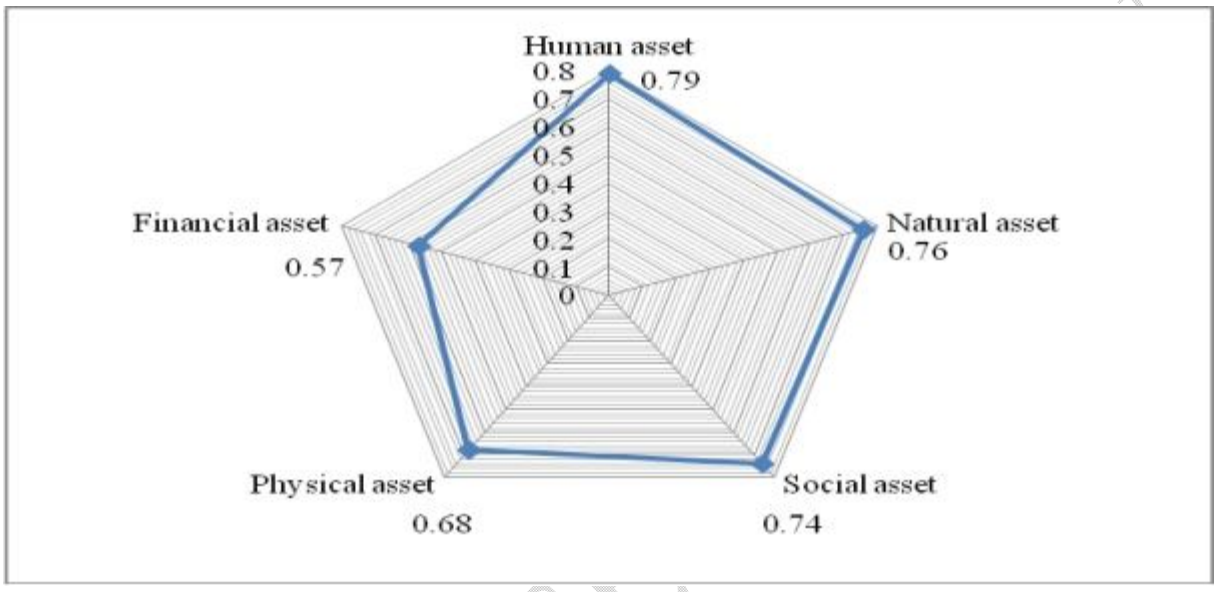

Figure 2: Livelihood asset levels

The honey subsector has marginally contributed to beekeepers financial asset (FA) component scoring an average of 0.57 (57%). The score were from whether the subsector has helped the beekeepers to access credit, ensure regular inflow of money from government transfer, family, gifts and in-kind; availability of finance/saving and ensure income from productive activities. Therefore, towards enhancing farmers' livelihood beekeeping activities still helps in human asset, personal asset and social assets compared to physical assets and financial asset. Thus, Table 4 indicates the ranks of the assets whereby human asset was ranked as the first asset while the last was financial asset.

Table 4: Livelihood Analysis

Livelihood Asset	Normalized value	Rank
Human asset	0.79	1
Natural asset	0.76	2
Social asset	0.74	3
Physical asset	0.68	4
Financial asset	0.57	5

From the results, several achievements were observed from beekeepers like easy to get place for market to simplify marketing process due to development of networking, ability to own assets like farm ownership and modern beehives. Thus, beekeeping seems to provide beekeepers with

additional benefits such as increased community participation in performing various activities and agency due to marketing (Woldewahid *et al.,* 2012) from the knowledge and skills obtained through education and training.

4.0 Conclusion

Findings clearly show that the capacity performance index of the three sampled beekeepers groups are at the performance stage while two groups were at norming stage. However, the members groups have an average of gross profit of 0.85USD per litre of honey, with a return on investment of 17.2%. This has contributed to improvement in climate change resilience and household local livelihoods. The smallholder beekeepers have recommendable human, natural and social assets, other factors being constant. This imply that the return to capital invested to honey could be a potential to local livelihood improvement as well as strengthening climate change resilience among the smallholder beekeepers. Therefore the observed potential need to be advocated and further integrated in climate change resilience strategies in semi-arid areas of Tanzania and other similar countries.

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