PROFITABILITY OF ZIMBABWE APICULTURE: A COMPARATIVE ANALYSIS OF IMPROVED AND TRADITIONAL HIVES

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ABSTRACT

Honey production in Zimbabwe is low against domestic demand for consumption and industry. There is scarce research information on productivity and viability of beekeeping projects in Zimbabwe. The study was carried out in Chipinge district which is in high rainfall areas of Zimbabwe. The overall objective of the study was to establish productivity and viability of apiculture in Zimbabwe, while comparing improved and traditional hives. Data were collected from 59 beekeepers that were randomly selected from a sampling frame of 70 beekeepers using a structured questionnaire. Data were analysed using descriptive statistics, non-parametric test and gross margin analysis. The findings revealed that apiculture projects in Zimbabwe are productive and viable. The mean percentage of colonised hives/mean hive occupancy was 65.43% and 77.76% for traditional and Kenyan Top Bar (KTB) hives respectively, and KTB hives had significantly more hives colonised (P <0.05). The average annual gross income for KTB hives of US$ 572.28 was significantly higher (P <0.05) than the average gross income of traditional hives of US$ 286.19. Mean total variable costs of US$ 89.69 and US$ 77.48 for KTB and traditional hives respectively were not significantly different (P >0.05). Both hive types had positive gross profit per hive of US$ 28.06 for Kenyan Top Bar (KTB) hives and US$ 10.81 for traditional hives. However, KTB hives had significantly higher mean gross profit per hive than traditional bee hives (P<0.05). The researcher recommends working on improving hive productivity, gross incomes and gross profits. Also, the researcher recommends robust adoption of KTB hive technology which has better financial returns. A deliberate government policy and finance programme can improve use of KTB hives and improve hive yield and incomes. Also, the researcher recommends adoption of ways to reduce variable costs. Group level strategies for coordinated transport and purchase of some inputs can reduce costs. In conclusion, apiculture enterprises in Zimbabwe are productive and viable.

Keywords: Apiculture, Gross Margin, Hives, Productivity, Viability.

INTRODUCTION

World production and consumption of honey has been on the rise. In 2019, world production of honey stood at 1,882 million metric tonnes after a drop from 1,926 million metric tonnes, a drop that may be attributable to the Covid-19 pandemic and decline in bee populations in Asia, Europe and the United States of America. China remains the largest producer with a share of 24% of the world production, followed by European Union with a share of 12%. African countries which are significant producers are Ethiopia (54 000 metric tonnes), Tanzania (31 000 metric tonnes), Angola (23 000 metric tonnes), Kenya (14 000

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metric tonnes) and Central African Republic (16 000 metric tonnes). These African countries have a combined contribution to world honey supply of 8% (FAO, 2021). Zimbabwe is not among the best African countries but there might be great potential since the country has good climatic and biotic environment for bees.

North America is the largest importer of honey worldwide with a share of 35.4%, followed by the European Union with 31%, with Asia importing about 13.3%. Major countries that exported honey to the European Union market are Ukraine, China and Argentina contributing 63.8% of European Union imports (Comtrade, 2021). Africa contribution to export receipts is insignificant, and therefore, researches into ways to improve the value chain are supposed to be done. Also, the current instability in Ukraine due to Russia invasion may negate its honey contribution to the EU market, thereby opening market opportunities to Africa.

Apiculture has potential to contribute to economic growth. Honey is the major product of apiculture products and is produced by almost all countries in the world with Ethiopia, Zambia, Tanzania, Uganda and Ghana as leading African exporters (Dube et al., 2020). In the SADC region, it was established that honey production and other related products have vast economic potential, but under-exploited resulting generally in net imports (Dube et al., 2020). In Zimbabwe most of the honey is produced by smallholder farmers and the smallholder commercial apiculture sector is still at its infancy. Most of the honey production is concentrated in the Midlands, Mashonaland west and Manicaland provinces (Nyatsande et al., 2014). In addition, apiculture is small yet having so much potential to drive the economy towards poverty reduction, contribute to rural food security, resilience, employment creation and foreign currency earnings. The subsector offers a window for passive household income and a potential foreign currency earner when commercialised.

The country has a long history of beekeeping but productivity remains low (Dube et al., 2020). The production is compromised by the weak organisation of beekeepers and policy related issues that need reviewing and strengthening. As a result, apiculture's contribution to livelihood of people has been minimal. Despite nutritional and medicinal value of honey and other bee products, most beekeepers in Zimbabwe produce honey mainly for family consumption.

Zimbabwe has high poverty and food insecurity figures which can be improved by making sure that rural households engage in diverse economic activities, including engaging in beekeeping enterprises. Recent food insecurity figures reveal that 720 to 811 million people (one in every eight) are affected by hunger (FAO, 2021) attributable to Covid-19 pandemic and climate change. An estimate 660 million people may still face hunger by 2030 (FAO, 2021). Seventy six percent (76%) of the people in developing countries live in rural areas and depend on agriculture on their livelihoods (Bashir & Schilizzi, 2013). The Zimbabwe Child Poverty Report of 2019 estimated 76.3% of rural households to be poor (ZimSTAT, 2019). The 2021 ZimVAC Rural Livelihoods Assessment (RLA) report projected rural food insecurity to reach 27% during the peak hunger period (January to March 2021) which improved from 59% (January to March 2020) due to good rains received.

Agriculture has been recognised as a vital sector for recovery and growth of the economy and provides livelihood options to 67% of the rural population in Zimbabwe (GoZ, 2020) and a major contributor in the quest to achieve Vision 2030 which emphasises achieving an upper middle income economy. Diversification of agricultural value chains provides resilience and buffer against climatic shocks, and consequently improves household incomes. The Livestock Growth Plan (MoLAFWRD, 2020) and National Development Strategy 1 (2020) mention the bee sector as an important sector in improving rural livelihood options (GoZ, 2020). Beekeeping in Zimbabwe is now being perceived as a potential

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income-generating enterprise. The country has a huge honey production and export potential due to its conducive climatic conditions, as well as its vast expanse of diversified flora and fauna. Its forests and woodlands plant species provide surplus nectar and pollen to foraging bees. However, the products obtained from this subsector are still low as compared to the country's potential. The potential of beekeeping and honey production for income generation is beginning to be realised.

Productivity of beekeeping is a measure of honey yield per colony/beehive. Hive productivity is a major factor affecting viability and profitability of a beekeeping business Al-(Ghamdi et al., 2017). There can be variations in honey yield within the same locality among honeybee colonies as a result of the colony strength, floral availability, management, proportion of hives colonised, and hive technology used. Profit in beekeeping is defined as profit per colony, which is calculated by subtracting total apiary product sales from total costs and dividing by the number of colonies (Urbisci, 2011) whilst viability is obtained by subtracting total variable costs from gross income. In addition, profitability is defined as the difference between income earned from the sale of products and the cost incurred during production.

Various studies have been done on viability and profitability of beekeeping in various countries (Tarekegn et al., 2017); (Kuboja, 2017); (CODIT, 2009) including Tanzania, Rwanda, Kenya and Ethiopia. The studies indicated varied production per colony per given hive technology and also different gross and net profits from across different countries. A study in selected districts of Ethiopia concluded that beekeepers can increase their profit more than double by using modern hive technologies apart from some other factors that affect productivity (Workneh, 2011). A separate study in Saudi Arabia showed differences in annual honey yields from colonies among different hive technologies of 3,7 kgs and 6,6 kgs for traditional and box hives respectively (Al-Ghamdi et al., 2017). Since the apiculture sector in Zimbabwe is still young and starting to be commercialised, there has never been a study on productivity and viability of the sector, and therefore it is important this research is done to come up with average honey yields per given hive technology and also gross profit. A study in Tanzania indicated that people find it difficult to harvest honey due to bee stings and the fear they have, and this may affect the number of harvests per annum (Kuboja, 2017). Studies in Zimbabwe by various scholars did much on contribution of apiculture on livelihoods resilience building and household income and food security (Chazovachii et al., 2013); (Mazorodze, 2015) but very little or nothing has been done on productivity and viability of apiculture projects. The study therefore was done to assess productivity and viability of the beekeeping enterprises in Zimbabwe so as to close the knowledge gap on productivity and viability of different hive technologies. Thus, the objective of this study was to establish productivity and viability of beekeeping enterprises in Zimbabwe using various hive technologies.

CONCEPTUAL FRAMEWORK

The conceptual framework has beekeepers that are made up of individual farmers and associations. Women are also part of the beekeepers. The beekeepers are affected by several socio-economic and other biotic factors. There are institutions which assist the beekeepers across value chain activities. The government provides assistance through extension, research, regulatory and trade services. Other research institutions are important in providing research information to the sector. Non-governmental organisations and the private sector are also important in offering services, but the private sector is very instrumental in providing market for the beekeepers. There are various key activities that beekeepers are engaged in.

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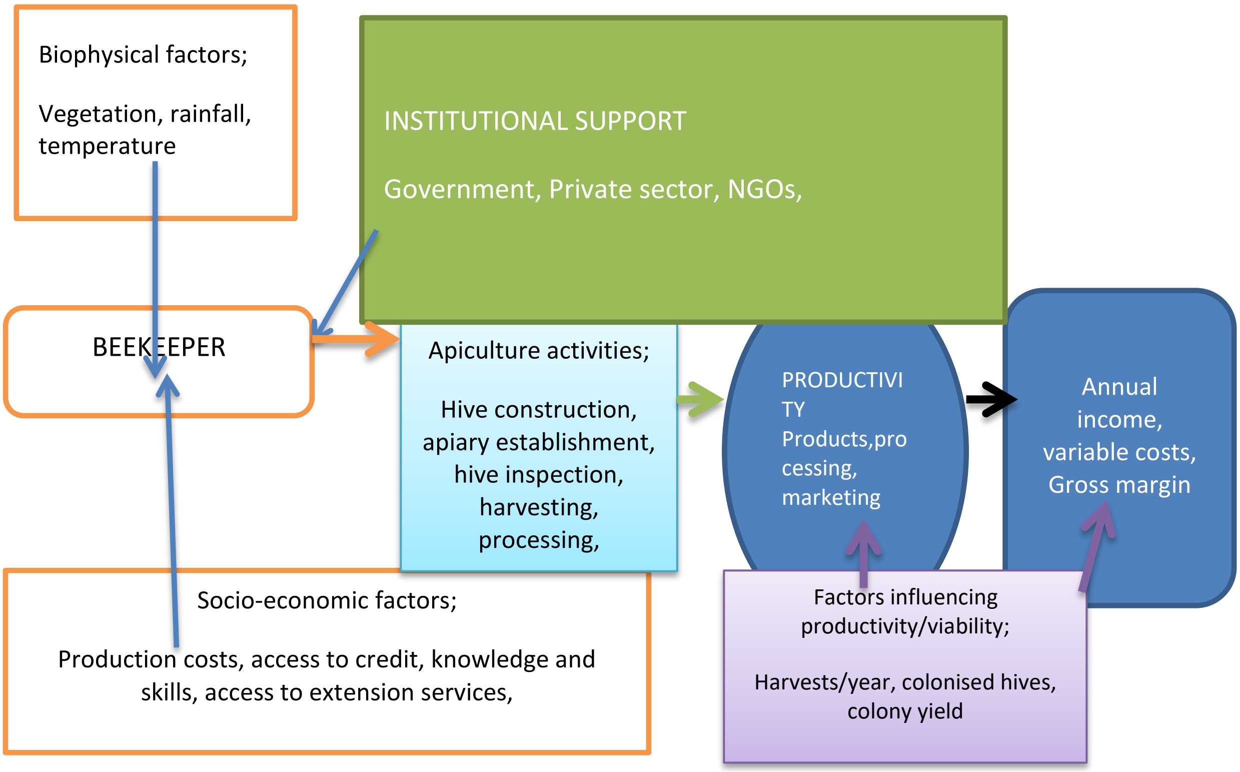

Source: (Kuboja, 2017)

FIGURE 1
CONCEPTUAL FRAMEWORK

Some of the activities are male dominated like hive construction and harvesting. The beekeepers then harvests hive products including honey combs, propolis, and pollen. After harvesting, some sell as raw honey whilst others process and sell (Kuboja, 2017). The market of honey and other hive products is still not very open since many producers are selling to middlemen, who in turn sell to big companies. The profit of the apiculture business in Zimbabwe is influenced by the buying prices from the middlemen and hive productivity, apart from other physico-chemical quality indicators of the honey (Dube et al., 2020) shows in Figure 1.

RESEARCH METHODOLGY

Site Description

The study was carried out in Manicaland province, Chipinge district. The research areas are in wards 2, 8 and 11 of Chipinge district, and are located 190 to 220 kilometres south-eastern direction from the city of Mutare. The locations of project research sites in wards 2, 8 and 11 are Lat: -24.6070691 Lng: 82.4159431, Lat: -21.4275035 Lng: 36.0005467 and Lat: -20.7509771 Lng: 35.7039868 respectively. The region was selected based on their potential for beekeeping and availability of clustered beekeepers in wards 2 and 8 which are Chipinge Beekeepers Association and Ngaone Beekeepers Association. The areas are in agro-ecological region I with abundant flora and fauna as a result of favourable climatic conditions with seasonal rainfall of about 1000 mm per annum and annual average

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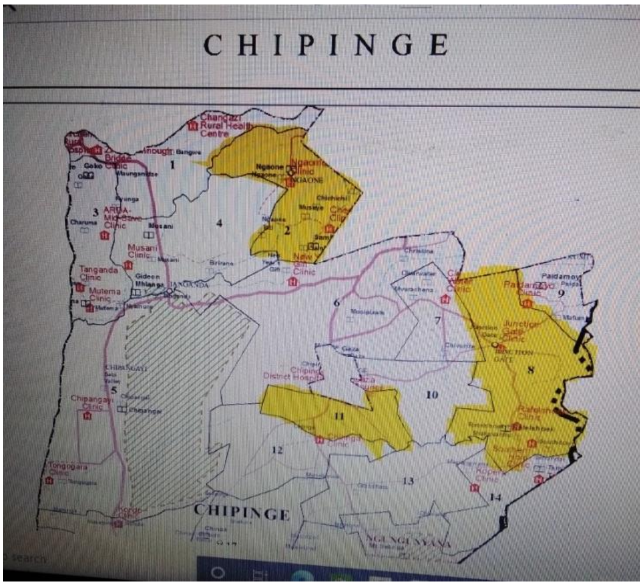
temperatures of about 22°C, although usually with cooler winter season with temperature as low as 4°C. The areas have abundant sources of bee forage throughout the year from the fields and the abundant forests. The rain season spans from December through March. Locations of the wards are shown on the map on Figure 2.



Source: (OCHA, 2021)

FIGURE 2
RESEARCH SITES MAP

Analytical Framework for the Data

Table 1 presents a summary of the objectives, the data required for analysis and the methods which were used for analysis.

Table 1
ANALYTICAL FRAMEWORK

Objective	Data requirements	Analytical methods
To establish and compare productivity of beekeeping businesses that use traditional and Kenyan Top bar hives.	Total hives the farmer has, number of colonised hives, and total raw honey harvested per colony, number of harvesting times per annum,	Descriptive statistics Means for two hive types (traditional, Kenyan Top bar hives) were compared using non parametric test (Mann-Whitney U)
To establish and compare viability of beekeeping businesses that use traditional and Kenyan Top bar hives.	Total variable costs incurred over a year period, and total income obtained from sale of honey and other hive products, gross margin	Gross margin analysis Mean gross margins, costs and gross income for traditional and Kenyan Top bar hives were compared using non-parametric tests (Mann-Whitney U)

RESEARCH DESIGN

The research design is a logical structure of the research whose function is to ensure that the data obtained enables the researcher to answer the research problems as clear as possible. A quantitative research design was used. Quantitative research encompasses the

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measuring and counting of event such as the frequency of harvesting honey per household. Quantitative research was used to gather data on the household demographics, productivity indicators and average costs and income received by every household per harvest and per annum.

Target Population and Sample Size

Population has been defined as the entire group of individuals, objects or things that share common attributes or characteristics and may or may not be found within the same geographic location (Gitau, 2008). The target population for this research was 70 apiculture farmers in wards 2, 8 and 11 of Chipinge district. Data was obtained from AGRITEX office. The sample was drawn by reading from Krejcie &Morgan tables (Krejcie & Morgan, 1970). From the table, a value of 59 bee farmers was obtained. According to some researchers, the sample size should depend on the funds and time available as well as other factors but not necessarily on the total population (Storck et al., 1991).

Sampling Procedure

The study area was divided into three strata; ward 2 (Ngaone Beekeepers Association) with 11 farmers, ward 8 (Chipinge Beekeepers Association) with 42 farmers and ward 11 with 17 farmers. These strata were purposively sampled, because they have the highest number of bee-farmers in a clustered form. Systematic random sampling was used to select the farmers from each stratum. Systematic sampling involves drawing every n^{th} element in the population starting with a randomly chosen element between one and *n* (Sekeran, 2006). Stratified random sampling was adopted so as to achieve correct representation from the three strata in district;

Ward 2, B1 -11 Beekeepers
Ward 8, B2 -42 Beekeepers
Ward 11, B3 -17 Beekeepers
$n_i = (Bi / N) \times n$

Where
n- Sample size of population in the whole district
Bi- population of each stratum (i=1, 2, 3)
N- Population target in the whole district (N=B1+B2+B3)
n_i- sample size in each stratum/division where i=1, 2, 3

Therefore:
Ward 2 = 11/70 ×59=9 Beekeepers
Ward 11 = 17/70×59= 14 Beekeepers
Ward 8 = 42/70 x 59 = 36 Beekeepers

Data Collection and Analysis Methods

Household interviews were used for data collection to capture all of the relevant information. The questionnaires were prepared in line with specific objectives of the study and were pre-tested on a small number of respondents.

The researcher developed and used a questionnaire in collecting data from the households. Household questionnaires contained closed ended questions. Closed ended

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questions were used so as to avoid long answers which are not necessary to the study. The questionnaire had general information of study areas, demographic information (sex, age, family size and main occupation), honeybee colonies holding size (hive occupancy) per apiary, number of hives in apiary, average honey yield per each type of hive per annum and number of harvesting times per colony per year, data on major expenditures for producing honey, quantity of inputs (such as labour, feeds, measures against diseases and pests, transport etc.,) and the average prices of honey and other hive products. Data was used for assessing productivity and gross margin analysis of the apiculture projects.

Analysis of quantitative data was done by using computer software Statistical Package for Social Science (SPSS), version 16.0. The questionnaires were scored, data edited to detect errors, coded by assigning numeral symbols to answers in the questionnaire so that responses could be put into limited number of classes and the data was entered into the computer for analysis. Descriptive analysis was carried out by summing total scores on the variables of study and data was presented statistically by use of frequency distribution tables and percentages using descriptive statistics. Means for the productivity and viability analysis parameters for different hive technologies were compared using non parametric test (Mann-Whitney U).

In order to perform viability analysis, major production costs (variable) for the farmers' beekeeping enterprises were considered. Based on the survey data, the costs of production and returns at the prevailing prices were used to estimate the benefits. This section aimed at identifying and quantifying the different costs, which are incurred by the beekeepers in production process. Where colonies are purchased, the prices for purchasing such bee colonies were considered. The costs included labour cost during preparation of foundation sheet and apiary establishment, harvesting, feed cost where supplementary feeding is done and transport cost. Viability analysis of bee colonies was determined using the following formula. Simple descriptive statistics, farm budget techniques and Gross margin analysis were used. The farm income model is as shown:

i. TVC = LC + FC + DPC + TC;

ii. TGI = (HPY/colony/kg) x (P) x (Nhives) x (Nharvests);

iii. GM = TGI – TVC,

Where, TVC = Total variable cost (annual);
TGI = Total gross income (annual)
GM/GP = Gross margins/Gross profit (annual);
LC = Annual labour costs;
FC = Annual feed costs;
DPC = Disease and pest control costs;
TC = transport costs;
HPY = Hive products yield (honey combs, pollen, propolis);
P = Price;
Nhives = number of hives/colonies;
Nharvests= number of harvests per year.

RESULTS AND DISCUSSION

Household Characteristics

Table 2 illustrates household characteristics for the surveyed households.

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Table 2 DESCRIPTIVE STATISTICS FOR SURVEYED HOUSEHOLDS					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Age of household head	59	25	69	46.69	11.334
Household size	59	1	14	5.53	2.438
Years in Beekeeping of household head	59	1	35	7.93	6.953
Number of members in beekeeping	59	1	5	1.58	.855
Valid N (listwise)	59				

The mean age of respondents was 46 years. The household family size was 5 people. The average period spend in beekeeping (experience) was 8 years. An average 2 people were participating in beekeeping at each household interviewed. Table 3 shows household characteristics for the surveyed households.

Table 3 HOUSEHOLD CHARACTERISTICS		
Characteristic	**Frequency (number)**	**Percentage (%)**
Sex of household head		
Male	50	84.7
Female	9	15.3
Level of education of household head		
Non-formal	8	13.6
Primary	21	35.6
Secondary	22	37.3
Tertiary	8	13.6
Main occupation		
Beekeeping	22	37.3
Formal employment	7	11.9
Other	30	50.8
Types of hives used		
Traditional	7	11.9
KTB	38	64.4
Both	14	23.7

From Table 2, the mean age of 46 years mean that many beekeepers are still in the productive stage and are still capable to improve their enterprises. The results compare very well with a study in Turkey on economic analysis of beekeeping enterprises which had mean age of 43.35 years, experience of 16.08 years and household size of 4 people (Samer et al., 2004. A different study by (Kuboja, 2017) in Tanzania showed that the average age of the beekeepers was 49 ± 16.11 years and beekeeping experience of 16.27 ± 16.42 years. From this study, the beekeepers' experience is lower than the studies as indicated mainly because there was little effort to commercialise the sector and therefore, there is a current drive to organise and commercialise the apiculture sector in Zimbabwe and many people are joining the sector. A study in Tanzania observed that the average experience of a beekeeper was 5 years, and the researcher indicated that 5 years was adequate experience (Kuboja, 2017). Experience is very important in beekeeping enterprises as it may improve the efficiency of apiculture enterprises, and hence profits. The household size also shows the available family labour for the apiculture enterprises. From the study, out of 5 people that forms the household size; approximately 2 people are involved in apiculture activities per household.

From Table 3, 84.75% of the household interviewed were male-headed whilst 15.25% households were female headed. The figures compare very well with a previous study done in Chirumhanzu on a beekeeping project which revealed that 70% were males and 30% were females (R137538M, 2017). A study in Tanzania had 94.5% male beekeepers and mere 4.5%

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female beekeepers (Kuboja, 2017). The lower numbers for females might be a result of the nature of the activities which are done in forests and usually at night.

In terms of educational level of sampled beekeepers, 13.6% attained non-formal education, 35.6% achieved primary level, 37.3% did secondary level and 13.6% did tertiary educational level. In a beekeeping research in Mwenezi district of Zimbabwe, researchers found that 20% of respondents did not go to school while 80% attended some formal education. Of the 80%, 10% attended tertiary education (Chazovachii et al., 2013. The level of education can be very important in technology adoption by beekeepers because those beekeepers may have a better understanding than their counterparts during their contact with extension service providers.

From the study, 37.3% respondents were exclusively engaged in beekeeping as main project whilst 11.9% and 50.8% indicated that their main activities are formal employment and other projects respectively. A study in Turkey revealed that 72.73% households relied on beekeeping whilst 27.27% relied on beekeeping and other activities (Samer et al., 2004. A lower percentage for this research as compared to that which was done in Turkey can be supported by low experience of Zimbabwean beekeepers as compared to those in Turkey which had a mean experience of 16 years. Also, those beekeepers with more experience in Zimbabwe have been using traditional hives and were doing apiculture as hobby whilst getting little income. Commercialisation which has begun in recent years has now brought in improved hive technologies.

From the study, 76.3% of the respondents were members of various associations whilst 23.7% were not. Cluster development is an interesting model which enhances group cohesion, access to input, output and financial markets, and improves on knowledge transfer among beekeepers. Most beekeepers are part of Chipinge District Beekeepers Association and Ngaone Beekeepers Association. This is an important step in the commercialisation of the sector.

On hive technologies the beekeepers have used, 11.9% of the respondents indicated that they exclusively have traditional beehives, 64.4% used Kenyan Top Bar hives and 23.7% used both. This compares well with a research done in Tanzania which showed that 46.5% beekeepers owned improved hives (langstroth and KTB hives) while 34.3% owned traditional hives, and 19.3% owned both (Kuboja, 2017). The adoption of improved hive technologies is a positive step in a bid to improve hive productivity and incomes.

Establishing Productivity of Apiculture

Table 4
DESCRIPTION STATISTICS FOR YIELD (kgs)

	N	Minimum	Maximum	Sum	Meam	Std. Deviation
Traditional hives colonisation percentage	22	50.0	79.0	1439.4	65.426	8.3263
KTB hives colonisation percentage	52	57.0	100.0	4043.4	77.758	11.4638
Average Traditional hive yield (kgs) per annum	22	3.9	13.5	175.6	7.982	2.7872
Average KTB hives yield (kgs) per annum	52	5.4	40.5	857.1	16.482	5.7579
Valid N (listwise)	15					

The mean hive occupancy/colonisation percentage for traditional hives was 65.43% ± 8.33 whereas it was 77.76% ± 11.46 for improved hives. The average honey yield for traditional hive was 7.98 kgs ± 2.79 while that of Kenyan Top Bar hives was 16.48 kgs ± 5.76 shows in Table 4.

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The data was tested for normality and most variables were not normally distributed. Therefore, instead of using independent sample t-test to compare means, non-parametric tests were used and Mann-Whitney U was the analytical tool of choice. Table 5 shows normality tests and Table 6 shows a presentation of the mean comparison on honey yield and colonisation percentage data.

Table 5
TESTS OF NORMALITY

	Hive Technology used	**Kolmogorov-Smirnov**[a]			**Shapiro-Wilk**		
		Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
Number of hives	Traditional hives	0.207	22	0.015	0.819	22	0.001
	Kenyan Top Bar hives	0.212	50	0.000	0.868	50	0.000
Number of colonised hives	Traditional hives	0.314	22	0.000	0.751	22	0.000
	Kenyan Top Bar hives	0.233	50	0.000	0.859	50	0.000
Hive yield per annum	Traditional hives	0.091	22	0.200*	0.952	22	0.342
	Kenyan Top Bar hives	0.143	50	0.012	0.880	50	0.000
a. Lilliefors Significance Correction							
*This is a lower bound of the true significance.							

Table 6
MEAN COMPARISONS FOR PRODUCTIVITY DATA

	Colonisation percentage	**Hive yield (kgs) per annum**
Mann-Whitney U	224.500	62.500
Wilcoxon W	477.500	315.500
Z	-4.115	-6.028
Asymp. Sig. (2-tailed)	0.000	0.000

a. Grouping Variable: Hive Technology used

Both mean yields and hive colonisation percentage were significantly different ($P<0.05$) for traditional hives and Kenyan Top Bar hives. The significant difference is shown diagrammatically as in Figure 3.

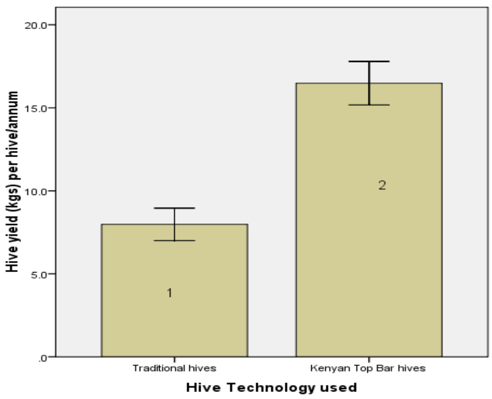

FIGURE 3
MEAN COMPARISONS OF HIVE YIELDS

The graph shows significant difference in hive yield between traditional and KTB hives. Kenyan Top Bar hives honey yields are significantly higher than traditional hives.

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In Zimbabwe, a presentation at an ApiExpo in 2014 reported that average yields were 12 kg per hive per year for traditional hives and 15 kgs per hive per year for KTB hives (Nyatsande et al., 2014). A research in Southern Ethiopia showed that traditional hives yielded 6.3 kgs per year whilst KTB hives had 13.2 kilogrammes (Dakka & Jaleta, 2010). A separate study in Chena district of Ethiopia showed yields of 7kgs/hive/annum for traditional hives as compared to 23 kgs per hive for improved beehives (Tarekegn et al., 2017). In Tanzania, a study observed yields of 11.98 litres ± 5.6 per hive per year for KTB hives and 7.90 litres ± 4 per hive per year for traditional hives (Kuboja, 2017). Honey in litres can be converted to kilogrammes by an average standard of 1.42. The results compare very well with national, regional and international research results. Yields for KTB hives are significantly different from those of traditional hives. In a study in Saudi Arabia, researchers observed average yields of 3.7 kgs for traditional hives and 6.6 kgs for improved hives, which were lower and even lower than the research results (Al-Ghamdi et al., 2017). The researchers pointed out that the low productivity was a result of shortage of bee forage due to longer dry periods. Although improved hives are expensive to make than traditional ones, results obtained should improve the zeal of the modern beekeepers to invest in improved hive technologies as they improve honey yields. However, there is still scope for further improving productivity since some researches revealed yields above the averages obtained in this study, and also the existence of good climatic conditions in Chipinge and parts of Zimbabwe which promotes natural production of bee forage.

The hive colonisation percentages were higher for improved hives. This is directly a result of better bee colonies management and conducive shelter in KTB hives than traditional ones. Once the conditions in a hive deteriorate, bee colonies swarm and look for better shelter. This is supported by the fact that farmers with traditional hives (log and bark hives) usually find it difficult to inspect their hives, which is contrary to KTB hives where beekeepers are able to routinely inspect their hives for possible problems identification which include bee diseases and pests that eat honey or the bees, and also the colony strength including queen condition and availability. However, improvements can be done in making all hives colonised by managing hive density per apiary site to enable enough provision of forage to a certain bee population, overall hive management and engage in queen breeding and rearing programmes so as to increase rate of colonies generation.

Evaluating Viability of Apiculture

Table 7 shows mean gross incomes, costs, and margins for traditional hives and Kenyan Top Bar hives (KTBs).

Table 7
MEAN GROSS INCOMES, COSTS AND MARGINS (US$)

ITEM	Kenyan Top bar hive mean values	Traditional hive mean values	Differences
Revenue/Gross Income (GI)	572.2788	286.1905	286.0883
Labour cost	22.5962	23.2857	-0.6895
Disease & predatory pest control	8.5769	12.6190	-4.0421
Transport cost	18.2885	12.5238	5.7647
Packaging cost	41.6154	28.5714	13.044
Total Variable Cost (TVC)	89.6923	77.4762	12.2161
Gross profit (GP)	479.8942	190.7619	289.1323
Gross profit per hive	28.0560	10.8097	17.2463

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Table 7 shows higher gross income and gross profit for Kenyan Top Bar hives. The results show gross profit per hive of US$28.06 for KTB hives and US$10.81 for traditional hives.

Data were tested for normality and found to be not normally distributed. Instead of using the previously planned independent sample t-test, mean comparisons were done using non-parametric tests, and because data was not matched, Mann-Whitney U was used and the results are shown on Table 8.

Table 8
MEAN COMPARISON OF INCOME AND COST DATA

	Gross income	Labour cost	Disease and pest control cost	Transport cost	Packaging cost	Total Variable Cost	Gross margin	Gross margin per hive	Gross margin per Total variable cost
Mann-Whitney U	352.000	523.500	382.000	484.500	396.000	507.500	280.500	47.000	28.500
Wilcoxon W	583.000	1901.500	1.607E3	715.500	627.000	738.500	511.500	278.000	259.500
Z	-2.364	-.275	-1.707	-0.754	-1.831	-0.469	-3.235	-6.083	-6.321
Asymp. Sig. (2-tailed)	0.018	0.784	0.088	0.451	0.067	0.639	.001	0.000	0.000
a. Grouping Variable: Hive technology used									

From the analysis and table, gross income, gross profit and gross profit per hive were significantly higher for KTB hives (P<0.05). Disease and pest control, and packaging costs were also significantly different at 10% significance level (P<0.1). Other costs were not significant (P>0.05).

The following graphical presentations on Figures 4 and 5 show the differences in mean gross income and profits between traditional hives and KTB hives which were significant.

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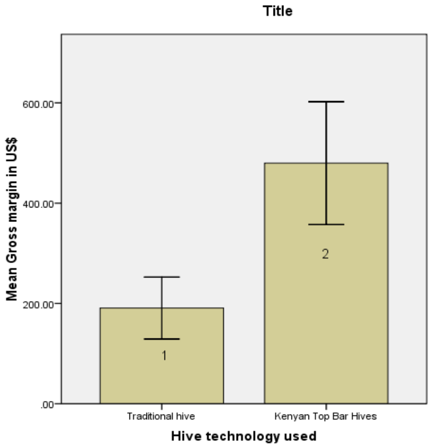

FIGURE 4
MEAN GROSS INCOME FOR DIFFERENT HIVE TECHNOLOGIES

The bars indicate significant differences in mean gross income between traditional and KTB hives, although both have positive gross incomes.

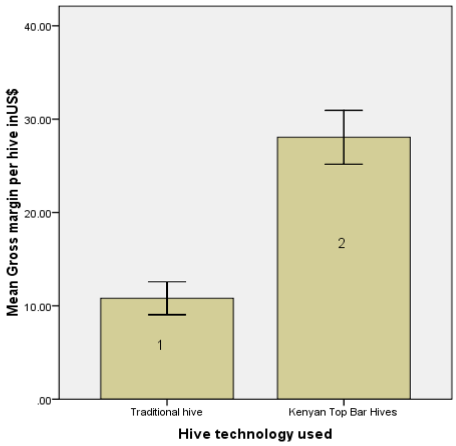

FIGURE 5
MEAN GROSS PROFIT PER HIVE TECHNOLOGY

The graph on Figure 5 shows a significant difference in mean gross profit per hive for traditional hives and KTB hives. Kenyan Top Bar hives had significantly more income and gross profit per hive than traditional hives.

Various studies observed higher annual incomes ranging from US$180 to US$500 (Chazovachii et al., 2013); (Mazorodze, 2015) which are almost similar to these research results. Kuboja study observed that beekeeping was a viable enterprise which can be used as a main source of income to rural households. The same study further observed that beekeeping using improved hives is a more profitable business as compared to traditional hives (Kuboja, 2017). A study that was done in Turkey observed gross income per colony of €38.10 and net income of €7.28 (Samer et al., 2004). All the researches have noted a significant difference between traditional and improved hives and also recorded positive incomes and profits. Therefore, apiculture enterprises are viable in Zimbabwe.

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RECOMMENDATION

From the results, it was found that improved beehives produce higher yield of honey and more profit. Therefore beekeepers should be encouraged to use improved beehives. Besides higher yield of honey and higher profit as compared to traditional beehives, improved beehives reduce the destruction of trees to make beehives. Destruction of trees also increase climate change which is affecting the world today.

CONCLUSION

The findings of the research compare very well with other researches done in Zimbabwe, regionally and internationally. The key findings under discussion were that more males are engaged in beekeeping activities than females. Also, average age of beekeepers was in the productive age category and there is scope for improving production since more beekeepers are still economically active. The average household size indicates availability of family labour, and more importantly, an average of 2 out of 5 people per household are engaged in beekeeping activities. Average experience of beekeepers seems to be low, but compares well with regional countries, however, is lower than European countries. Most beekeepers attained some form of education which is important in technology transfer, as evidenced by a bigger number of households who have adopted KTB hive technology.

Kenyan Top Bar hives yields (16.48 kgs ± 5.76) were significantly higher ($P<0.05$) as compared to traditional hives (7.98 kgs ± 2.79). Kenyan Top Bar hives (US$ 28.06) had significantly higher ($P<0.05$) gross profit per hive than traditional hives (US$ 10.81). Apiculture viability indicators were positive indicating that apiculture enterprises with both types of hives are viable although better gross profits are obtained with improved (KTB) hives.

Beekeepers are supposed to scale up management of beekeeping projects or apiaries to improve incomes. Despite incomes and gross profits being positive, improving on management and adoption of KTB hives will further improve incomes.

There is also need to further find ways of improving hive colonisation like queen rearing and colony splitting. Also, some other methods can be used to catch feral swarms and put in non-colonised hives. Regular inspections are also recommended to further improve hive productivity. The research further recommends harvesting at least two times per year which can be achieved once inspections are done regularly.

The researcher recommends further researches on bee feeding. All the respondents indicated that they were not feeding their bees and indicated that bee forage is available throughout the year. There is need for a further research to establish this and find out if it is not part of the factors affecting hive productivity. Also, there is need for further researches to capture fixed costs of beekeeping enterprises and carry out profitability analysis. This will give further evidence and indication of profitability of the sector, possibly in comparison with other agricultural enterprises.

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