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Resource Use Efficiency in Beekeeping Using Modern Beehives: A Case of Sikonge District, Tabora - Tanzania

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ABSTRACT

This study revealed detailed information concerning resource use efficiencies using modern beehives essential in planning to improve yield and profit of beekeeping in Sikonge District. Choices made by a beekeeper to use what and how much resources in beekeeping vary among beekeepers basing on availability of the resource itself. This study analysed the resource use efficiency in beekeeping activities in Sikonge District. The specific objective for this study was to evaluate resource use efficiency of beekeeping using modern beehives. Data was collected by semi-structured questionnaire, key informants' interview, focus group discussion and direct field observation. This study was done in four wards; Chabutwa, Tutuo, Kipanga and Kiloleli. The wards were randomly selected out of the 15 wards of Sikonge District. Descriptive statistics were obtained using Statistical Package for Social Science (SPSS) computer programme as analytical tool. Results revealed that the number of beehives and number of man-days for hired labour were underutilised with resource use efficiency coefficient (r) values of 1.5 and 121 respectively while family labour man-days were over utilised (r = -91.82). It is recommended that beekeepers in Sikonge utilize the available resources optimally to maximize yield and profit of their beekeeping activities.

Key words: Beekeeping - Modern beehives – efficiency - Resource use .

INTRODUCTION

Beekeeping is the practice and management of raising honeybees for man's economic benefits by production of valuable materials such as honey, beeswax, propolis, bee pollen, bee venom and royal jelly (Chinaka 1995, Ojeleye 1999, Ojeleye 2003, Ojo 2003, Shuaib *et al.* 2009). Beekeeping is one of the widespread activities practiced in the world while honey and beeswax being the major products in many parts (Vural and Karaman 2009). Recently, in many parts of the world beekeeping has been promoted so as to tackle unemployment and improve the living standards of the populace (Abdulai and Abubakari 2012). World honey production is over 1.1 million tonnes per year and the world leading honey producers are China, Turkey, Argentina, Ukraine, United States of America and Ethiopia (FAOSTAT 2016). In Africa, Tanzania is ranked second after Ethiopia and its production stands at 4860 tons and 324 tons of honey and beeswax respectively which is only 3.5% of the potential production of honey and beeswax (URT 1998a). Tanzanian honey is a pure organic honey as it does not involve any chemical processing in all its production and packaging processes (URT 1998a).

Beekeeping provides both social and economic benefits to rural communities and has received primary attention in recent years (Fumayied *et al*.2014). Economic benefits are usually measured in monetary terms as income from employment in the sector while social benefits are reflected in many local uses they offer to the communities ranging from honey being used as food and medicine for the treatment of various ailments such as cough, constipation, diabetes, sore, burning, indigestion and arthritis (Fumayied *et al*.2014). In Tanzania beekeeping provides employment, income and economic security for many people in rural areas (Lalika 2008, Mwakatobe and Mlingwa 2005, Ngaga *et al* 2005). It is estimated to generate about USD 1.7 million each year from sales of honey and beeswax and employ about 2 million rural people (Mwakatobe and Mlingwa 2005). It requires little start–up investments, does not require complex technologies and techniques to start with and bees usually look after themselves, with little need for tendering (Mwakatobe and Mlingwa 2005).

Beekeeping provides local people and the government economic incentives for the protection of natural habitats and is a useful activity in any forest conservation initiatives (Agera 2011, Lalika 2008). Bees are important pollinators and many ecosystems depend on the pollination by bees thus increasing the genetic diversity through cross pollination (FAO 2007). The process of pollination is largely successful as many bees are involved in making of honey increasing the chances of pollination (Lusambo and Mbeyale 2016). Beekeeping has been used as a useful approach in management of forests in areas where beekeepers put their beehives avoid bush fires and sometimes take initiatives to guide to ensure safety for their apiaries and this discourages illegal logging or cutting poles. Additionally in apiaries people avoid doing activities or passing in fear of being stung by bees. Therefore, where there is an apiary, forest resources are conserved (Lalika 2008). Beekeeping can also be used in reforestation projects by paying attention to plants which are good sources of pollen and nectar (Agera 2011).

The modern beehives which are synonymously called appropriate beehives are beehives with proper measurements based on research findings (Cramp 2008). This category is one promoted by the government through the Ministry of Natural Resources and Tourism (MNRT) to be used by beekeepers all over the country because of its major stated benefits: improved yield (quality and quantity) and environmental conservation (URT 1998a) and a category includes the top bar hives (Tanzania and Kenya top bar hives) and the langstroth (Tanzania commercial hives). These beehives are usually constructed by carpenters using timbers extracted from mature trees of good quality and the advantage is that from one tree several beehives can be obtained after timber extract and are usually durable and easy management of bee colonies (URT 1998a).

Beekeeping in Tanzania is carried out using both traditional (but highly discouraged due to its low productivity and negative effects to the forests) and modern methods (Kihwele 1991). Approximately 95% of all beehives in Tanzania are traditional beehives including log and bark hives and only 5% are the modern beehives including the top bar hives and the langstroth hives (Kihwele 1991, Mwakatobe and Mlingwa 2005). The traditional methods accounts for 99% of the total produce of honey and beeswax in the country (Mwakatobe and Mlingwa 2005, Prandin *et al* 2000). Sikonge District has the potential of 6000 tonnes of honey production per annum while its production stands at 2000 tons per annum, rendering it the leading District in the country with respect to honey production (URT 2001). The presence of both stinging and non-stinging honeybees coupled with existence of indigenous knowledge in beekeeping is also a great potential in honey and beeswax production in Sikonge District (Sikonge District 2015).

The nature and amount of materials and resources used in beekeeping activities, constraints of beekeeping activities together with the monetary values vary from place to place and therefore contributes to differences in resource use efficiencies (Cheryl and Matt 2013) which necessitated this study. The variations on amounts of resources used in production units accounts for the differences in resource use efficiencies among different economic activities in different areas (Ahmadi 2016). The resource use efficiency of beekeeping using modern beehives in Sikonge is poorly known and therefore this study aimed to carry out an analysis of resource use efficiency of beekeeping using modern beehives in Sikonge District, Tabora Region so as to bridge the gap by focusing on efficiency of key resources used in the production process. The findings of this study will be used by different beekeeping stakeholders to understand how resources are used in Sikonge and what could be done to improve resource utilisation and eventually have optimal production of honey and beeswax.

MATERIALS AND METHODS

Description of the study area

This study was conducted in Sikonge District in Tabora Region (Fig. 1). A District lies between 5° 38' 0" South and 32° 46' 0" East. It is 71 km from the headquarters of Tabora Region in the Southern part. The District has fifteen wards which are: Chabutwa, Kikungu, Ipole, Kiloleli, Kiloli, Kipili, Kitunda, Misheni, Mpombwe, Mtakuja, Ngoywa, Nyanhua, Pangale, Sikonge, Tutuo and Usunga. The total area of the District is 27 873 km² of which 26 834 km² are in forest and game reserves which is suitable for beekeeping activities and the remaining 1039 km² is for settlements and other economic activities (Sikonge District 2015). Sikonge District is leading in honey and beeswax production (2000 tonnes annually) with the highest potential of honey and beeswax production in the country (URT 2001).

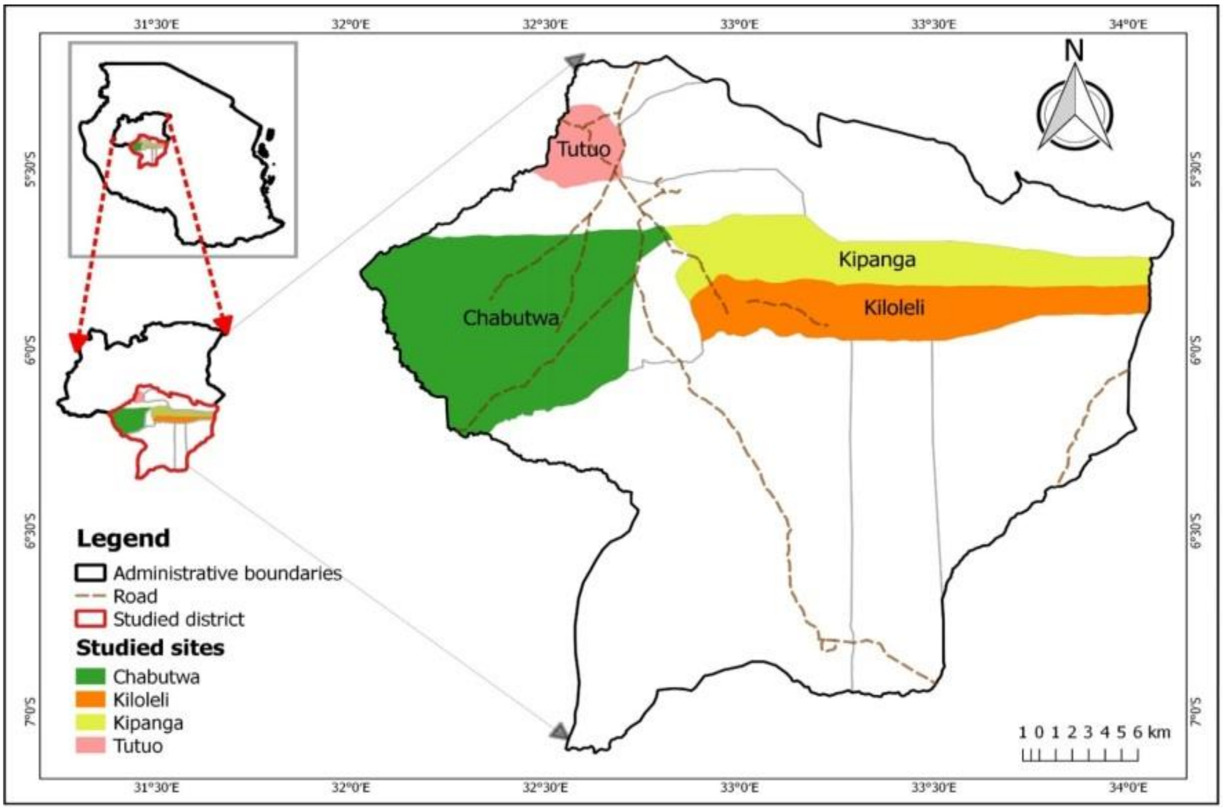

Figure 1: A map of Sikonge District showing the study sites

Sikonge District has rainfall ranges from 600 mm to 900 mm annually and temperatures from 22˚C to 32˚C with the highest temperatures experienced in August, September and October and low temperatures in May. The daily mean temperature is around 23˚C. There is a slightly cooler period from May to July, marked by onset of dry winds which continue until October. Rainfall is seasonal, falling almost from June to October. In the West the rainfall totals over 1000 mm, while in the East it drops to 700 mm or less (URT 1998b). Vegetation of Tabora Region includes woodland, bushland thicket, grassland; lowland or wetland vegetation consisting of wooded grassland and swamps which favours beekeeping. Woodland is the natural vegetation over most of the region and can be divided into two groups: (a) Miombo woodland and Acacia (b) Cambretum and Albizia species (URT 1998b). Climate and the nature of vegetation covering Sikonge District (*largely Miombo woodland*) provide suitable environment condition for beekeeping activities rendering it with the high potential of beekeeping in the country.

The main economic activities of Tabora Region are agricultural production and livestock keeping. About 90% of the population is engaged in agriculture and livestock keeping apart from other activities like beekeeping, fishing and lumbering (URT 1998b). The region is estimated to have 2.4 million hectares of potentially cultivable land but only less than 20 percent is under cultivation (URT 1998b). Subsistence farming is the main form of farming while tobacco and cotton are the major cash crops. Livestock keeping is the second predominant economic activity which if properly exploited can contribute significantly to the Region's economy (URT 1998b). The natural forests which provide high quality hardwood for timber and fuel wood are also a source of beekeeping for honey, beeswax production and also harbors wildlife. Fishing potentials are not fully exploited and fishing activities are mainly confined to Lake Sagara and Ugalla rivers. Industries, trade and mining activities are carried out at a small scale although commercial gold mining is under exploration (URT 1998b).

Sampling procedure and sample size determination

Sampling procedure

A sampling unit was the household. For the purpose of this study, existing fifteen wards of Sikonge District were stratified into three strata based on levels of honey and beeswax production (low production, medium production and high production. Thereafter, four wards were randomly selected proportionately to the total number of wards in each strata using random numbers developed from excel computer program. The four wards selected include; Chabutwa (*low production*), Tutuo and Kipanga (*Medium production*) and Kiloleli (*High production*). The three strata allowed the capture of information in all levels of beekeeping production in the District. From each ward, one village was randomly selected using random numbers technique. The selected villages and their wards in brackets include: Chabutwa (*Chabutwa*), Muungano (*Tutuo*), Imalampaka (*Kipanga*) and Kiloleli (*Kiloleli*). Households from each village using modern beehives were identified and randomly selected for survey.

After selecting the household to take part in the survey, either the *husband* or *wife* of the respective household (*for a married couple*) was responsible for answering the questionnaire which is consistent with approach used by Lusambo (2009). In the event both (husband and wife) were present at the time of interview, then a *random sampling technique* (using playing cards) was used to determine who should be the respondent. Otherwise, for those beekeepers' households whose heads were single or at the time of the visit there was only one of the couple present, the questionnaire was administered to either single household heads or the available couple member (for the latter case). District Beekeeping Assistant (DBA) and District Forest Officer (DFO) were used as key informants for the study and a checklist was administered. On the other hand, two experienced beekeepers for each type of beehives used in the area formed a focus group discussion and a checklist was administered.

Sample size determination

The total sample size for the study was 50 beekeepers' households using modern beehives. The total Sample size of the District beekeepers households was obtained using the formula developed by Bartlett *et al.* (2001):

$$n = \left(\frac{n_0}{1 + \frac{n_0}{N}} \right) \quad (1)$$

Where: n is the required (adjusted) sample size, *N* is the population size; n_0 is the sample size as calculated by Cochran's (1977) formula:

$$n_0 = \left(\frac{t^2 \times pq}{d^2} \right) \quad (2)$$

Where: *p* is the proportion of respondent that give information of interest (the proportion *confirming*), *q* viz (1-*p*) is the proportion not giving information of interest (proportion *defective)*, and *p* q* is the estimate of variance (*which is maximum when p = 0.50 and q = 0.50)*. The maximum population variance of 0.25 will gave the maximum sample size.

Krejcie and Morgan (1970) suggest the following values for survey studies: the appropriate *margin of error* is 0.05 (i.e. 5 percent), and *alpha* is 0.05 (i.e. 95% confidence level); and *p* and *q* should be 0.5 and 0.5 respectively. Based on the information above, the sample size for infinity population (n_o) is 384. Therefore Lusambo (2009) modified the sample size formula as:

$$n = \frac{384}{1 + \frac{384}{N}} \quad (3)$$

Where *n* is the sample size of finite population, and N is the population size. Table 1 provides a summary of sample size in respective study villages.

Table 1: Summary of respondents in the respective study sites

Village	Total Number of beekeepers (N)	Sampled beekeepers (n)
Chabutwa	27	25
Muungano	15	14
Imalampaka	4	4
Kiloleli	7	7

Data collection

Data used for this study consisted both primary and secondary data. Primary data was obtained through questionnaire survey, focus group discussion, key informant interview and direct field observations while secondary data were gathered through documentary review.

Questionnaire survey

Prior to actual data collection, questionnaire was pilot tested for a number of reasons as were suggested by Lusambo (2009): (i) to gauge whether questions, as set in the questionnaire, are understood by the respondents, (ii) to check whether the questions elicit the intended information, (iii) to find out the sensitive questions contained in the questionnaire, (iv) to determine the respondents' *interest*, *attention* and *cooperation* towards the survey, (v) to test the competency of assistant data collector, (vii) to estimate the time it takes to complete one questionnaire. The questionnaire used in the survey was semi-structured and were administered through personal interviews in order to encourage interviewees to participate and also allow probing and clarification by interviewer (Njogu 2011). Open and closed ended questions with a series of choices were used for respondents to choose the proper answer. The questionnaire was used to collect information on socio-economic variables of beekeepers' households, type and number of beehives owned, beekeeping management practices, the costs incurred in beekeeping production data and factors for adoption of modern beehives. Prior to actual data collection, questionnaire was pilot-tested in order to improve its validity and reliability.

Focus group discussion

Focus group discussions are the *exploratory* research tools 'structured group process' conducted for the purpose of exploring peoples' thoughts and feelings and obtaining information about a particular topic or issue in a permissive, non-threatening environment (Ogunbameru 2003, Zikmund 1997, Chang and Zepeda 2005, Kreuger 1988, Dewey 2000, Lewis 1995, Davies *et al.* 2008). The data Collection team employed Focus Group Discussions (FGD) to collect information from various groups that constitute information needed for the study. FGDs collect data related to beekeeping activities in the study area (including production of honey and beeswax, costs involved in production, revenues accrued from beekeeping and challenges encountered). The participants to the FGD were the experienced beekeepers and village government leaders. The number of participants ranged from 6 to 8 people, which is consistent with the acceptable range of FGD size of between 4 and 12 people as suggested by various researchers (Chang and Zepeda 2005, Krueger 1988, Davies *et al.* 2008, Ogunbameru 2003, Dewey 2000). Deliberate efforts were made to strike a gender balance among the participants.

Interview with key informants: Key informant interviews are qualitative in-depth interviews with people who know what is going on in the community. The purpose of key informant interviews is to collect information from a wide range of people—including professionals. Key informant interviews (KII) can be conducted by telephone interviews or face-to-face interviews. The key informants for this study included District Forest Officers, Community Development Officers, TFS officials and Officials from Forest and Beekeeping Division (FBD). KII aimed to collect data on beekeeping activities including; availability and costs of modern beehives, markets for bee products and selling prices of bee products.

Direct field observations

Direct observation is the collection of information using your senses. By observing, you can document activities, behavior, and physical aspects of a situation without having to depend on peoples' willingness or ability to respond accurately to questions. Observation is useful when: you are trying to understand an ongoing process or behavior, an unfolding situation or event; there is physical evidence, or products or outcomes that can be seen; and written or other data collection methods seem inappropriate. In this study, the research was keen in observing the presence of beekeeping activities, markets for bee products, availability of modern beehives, and enthusiasm of the target population towards the beekeeping activities. Furthermore, direct observations were used to identify key inputs of beekeeping using the modern beehives.

Documentary review

The research team (RT) conducted in-depth literature review of the information pertaining to the study (beekeeping) in the study area. The reviewed documents included (but not limited to): previous research reports relevant to beekeeping, both grey literature and published Journal articles relevant to the study, and beekeeping programme reports from Forestry and Beekeeping Division (FBD). Besides, literature review on best practices and success stories of beekeeping from other parts of world was conducted and synthesized.

Data analysis

Resource use efficiency of honey and beeswax production

Research on resource use efficiency (r) fundamentally commences with the assumption regarding the goal of producers. The classical assumption is the motive of profit maximisation, which is an ideal framework against which various forms of efficiencies of production can be adequately measured. It is related to the ability of a firm to choose its inputs in a cost-minimizing way. In order to achieve this objective, the study employs the MVP-MFC analysis approach. This approach has been used by researchers such as Ishiaku *et al.* (2017), Awunyo-Vitor *et al.* (2016), Danso-Abbeam *et al.* (2015) Kadiri *et al.* (2014) and Konja *et al.* (2019) where the MVPs for each input used were computed and such computed MVPs were then compared with their respective acquisition cost, MFC.

Resource use efficiency for this study was analysed in three major inputs of production in the area which are; number of beehives, number of man-days of hired labour and number of man days of family labour. These resources were analysed independently with respect to the costs incurred and the revenue obtained in each level of unit input addition. The ratio of Marginal value of products (MVP) and marginal factor cost (MFC) were computed to obtain the resource use efficiency coefficients (r). The MVP was obtained from the ratio of change of total value product (TVP) to change in input level (*number of beehives, hired labour man days and family labour man-days*). The TVP (Revenue) was obtained as the product of total physical product (TPP) and the selling price of a product. TPP is the amount of production (yield) expected from using each input level. The ratio of the MVP to MFC gave the resources use efficiency coefficient (equation 4) as it was adopted by Ahmad (2016):

$$r = \frac{MVP}{MFC} \qquad (4)$$

While MVP was calculated using the formula:

$$MVP = MPP \times Pq \qquad (5)$$

Whereas MPP is marginal physical product and Pq = price of unit output and r = resource use efficiency coefficient.

The decision rule is such that: ***r* = 1** implies that resources are used efficiently; ***r* > 1** implies resources are underutilised and increasing the rate of use of that resource will help increase productivity; ***r* < *1*** implies resources are overutilised and reducing the rate of use of that resource will help improve productivity.

RESULTS AND DISCUSSIONS

Resource use efficiency of honey and beeswax production

Number of beehives

Findings of the study indicate that, the number of beehives owned by beekeepers was seen to be underutilized with a resource use efficient coefficient (*r)* of *1.50* (Table 2). This means that the beehives owned are currently producing less than their potential capacity, this alerts that if efficiently used the current number of beehives owned by beekeepers could produce more hence high yield attained. This inefficiency is likely to have been attributed by improper management techniques the beekeepers use in the production process which is likely to have been attributed by traditional approaches as 86.5% of modern beehives users responded that they conduct beekeeping conventionally, this means even those who have adopted modern beehives still poorly manage them. Therefore, this study revealed that poor management could be a reason for underutilisation of number of beehives and therefore there is a need to improve management practices so as to raise the level of production.

Table 1: Resource-use efficiency for number of beehives

Number of beehives	Total cost of beehives	Marginal Cost (MFC)	Total Revenue	Marginal Revenue (MVP)	r
1	67 831.38	-	105 916.56	-	-
2	134 580.65	66 749.27	152 723.01	46 806.45	0.70
3	205 935.48	71 354.84	348 104.92	195 381.91	2.74
4	266 993.55	61 058.06	402 092.50	53 987.59	0.88
5	333 605.57	66 612.02	468 360.88	66 268.38	0.99
6	407 806.45	74 200.88	603 466.60	135 105.72	1.82
7	461 548.39	53 741.94	650 350.27	46 883.67	0.87
8	527 483.87	65 935.48	837 483.40	187 133.13	2.84
10	689 689.15	81 102.64	939 988.30	51 252.45	0.63
12	806 392.96	58 351.91	1 188 448.64	124 230.17	2.13
15	989 032.26	60 879.77	1 290 727.88	34 093.08	0.56
20	1 369 266.86	76 046.92	1 477 984.56	37 451.34	0.49
21	1 464 272.73	95 005.87	2 167 731.28	689 746.72	7.26
30	1 978 064.52	57 087.98	2 896 689.12	80 995.32	1.42
38	2 505 548.39	65 935.48	3 577 173.60	85 060.56	1.29
40	2 800 000.00	147 225.81	4 054 880.00	238 853.20	1.62
50	3 296 774.19	49 677.42	4 334 844.80	27 996.48	0.56
110	7 252 903.23	65 935.48	11 683 703.20	122 480.97	1.86
135	8 901 290.32	65 935.48	12 512 078.80	33 135.02	0.50
200	13 187 096.77	65 935.48	15 662 868.00	48 473.68	0.74
Resource use coefficient (r)					**1.50**

Hired labour man-days

Results revealed that the resource use efficiency for hired labour is underutilised with a resource use efficiency coefficient (*r)* of 121 (Table 3). This implies that beekeepers employed larger number of hired labour man-days and did not optimally utilise them. There is a need therefore to optimize the utility of the hired labour man days which when other factors remain constant could improve production efficiency of honey and beeswax from the modern beehives in the study area.

Family labour man-days

Findings of this study revealed that family labour is over utilised with an r value of -91.82 (r < 1) (Table 4). This tells that with the current level of production and number of beehives owned by beekeepers in the study area, more family labour man days were used than the optimal level required, that the same level of production could have been attained by less number of family labour man days. Further, the larger number of family labour man days could have contributed to raising of production costs thus decreasing the marginal output (*diminishing return)*. This is in-line with many studies that many beekeepers rely on household labour which seem to be a readily available resource resulting to its overutilization (Vural and Karaman 2009, FAO 2015, Ahmadi 2016). Less family labour man-days usage in the production process, if other factors are held constant, could have improved efficiency of production of honey and beeswax in Sikonge.

Table 2: **Resource-use efficiency for hired labour man-days**

Man-days of hired labour	Total Cost of hired labour	MFC	Total Revenue	MVP	r
1	16 000.00	-	496 197.73	-	-
2	56 111.11	20 054.56	751 938.91	255 741.18	12.75
3	135 000.00	26 294.30	1 895 722.82	1 143 783.91	43.50
4	145 000.00	2 497.00	3 262 652.40	1 366 929.58	547.43
7	600 000.00	64 996.00	15 662 868.00	4 133 405.20	63.59
10	400 000.00	-20 007.00	12 097 891.00	-1 188 325.67	59.40
Resource use coefficient (r)					**121**

Table 3: Resource use efficiency for family labour man-days

Man-days	Total cost	MFC	Total Revenue	MVP	r
1	18 575.00	-	447 598.40	-	-
2	30 361.54	5 892.27	745 936.96	149 168.28	25.32
3	54 333.33	7 988.60	2 175 964.61	476 673.89	59.67
4	54 000.00	-86.33	2 332 154.57	39 044.49	-452.25
Resource use coefficient (r)					**-91.82**

CONCLUSIONS AND RECOMMENDATIONS

The study concludes that input resources; number of beehives owned and number of hired labour man-days were underutilised. On the other hand, this study affirms with other studies that many small famers household activities over utilise family labour man-days. To improve productivity from the modern beehives, it is imperative that resources are utilised efficiently and production costs are reduced. Proper management of input resources including beehives, number of hired and family labour man-days will raise yield of bee products such as honey and beeswax from the modern beehives and therefore profit maximization.

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