

# Assessment of Colony Carrying Capacity and Factors Responsible for Low Production and Productivity of Beekeeping in Horro Guduru Wollega Zone of Oromia, Ethiopia

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**Abstract:** The study was conducted in Horro Guduru Wolega Zone of Oromia region, Ethiopia in view of investigating colony carrying capacity and prime factors responsible for the low production and productivity of beekeeping in the area. Individual questioner survey, focus group discussions and field assessment were used to collect the relevant data. Moreover, data on suitable land size for beekeeping, seasons and frequency of honey harvest, months of dearth period for colonies, honey potential of the area, number of colonies in one apiary and other issues were collected. Personal observations were also made to the apiary management of the beekeepers. The study revealed that out of 820,956 ha land mass of the zone, about 59% was found to be with the highest potential for beekeeping with the remaining portion with medium potential. Two major honey-harvesting seasons with average frequency of 1.66 times and two months long dearth period in between the two seasons were identified. Estimated honey reserve potential of the zone is about 89.2 thousand tons/year with colony carrying capacity of 520 bee colonies per single apiary. However, the average number of bee colonies managed per apiary is found to be 260 indicating the overall ratio of actual existing colonies to the carrying capacity of an apiary is 0.5. From this analysis, current average honey production from traditional transitional and modern were found to be 3.5, 14.6 and 21.0 kg/colony/year, respectively with pulled average of 10.6 kg/ colony/year in the study area. With the current bee colony holding size and production level, each beekeeper produces about 244 kg/year, while it has a possibility of achieving 700 kg honey per year. From this, the annual yield loss per individual beekeeper can be estimated to 460 kg honey which can further explored to over \$820 financial loss. Bee colony miss-management is identified as fundamental major cause of low production and productivity of beekeeping in the study area than the carrying capacity of individual apiary. It is recommended from this study that beekeepers should follow the standard apiary setting to utilize the production potential of their beekeeping endeavor.

**Keywords:** Colony Carrying Capacity, Flowering Calendar, Horro Guduru Wollega and Honey Yield Potential

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## 1. Introduction

Having favorable environmental conditions for growth of diversified natural vegetation and cultivated crops, Ethiopia is one of the best areas in the world for beekeeping. Apiculture is one of the agricultural subsectors that most suits the livelihood of rural community in an immense benefit in contributing significantly to income generation and diversification, enhance crop production through pollination,

create jobs for landless youths, sustain ecosystem conservation and rehabilitation. In general, beekeeping has positive impacts on food security and environmental stability. As one of the most important economic activities for rural communities in Ethiopia, approximately one out of ten rural households keeps honeybees [1]. According to [2], there are estimated 6.2 million colonies in Ethiopia, of which 90% are kept in traditional methods. These colonies are managed by about 1.7 million farm households, who are keeping bees as a means of additional income generation [3]. The production

potential of honey and beeswax is 500,000 and 50000 tons of honey and beeswax, respectively [4]. Therefore, beekeeping in Ethiopia is one of the few sectors that have the most inclusive ability to achieve transformation and growth across all categories of rural households [1, 5]. However, the current actual production from managed bee colonies is limited to 53,000 and 5000 tons of honey and beeswax per year in that order, which is nearly 10% of the estimated potential [2]. This indicates that the production and adhering benefits being obtained from this subsector is not commiserating with the existing potential.

Oromia Regional State is one of the potential beekeeping regions of Ethiopia. Horro Guduru Wollega zone is among the 20 administrative zones found in Oromia region comprising 11 districts. Three of the study districts, namely Guduru, Hababo Guduru and Horro, are located in the zone, where especial focus is given for this study. These districts are commonly covered with natural vegetations, shrubs, annual and perennial crops suitable for beekeeping and honey production.

Despite the presence of great opportunities, beekeeping in Horro Guduru Wolega zone is yet underutilized compared to the area's potential. This can be attributed to several factors of which, lack of knowledge on colony carrying capacity, inappropriate stocking and miss management of bee colonies irrespective to the hive type, lack of awareness on flowering calendar of available bee forages in the area and lack of awareness on major and minor honey flow seasons in line with flowering calendar of the area are some of major factors. However, there was no report which specific factor (s) are contributing to the low production and productivity of beekeeping in the study area. This study was therefore, carried out to identify the underpinning factors responsible for low production and productivity of beekeeping and assess the colony carrying capacity of the beekeeping resource of the study area.

## 2. Methodology

### 2.1. Description of the Study Area

The assessment and data collection areas are located between 037° 04.08' to 038° 06.45' E and 09° 02.11' to 09° 42.45' N, distributed in three representative districts, namely Guduru, H/Guduru and Horro of Horro Guduru Wollega zone of Oromia Regional State, Ethiopia. The districts were purposively selected for the study based on beekeeping potential and accessibility.

The climate of the area is humid subtropical, with noticeable dry winters and very rainy summers by traditional classification. The mean annual temperature is 22°C with the range extends between 12°C and 32°C. The pluviometric precipitation varies from 500 mm to 2,750 mm with the average rainfall of 1625 mm and relative humidity of the air remains close to 60% (from the current data).

### 2.2. Study Approach

For the selection of data collection sites, agro-ecological conditions, available resource (bee forage) and local land use patterns were considered (Figure 1). Based on the secondary information about the study zone, three Peasant Associations (PAs) were systematically selected from each sample districts and a total of 9 PAs were covered for data collection. An average of about 35 respondents (individual beekeepers) was contacted for household survey per selected district and a total of 110 individuals were interviewed for data collection. The respondents were selected based on their experience in beekeeping, knowledge on locally available honeybee forages and honeybee colonies ownership.

### 2.3. Sampling Design

A stratified sampling procedure was followed starting at Zone level with the final sampling unit being a household. Districts were taken to be the primary sampling units, PAs were considered as the secondary sampling units, Enumeration areas (PA zones) were taken to be the tertiary sampling units and the beekeepers were taken as final sampling units. PAs were purposively selected with the sample enumeration areas and respondents from each area selected based on the existing experience on beekeeping.

### 2.4. Data Collection on Bee Forages Distribution, Density and Flowering Period

Data collection was done through beekeepers and institutional interviews, field assessment and focus group discussions. Well-developed questionnaires and checklists were used to ensure the collection of relevant qualitative and quantitative data. Accordingly, data on: land use patterns, floral diversity, flowering time and duration, honey harvesting seasons and honey types were collected for analysis. Personal observations were also made to the apiary management systems of some beekeepers to take representative views through taking picture records. Primary data were collected from direct beneficiaries through key informant interviews and group discussions. Secondary data were collected from local government offices: office of Agriculture and natural resources, Land Administration offices, office of livestock and Fishery resources and local NGOs.

### 2.5. Colony Carrying Capacity Determination

In order to determine the optimum colony carrying capacity of the area, the following assumption was considered: A colony consumes from 60 to 200 kg honey per year for all the life activities Chaudhary 2009 quoted in [6]. By assuming the annual requirement of all colony groups (weak to strong) for survival, for brood rearing and as fuel for forages to be the mean of the minimum and maximum, a colony can consume 130 kg to give whatever surplus honey yield for the beekeeper per year. Based on this rough estimation and assuming that the average annual honey yield

per colony from traditional, transitional and box hives, respectively are: 12, 30 and 50 kg/year. Adding 130 kg to these honey yield amounts, potential honey per colony from the area would be 142, 160, and 180 kg, respectively.

To estimate colony carrying capacity per apiary, economical flight range (radius,  $r$ ) of 2 km assumed for worker bees from their nest [7]. Accordingly, workers of a colony at one site can economically forage and provide surplus honey from a total area of 12.6 km<sup>2</sup> (that can be calculated by the formula  $A = \pi r^2$ ), which is equivalent to 1260 ha. According to [8] average potential usable honey reserve value from forest cover and non-arable land assumed to be 84 kg/ha and usable honey potential reserve value from different crops and melliferous weeds across cereals (arable land) assumed to be 24 kg/ha. Therefore, an apiary established in forest and/or non-arable land will have 84 kg/ha \* 1260 ha = 105,840 kg honey reserve, while an apiary established in arable land will have 24 kg/ha \* 1260 ha = 30,240 kg honey reserve with the expected commercial yield indicated earlier. These results, of honey yield assumption were used for calculating optimum number of colonies that can be stocked per apiary under different land use patterns.

## 2.6. Data Analysis

All the collected data were properly coded and key was prepared for each code. Data were then entered to the software and analyzed by using SPSS version 20.0. Descriptive analysis, which included mean, standard deviations of the mean, percentages as well as descriptive graphs and tables were used with respect to the given variables. Detailed calculations on the structure of the major honey source plants were conducted and potential honey reserves were identified and further explored to financial loss for the study area.

## 3. Results and Discussions

### 3.1. Land Allocation and Floral Diversity of the Study Areas

The major portion of the study area belongs to the forest covered and non-arable lands. According to the information collected from different offices of the zone, the forest covered and non-arable lands out of 820,956 ha total land mass of the zone is 482,677 ha, indicating about 59% of the land mass of the area is with huge honey potential (Table 1).

**Table 1.** General information about land allocation patterns of Horro Guduru Wollega zone and the three districts.

Type or land pattern	Area (ha)
Total land area	820,956
Total arable land	338,279
Non-Arable land	272,373
Forest cover	210,304

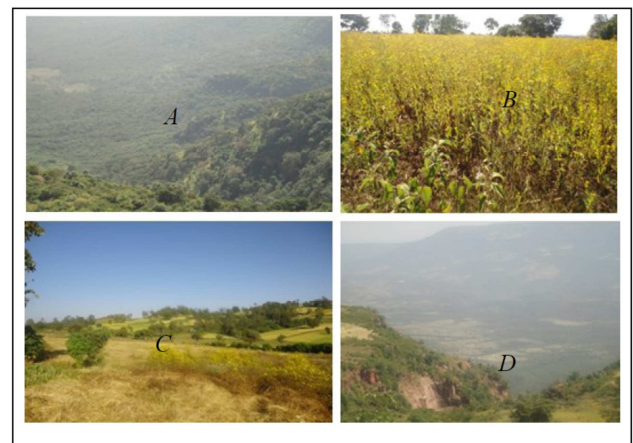
The main forest covered and non-arable areas of the study zone is herbaceous, shrubs and trees with potential nectar and pollen sources plant species. Some of the identified abundant

potential honey source bee forage plants include: *Guizotia scabra*, *Guizotia abyssinica*, *Vernonia amygdalina*, *Justicia schimperiana*, *Syzygium guineense*, *Croton macrostachyus*, *Schefflera abyssinica*, *Albizia gummifera*, *Eucalyptus globules*, *Eucalyptus camaldulensis*, *Dombeya torrida*, *Combretum molle*, *Acacia spp* (like *A. abyssinica*, *A. mellifera*, *A. albida* etc.), *Trifolium ruppellianum*, *Bidens prestinaria*, *Acanthus pubescens*, *Carissa edulis*, *Grewia bicolor*, *Vernonia rueppellii*, *Apodytes dimidiata*, and *Cordia africana*-found distributed over the total area of 482,677 ha.

The remaining significant area (338,279 ha) is occupied by cultivated melliferous species like *Guizotia abyssinica*, *Vicia faba*, *Pisum sativum*, *Zea mays*, *Eucalyptus globulus*, *Eucalyptus camaldulensis*, *Grevillea robusta* etc. of which some of them are known to produce large quantity of nectar [9].

### 3.2. Honey Bee Flora Distribution and Abundance

Presence and distribution of honeybee flora around apiary is very important for beekeeping. In this regard, all the assessed study area had a huge potential in terms of bee forage to sustain large number of bee colonies (Table 2). Some of major source of special honey plants throughout the study area include: *Guizotia spp.*, *Vernonia amygdalina*, *Syzygium guineense*, *Croton macrostachyus*, *Pouteria adolfi-friederici*, *Schefflera abyssinica* etc. and in some lowland portion of the zone: *Combretum molle*, *Sesamum orientale*, *Terminalia brownii*, *Sida schimperiana* and unidentified *Cinni* and *Dhandhansa*. According to [9, 10] these plants are also known honey sources in many parts of Ethiopia as well.



**Figure 1.** Land use patterns and example of forest (A), arable (B and C) and non-arable (D) lands in the study districts areas in Horro Guduru Wollega zone.

### 3.3. Major Honey Types and Expected Yield from the Area

From the assessment of the area, there are more than 20 species of plants, which can provide nectar and pollen, but only 6 honey types were reported by the respondents of the area. The honey types in the area are named after the major (dominant) plant species recorded during the survey from the area (Figure 2). Among the reported honey types, *Guizotia* accounts the biggest portion, while *Cinni* accounts the

smallest quantity. From Figure 3, the total expected commercial honey from the current analysis is 7582.6 tons per year. Therefore, according to the respondent's view, the amounts of potential honey expected by type from the area were: *Guizotia* -2890.9 t, *Vernonia*- 1343.7 t, *Syzygium*-555.5 t, *Cinni* – 412.9 t, *Dhandhansa*- 465.4 t and mixed flora 1914.2 t.

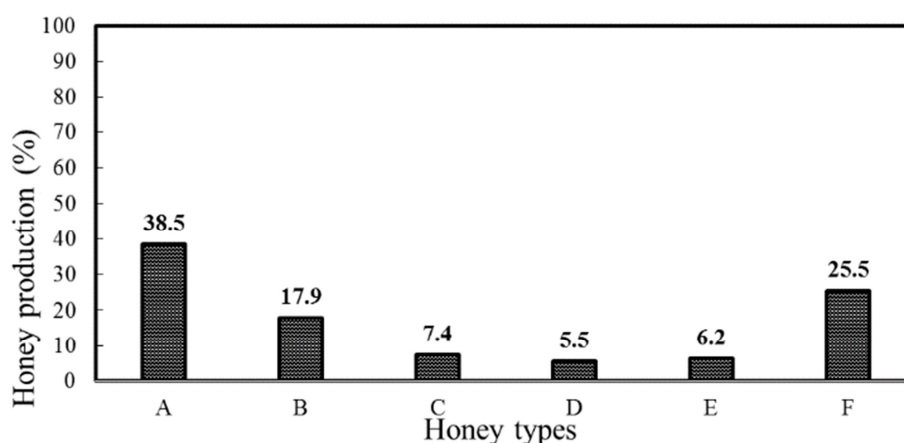
**Table 2.** Honey bee flora distribution abundance in different agro-ecological zones of the study area with their abundance rank.

Distribution of the plants across different agro ecological zones the study area		
Abundance rank	Species	Honey type
1 <sup>st</sup>	<i>Guizotia s spp</i>	Mono floral honey source
2 <sup>nd</sup>	<i>Vernonia amygdalina</i>	Mono floral honey source
3 <sup>rd</sup>	<i>Syzygium guineense</i>	Mono floral honey source
4 <sup>th</sup>	<i>Cinii (unidentified)</i>	Mono floral honey source
5 <sup>th</sup>	<i>Dhandhansa (unidentified)</i>	Mono floral honey source
6 <sup>th</sup>	<i>Croton macrostachyus</i>	Mono floral honey source
7 <sup>th</sup>	<i>Pouteria adolfi-friederici</i>	Mixed honey sources
8 <sup>th</sup>	<i>Eucalyptus spp</i>	Mixed honey sources
9 <sup>th</sup>	<i>Schefflera abyssinica</i>	Mixed honey sources
10 <sup>th</sup>	<i>Combretum molle</i>	Mixed honey sources
11 <sup>th</sup>	<i>Sesamum orientale</i>	Mixed honey sources
12 <sup>th</sup>	<i>Sida schimperiana</i>	Mixed honey sources
13 <sup>th</sup>	<i>Terminalia brownii</i>	Mixed honey sources

This estimation is possible with the frequency of two honey harvesting seasons as per the floral calendar of the area. But analysis of the frequency of the area indicated that honey is harvested only 1.66 times (Table 4). From this fact it is possible to estimate that 17% of the potential honey yield is lost due to low frequency of honey harvesting. From the drawn floral calendar (Table 3) of the area, there is a possibility of producing at least three times using improved techniques and technologies. Development actors and beekeepers will be able to use this information much more efficiently than following the current traditional approach by specifying the contribution of major available bee forages at least in the study area and other similar agro ecologies.

### 3.4. Floral Calendar of the Study Areas

In all the study areas, high availability of honeybee forage plants was noted to provide the honeybee colonies with ample nectar and pollen at two distinct time of the year (from September to November, first season and from April and June, second season) (Table 3). Similarly, in many parts of the country, majority of similar plants in different floristic regions produce flower in these two periods of the year [9–11]. As a result, these seasons give an opportunity for beekeepers to prepare their colonies for honey production. There are also major honey source plants with more than one flowering calendar like *Eucalyptus camaldulensis* and *Cordia africana*. These plants are found in abundance and have large distribution areas in the study zone and this is an opportunity if properly utilized.



**Figure 2.** Honey types A (*GUIZOTIA*), B (*VERNONIA*), C (*SYZYGIUM*), D (*CINNI*), E (*DHANDHANSA*) and F (*MIXED FLORA*) from the area. Honey naming is as proposed by the respondents and production percentage is calculated from potential honey reserve of the area.

### 3.5. Honey Harvesting Seasons of the Study Areas

From the flowering calendar, it is possible to clearly observe that there are two major honey-harvesting seasons. The first major honey harvesting time is in the month of November with the possibility of harvesting honey in late December and early January with planned colony management. The second honey harvesting is in between the months of May and June. Information collected from beekeepers also indicated that there are two seasons with

major and minor honey harvesting in a year in the area. However, there are variations among the sampled districts in terms of defining the major and minor honey harvesting months and also the frequency of honey harvesting (Table 4). The result of the survey shows that even though there is a possibility to harvest honey at least twice a year, the beekeepers are not fully utilizing the opportunity. This is one factor for the low production of beekeeping in the study area.



**Table 3.** Flowering calendar of major bee flora of the Horo Guduru Wolega zone. Months starts with September (S) and end with August (A). Dark yellow shaded part of the table shows months in which the plants are in flowering time.

Plant local name	Plant scientific name	Flowering period (months)											
		S	O	N	D	J	F	M	A	M	J	J	A
siddisa	<i>Trifolium ruppelianum</i>												
Salixii	<i>Sesamum orientale</i>												
Keelloo	<i>Bidens prestinaria</i>												
Harooressa	<i>Grewia bicolor</i>												
Tuufoo	<i>Guizotia scabra</i>												
Nuugii	<i>Guizotia abyssinica</i>												
Daannisa	<i>Dombeya torrida</i>												
Waddeessa	<i>Cordia africana</i>												
Dhumuugaa	<i>Justicia schimperiana</i>												
Kosorruu	<i>Acanthus pubescens</i>												
Daannisa	<i>Combretum molle</i>												
Barzafii	<i>Eucalyptus camaldulensis</i>												
Bahaa	<i>Apodytes dimidiata</i>												
Eebicha	<i>Vernonia amygdalina</i>												
Reejjii	<i>Vernonia spp</i>												
Agamsa	<i>Carissa edulis</i>												
Laftoo	<i>Acacia spp</i>												
Gatamaa	<i>Schefflera abyssinica</i>												
Baddeessaa	<i>Syzygium guineense</i>												
Bakkaniisa	<i>Croton macrostachyus</i>												
Bargamoo adii	<i>Eucalyptus globulus</i>												
Dabaqqaa	<i>Terminalia brownii</i>												
Dhandhansa	unidentified												
Cinii	unidentified												
Mokkoo Dhala	unidentified												
Ajata	unidentified												
Kottee	<i>Sida schimperiana</i>												

### 3.6. Bee Forage Scarcity Period (Dearth Period)

Although there are ample honeybee floras throughout the year, in the months of February to March and from July to August, there is shortage of bee forage sources (Table 3). These months were identified as dearth period in which there is no or little bee forage in the study area as reported by the respondents almost similar to season of flower dearth seasons (data not presented). One of these identified bee forage scarce period (February to March) in current study is in agreement with the report of [9, 10] in most Ethiopian areas. During these dearth periods, bees exhaust their reserve food and abscond from their nest.

From the drawn flowering calendar (Table 3), it is clear that February and March months are moments of extreme dearth as there is no flowering plant reported in the study area and hence colonies can be seriously affected unless supplementary feed is provided. Although, months of July and August colony are reported as death period, there are still some flowering forages. Nevertheless, the problem will be heavy rain during these months which may wash pollen and dilute nectar resulting in forage scarcity condition for the bees. Therefore, providing supplementary feed will also help in reducing colony absconding during this time as well.

**Table 4.** Honey harvesting months in the sampled districts and overall study area.

Districts	N	Honey harvesting months		Frequency of honey harvest per year
		Major harvesting months	Minor harvesting months	
Guduru	41	November	June	1.74
Hababo Guduru	34	November	May	1.77
Horro	35	May	Mid December	1.46
Overall	110	November	May to June	1.66

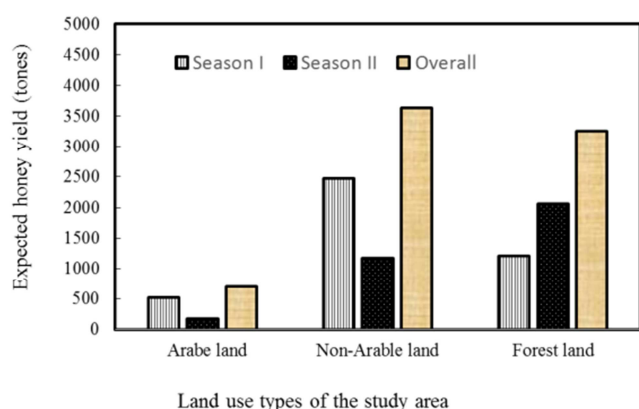
### 3.7. Honey Reserve and Production Potential of the Study Area

Figure 3 shows major bee forage land types and their potential contribution to the total estimated honey production. In this calculation, estimation has been carried

out by considering the contribution of each major plant species for honey production in two seasons. When calculating the first season potential, all recorded bee forage (both major and minor) sources that can give flower during this time were taken into account as contributors for a single honey harvest. When calculating the second season, only

areas covered by forest and non-arable land were considered as cultivated crops assumed to be nonexistent during this season. Horticultural crops and irrigable land can contribute negligible amount with the current information obtained as the coverage is very insignificant to affect the relevance of current calculation at least for the coming few years.

By assuming 84 kg/ha honey potential reserve for the forest and non-arable areas and 24 kg/ha for the arable areas, the calculated total honey reserve is 89208.3 tons per year of which 7582.6 tons is possible commercial production. But from the current study, an apiary was found to hold only 260 bee colonies (Figure 5) with average honey yield of 10.6 kg/year (Table 7). These figures showed that the total honey production from the area is only about 1806.1 tons.



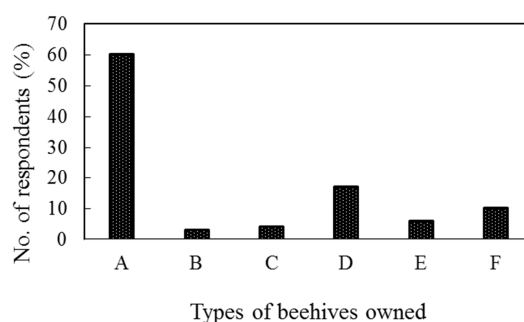
**Figure 3.** Potential honey reserves of the study zone (Horro Guduru Wollega).

### 3.8. Honey Bee Colony Holding Size by Type of Hive Per Beekeeper in the Study Area

About 60% of the respondents are keeping their colonies only in traditional beehives (Figure 4) with the colony holding size 31 (Table 5). The domination of traditional beekeeping in the study area can be part of a deep-rooted cultural practice under exercise for generations in different parts of the country [1]–[3]. This traditionally dominated beekeeping practices is an indication for a critical need for more skill development and awareness creation to transform these beekeepers from traditional to improved beekeeping. Of course, high cost and non-affordability of modern beekeeping equipment and the accessories that can be difficult for individual to acquire can also play great role to force the beekeepers to sustain the traditional beekeeping. However, compared to the general 90% traditional beekeeping level [4] in Ethiopia, 60% still better. This improvement can be attributed to the intervention by Gurm Development Association (GDA) and Education for Development Association (EFDA) for the last ten years [12], which probably had helped the beekeepers to transform their beekeeping from traditional system to transitional, modern or mixed types. About, 7% of the beekeepers in the study area possessed only transitional or modern beekeeping while 33% of the beekeepers run mixed (all the three beehive) beekeeping type in their apiaries (Figure 4).

**Table 5.** Number of colonies owned by type of hive per beekeeper in the study area.

Hive type	Av. colony holding per beekeeper
Traditional only	31
Transitional only	10
Modern only	8
Traditional and transitional	15
Traditional and Modern	25
All the three type	23



**Figure 4.** Percentage distribution of honeybee colonies owned by hive types: A (traditional), B (transitional), C (modern), D (traditional and transitional mixed), E (traditional and modern mixed) and F (all the three hive types) in the study area.

### 3.9. Optimum Colony Carrying Capacity Per Apiary of the Area

From the result of the current study, different land use types have different theoretical potential of honey yield for optimum colony carrying capacity per apiary. For optimum colony carrying capacity calculation, average commercial honey harvest per colony of traditional, transitional and modern hives were assumed to be 12, 30 and 50 kg/year. Adding 130kg consumed by bees to these commercial honey yield amounts, optimized potential of honey reserve of 142, 160 and 180 kg/year, respectively for traditional, transitional, and modern hives from the flora per year was considered. In order to determine the colony carrying capacity per apiary, we used these optimized production potential rate of the different hive types. To establish optimum colony carrying capacity per apiary, first we also need to establish standard for an apiary size. To this end, from the commercial beekeeping point of view, the economical flight radius (r) of honeybees is assumed to be 2 km [7]. Therefore, colonies at one site can economically forage and provide surplus honey from a total area of 12.6 km<sup>2</sup> (that can be calculated by the formula  $A=\pi r^2$ ), which is equivalent to 1260 ha.

By taking the average potential honey reserve value of 84 kg/ha from the forest cover and non-arable land areas and 24 kg/ha honey potential reserve from arable land an optimum colony carrying capacity of each apiary was calculated. With this potential rate, the minimum total honey available for the bees in an apiary established in forest and/or non-arable land will be 84 kg/ha \*1260 ha= 105,840 kg. As a result, the optimum number of colonies for example in traditional hives per apiary in such areas is calculated as: Optimum number of colonies in traditional hives = optimum honey yield expected per apiary divided by 142 =105840/142= 745colonies. Similarly, to produce optimum honey yield (50

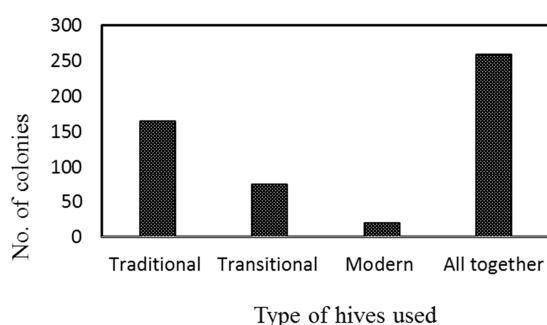
kg/yrs./colony) from modern hives in forest covered potential areas per apiary is 588 (Table 6).

From the current analysis, there is a possibility of sustaining about 520 bee colonies in traditional hives per single apiary on average. However, the average number of colonies maintained in each apiary at present are only 260 (Figure 5) indicating only 0.5 (50%) of the existing capacity

is utilized. On top of this, the numbers of transitional and modern are very few compared to the dominant traditional beekeeping, indicating huge gap between actual stock and carrying capacity. Therefore, from the study it was proved that colony overcrowding was not a problem; rather it is possible to have additional colonies by properly setting the apiaries.

**Table 6.** Optimum carrying capacity of an apiary in the study areas for well managed colonies.

Type of land to be utilized	Optimum honey available per apiary (kg)	Type of hive	Honey Requirement per colony (kg)	Number of colonies that can be stocked per apiary
Forest cover and non-arable land	105,840	Traditional	142	745
		Transitional	160	662
		Modern	180	588
Arable land	30,240	Traditional	142	213
		Transitional	160	189
		Modern	180	168
All land use types	74,689	Traditional	142	526
		Transitional	160	467
		Modern	180	415



**Figure 5.** Number of colonies exists in a given apiary by type from the collected data.

### 3.10. Key Factors Responsible for Low Production and Productivity of Bee Keeping

Despite the fact that there is optimum or bellow optimum colony carrying capacity exist in the locality, production and productivity of the colony is very low (Table 7). This indicates that the problem associated with low production level is not colony overstocking rather it is the way beekeepers manage their colonies. From our field observation, the number of beehives kept under 3 \* 10 m roof in the backyards was more than 100 bee colonies (Figure 6), the condition being similar in almost every village.

**Table 7.** Amount of total honey produced (kg) per hive type and productivity per hive per year in the study zone. Data was obtained from beekeepers (n=110).

Hive Type	Honey yield obtained per beekeeper/year (kg)			Av. honey yield per colony (kg)
	Minimum	Maximum	Average	
Traditional only	62	155	110	3.5
Transitional only	78	195	146	14.6
Modern only	90	244	210	21.0
Traditional and Transitional	80	150	114	7.6
Traditional and Modern	145	300	225	9.0
All the three types	160	700	244	10.6

As a result, even though the total number of bee colonies in apiary was below the optimum carrying capacity, maintaining more than a maximum of 50 bee colonies under congested roof is hardly recommendable. This is because, the situation can create a difficult condition for colony management, facilitate favorable condition for disease transmission and pest attack. On top of these, congested beehives can facilitate drifting of foragers to only certain beehives and this leads to the deteriorating of the majority of the colonies and only few good performing ones. Therefore, to prevent drifting of the forages and reduce pest and diseases incidence, the minimum distance between two colonized hives should be at least 1.5 meters apart.



**Figure 6.** Congested colony setup and miss management.

To substantiate, the effects of congested colony on production and productivity, honey production trend analysis conducted and the result presented in Table 7. From the result of analysis, production of honey per colony in traditional beehive was only 3.5 kg on average indicating more than 3-fold yield loss in the study area. Similarly, the recorded

production level of honey yield per colony in transitional and modern hives was also less than 50% of the expected production. This result demonstrated that the total production level of honey/colony/year is very low, contrary to the honey yield potential of the area. Currently, a beekeeper holds 23 bee colonies within all the three hive types and average annual production of 244 kg/year. But with equal proportion of the three types of hives and same number of colonies, it is possibility for producing about 700 kg honey per year. From this, the annual yield loss per individual beekeeper can be estimated to 460 kg honey which can further explored to over \$820 financial loss. From zonal honey yield potential perspective, the analysis indicated possibility of producing 7,582,600 kg per year. However, the currently achieved honey yield production is 1,806,100 kg per year indicting that only about 24% of the potential was tapped. So, because of mismanagement, and other contributing factors about 76% of the potential of the area was unutilized. Several reports [1-4, 9, 11] also indicted that the level of production is very low compared to the potential of the country.

#### 4. Conclusions and Recommendations

Production and productivity of beekeeping in the study area was found to be very low as compared to the existing potential resources. However, the problem associated with low production level was not colony overstocking rather factors like technical skills associated with colony management were identified as the major obstacles. Low frequency of honey harvesting (only 1.66) was also another factor contributing for low honey production level in the study area.

In order to improve production and productivity, therefore, use of improved management and technologies is very important. For this, training of beekeepers, assuring improved technology supply, building capacity of extension agents and supporting establishment of market places with requisite facilities should be considered in the future development activities for improving honey production, productivity for maximizing the benefit of the target beneficiaries.

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