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A close-up photograph of a hand holding a curved sickle, ready to harvest golden wheat in a field. The background is a dense field of wheat stalks under bright, natural light.

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# Journal of Agricultural Extension and Rural Development

Table of Contents: Volume 10 Number 12 December 2018

## ARTICLES

<b>Gender roles in fisheries post-harvesting activities in catch-locations within Coastal Areas of Lagos State Nigeria</b>	<b>245</b>
Olusola Benson, Isaac Ambee, Oluwatoyin Akinnigbagbe, Bunmi Omotuyi and Adepeju Solagbade	
<b>Determinants of commercialization of teff crop in Abay Chomen District, Horo Guduru wallaga zone, Oromia Regional State, Ethiopia</b>	<b>251</b>
Edosa Tadesa Leta	
<b>Beekeeping management practices and gap analysis of beekeepers at different agro-ecological zones of Tigray region, Northern Ethiopia</b>	<b>260</b>
Guesh Godifey, Amssalu Bezabeh, Hailu Mazengia and Yayneshet Tesfay	

*Full Length Research Paper*

# **Gender roles in fisheries post-harvesting activities in catch-locations within Coastal Areas of Lagos State Nigeria**

**Olusola Benson<sup>1\*</sup>, Isaac Ambee<sup>1</sup>, Oluwatoyin Akinnigbagbe<sup>2</sup>, Bunmi Omotuyi<sup>1</sup> and Adepeju Solagbade<sup>1</sup>**

<sup>1</sup>Department of Research Outreach, Nigerian Stored Products Research Institute (NSPRI), Yaba, Lagos, Nigeria.

<sup>2</sup>Department of Fisheries Resources, Nigerian Institute for Oceanography and Marine Research (NIOMAR), Victoria Island, Lagos, Nigeria.

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**This study examined the gender roles in Fisheries Post-harvesting Activities (FPhA), which stems from a significant knowledge gap regarding gender roles in the subsistence fishery industry. The research was conducted in five catch-locations within the coastal areas of Lagos State, Nigeria, namely: Ikorodu, Badagry, Epe, Lekki and Makoko. The respondents were selected using purposive and snowballing sampling techniques. A validated structured questionnaire was used for data collection. Chi-square analysis ( $\chi^2 = 22.6$ , df 2) revealed that gender participation was significantly different ( $P < 0.05$ ). The study identified ‘knife’, ‘smoking kiln’ and ‘baskets’ as the major equipment used by fisher folks; while it also noted “personal interest”, and “a means of sustenance” as the main reason(s) for participation. Findings across the locations show that despite the fact that both genders are engaged in various FPhA; certain activities are gender specific. To aid the efficiency of fisher folks in FPhA, fish processing center with modern facilities should be built across the catch locations. Policy makers in the domain of FPhA should involve women in policy formulation and decision-making due to their huge clear dominance. Finally, to bridge the gender participation gap in FPhA for employment and income purposes, there is a need for training and capacity building targeted especially for male fishers.**

**Key words:** Gender, male, female, Fisheries Post-harvesting Activities (FPhA), catch-locations.

## **INTRODUCTION**

The act of fishing has been one of the major economic activities of human beings which transverses many generations. According to FAO (2018), global total capture fisheries production was 90.9 million tonnes in 2016, with significant contributions to supplies of food, employment, income and well-being of artisanal fisher

folks in coastal, riverside and lakeside communities who are directly dependent on fishing and related activities for their livelihoods (Allison et al., 2009).

While it is widely known that men are predominantly the harvester of wild fish species (Olubanjo et al., 2007) and women are engaged in fish processing, marketing

\*Corresponding author. E-mail: [gueshgod@yahoo.com](mailto:gueshgod@yahoo.com).

and distribution, these facts are changing. Lambeth et al. (2002) noted that women are now involved where only men used to operate and vice versa.

The coastline in Nigeria, and especially of the coastal Local Government Areas (LGAs) of Lagos State, is well-endowed with river networks, and a large expanse of exclusive ocean waters for commercial fishing. Also, capture fisheries account for over 90 percent of the total annual fish production in Nigeria (Olaoye et al., 2012; NIOMAR, 2011) and culture fisheries contribution to fish was estimated at 6.06% (Ozigbo et al., 2014; NIOMAR, 2011). Consequently, several of the natives and residents in coastal (or littoral) states and communities in Nigeria are involved in the capture fisheries sub-sector of the nation's economy.

According to Sinkaiye (2005), gender is a term often associated with roles and responsibility of males and females in the society, as a social classification of sex. It is the socio-cultural differences between males and females as against the biological differences. Gender is a concept used in social science analysis to look at roles and activities of men and women (IITA, 1996). Knowledge of gender roles are an important part of fisheries management because it allows interventions to be tailored to specific groups of fishers.

Thus, there is a need for data that accurately defines the nature of coastal fisheries and associated postharvest activities that informed the present study. This study, therefore, aims to identify the post-harvesting activities that fishers engage in across small-scale fisheries within the coastal area of Lagos, Nigeria. The objective of the study amongst others is to: describe the socio-economic characteristics of the respondents; ascertain various FPhA carried out by both gender; identify equipment used in FPhA, and ascertain reason(s) for gender participation in FPhA sector in the study areas.

## HYPOTHESIS OF THE STUDY

The hypothesis of the study is stated in null form ( $H_0$ ).  $H_0$  = There is no significant difference in gender roles in FPhA in catch-locations within the coastal areas of Lagos State.

## METHODOLOGY

### Description of the study area

The study was conducted between June and November, 2017 in five coastal zones of Ikorodu, Badagry, Epe, Lekki (Ibeju-Lekki) and Makoko (Lagos Mainland) in Lagos State, Nigeria (Figure 1). The state is situated in the Southwestern geo-political zone of Nigeria. It shares boundaries with Ogun State, both in the North and East and is bounded in the West by the Republic of Benin. Its Southern border stretches for about 180 km along the coast of the Atlantic Ocean. The State occupies an area of 3,577 km<sup>2</sup>

landmass with about 22% (786.94 km<sup>2</sup>), representing the Lagos lagoons. Lagos State is very rich in different forms of aquatic ecological zones that support different varieties of fish species and aquatic organisms; thereby providing productive fishing opportunities for fishers. Lagos is home to traders, artisans, industrialists, civil servants, and office workers.

### Sampling techniques and sample size

The population of the study comprised both men and women that engage in fishing in the coastal area of Lagos State, Nigeria. In the absence of a comprehensive list of the respondents who are involved in post-harvesting fish activities in the study area, purposive sampling and snowballing techniques were used to select the respondents. Snowballing sampling techniques, the process of selecting respondents based on referral-chain on the subject matter, was used to generate respondents who formed the focus of the study. In the course of administering the questionnaire, the target was 15 respondents for each of the five catch-locations, which implies 75 respondents. However, only 60 respondents were sampled as indicated in Table 1, which translates to 80% total respond and this was used for the analysis carried out.

### Validity and reliability test of the questionnaire

Validity is the degree to which an instrument and its measurement serve the purpose for which they were intended. Face and content validity was used to adjudge the questionnaire. Experts in the Department of Agricultural Extension and Rural Development of Federal University of Agriculture, Abeokuta were contacted to carry out the assessment for face validity. The content validity of questionnaire was done by computing the level of agreement, (on appropriateness of the content of the questionnaire) between five judges who are experts in the area of post-harvest research survey in the Research Outreach Department of Nigerian Stored Products Research Institute, Lagos (NSPRI). The coefficient of concordance ( $w$ ) was 0.76, an indication that the content is valid.

Reliability is the degree of consistency of measurement. For this study, test re-test method of reliability was employed. The questionnaires were pre-administered on eight respondents in a day trip to two catch-locations in Ogun Water Side Local Government in Ogun State. The results were correlated using Spearman-rho correlation. The coefficients of reliability ( $r$ ) was  $r = 0.77$ , thus adjudging the questionnaire as being reliable.

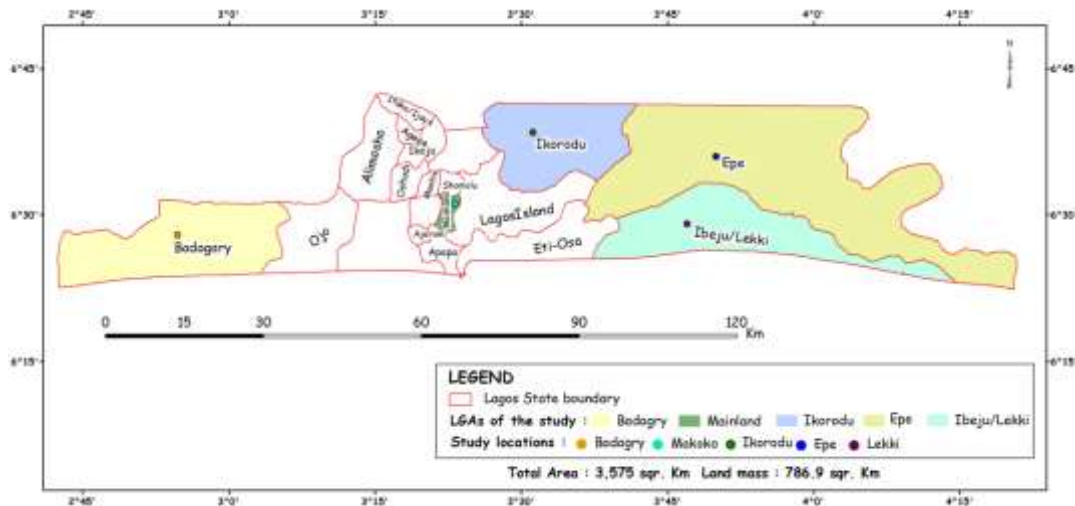
### Data analysis

Using SPSS 20.0, the data collected were subjected to descriptive and inferential statistical analysis. Inferential statistical tool, such as Chi-square, was used to determine gender role in post-harvesting activities at 0.05 level of significant.

## RESULTS AND DISCUSSION

### Socio-economic characteristics of the Respondents

Result in Table 2 showed that the mean age of the respondents was 52.5 years, which indicate economically active fisher folks in tandem with (Olaoye et al., 2012). Most (75%) of the respondents were females, while 25% were males; this goes to show the



**Figure 1.** Map of the study area indicating the five coastal zones.

**Table 1.** No of respondents in catch-locations.

S/N	Lagos Coastal LGAs Sampled	Catch-Locations	No. of Respondents
1	Badagry	Ajindo, Topo, Gbethrome, Yovoyan, Yeketomeh	18
2	Epe	Odo-Egiri, Iraye-Oke, Ikoikin	12
3	Ikorodu	Ibeshe, Ijede, Igbalu	11
4	Ibeju-Lekki	Iberikodo, Alade, Aiyeteju, Awoyaya	14
5	Lagos Mainland	Makoko	5
Total			60

Source: Field survey 2017.

dominance of the female fishers in post-harvesting activities, which is in agreement with Kronen and Vunisea (2007) and Tawake et al. (2007), that women are involved in post-harvest activities, marketing and distribution of marine products. With 25% of the respondents as males, it goes further to show that post-harvesting activities is no longer women affair; this is in line with Lambeth et al. (2002) who submitted that with new technologies, activities in fisheries are no longer gender specific. The findings of this study further revealed that majority (80.0%) of the respondents were married with 4-6 members in their households, which could imply availability of cheap labor for the household head. Most (75%) of the respondents had one form of formal education or the other, indicating the ease of adopting new innovations; this corroborates with the findings of Akingba et al. (2017) who reported high educational level for fisher folks in some fishing communities of Ondo State. On the contrary, Olaoye et al. (2012) showed 60.0% of respondents as uneducated. About 75.0% of the respondents in the catch-locations indicated post harvesting activities as their major occupation with mean annual income

estimated at ₦107,200, which infers that respondents had moderate income. This lends credence to the findings of Olaoye et al. (2012) who reported ₦86,300 income level for fisher folks in some communities of Ogun State.

#### Various equipment used in fish post-harvesting activities

Figure 2 shows different types of equipment used by the respondents in post harvesting activities. Knife ranked 1<sup>st</sup>, smoking kiln 2<sup>nd</sup> and basket 3<sup>rd</sup>, these three equipment were the most used in post harvesting of fish in the study location. Wire mesh ranked 4<sup>th</sup>, bowl ranked 5<sup>th</sup>, and drum 6<sup>th</sup>. Across the catch-locations, the study revealed that the equipment used in post-harvesting activities were the same and not automated.

#### Gender reasons for participation in fish post-harvesting sector

Based on multiple responses, Figure 3 represents



**Table 2.** Distribution based on respondents' socio-economic characteristics (n = 60).

<b>Variables</b>	<b>Frequency</b>	<b>Percentage</b>	<b>Mean (x)</b>
<b>Sex</b>			
Male	15	25.0	
Female	45	75.0	
<b>Age (year)</b>			
Less than or equal 30	5	8.3	
31 – 40	7	11.7	
41 – 50	20	33.3	
51 – 60	24	40.0	52.5years
Above 60	4	6.7	
<b>Marital status</b>			
Single	5	8.3	
Married	48	80.0	
Widowed	5	8.3	
Divorced	2	3.4	
<b>Household Size (persons)</b>			
1 – 3	15	25.0	
4 –6	38	63.3	5.3persons
7 –9	2	3.4	
Above 10	5	8.3	
<b>Educational status</b>			
No formal education	15	25.0	
Primary education	25	41.7	
Secondary education	15	25.0	
Tertiary education	5	8.3	
<b>Fisheries as major occupation</b>			
Yes	45	75.0	
No	15	25.0	
<b>Fish Farming experience (years)</b>			
Less than or equal to 10	18	30.0	
11 – 20	26	43.3	14.6years
21 – 30	11	18.3	
31 – 40	5	8.3	
<b>Annual income (naira)</b>			
Less than or equal to 20,000	3	5.0	
21,000 – 40,000	13	21.7	
41,000 – 60,000	9	15.0	
61,000 – 80,000	10	16.5	
Above 81,000	25	41.7	₦107.200

Various equipment used in fish post-harvesting activities.

gender reason(s) for participation in fish post-harvesting sectors in the study area. The study revealed “personal

interest”, “means of sustenance” and “market participation with female fishers’ dominance. Thus, it

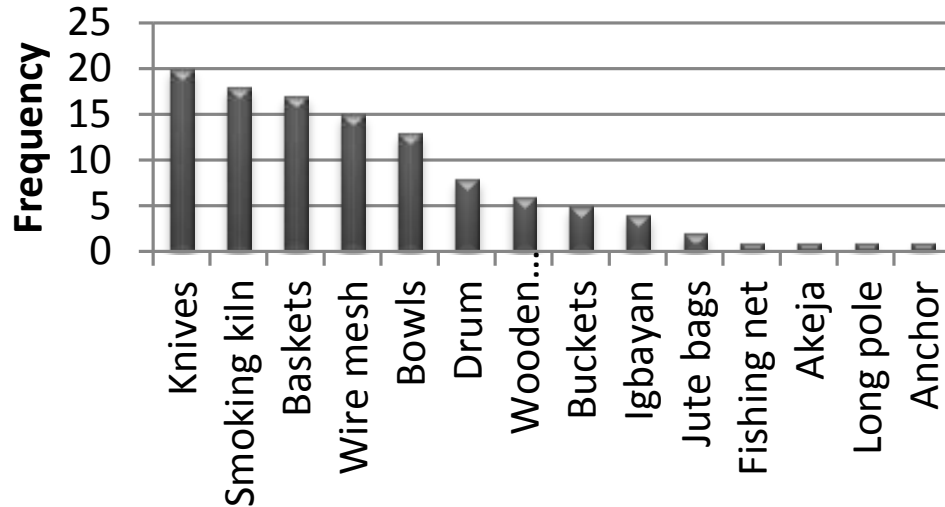


Figure 2. Equipment used in post-harvesting activities.

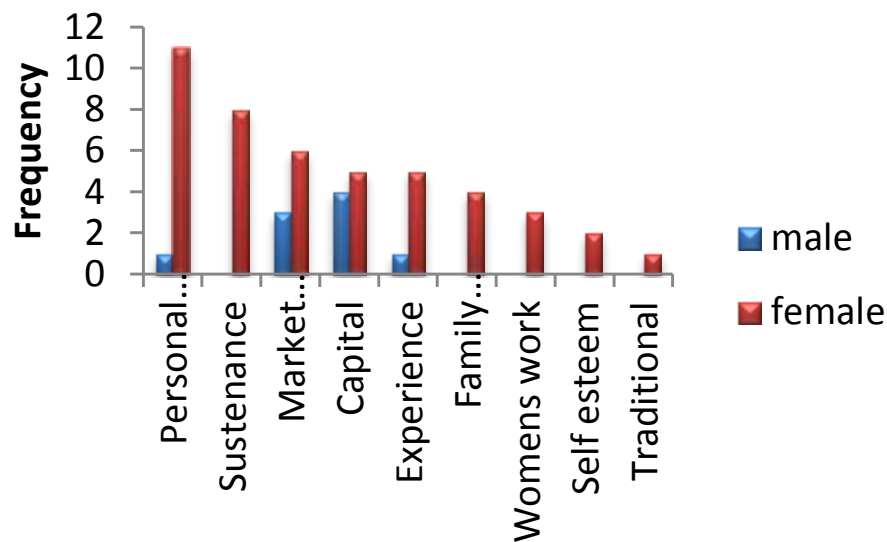


Figure 3. Gender reasons for participation in fish post-harvesting sector.

could be inferred that participation in post-harvesting sector of fisheries may be unconnected with the socio-economic characteristics of the fisher folks.

**Post harvesting activities carried out by male and female**

Based on multiple responses, Figure 4 reveals various post-harvesting activities carried out by both male and female in the study area, it shows that fish processing such as sorting, packaging and purchase are gender specific, which could be regarded as the activities for women only. This is in line with Olubanjo et al. (2007)

who submitted that women are more involved in the low-ends of fishing activities. However, it was observed that male fishers now engage in fish smoking, marketing, drying and storage activities, as against earlier submission (Olubanjo et al., 2007) that they are only involved in the high-ends of fisheries activities.

**CONCLUSION AND RECOMMENDATIONS**

In this study, particular references were made of the equipment used by fisher folks in FPhA, gender reason(s) for participation as well as various activities engaged by both fisher folks in FPhA. However, it was observed that certain activities are gender specific as

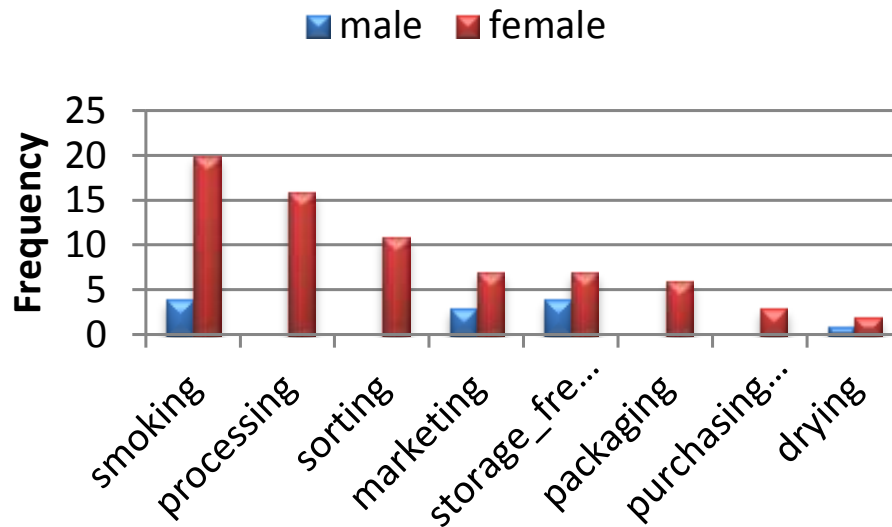


Figure 4. Post-harvesting activities.

depicted above (Figure 3). It was also noted that participation in FPhA has nothing to do with the socio-economic characteristics of the fisher folks. The study further reveals that fisher folks across the catch-locations employed the same equipment in fish processing, sorting, storage and preservation. To aid the efficiency of fisher folks in FPhA, fish processing center with modern facilities should be built across the study locations. Owing to the fact that women constitutes clear majority in this sector, they must be involved in policy formulation and decision-making.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

## ABBREVIATIONS

**FPhA**, Fisheries Post-harvesting Activities; **NSPRI**, Nigerian Stored Products Research Institute, Lagos; **NIOMAR**, Nigerian Institute for Oceanography and Marine Research; **FAO**, Food and Agriculture Organization.

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*Full Length Research Paper*

# **Determinants of commercialization of teff crop in Abay Chomen District, Horo Guduru wallaga zone, Oromia Regional State, Ethiopia**

**Edosa Tadesa Leta**

Department of Agricultural Economics, College of Agriculture, Oda Bultum University, Chiro, Ethiopia.

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**This paper aims to identify factors affecting teff commercialization in Abay Chomen District using primary data collected during February and January 2017 from teff sampled household producers. Semi structured interview schedule and Focus Group Discussion were used for data collection. Descriptive statistics and heckman two stage models were used to analyze the data collected. The paper showed that among sixteen explanatory variables entered into the model, six variables affect the level of teff commercialization. Based on the probit regression model result, land allocated for teff production and ownership of oxen have significant and positive association with the probability of market participation decision whereas, age, family size, and access to village town have significant and negative association with the probability of market participation decision of households. The result of Heckman second stage model revealed number of donkey owned, number of oxen owned, land allocated for teff production, frequency of agricultural extension contact, Landholding size and inverse mill's ratio were significantly and positively related to level of teff commercialization whereas, livestock ownership excluding oxen and donkey and distance from the district market were significant and negatively related to the level of teff commercialization. Therefore, government policies that give emphasis to specialization of teff, provision of market infrastructure, ownership of oxen and donkey as well as family planning are recommended to increase teff market participation decision and intensity of its sale in Abay Chomen District.**

**Key words:** Abay Chomen, commercialization, Heckman two stage model, market participation, teff.

## **INTRODUCTION**

Ethiopian economy is highly dependent on agricultural activities. Agricultural sector contributes 42.7% of GDP, providing employment opportunity for 80% of total population, generates about 70% of the foreign exchange earnings of the country and supplies over 70% of raw materials for domestic industries (Zerihun et al., 2015). However, having such great significance in countries'

economy, commercialization of agricultural products until recently has been low. Commercialization of agricultural sector is faced with many challenges such as poor infrastructure especially in rural area where huge agricultural activities are carried out, where there are poor institutional services, lack of awareness of farmers on value addition of goods and so on.

E-mail: [edstds2016@gmail.com](mailto:edstds2016@gmail.com).

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Currently, the agricultural sector cannot feed the rapidly growing population of the country in which more than 27 million people are food insecure and 18.1 million people require food assistance in 2016 due to climate change and 2015 El Nino drought derived problems in the country which was the strongest droughts that have been recorded in the history of the nation (Catley et al., 2016; cited in Abduselam, 2017).

Teff crop is the dominant food crop in Ethiopia. Even though every individual in the nation wants the crop for consumption, its supply to the market is very low due to its demand in rural and urban areas and the crop producers not knowing that it can both be a cash and food crop. Therefore, this study was undertaken to identify factors influencing market participation and volume of teff supply to the market in Abay Chomen district. They are affected by different factors such as lack of infrastructure, lack of information and shortage of asset endowment. Smallholder farmers of the study area have the potential to reduce poverty and achieve sustainable food security if these constraining factors can be reduced or eliminated.

There has been a considerable shift from teff to maize consumption, influenced by a number of factors. Teff is a commercial crop mainly due to its high price and the absence of alternative cash crops (such as coffee, tea or cotton) in the study area. Assemblers in village markets and wholesalers in regional markets pay close attention to the quality of teff. Teff can provide a good source of income and can also have beneficial effects on the environment. The chief agricultural cereal crop products in Horo Guduru zone especially in Jimma Geneti, Oromia include maize, teff, wheat, sorghum and barley (CSA, 2015/2016). In Horo Guduru zone, of the total land of 286,631.05 ha under grains production teff occupies 90,316.67 ha followed by maize which occupies 57,356.09 ha (Horo Guduru Zone's Bureau, 2016).

Padmanand et al. (2015) used multivariate probit model and confirmed that, income, education, employment status, household size, and distance influence shopping frequency in all five outlet types selected. Income had positive effect whereas household size was negatively associated with teff market participation decision. Jari and Fraser (2009) identified that market information, expertise on grades and standards, contractual agreements, social capital, market infrastructure, group participation and tradition significantly influence household marketing behavior. The study uses multivariate probit model to investigate the factors that influence marketing choices among smallholder farmers.

## METHODOLOGY

### Description of the study area

Abay chomen District is one of the eleven districts found in Horo Guduru Wolega Zone, Oromia National Regional State of Ethiopia. The Ethiopian population projection by CSA for 2017, based on

2007 national census reported a total population for this district to be 64,672, of whom 33,263 (51.43%) were males and 31,409 (48.57%) were females; 15,232 or 23.55% of its population were urban dwellers (CSA, 2013). The majority of the inhabitants were protestant, (59.73%), while 31.84% were Ethiopian Orthodox Christians, 5.5% had traditional beliefs, and 1.61% were Muslim (CSA, 2007).

Abay chomen is one of the major crop production areas in which teff, wheat, maize, and barley from cereals and Niger seed from oil crops are the important crops grown in the district (CSA, 2014). The district is also one of tourist attracting places in the western part of the countries. The district is rich in natural resources such as Fincha and Amarti Neshe Lake, different wild life such as lion and tiger.

### Geographical location of the district

The district capital is Fincha which is 49 km far away from Zone capital (Shambu) and 289 kms far northwest of Addis Ababa (the country capital). Abay Chomen District is located at 9° 31' 42" to 9° 59' 48" N latitude and 37° 10' 03" to 37° 28' 44" E longitude. It is bordered on the South by Lake Fincha, on the Southwest by Horo district, on the Northwest by Amuru Jarte district, on the North by Abay River which separates it from the Amhara Region and on the East by Ababo Guduru district (Figure 1).

### Objective of the study

The overall objective of the study was to identify the determinants of commercialization decision and level of commercialization of teff production in Abay Chomen District.

1. To identify the determinants of participation decision of teff producer farmers in teff market in Abay Chomen district.
2. To assess factors influencing the degree of teff commercialization of smallholder farmers in Abay Chomen district.

### Sampling techniques

For this study four stage sampling techniques were used to select sample from total household farmers in the district. In the first stage, 15 high potential teff producing Kebeles found in the district were identified purposively in collaboration with the District's Agricultural Office. In the second stage, the 15 rural kebeles of the selected district were stratified into three different strata based on their distance from the district market. Thirdly, from each stratum one kebele was selected randomly as the other characteristics are uniform across their stratum kebeles. Finally, from three randomly selected kebeles a sample of 133 were selected randomly proportional to their total population size.

### Data collection methods and analysis

For this study different data collection methods were used. To collect primary data from the sampled household semi structured questionnaire was used. In addition to semi-structured questionnaire, Focus Group discussion and interview schedule were used for data collection purpose. The collected data were analyzed by using descriptive statistics such as mean, frequency distribution, percentages, minimum and maximum and Heckman two stage model.

### Econometric model specification

Different empirical study on market participation and its intensity of

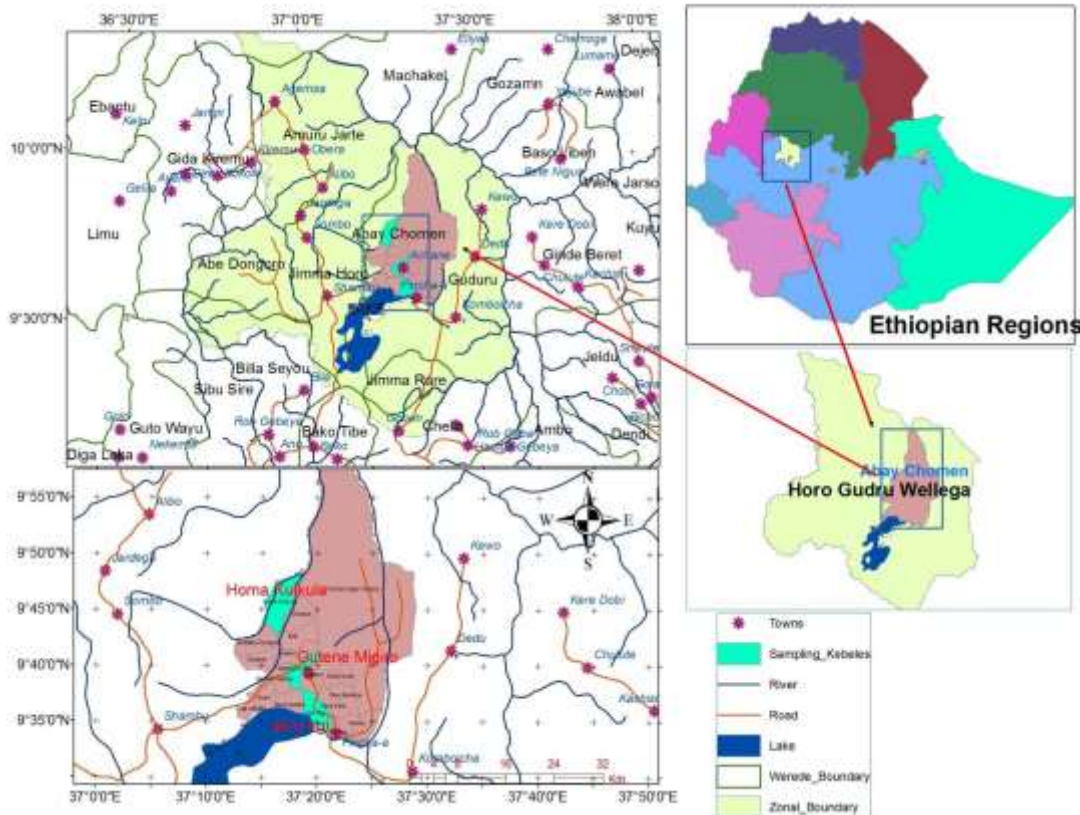


Figure 1. Map of the study area.

commercialization employed different econometric models. For this study Heckman two stage model was employed to analyze the factors influencing teff market participation decision and level of commercialization of sampled households in the study area due to its advantage over the other possible models: over OLS model it is considered that those non-market participants might be found in the sampled households; over Tobit model it separates factors influencing market participation decision and its intensity; over probit model it permits intensity of market participation. Generally, Heckman two stage selection model was used due to its ability to overcome the selectivity bias problems.

In order to identify factors that influence teff producers' market participation decision and level of teff commercialization, Heckman two stage selection models was employed. Participation in teff market was seen as a sequential two stage decision making process. In the first stage, teff producers make a choice decision whether to participate or not in teff market. In the second stage, based on their participation decision in teff market, farmers make continuous decision on the amount of teff they sell. Binary probit model (first stage of heckman model) was used to identify factors that influence households' teff market participation decision. The dependent variable (teff market participation) in this model has a value, 1 if the households participate in teff market; 0 if otherwise. The probit model is built on a latent variable with the following formula:

$$Y_i^* = \beta_i X_i + u_i \quad Y = 1 \text{ if } Y_i^* > 0, \quad Y = 0 \text{ if } Y_i^* \leq 0$$

Where:  $Y_i^*$  is a latent variable representing farmers' discrete decision whether to participate in teff market or not;  $X_i$  is explanatory variables hypothesized to affect farmers decision to

participate in teff market,  $\beta_i$  is a vector of parameters to be estimated which measure the effect of explanatory variables on household decision to participate in teff market.  $u_i$  is normally distributed disturbance term which captures all unmeasured variables that affect teff market participation decision of sample households.  $Y$  is a dependent variable which takes the value of 1 if the farmers participate in teff market and 0, if otherwise.

Since the probit parameter estimate does not show how much a particular variable increases or decreases the likelihood of participating in teff market, average marginal effect of independent variables on probability of a household to participate in teff market was considered. Inverse mill's ratio was estimated from probit (Frist stage of Heckman selection model) and included into the second stage (OLS) as additional independent variable to estimate the parameters that determine the level of teff commercialization consistently. The inverse mill's ratio was estimated as follows:

$$(\lambda_i) = \frac{\phi(Z_i)}{1 - \Phi(Z_i)} = \frac{\phi(Z_i)}{\Phi(-Z_i)} \quad Z_i = X_i \beta / \sigma_e$$

Where:  $\lambda_i$  is the inverse Mill's ratio;  $\phi$  denotes the standards normal probability density function.  $\Phi$  denotes standard cumulative distribution function;  $\beta$  is a vector of regression parameters for variable  $X$ , and  $\sigma_e$  is the standard deviation of the error term which does not correlate with  $u_i$ ,  $v_i$  and other independent variables. The Heckman second stage (OLS) model for observed volume teff sold is given by:  $Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \dots + \beta_n x_n + \mu \lambda + v$

Where:  $Y$  represents the level of teff commercialization;  $X$  represents the factors that affect the volume of teff crop sales;  $\beta_0$  and  $\beta_{1-k}$  are estimated parameters;  $\mu$  is a parameter that shows the impact of participation on the quantity sold,  $\lambda$  is an inverse mill's ratio;  $v$  is the error term.

**Table 1.** Variable hypothesis.

<b>Variables</b>	<b>Measurement</b>	<b>Hypothesis</b>
Sex	1=male 0=female	Positive
Family size	Number	Negative
Education status	1= Illiterate 2= Literate	Positive
Landholding size	Hectare	Positive
Distance from all-weather road	kilometer	Negative
Amount of fertilizer used	Kg	Positive
Land allocated for teff production	Hectare	Positive
Ownership of Donkey	Number of Donkey owned	Positive
Ownership of Oxen	Number of oxen owned	Positive
Non and off farm income	ET Birr	Negative
Distance from district market	Kilometers	Negative
Access to village town	1=access to town, 0 otherwise	Positive
Marital status	1= married 0 otherwise	Positive
Age	Year	Negative
Ownership of livestock	TLU for livestock	Negative

Since the two stage decision making processes are not separable due to unmeasured household variables affecting both discrete and continuous decision, there is correlation between errors of the equations. If the two errors are correlated, the estimated parameter values on variables affecting volume of supply are biased (Wooldridge, 2002). Thus, the model that corrects selectivity bias while estimating factors affecting volume of supply needs to be specified. The inverse mills ratio ( $\lambda$ ) is included in the OLS regression to control for the influence of unobserved characteristics of the variables on continuous dependent variable. STATA 13 version software application was used for the analyses using binary probit and Ordinary Least Square models.

## RESULTS AND DISCUSSION

### Study results of descriptive statistics

#### *Sex of the household head*

From the sampled households, 84.2% of them were male headed while 15% of them were female headed households. Among non-participants 69.4 and 30.6% were male headed and female headed households respectively and among participants, 89.7% were male headed and 10.3% were female headed household. The variability of sex between the two groups is significant at less than 1% significance level, indicating existence of statistically significance difference between teff market participants and non-participants in terms of sex of sampled households (Table 1).

#### **Educational status**

From the survey result 64% of sample respondents were literate, while 36% of them were illiterate. The majority of

participants (73.2%) had education whereas majority of non-participants (61%) were illiterate. The value of chi-square shows that attending school was statistically significant at less than 1% significance level between participants and non-participant sampled households.

#### **Landholding size**

The average landholding size of the sampled households is 2.6 ha with maximum landholding size of 6 ha. Results of the survey data indicate that the majority of the households (49.6%) own land between one and four hectares, 33.8% own above 4 ha, 3% own less than 1 hectare and 13.6% have no land. Survey results indicate that there was significance difference at  $p < 0.01$ .

#### **Land allocated for Teff production**

The average size of land allocated for teff crop among participants was 1.5 and 0.85 ha among nonparticipants and 1.33 ha in total sample respondents. The value of t-test (6.85) shows that there was a significant difference in the mean size of land allocated for teff production between participants and non-participants at less than 1% level of significance.

#### **Number of donkey and oxen owned**

Oxen and donkey have received attention in the study area in line with crop production and marketing serving as source of drafting power and transportation materials respectively. On average the household of the study area

owned 3.35 number of oxen with minimum and maximum numbers of 0 and 12 respectively. Households that do not own or own less than a pair of oxen participate in crop production by renting ox from those who own more than two oxen or from households who own oxen but unable to participate in crop production due to lack of labor and or opting for crop sharing. Generally, 61.7% of the sampled households in the study area have had at least three oxen. Moreover, out of the total sampled households, 30.8% have had two or less oxen. 7.5% of the sampled households do not own oxen at all.

### **Frequency of agricultural extension contact**

Almost all sampled respondents (88.7%) have been visited by extension agents, but there were variability concerning the frequency of days they were consulted per year. About 11.3% of the respondents had not been visited by extension workers, while 66.9% of them had contact which ranged from once to ten times, 16.5% range from ten to 15 times and only 5.3% had contact above 15 times annually in the production year of 2015/16. This result indicates that even if all most all households are visited by development agents, the frequency they visit per year is very low and varies among households.

### **Results of econometric model**

#### ***Estimation of first stage Heckman two stage model***

The first stage of the Heckman selection model or the probit model was employed to identify factors influencing teff market participation decision of households of the study area. Average marginal effect was used in this study as a useful measure to interpret the result as the coefficient of probit model is difficult to interpret since it only shows the direction of the effect.

The likelihood ratio test indicates that, the overall goodness of fit of the probit model is statistically significant at less than 1% probability level. This indicates that the explanatory variables included into the probit model regression jointly explain the variations in the teff producers' probability to participate in teff market. Pseudo R<sup>2</sup> values indicate that the independent variables included in the regression explain 81.5% variations in the likelihood to sell teff output. The probit model was fitted with 15 variables and 5 of them were significant. Access to village town was included as exclusion restriction variable in the participation equation but not in the outcome equation. The possible explanation is that farmers who have access to village town participate in various non-farm activities. This increases the income of smallholder farmers which reduces their probability of entering into the teff market. In the first stage (probit

model) results family size and oxen ownership of the household heads were significant at less than 1% probability level. Proportion of land allocated for teff production and age of the household head were significant at less than 5% significant level. Access to village town was significant at less than 10% probability level. The inverse mill's ratio was significant and positive at less than 10% level of significance which suggests that the error term in the selection and outcome equation is positively correlated. This indicates that there is selection bias problem. Therefore, Heckman two stage selection models was the right model due to its ability to handle selection bias problem.

### **Family size of the household heads**

Family size of the household heads was significant and negatively influences the probability of market participation of teff producers at less than 1% level of significance. As indicated in Table 2, on average, an increase in the family size of the household head by one person decreases the probability of participating in the teff market by 4.7% holding all other factors constant. The implication is that as the number of persons in the household increases, their consumption needs also increase which leads to reduction of marketable surplus. This is in agreement with previous studies conducted by Shewaye et al. (2016) and Musah et al. (2014) that households with larger family size were unable to produce marketable surplus beyond their consumption needs.

### **Land allocated for teff production**

Proportion of land allocated for teff production significantly and positively influences the probability of teff market participation of households at less than 5% significance level. A one hectare increase in allocation of land for teff production increases the probability of market participation decision by 14.4%, on average. The implication of this result is that specialization in teff production increases the marketable surplus as it increases the productivity of teff. This finding is confirmed with the study conducted by Mebrahatom (2014) who found that specialization in teff positively influenced the level of teff commercialization.

### **Oxen ownership**

Oxen have significant and positive effect on the probability of household participation in teff market at less than 1% level of significance. Ox is a production asset used in the study area. The marginal effect indicates that on average the probability of farmers' decision to



**Table 2.** Determinants of teff market participation decision of farmers.

Model variable	Average marginal effect	Coefficient	Std. Err
Sex	0.13	2.2	1.74
Family size	-0.047	-0.8***	0.28
Education status	0.125	0.21	0.28
Landholding size	0.054	0.93	0.62
Distance from all-weather road	-0.014	-0.248	0.217
Amount of fertilizer used	0.00025	0.004	0.007
Land allocated for teff production	0.144	2.46**	1.15
Ownership of Donkey	0.008	0.136	0.545
Ownership of Oxen	0.07	1.2***	0.448
Non and off farm income	1.67E-06	-3.80E-06	0.0001
Distance from district market	-0.0034	-0.057	0.084
Access to village town	-0.081	-1.39*	0.79
Marital status	0.048	0.834	0.28
Age	-0.005	-0.092**	0.04
Ownership of livestock	-0.138	-0.137	0.091

Source: Own estimation, 2017.

participate in teff market increased by 7% as one additional ox to the teff producers. The implication is that farmers who own higher number of ox can produce more teff output which increases marketable surplus. This finding is in agreement with finding of Matz (2014) who found that ownership of oxen increases output market participation due to its effect on production.

#### Access to village town

Access to village town is another variable which was found to significantly affect market participation decision of teff producers at 10% level of significance in this study. Farmers' access to village town is hypothesized as positively affecting the probability of households' market participation decision, but unexpected result was obtained from the model result as it affected the market participation decision of households negatively. The survey result reveals that, teff producers who live near village town sell on average 8.1% less teff than farmers who cannot access village town. The possible explanation for this result is that those near village town have multiple options for nonfarm activities to earn income and reduce their interest to supply teff to market to earn cash. This result is contradicting with John et al., (2009) who said those farmers in peri-urban area sold higher proportion of their output than those in rural areas.

#### Age of the household head

Age of the household head was significant at less than 5% and related negatively to teff market participation decision of sampled households. The variable could have negative effect because older households tend to be risk

averse than younger household heads. The average marginal effect for age of the household head indicates that a one year increase in the age of household heads decrease the probability to enter into teff market by 0.5%, on average. In addition, older household heads have limited access to market information; whereas younger household heads could sell a relatively large portion of their product through better access to price information (Demeke and Jema, 2014). The finding is consistent with the study by Chalwe (2011), who found younger people participating more than older people in marketing of beans in Zambia (Table 2).

#### Estimation of second stage Heckman two stage model

To know factors influencing level of teff commercialization, second stage of Heckman selection (OLS) model was employed. The overall joint goodness of fit for the Heckman selection model parameter estimates is assessed based on the likelihood ratio test. The null hypothesis for the likelihood ratio test is that all coefficients are jointly zero. The model chi-square tests applying appropriate degrees of freedom indicate that the overall goodness of fit for the Heckman selection model is statistically significant at less than 1% probability level. This shows that jointly the independent variables included in the selection model regression explain the marketed surplus.

#### Landholding size of the household head (LHSIZE)

As hypothesized landholding size of farm household

**Table 3.** OLS model show degree of commercialization among teff producers.

<b>Model variable</b>	<b>Coefficient</b>	<b>Std. Err.</b>
Sex	0.26	3.72
Age	0.15	0.14
Family Size	0.1	0.5
Education level	0.0036	0.74
Land holding size	2.06**	0.88
Marital status	0.23	1.6
Land allocated for teff production	11.79***	2.36
Number of Oxen Owned	2.12***	0.68
Amount of fertilizer used	-0.013	0.01
Total Cost for Hired Labor	0.00012	0.00047
Non and Off farm Income	0.0005	0.0003
Distance from main road	0.274	0.38
Extension contact per year	0.37*	0.197
Distance from district market	-0.36*	0.195
Livestock Ownership	-0.375**	0.222
Inverse Mill's ratio (LAMBDA)	8.25*	4.25

positively affects the level of teff commercialization at less than 5% level of significance. As shown in Table 3 a hectare increase in landholding size increases the level of teff commercialization by 2% (0.02) Household commercialization index (HCI). Similarly, a study done by Masuku et al. (2010) showed a positive significant relationship between land size and commercialization.

#### **Land allocated for teff production (LAFTEFF)**

Proportion of land allocated for teff production had a positive and significant influence on the level of teff commercialization at less than 1% probability level of significance. Data in Table 3 show that a hectare increase in land allocated for teff increases the level of teff commercialization by 11.8% (0.118 of HCI). The implication is that the more households share their land for teff crop the more marketable surplus they have due to increase in the production of teff. This result is in agreement with the finding reported by Samuel and Sharp (2007) and Alemu (2015) which show that proportion of land allocated for output production positively affected marketable surplus of outputs.

#### **Number of donkey owned (NDONKEYO)**

As hypothesized, number of donkey owned was found to have a positive and significant influence on level of commercialization of teff at 1% significance level. Donkey ownership plays a crucial role in reducing transportation costs as teff is easily transported from home to the market as well as from farm to home where the road is

not suitable for other transportation material in the study area. Due to these reasons, it increased the proportion of teff sales in the market. The result presented in Table 3 showed that an increase in donkey owned by one unit increased level of teff commercialization by 4% (0.04), holding all other factors constant. The result is consistent with various finding (Mebratom, 2014; Shewaye et al., 2015).

#### **Oxen ownership (NOXENO)**

As hypothesized oxen owned was found to have positive and significant influence on the level of teff commercialization at less than 1% level of significance. Ownership of oxen increases the level of teff commercialization due to its effect on production. The possible explanation for this result is that households with large number of oxen usually enter into crop sharing agreements with poor households having no ox at all. This increases the level of teff available for sale. The result showed that an increase in oxen owned by one unit increased the level of teff commercialization by 2.12% (0.0212 HCI). This result is in a line with previous studies conducted by Berhanu and Moti (2010).

#### **Distance from the district market:**

As expected, the survey results showed that distance from the district market is negatively related with teff crop commercialization at 10% significance level. An increase in market distance by 1km decreases the level of teff commercialization by 0.36% or 0.0036. This finding is

confirmed with the study conducted by Aman et al. (2014) and Solomon et al. (2010) who found that being closer to the market enhanced market participation.

### Frequency of agricultural extension contact

As hypothesized frequency of agricultural extension contact per year significantly and positively influence the level of teff commercialization at less than 10% level of significance. From Table 3, a one day increase in the agricultural extension contact increased the level of teff commercialization by 0.37%. This finding is confirmed with the finding of Osmani and Hossain (2016) that Agricultural extension services appear effective in inducing market orientation for smallholder farmers.

### Livestock ownership excluding oxen and donkey:

It had significant and negative influence on the level of teff commercialization at less than 10% level of significance. Since livestock serve as a means of generating income through sale of livestock and livestock product farmers with large TLU are not encouraged in producing teff as a means of income generation. Therefore, as a unit of TLU increased the level of teff commercialization decreased by 0.375% or 0.00375. This finding is confirmed with the finding of Mebrahatom (2014) that livestock ownership reduces the commercialization of teff output.

### Inverse Mill's Ratio (LAMDA)

It was significant and positively related to the level of teff commercialization at less than 10% significance level, which implies that there are unobserved factors that might affect both probability of teff farm household market participation decision and marketed surplus. Its significance implies the existence of selection bias problem. The positive sign of inverse mills ratio shows that there are unobserved factors that positively affect both participation decision and level of teff commercialization.

### CONCLUSION AND RECOMMENDATIONS

This study used primary data collected from 133 sampled household through semi-structured questionnaire, Focus Group Discussions and key informant interview in the study area. For data analysis purpose both descriptive and econometric model were used. The result from first stage of heckman two stage models or probit model shows that proportion of land allocated for teff production, oxen ownership and access to village town significantly and positively affect household teff market participation decision while family size and age of household head

significantly and negatively affect household teff market participation decision. The heckman second stage model shows that landholding size, proportion of land allocated for teff production, oxen and donkey ownership and frequency of agricultural extension contact significantly and positively affect the level of teff commercialization; distance from market and livestock ownership significantly and negatively affect the level of teff commercialization. From the study results the following recommendations are drawn:

- (i) The government should improve infrastructure found in the district as access to village town positively affects teff market participation decision in the study area.
- (ii) Family size also significantly and negatively influences the probability of market participation decision of households in the study area. Therefore, the government should work strongly on family planning strategy and strengthen the already started awareness on family planning given to rural farm households by health extension workers at kebele level.
- (iii) Number of oxen owned by household was found to significantly influence *teff* market participation decision of households, and level of teff commercialization and ownership of donkey also significantly and positively influenced the level of teff commercialization in the study area. Therefore, development interventions to enhance health of oxen and donkey should get an emphasis through enhancing livestock package program.
- (iv) The district agricultural office should create an enabling environment, especially by given support to increase production of *teff*.

### CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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*Full Length Research Paper*

# **Beekeeping management practices and gap analysis of beekeepers at different agro-ecological zones of Tigray region, Northern Ethiopia**

**Guesh Godifey<sup>1\*</sup>, Amssalu Bezabeh<sup>2</sup>, Hailu Mazengia<sup>3</sup> and Yayneshet Tesfay<sup>4</sup>**

<sup>1</sup>Apiculture and Sericulture Research Case Team, Mekelle Agricultural Research Center, Tigray Agricultural Research Institute, P. O. Box 2582, Mekelle, Tigray, Ethiopia.

<sup>2</sup>Holeta Bee Research Center, Ethiopia.

<sup>3</sup>Department of Animal Production and Technology, Bahrdar University, Ethiopia.

<sup>4</sup>ILRI -LIVES Project, Ethiopia.

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The study was conducted to assess beekeeping practices, seasonal colony management gaps in eastern, south-east and central zones of Tigray region in northern Ethiopia. About 384 beekeepers were interviewed. The trend of honeybee colonies indicated an increase in the last five years but with variables (72%) in honey production. Majority (77.3%) of beekeepers inspected their apiary and honeybee colonies externally and only 21.7% did such inspection inside the hive. The most common locally available supplement feed included sugar syrup (94.6%), Shiro (peas and beans flour) (89.1%), tihni (barley flour) (87.6%), maize flour (25.5%), honey (14.4%) and fafa (supplementary food for infants) (7.9%). Major colony management gaps observed entailed adding super by guessing (47.9%), reluctance to decreasing super (35.5%), continued use of foundation sheets (40.4%) and queen excluder not removed (37.9%). The frequency of colonization was significantly different ( $p < 0.05$ ) in frame beehives but not in traditional hives. The seasonal colony activities included brood rearing in July to September; reproductive colony swarming, August to September; absconding, March to June; dearth periods, January to May; high availability of honeybee plants, July to December; and honey harvesting period, September to November. Therefore, seasonal colony management practices followed by floral cycle should be practiced by empowering beekeepers with skill in modern beekeeping management in order to improve their seasonal bee management practices, thus increasing honey production.

**Key words:** Agro-ecology, beekeeping, honeybee colony, management, seasonal, Tigray

## **INTRODUCTION**

In Ethiopia, the contributions of beekeeping in poverty reduction, sustainable development and conservation of natural resources have been recognized and well

emphasized (Global Development Solutions-GDS, 2009; Gidey and Mokenen, 2010; Gebremedhin et al., 2012). Beekeeping is also considered as one of the income-

\*Corresponding author. E-mail: [gueshgod@yahoo.com](mailto:gueshgod@yahoo.com).

generating activities for resource-poor farmers, including women, youth and the unemployed sectors of the community

Ethiopia has about 1.4 to 1.7 million households that are engaged in beekeeping and produce different types of honey that vary regionally as well as in terms of color, consistency and purity (Haftu, 2015). Nowadays, the well known and popular Tigray white honey is brought to the attention of beekeeping service provider partners in the region. Throughout the country, Tigray white honey is mainly sold in bulk to intermediaries and often distributed in big towns (Slow Food, 2009).

Although Ethiopia is recognized as one of the top ten producers of honey globally, the nation's output is still below 10% of its production capacity (Central Statistical Agency - CSA, 2017). Hence, the country in general and the region in particular are not benefiting from the Subsector as its potential would allow. Among the major challenges of beekeeping in Ethiopia, more than 90% of the beekeeping is practiced in traditional ways using traditional hives with low production and productivities of the subsector, lack of technical skill or poor management, the critical shortage of inputs, inadequate extension delivery system and lack of bee forage (Gezahegn, 2012).

Regardless of the beekeeping potential of smallholder farmers, little is done to identify the seasonal cycles of activities in honeybee colonies in Tigray region. Beekeepers lack a basis to undertake their beekeeping activities based on possible information on seasonal floral calendar (Haftom et al., 2013). This would have a negative effect on practicing appropriate hive and apiary management, honeybee feeding, honey harvesting and controlling natural swarming. For this reason, proper seasonal colony management practices would greatly improve colony performance and honey yields (Tolera and Dejene, 2014). The beekeeping practice and the gaps in beekeeping management are the basis for future intervention by professionals, organizations and beekeepers.

Hence, the present study was undertaken to assess beekeeping practices, identify seasonal colony management and determine gaps in colony management as currently applied by smallholder beekeepers.

## MATERIALS AND METHODS

### Study area

The study was conducted in six districts (Atsbi-Womberta, Kilde-Awlaelo, Degua-Temben, Saharti-Samre, Ahferom and Kolla-Temben) of Tigray Regional State, Northern Ethiopia (Figure 1). The districts were selected based on their potential for beekeeping; representing three agro-ecologies (low altitude, mid altitude lands and high altitude areas). Atsbi-Womberta and Degua-Temben districts represented high altitude areas; Kilde-Awlaelo, Ahferom and Saharti-Samre districts represented mid altitude areas; and Kolla-Temben district represented lowland agro ecologies. The agro-ecology of Tigray contains the three main traditional divisions

of arable Ethiopia: the *kolla* – lowlands (1400-1800 m above sea level) with relatively low rainfall and high temperatures; the *woina dega* – middle highlands (1800 - 2400 m.a.s.l.) with medium rainfall and medium temperatures; *dega* – highlands (2400 - 3400 m.a.s.l.) with somewhat higher rainfall and cooler temperatures. Most of the area is arid or semi-arid with annual precipitation of 450 to 980 mm. The annual mean temperature for the most part of the region is between 15 to 21°C (Bureau of Finance and Economic Development - BoFED, 2014).

### Data sources and methods of collection

Both primary and secondary sources of data were used in this study. Primary data were collected from sample household beekeepers through semi-structured questionnaire and field observation. Secondary data were obtained from the reports of Office of Agriculture and Rural Development in the respective districts, Regional Bureau, NGOs and other published and unpublished materials.

### Sampling technique and sample size determination

A multistage sampling procedure was employed to select beekeepers and honeybee colonies. At the first stage, three administrative zones were selected using purposive sampling based on their potential for beekeeping. In the second stage two districts were selected from each zone purposely based on their relative beekeeping potential and representing the three agro ecologies. In the third stage, three rural peasant associations from each district were sampled using purposive sampling based on their beekeeping potential and transport accessibility. In the fourth stage, beekeepers were sampled from all rural peasant associations using simple random sampling technique. Sample size for beekeepers was calculated based on Cochran (1963) as follows:

$$n_0 = Z^2 pq / e^2$$

Where,  $n_0$  is the sample size;  $Z^2$  is the abscissa of the normal curve that cuts off an area  $\alpha$  at the tails, which is 1.96;  $e$  is the desired level of precision (5%);  $p$  is the estimated proportion of an attribute that is present in the population which is 50%; and  $q$  is also 50%. Accordingly, a total of 384 beekeepers was used for the study.

### Data management and statistical analysis

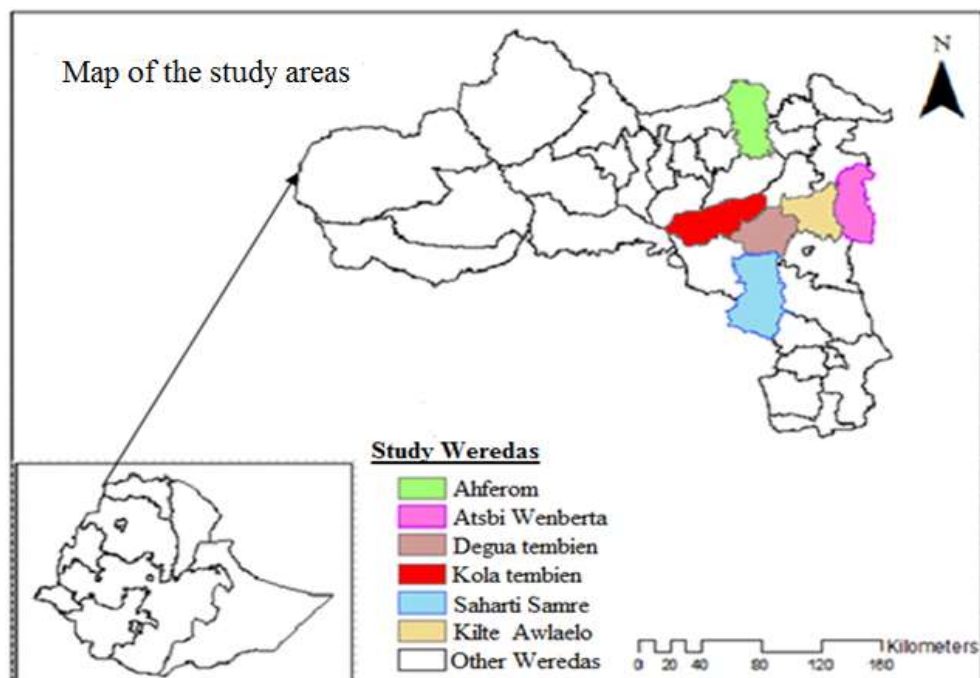
The collected data were coded, managed and tabulated for analysis. Simple descriptive statistics such as mean, standard deviation, frequency, percentage and one way ANOVA were used to analyze the data using SPSS (Version 20, 2011). Independent sample T-test methods were used to compare honeybee colonization. Tukey HSD was used to separate means and mean differences were considered significant at  $p < 0.05$ .

## RESULTS

### Beekeeping practices

#### *Types and number of beehives owned by the respondents*

The number of traditional and improved frame beehives owned per household vary among agro-ecologies and



**Figure 1.** Map showing the study area.  
Source: Extracted from Tigray 2012 map.

**Table 1.** Ownership of colonies managed under traditional and frame hives per household across agro-ecologies.

Agro ecological zone	Number of colonies in traditional hive					Number of colonies in improved frame hive				
	N	Min	Max	Mean	SD	N	Min	Max	Mean	SD
Highland	85	1	12	4.6 <sup>b</sup>	2.8	110	0	49	7.6 <sup>a</sup>	8.1
Midland	120	0	40	6.8 <sup>a</sup>	6.1	154	0	47	5.4 <sup>ab</sup>	6.6
Lowland	48	2	20	6.8 <sup>a</sup>	3.2	58	0	30	5.2 <sup>b</sup>	5.0
Overall	253	0	40	6.1	4.8	322	0	49	6.1	6.9

Superscript a, b are significantly different at  $p < 0.05$ .

beekeepers (Table 1). The result revealed that the average number colony ownership per household recorded in traditional and improved frame hives were almost the same for all respondents. It was observed that the mean number of honeybee colonies managed under traditional hive in lowland and midland was significantly ( $p < 0.05$ ) higher than that in highland agro-ecological zones. Whereas, significantly ( $p < 0.05$ ) large number of bee colonies in improved frame hive were found in highland agro-ecologies.

According to the survey result, the numbers of honeybee colonies in traditional and framed hives increased in the last five years (2010 to 2014) (Figure 1). However, slight decrease was observed in improved frame hives in 2014. Even though the presence of the high demand of honeybee colony, skill of splitting queen rearing technique and frame hive adoption by most beekeepers is assured, lack of appropriate beekeeping

equipments affect the increment of improved frame hives (Figure 2).

### Apiary types

Majority of the beekeepers in the study areas placed their honeybee colonies in their back yard; while about 12.5% of the beekeepers placed their honeybee colonies in closure areas (protected areas). Some placed the colonies inside a house (10.9%) and others hanged them on trees around the home (0.3%) (Table 2).

### Source of bee colony and means of stock increment

The result indicated that majority of the beekeepers obtained their establishing colonies by purchasing them from market places and other beekeepers; while the

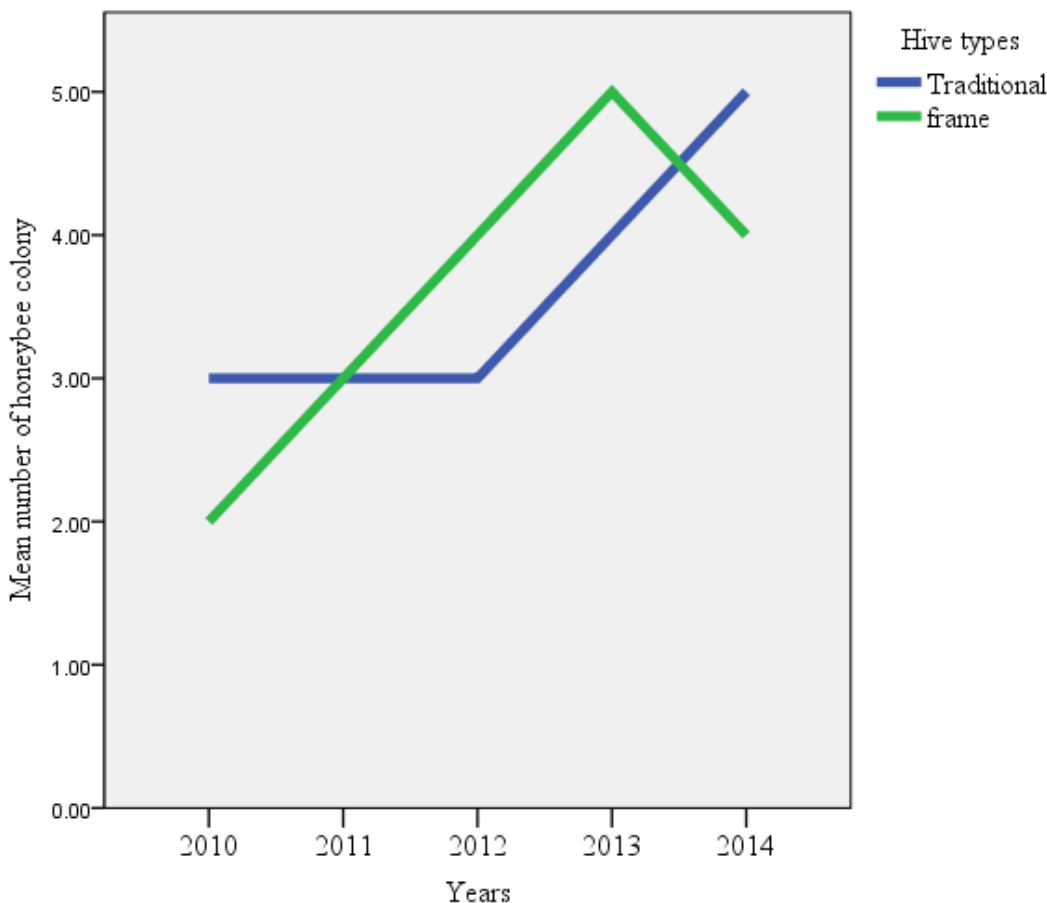


Figure 2. Trend of honeybee colony in the last five years.

Table 2. Placement of honeybee colonies across agro ecologies.

Placement	Agro-ecologies			Overall
	Highland	Midland	Lowland	
Homestead	104 (81.3)	154 (80.3)	35 (54.7)	293 (76.3)
Inside house	7 (5.5)	24 (12.5)	11 (17.2)	42 (10.9)
Closure areas	17 (13.3)	14 (7.3)	17 (26.6)	48 (12.5)
Hang on trees	0	0	1 (1.6)	1 (0.3)

Values in parenthesis are in percentages.

remaining got them as gift from parents and through catching swarms, using hanging bait hives on the apex of trees (Table 3). The proportion of swarm catching was the highest in lowland agro ecological zones and lowest in midlands. On the other hand, majority of the respondents from midlands and highlands got their bee colonies through purchase.

Once the bee colony is established, beekeepers of the respective districts use different means to increase their colony stock number (Table 4). Majority of the beekeeper respondents' indicated that their colony numbers were with no change over time. Additionally, the respondents

used splitting, natural reproductive swarming, purchasing and swarm trapping. Splitting and overcrowdings were the major colony sources in the study areas. The main source of colony sizes for highland, midland and lowland was splitting (25%), overcrowding (26.6 %) and splitting (46.95%), respectively.

### Honey production and harvesting frequency

According to the survey results, most of the respondents' harvested honey once followed by twice a year. However,



**Table 3.** Source of colonies.

Colony source	Agro-ecologies {No. (%)}			Overall {No. (%)}
	Highland	Midland	Lowland	
Gift from parents	27 (21.1)	40 (20.8)	19 (29.7)	86 (22.4)
Swarm catching	21 (16.4)	19 (9.9)	21 (32.8)	61 (15.9)
Purchasing	80 (62.5)	133 (69.3)	24 (37.5)	237 (61.7)

Values in parenthesis are in percentages, out of respondents in the same agro ecology.

**Table 4.** Methods of colony stock increment.

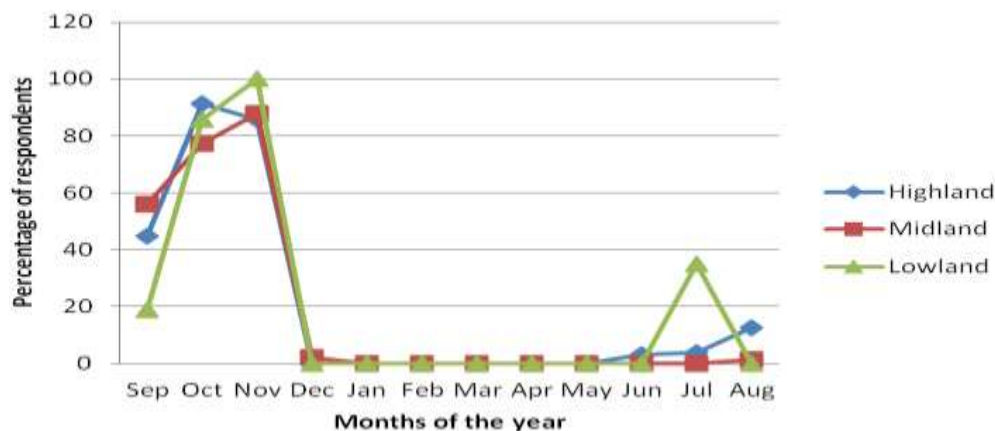
Colony source	Agro-ecologies {No. (%)}			Overall {No. (%)}
	Highland	Midland	Lowland	
Swarm catching	2(1.6)	6(3.1)	6(9.4)	14(3.6)
Purchasing	29(22.7)	13(6.8)	5(7.8)	47(12.2)
Natural swarming (Overcrowding)	27(21.1)	51(26.6)	18(28.1)	96(25)
Splitting	32(25)	35(18.2)	30(46.9)	97(25.3)
Constant	38(29.7)	87(45.5)	5(7.8)	130(33.9)

Values in parenthesis are percentages out of respondents in the same agro ecology.

**Table 5.** Honey harvesting frequency.

Frequency	Agro-ecologies {No. (%)}			Overall {No. (%)}
	Highland	Midland	Lowland	
Once	46 (35.9)	138 (71.9)	47 (73.4)	231 (60.2)
twice	64 (50)	45 (23.4)	17 (26.6)	126 (32.8)
Three times	15 (17.7)	9 (4.7)	0 (0)	24 (6.3)
Four times	3 (2.3)	0 (0)	0 (0)	3 (0.8)

Values in parenthesis are percentages out of respondents in the same agro ecology.

**Figure 3.** Honey harvesting months by agro-ecological zones.

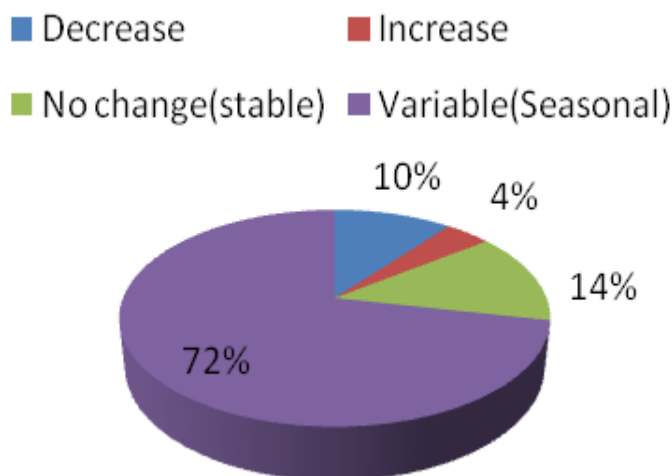
few respondents explained that they could harvest three to four times per a year (Table 5). The highest honey harvesting frequency was observed in highlands as compared to midland and lowlands. The major honey

harvesting months were September to November (Figure 3) in all agroecological zones. Whereas, the minor honey harvesting months were June to August. In the major honey harvesting months, the beekeepers could harvest

**Table 6.** Average honey yield (kg/hive/year) from traditional and improved frame beehives.

Agro ecology	Traditional beehive		Improved frame beehive	
	N	Mean $\pm$ SEM	N	Mean $\pm$ SEM
Highland	65	9.5 $\pm$ 4.5 <sup>a</sup>	100	27.5 $\pm$ 8.5 <sup>a</sup>
Midland	103	9.9 $\pm$ 3.4 <sup>a</sup>	138	25.7 $\pm$ 9.1 <sup>a</sup>
Lowland	45	12.7 $\pm$ 5.6 <sup>b</sup>	48	26.8 $\pm$ 8.5 <sup>a</sup>
Overall mean	213	10.4 $\pm$ 4.4	286	26.5 $\pm$ 8.7

Superscript a, b are significantly different at  $p < 0.05$ .

**Figure 4.** Trends of honey production.

honey twice in a month if the season is with well rained.

As could be indicated in Table 6, the amount of honey harvested from traditional and improved frame hives were 10.4 $\pm$ 4.4 and 26.5 $\pm$ 8.7 kg per year, respectively. The result indicated that there was a significant difference ( $p < 0.05$ ) in honey yield, using traditional bee hive among agro-ecologies. However, there was no significant difference in honey yield ( $p > 0.15$ ) using frame hive. The highest honey yield obtained from traditional hive was recorded in lowlands compared to highland and midland.

However, majority (72%) of the beekeepers declared that honey production varies among the years. The others, 14, 10 and 4% of the beekeepers responded as the production of honey remains stable, decreased and increased, respectively (Figure 4).

## Seasonal colony management

### Colony inspection

Beekeepers inspect their honeybee colonies at different times (Table 7). Majority of the respondents mentioned that they frequently (daily to weekly) inspect their apiary and honeybee colonies externally. The result indicated

that an external inspection of apiaries and honeybee colonies is done by most of the respondents. In the external inspection, beekeepers visit their hives and apiary to safeguard honeybee colonies from different natural disasters and various hazards and to observe their flight movement. However, only 13 and 27.9% of the respondents do undertake internal inspection of their bee colonies frequently for traditional and frame hives, respectively. Majority of the beekeepers internally inspected their honey bee colonies by chance at their convenient time. For the external honeybee colony inspection, there was no significant difference ( $\chi^2 = 2.625$ ,  $p > 0.05$ ) done on traditional and frame hives by the beekeepers. However, there was significant difference ( $\chi^2 = 49.180$ ,  $p < 0.01$ ) in the internal inspection undertaken for frame hives than traditional beehives.

### Feeding management

Honeybees store honey for their own consumption during dearth periods. Beekeepers harvest honey, which the honeybees stored for themselves. As a result, honeybees face starvation due to lack of feed. To overcome the problem, supplementary feed is required for the

**Table 7.** Percent distribution of frequency for inspection of apiary by respondents.

Types of Inspection	Frequency of inspection	Hive types		$\chi^2$	P-value
		Traditional	Frame		
External	Daily to weekly	74	77.1	2.625	0.453
	At convenient	19.5	20		
	Yearly	5.2	2.9		
	No inspection	1.3	0		
Internal	Daily to weekly	13	27.9	49.180	0.001
	At convenient time	37.7	57.1		
	Yearly	9.1	11.4		
	No inspection	40.3	3.6		

**Table 8.** Locally available feed types for honeybee colony supplementation used by the beekeepers in the study districts (%).

Types of feed	Agro-ecological zones			Overall
	Highland	Midland	Lowland	
Sugar syrup	93.2	93.9	100	94.6
<i>Shiro</i>	93.2	88.9	79.3	89.1
<i>Tihni</i>	94.6	84.8	35.9	87.6
Maize flour	32.4	24.2	10.3	25.2
Honey	1.4	21.4	24.1	14.4
<i>Fafa</i>	0	8.1	27.6	7.9

honeybees. The most common locally available feed types used for colony supplements identified were sugar syrup (94.6%), *Shiro* (peas and bean flour) (89.1%), *tihni* (barley flour) (87.6%), maize flour (25.5%), honey (14.4%), and *fafa* (supplementary food for infants) (7.9%) in their order of utilization (Table 8). In all agro-ecological zones of the study areas, beekeepers offer supplementary foods for their honeybee colonies.

### Manipulation of hive supers, foundation sheet and queen excluders

Movable frame beehives allow common bee management practices such as migratory beekeeping, supers adding or reducing, regular inspection, quality honey harvest, swarm control, feeding during dearth periods, stimulating early colony growth, and pest and disease control. Table 8 indicates the common practice for seasonal colony management. The result reveal that 52.1% of respondents put additional hive supers by inspecting the internal condition of the colonies and the rest of them put without inspection (47.9%). Even though majority of the respondents (64.5%) reduce the super during the dearth period; still, 35.5% of them keep their colonies without reducing during the dearth period. These finding also suggest that some beekeepers replace very old brood combs from their colonies every year (41%), every 2 to 3

years (18.6%), and some forever (40.4%). Most of the respondents explained that 62.1% of them remove the queen excluder immediately after honey was harvested. However, in some beekeepers, queen excluders were left on top of the base hive or without reducing the supers (37.9%) even during the dearth period (Table 9).

### Absconding and swarming of honeybee colonies

According to the survey result, the trend of honeybee colony absconding in the study districts increased from 6 to 242 and 25 to 441 in traditional and framebeehives respectively between year 2010 and 2014 (Figure 4). Within the last five years, a total of 441 traditional and 854 frame beehives were absconded in the study areas.

An average number of modern beehive enumerated during survey in beekeepers apiary were 3.03 of which 1.15 were colonized and the other 1.88 without bees due to colony absconding at different time for different reasons. The average number of traditional beehive colonized were 3.25 whereas 3.85 were without bees. The frequency of colonization was significantly different ( $p < 0.05$ ) in frame beehives but not in traditional hives (Table 10).

There was a financial loss due to absconding of honeybees from frame and traditional hives. A total of 441 traditional and 854 frame beehives without honeybee

**Table 9.** Percent distribution of improved honeybee colony manipulation in the study areas.

Manipulation variable	Category	Frequency	%
Super adding	Through inspection	162	52.1
	Through guessing	149	47.9
Super reducing	Yes	198	64.5
	No	109	35.5
Foundation sheet change	Every years	126	41.0
	Every 2-3 years	57	18.6
	No change	124	40.4
Queen excluder removal	Yes	190	62.1
	No	116	37.9

**Table 10.** Mean number of honeybee colonies with and without bees in traditional and frame beehives.

Hive type	Colonization		Significant
	With bees	Without bees	
Traditional	3.25	3.58	NS
Frame	1.15	1.88	**

NS=Not significant difference, \*\* Significantly different at  $P < 0.01$ .

**Table 11.** Average number of swarms produced and used for next generation (N=241).

Agro ecological zone	Number of swarms produced per colony (Mean $\pm$ SD)	Number of swarms used for next generation
Highland	8.77 $\pm$ 2.38 <sup>a</sup>	1.44
Midland	9.12 $\pm$ 3.06 <sup>a</sup>	1.71
Lowland	8.64 $\pm$ 2.80 <sup>a</sup>	1.90

Superscript 'a' indicates significant difference at  $p < 0.05$ .

colonies represented a minimum loss of about 661,500 ETB and 3,996,720 ETB, respectively. From the existing total 1295 empty beehives, it would be possible to earn 4,658,220 from the sale of honey.

Some beekeepers consider swarming as a good thing because beekeepers are able to naturally increase the number of colonies by capturing swarms. However, in more recent times, swarming is considered a nuisance because it instantly reduces honey production. The mean reproductive swarming incidence per colony was 8.77, 9.12 and 8.64 in highland, midland and lowland agro ecological zones respectively and insignificant difference ( $p > 0.05$ ) was observed (Table 11). However, the average number of incidental swarms caught by the respondents was 1.44, 1.71 and 1.90 in highland, midland and lowland agro ecological zones respectively and the swarmed

return to their original hive.

### Seasonal colony activities

Brood rearing, reproductive swarming and absconding are a common phenomenon in honeybee colonies. Honeybees perform their normal activities based on seasons, normally during honey flow and dearth period seasons.

The respondents replied that there was an incidence of major brood rearing in the months of May (25.8%), July (99%), August (99.7%), September (100%) and October (63%) in their increasing order. As regards season of reproductive colony swarming, beekeepers of the survey area indicate that September (99.7%), August (92.4%),

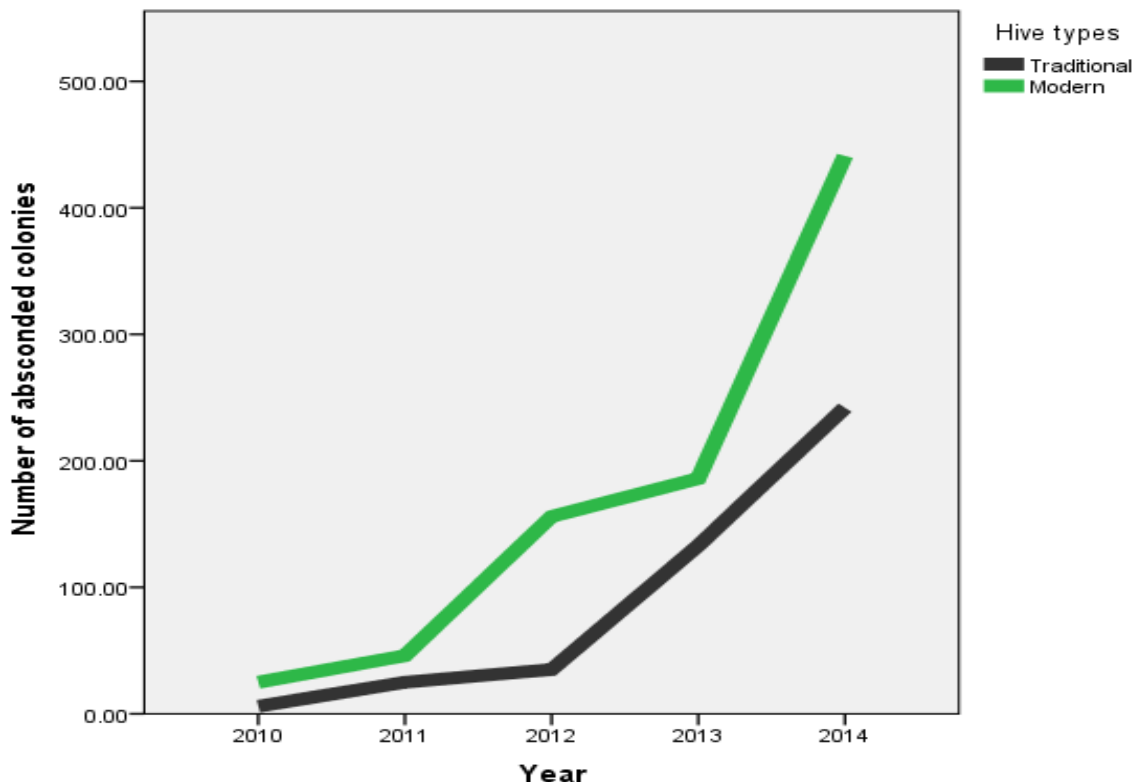


Figure 5. Trend of honeybee colony absconding.

July (33.1%) and October (20.6%) are the main months in which colony swarming occurs owing to availability of pollen, vegetation coverage and instinct behavior of bees; while, November, December, January, February, March, April and May are months in which there are no record of incidence (Figure 5).

Honeybee colonies abandoned their hives at any season of the year for different reasons. The beekeepers indicate that March (50.3%), April (54.4%), May (63.3%) are June (59%) as the first four main colony absconding months in their locality. As indicated by the beekeepers, incidence of pests and predators, poor management, and excessive weather conditions (sun, wind and rain) are the causes of colony absconding. According to beekeepers, the peak dearth periods of the year are dry season period (March to May) as there is no flowering plant as a source of pollen and nectar; and during rainy season (June to July), as the pollen of the flowering plants is diluted and the nectar is washed by the rain and is referred to as dearth period and agro-chemical applications.

Similarly, high availability of honeybee plants, from July to December, was recorded. September to November are regarded as the main honey harvesting period of the year as this period is the main flowering season of the year; while, June is regarded as the second honey flow season/ harvesting period of the year. Dearth period of honeybees occur between January and June (Figure 6).

## DISCUSSION

The number of colonies owned per household were significantly ( $p < 0.05$ ) different across the agro ecologies. Improved frame hives and traditional beekeeping practices are found to co-exist in all the areas, which is similar with the finding of Workneh (2011a, b). The sample households in highland had significantly larger number of bee colonies in improved frame hives but lower in traditional hives compared to the sample households in low land and midlands. However, the number of improved frame hives owned by the sampled respondents in highland and midland were insignificantly difference. The greater number of honeybee colonies in improved hives in highland and midland is probably because of strong intervention on beekeeping by Government and non-government organizations in the areas. According to Workneh (2011), improved box hive was introduced into the highland districts of Tigray region in 1998 for the first time. Contrary to this, Alemayehu Abebe et al. (2016) reported that highlands with dense forest and lack of access to modern box hives would have greater number of honeybee colonies in traditional hives.

Majority of the respondents kept their honeybee colonies in their backyard and traditional hives inside the house. This finding is in line with the reports of Tessega

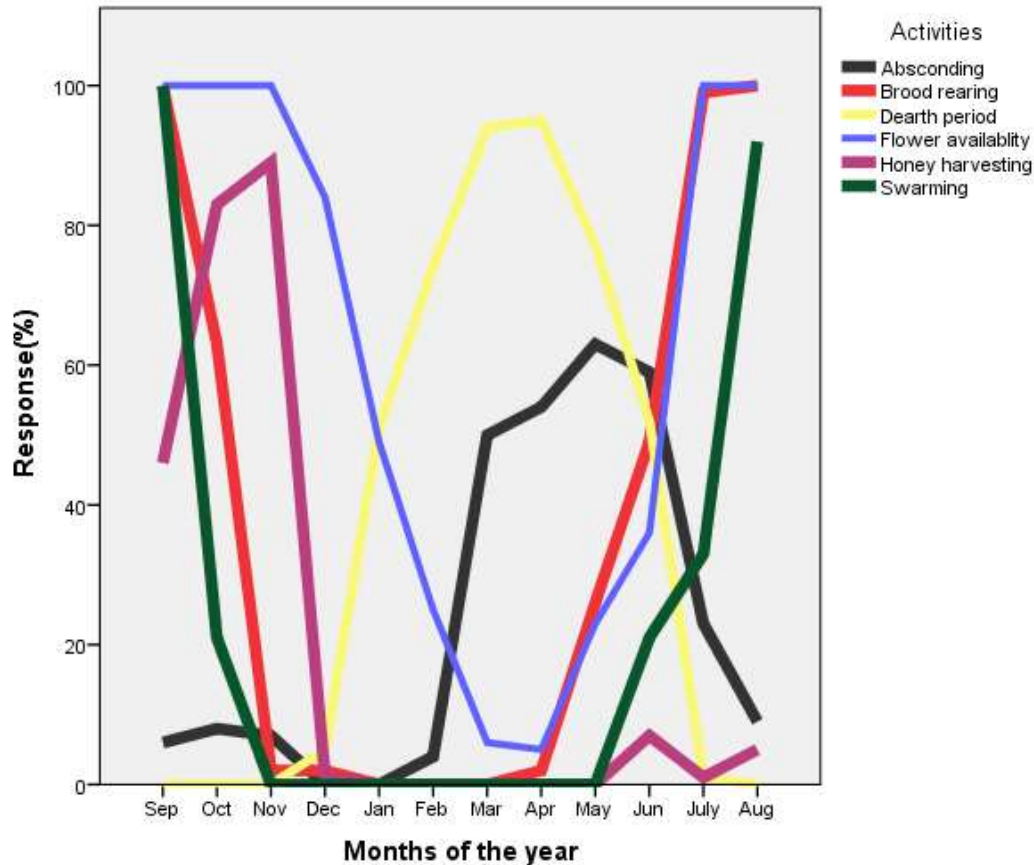


Figure 6. Seasonal activities of honeybees.

(2009), Gidey et al. (2012), Nebiyu and Messele (2013), and Niguse (2015). Placing hive around homestead and in house apiary sites is appropriate for daily follow up of beekeeping activities (Berhanu, 2016). However, Kidane (2014) reported that majority of the traditional hives are hung in the dense forest, which are mostly far from residential areas and are visited only one or two times until harvest among Gambella people in the national regional state.

The honey yield obtained in the current study was similar to the result of Gidey and Mekonen (2010), who reported 8-15 kg and 20-30 kg of honey from traditional and improved movable frame beehives in the region respectively. According to CSA (2017), the amount of honey obtained from traditional and improved movable frame beehives was higher than the national average honey yields of 9.2 and 19.1 kg. Honey yield fluctuates from year to year and varies between colonies. The difference may be due to climatic condition, beekeeping management and extension support offered to beekeepers. The frequency of harvesting honey per hive in the same area and year is also different among beekeepers. Kajobe et al. (2009) stated that the frequency and amount of honey harvested varies depending on, seasonal colony management practices (skill of

beekeepers); flowering condition of major bee forage (rainfall) and type of beehive (Belets and Gebremedhin, 2014).

Most beekeepers visit and inspect their beehives externally. However, internal hive inspection was limited. Beekeepers inspect colonies when colonies become weak and during honey harvesting seasons. This is apparently because of the absence of personal protective cloths and tools, fear of being stung, the risk of colony absconding and lack of awareness of the value of doing so. Moreover, almost all beekeepers in the study area perform external inspection and also clean their apiary to prevent ant and other insect pests from getting access to hives. This result is consistent with other findings (Kerealem et al., 2009; Nuru, 2007; Kebede and Lemma, 2007; Teklu, 2016) which report that farmers in Ethiopia do not commonly practice internal hive inspection. However, Yetimwork et al. (2015) reported that 53.5% of respondents (beekeepers) visit their honeybee colonies frequently.

In the present study, beekeepers were adding supers by guessing and continued to keep constant number of supers during the dearth period. This is due to low awareness of the beekeepers. Similar result was reported by Gidey and Mekonen (2010) who indicated that lack of

proper bee management is one of the problems facing the honey sub sector in the region. Similar result was reported by Tolera and Dejene (2014). Furthermore, there are beekeepers that do not change the old comb for many years.

During the shortage of bee forage, most of the beekeepers supplement their honeybee colonies from locally available feed types to survive dearth periods in the region. This finding is in line with that of Yetimwork (2015), Tessega (2009), and Solomon (2009); stating that majority of the beekeepers in Ethiopia practice dry season supplementary feeding. Providing supplemental feed to honey bee colonies increase their performance through improving colony maintenance, buildup, and production during shortage of natural pollen (Lumturi et al., 2012).

Absconding due to inappropriate colony management is the major constraint in the districts and beekeepers fail to produce sufficient amount of honey, regardless of apiculture potential in study the areas. Proper bee management practices enhance colony performance, such as reduced absconding, improved colony strength and higher hive yields (Wilson, 2006; Tolera and Dejene, 2014). Such loss is partially compensated by the high rate of swarming of colonies.

## Conclusions

Beekeepers of the study areas own both traditional and frame hives. Even though absconding of honeybee colonies was the most phenomena in the study areas, the number of bee colonies showed an increase in the last five years. Some beekeepers have not considered absconding as the major problem because there is high swarming tendency to substitute the absconded colonies.

Despite feeding management was practiced during the dearth period, management gaps on super adding or reducing and old comb replacement were observed.

The incidence of major brood rearing was in the months of July to September. As regards season of reproductive colony swarming was August to September. Honeybee colonies abandoned their hives at any season of the year for different reasons. March to June was recognized as colony absconding months in most localities. According to beekeepers, the peak dearth periods of the year are dry season period (January to May) as there is no flowering plant as a source of pollen and nectar. Similarly, high availability of honeybee plants from July to December was recorded. September to November were regarded as the main honey harvesting period of the year as this period is the main flowering season of the year; whereas, June was regarded as the second honey flow season/ harvesting period of the year.

Therefore, seasonal colony management practices followed by floral cycle should be practiced by empowering beekeepers with skill in modern beekeeping management in order to improve their seasonal bee

management practices; thereby, increasing honey production.

## CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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